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

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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NON-POWER PRODUCTION AND UTILIZATION FACILITIES

SUBCOMMITTEE

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THURSDAY

MARCH 17, 2022

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The Subcommittee met via Teleconference, at 8:30 a.m. EDT, Ronald G. Ballinger, Chair, presiding.

COMMITTEE MEMBERS:

RONALD G. BALLINGER, Chair

VICKI M. BIER, Member

CHARLES H. BROWN, JR. Member

VESNA B. DIMITRIJEVIC, Member

GREGORY H. HALNON, Member

JOSE MARCH-LEUBA, Member

DAVID A. PETTI, Member

JOY L. REMPE, Member

ACRS CONSULTANTS:

DENNIS BLEY

STEPHEN SCHULTZ

DESIGNATED FEDERAL OFFICIAL:

CHRISTOPHER BROWN

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

P R O C E E D I N G S

8:30 a.m.

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

The ACRS Members in attendance are Charles Brown, Greg Halnon, Vicki Bier, Joy Rempe, Dave Petti, Jose March-Leuba, and I think Vesna's on the line. Matt Sunseri might be on the line, and we have our consultants, Steve Schultz and Dennis Bley.

If I've missed anybody, please let me know. Chris Brown of ACRS Staff is the designated federal official for this meeting. During today's meeting the Subcommittee will receive a briefing from the NRC Staff on SHINE Medical Isotopes.

The Subcommittee will hear presentations and hold discussions with the NRC Staff, SHINE representatives, and other interested persons regarding Chapters 1, 2, 4, 5, 6, and the quality assurance program from Chapter 12.

I might remind the Members that please send your feedback through Chris to myself within one week of this meeting so that we can stay on our schedule.

In part of the presentations by the Applicant at an NRC Staff meeting closed in order to discuss information that is proprietary to the licensee and its contractors pursuant to 5 U.S.C. 552BC4.

Attendance at the meeting that deals with such information will be limited to the NRC Staff and its consultants, SHINE and those individuals and organizations who have entered into an appropriate confidentiality agreement with them.

Consequently, we need to confirm that we have only eligible observers and participants in the closed part of the meeting, and the closed part of the meetings will be if necessary in the afternoon.

The rules for participation in all ACRS meetings including today's were announced in the Federal Register on June 13, 2019.

The ACRS Section of the U.S. NRC public website provides our charter, bylaws, agendas, letter reports, and full transcripts of all full and Subcommittee meetings including slides presented in the meeting notice. And the agenda for this meeting was posted there.

We have received no written statements or requests to make an oral statement from the public. The Subcommittee will gather information and analyze relevant issues and facts, and formulate proposed positions and actions as appropriate for deliberation by the full Committee.

The rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register.

Today's meeting is being held over Microsoft Teams, which includes a telephone bridge line, a line for participation for the public over their computer using Teams or by phone.

Additionally, we have made an MS Teams link available on the published agenda.

The transcript of today's meeting is being kept, therefore, we impress that meeting participants on Teams and on the Teams call-in line identify themselves when they speak and to speak with sufficient clarity and volume that they can be readily heard.

Likewise, we request that meeting participants keep their computer and/or telephone lines mute when not speaking to minimize disruptions and feedback. The chat feature on the Teams should not be used for technical exchanges.

I'll make sure that everybody is muted. I want to note that SHINE has an NRC-approved QAPD issuance of the permit and has only revised it on the line few years.

The Staff can certainly answer any questions that the Subcommittee has on QAPD. The discussion of the QAPD will be minimal. I'll proceed and call on Sean Anderson, who is sitting over there for acting Deputy Director in NRR for opening remarks.

Sean?

MR. ANDERSON: Thank you, good morning, Chairman and ACRS Members. My name is Sean Anderson and I'm the acting Deputy Director in the Division of Advanced Reactors and Non-power Production and Utilization Facilities.

We appreciate the ACRS ongoing support for the schedule flexibility and the review of the application. As you mentioned, the goal here is to review the first batch of chapters provided to ACRS.

SHINE will provide the design of the review and the Staff will present their review approach and their conclusions. Some chapters will also focus on the changes since the construction permit.

Specifically, Chapter 2 and QAPD.

We also appreciate the feedback that the ACRS has provided from the overview meeting that we held previously and also any subsequent questions and documents requests that have been requested prior to the meeting so that we can sufficiently prepare both SHINE and the Staff accordingly for your questions today.

If there's any unanswered questions we'll make sure we take them back and provide you the answers appropriately and schedule an official meeting as necessary.

And while the Staff is working towards an aggressive schedule, we will not make a final decision unless we have the information needed to come to a reasonable assurance of adequate protection federal.

This is a risk-informed review that considers the size and risk of the facility. The application of this approach will also be touched on by the Staff as appropriate in their presentations today.

Finally, while some reviewers will touch on the phased approach in their presentations, the phased approach review will also be discussed at a future ACRS meeting. Thank you.

CHAIR BALLINGER: One more thing, I would be remiss if I didn't thank the SHINE folks for being extraordinarily forthright in establishing this Committee's ability to access files through this box. And so I want to thank the SHINE people for doing that.

Okay, so who is the presenter for SHINE? Is it Jeff?

MR. BARTELME: Tracy Radel, our VP of engineering, will be starting the presentation this morning.

CHAIR BALLINGER: Thank you, the floor is yours.

MS. RADEL: Thank you, we're going to start off today with a facility overview with Chapter 1 and then move into Chapter 2, where we're going to cover the analyses that have changed since the construction permit PSAR phase, which include the chemical hazard analysis and the aircraft hazard analysis.

Next slide.

The SHINE site is located outside of Janesville, Wisconsin.

Our radiologically controlled area is divided into two regions, the radiation facility which contains eight accelerator-driven subcritical assembly irradiation units and supporting equipment for those irradiation units, and then the radioisotope production facility which contains the target solution preparation, target solution storage, three processing lines for isotope extraction, and waste handling processes.

The structure is seismically qualified and we use geometrically favorable equipment where practicable to ensure passive safety and reduced risk.

The structure systems and components whose intended functions are to prevent accidents that could cause undue risk to health and safety of workers and the public or mitigate the consequences of such accidents are classified as safety-related SSCs.

Next slide.

Listed here are major operations that are performed in the SHINE facility.

These include target solution preparation from the raw feed material, irradiation of target solution, moly extraction from irradiated target solution, purification, target solution adjustments, and solidification of radioactive liquid waste.

The IU Cell Safety Actuation automatically transitions the units to a safe state if there are upset conditions.

In this actuation, we de-energize the neutron driver, open redundant target solutions dump valves that drain the target solution to geometrically favorable TSV dump tank, and isolate the primary system boundary.

Any questions on the facility overview? Otherwise, we'll move into the chemical hazard analysis.

Okay, accidents involving detonations of chemicals or fuels were considered for facilities and activities onsite and offsite. Allowable standoff and actual distances of hazardous chemicals transported or stored near the facility were determined in accordance with Reg Guide 1.91.

Stationary explosions at the source and vapor cloud explosions were considered. The stationary explosion evaluation used the TNT equivalence method described in Regulatory Guide 1.91.

The vapor cloud explosion evaluation used ALOHA computer program. Where the postulated explosion has a standoff distance greater than actual distance, a probabilistic analysis was used.

The conclusions of this analysis were that no chemical explosion hazards were found to pose an unacceptable risk to the SHINE facility.

Next slide.

Moving to toxic chemicals, chemical hazards within five miles of the SHINE site including onsite were evaluated for their potential toxicity. Chemical hazards not screened out in the screening criteria were evaluated using ALOHA.

CHAIR BALLINGER: Folks, we're getting some feedback from somewhere. Hopefully we can correct it. Okay, keep going, thank you.

MS. RADEL: If concentrations in the facility control room for a chemical release exceeded the evaluation criteria, a probabilistic --

CHAIR BALLINGER: Can you be a little bit louder? We're having trouble hearing you.

MEMBER MARCH-LEUBA: You are very garbled. Can you try again? Say something, we'll see if it's fixed.

MS. RADEL: If concentrations in the facility control room --

MEMBER MARCH-LEUBA: You are very low, low volume. Speak louder, thank you.

DR. BLEY: It has an echo, kind of like we're getting feedback from a speaker back into your microphone.

MS. RADEL: I'm not sure how to turn it up or fix feedback.

MEMBER REMPE: Can you get closer to the microphone?

MS. RADEL: I'll try to speak a lot louder. Is that better?

MEMBER MARCH-LEUBA: Yes, it's better.

CHAIR BALLINGER: Give it a try.

MS. RADEL: If concentration in the facility control room for a chemical release exceeds the evaluation criteria, a probabilistic evaluation was performed.

A simple probabilistic analysis was not sufficient to eliminate ammonia from consideration as a hazard to the site, however, in the most limiting case assuming the most limiting location of release, maximum inventory of release, worst-case wind directions and five percent annual exceedance maximum wind speeds and atmospheric stability class, the facility control room operators will still have two minutes to take self-protective actions.

Next slide.

MEMBER BROWN: Can you go back to the protected actions slide? Two minutes. Does that mean just leave and close the door? Is there something else that has to be done?

MS. RADEL: The two minutes would be sufficient time for the operators to place the facility in safe condition prior to donning the protective equipment and exiting the control room.

Placing the facility in safe condition is not required for safety, just something they would do per their procedures prior to leaving their control room.

MEMBER BROWN: So, something tells them there's a problem, something alerts them to this, right? And all they do is get up and walk out the door, that's what they have to do, close it?

MS. KOLB: This is Catherine Kolb, Director of Plant Operations for SHINE.

That is the scenario that we've postulated there, that if they needed to leave the control room for any reason, we will have emergency procedures that direct them to push down processes that are in process and leave the control room.

So, that is what that's referring to, the two minutes, they would have enough time to do that and if needed to use any kind of PPE that they might need.

MEMBER HALNON: This is Greg. Could you

describe the actions that have to take place in two minutes after recognition that they have an ammonia issue and have to initiate --

MS. KOLB: Again, the actions are not required for the safety of the facility. This would be the actions that the operators take per their evacuated control room emergency procedure, and that would be to shut down the irradiation units, any of them that are running.

That could be accomplished with these single key -- sorry, I think I went on mute there briefly -- switch that we have on the main control board. So, a single action.

MEMBER HALNON: How long does it take them to recognize that action needs to be taken? In other words, if you have the ammonia on site and you have I assume detectors that after the alarm is at the two-minute countdown?

MS. KOLB: We have no chemical detectors that would cause alarms in the control room. We have not done time studies.

MEMBER BROWN: How do you know you've got the ammonia?

MEMBER HALNON: Yes, how do you know? I know you start smelling it but how do you know when that two-minute countdown starts? I'm not saying it's a two-minute hard and fast countdown but there's obviously a very short period of time between I smell it and I have to get things done.

Seasoned firefighters take about 45 seconds to a minute to put on an SCBA and they practice it. So, if you're talking about recognition, taking an action, donning an SCBA, and getting out of the control room, two minutes is not even close.

MS. KOLB: We have not evaluated that because the action was not required for the safety of the facility. So, the ammonia in the facility doesn't cause any direct hazard to the facility, it is for the safety of the operators.

So, we have not evaluated that or done any time studies.

MEMBER BROWN: But what tells them they've got an ammonia problem in the first place? Just they sniff it and that's it, is that the detector?

MS. KOLB: The smell, yes.

MEMBER BROWN: So, if they're sitting there and they smell it they should halt -- that's a crude way of phrasing it but that's what I would do.

MS. KOLB: Yes, they should follow their procedures for any need to evacuate the control room.

So, if there was similarly a fire or smoke in the control room for some reason for any reason needing to evacuate the control room, they would follow their evacuate the control room procedure, which they will receive training on as part of their license operator training.

MEMBER HALNON: So, the other question is they evacuate the control room, which is probably the most protected spot for people and they go out into an ammonia cloud.

Assuming they're all incapacitated at that point, is there anything that has to be done for the safety of the facility post ammonia knock-out?

MS. KOLB: No, there is no immediate action required for the safety of the facility.

There are no required mitigated actions in any of the scenarios that we've evaluated that the operators need to take in order to mitigate the consequences of accidents.

MEMBER HALNON: So, as soon as they hit that key switch, we're in a perennial state safe condition?

MS. KOLB: Yes.

MEMBER BIER: Another quick question, this is Vicki Bier.

Have you thought through what the training would be to ensure that the operators feel essentially entitled to take that action rather than having to call up their supervisor and say something is fishy here, is it okay for me to evacuate kind of thing?

MS. KOLB: We are currently in the process of training the operators, we started an initial license training class.

We haven't developed the lesson plan for the emergency procedures yet but in terms of their supervisor, the license operators' supervisor or a senior license operator is required to be in the site at all times.

So, there would be no need to call anyone offsite if they had questions in any scenario.

CHAIR BALLINGER: This is Ron Ballinger. I guess another way to state the question is who has the primary responsibility?

You don't want to get into a conversation with three or four different people to decide something, so who has the responsibility?

MS. KOLB: The shift supervisor, that would be a senior licensed operator, the most senior licensed person at the site, which we are calling the shift supervisor.

CHAIR BALLINGER: And that person will know that?

MS. KOLB: Yes.

MEMBER HALNON: So, just a last question, when you finally do your time studies and you find out that you're well over two minutes, and being able to, one, recognize hazardous cloud to decide who can give the order to the shift supervisor to turn the key switch, make a significant decision to evacuate a control room, decide where you're going to go, don SBCAs to prevent incapacitation when you leave the protected environment of a control room.

If that's more than two minutes, do you have a backup plan to install toxic gas monitors or any other early warning systems?

MS. KOLB: This is Catherine again. We have no plans to conduct time studies because the actions required are not for the safety of the facility, they're not required to mitigate any consequences so we're not doing time studies.

MR. LELLI: My name is Joe Lelli, I'm an engineer here at SHINE and I think it might be good if I discuss how we evaluated the ammonia release and talk about the standards we evaluated.

So, to be clear, this is not an onsite

release of ammonia. I don't know if we have any anhydrous ammonia onsite.

We do not have any anhydrous ammonia onsite, so this is an offsite release and this worst-case scenario we're talking about basically a tanker truck full of ammonia that crashes.

I think we evaluate a couple hundred meters away from the facility. So, basically right offsite the facility gate you have a bad truck accident that releases ammonia.

And so again, we use very conservative meteorological condition, we postulate that the facility air intake is directly downwind of the release at that time, that the meteorological conditions are such that we would expect the maximum concentration at the facility intake point.

So, I think we modeled based on one meter per second wind, so very low wind, and a PASCO stability class F, so very stable. So, think of a very narrow dense plume aimed directly at the facility intake.

I'll give you a little more perspective. Just to give you a little bit more perspective on how we got this.

MEMBER HALNON: Thanks, I think we can

appreciate the low probability and all the conditions that have to line up especially perfect.

But the point is you're designing a facility to a certain set of criteria and you've offered this criteria up that operators will have sufficient time in two minutes to take all the action.

So, that's what we're questioning, we're not necessarily questioning whether or not this is going to happen and really affect the safety. Take a look at that and really make sure the statements you're making are self-contained and they can stand on their own.

This one can't stand on its own. You won't be able to convince me that two minutes is enough time to take the actions you've talked about. So, maybe they don't have to be taken, maybe that's the statement rather than we have two minutes to take the actions.

Just think through that.

DR. BLEY: This is Dennis Bley.

I agree with Greg on what he just said and if you haven't dealt with ammonia, it hits quickly and incapacitates quickly. Maybe you don't have concentrations high enough or I don't know exactly how likely it is that you do.

But there seems to be an attitude that if the facility says everything is fine -- but you've got to think about the workers too. That might not be part of the license but it's an important part.

MEMBER HALNON: We can move on, I think we've beat this horse.

MS. RADEL: Next slide. Fires in adjacent industrial plants and storage facilities, oil and gas pipelines, and fires from transportation accidents were evaluated.

Three types of fires were analyzed, boiling liquid expansion vapor explosion, or BLEVE fire balls, pool fires, and jet fires. The three types of fires were analyzed using ALOHA.

The limiting fire scenario resulted in a temperature rise on the facility concrete wall of 44 degrees Fahrenheit. This is an insignificant temperature rise compared to the ACI standards for short and long-term maximum concrete temperatures.

Next slide.

MEMBER HALNON: Just real quick on the fires, there is a document out there called the commercial aeronautical activities, it's a standard contract for the airports' fuel capacity.

And it states there's always going to be at least a minimum of 12,000 gallons of jet fuel onsite. One of your tables had less than that as the amount of fuel that is onsite, and I believe it's in either Table 2.215 or 2.216, I'm not sure which one.

I don't have it in front of me right now. But maybe you and the Staff can check the numbers and make sure we don't have a number that someone gave you that is not necessarily bounding.

If the contract with the fuel vendor says you'll always have a minimum of 12,000 and the maximum is, what you said, onsite, so 11,000 gallons, there's some disconnect there.

It's not a big deal, I don't have a problem with the analysis, it's just the correctness of the table.

CHAIR BALLINGER: This is Ron Ballinger again. Whenever I see a number for one of these analyses, it's got two significant figures. Without any uncertainty it makes me wonder.

So, 44 degrees, what could it be, or is that the upper limit?

MS. KOLB: Joe, are you able to speak at this time to the uncertainty in the calculation or should we follow up on that?

MR. LELLI: I think we should follow up so

I can speak with more certainty on that.

MEMBER HALNON: One last question on the BLEVE, was the orientation of the tanker trucks, was that factored into the models for the fireball and the BLEVE itself?

From the standpoint of a missile, BLEVEs in horizontal tanks tend to have sideways missiles coming out as the tank explodes. Was that part of it?

MS. RADEL: Joe, can you speak to that?

MR. LELLI: We didn't evaluate the missile hazard of the BLEVE tank.

MEMBER HALNON: I know sometimes it's up to a mile. If the BLEVE occurs on the highway nearby it could look at that.

So, it may be that the orientation would not be an issue but think through that as you look through this again and see if the BLEVE is a comprehensive evaluation considering the orientation of the tank as well.

MS. RADEL: Okay, we can take a look at that. Next slide. The site meteorological data set covered the period from 2005 to 2010 and was developed to support the atmospheric concentration and radiological dose assessments.

Met data was taken from the southwest

regional airport which is across the highway from the site. Data taken includes hourly dry-ball temperature, humidity, wind speed, and wind we direction.

Pasquill stability class is calculated from the hourly wind data sealing height and sky cover measurements. Winds at the site are predominantly westerly and southerly but there is significance and no variation.

Next slide.

Joint frequency distributions of wind speed, direction, and Pasquill stability class are used to calculate chi over q values of the site boundary and at the nearest residence.

The value was used to calculate the short-term chi over q values while NRC dose was used to calculate the long-term chi over q values. ARCON96 was used to calculate chi over q values for the control room habitability.

And chemical concentration calculations using ALOHA do not take chi over q values so the 95th percentile values for wind speed and atmospheric stability were used as direct inputs.

Were there any further questions on the chemical fire atmospheric dispersion sections?

Otherwise, we will move to the aircraft hazard analysis, which Catherine will present.

Catherine?

MS. KOLB: Thank you. As Tracy mentioned previously, the site is located across Highway 51 about 0.4 miles to the east of the Southern Wisconsin Regional Airport.

When we updated the aircraft hazard analysis for the EPSAR, we used the same methodology as we used in the PSAR that was presented several years ago. We used DOE standard, DOE-STD-3014-96, crash probability for airways overhead for over plate crashers.

We used NUREG 0800 methodology for crashes from the nearby airport, of which only the Southern Wisconsin Regional Airport apply those screening criteria.

Go ahead.

CHAIR BALLINGER: Excuse me, I think I'm remiss. Dennis has his hand raised, and I'm not sure whether it's previous or current. So, Dennis?

DR. BLEY: Sorry, that was left over.

CHAIR BALLINGER: Sorry, keep going, thank you.

MS. KOLB: Non-frequent airport events or air shows were considered in the hazard evaluation based on an increased number of airport aberrations due to extra planes flying in and out for the air show.

And the acceptance criteria for total crash probability was established as 1e to the -6 per year, base time guidance from that same DOE standard 3014-96.

MEMBER HALNON: When you considered the air shows, did you only increase the increased air traffic activity or did you look at the higher-risk functions or actions of the airplanes themselves since air shows tend to push the edge of the limits of the aircraft?

MS. KOLB: We only considered quantitatively an increased number of airport operations due to the air show, planes flying in and out and over flights, things like that.

The issue of an increased risk due to aerobatic activities or things that might occur at air shows, that was evaluated qualitatively, the same method that we did at the PSAR stage, which was we looked at the FAA requirements around air shows and we contacted a member of the FFA for confirmation.

And their rules were allowing for

permitting air shows requires them to take into consideration the nearby facilities population and SHINE's existence would be considered in permitting air shows and allowing the activities at the air show, and setting the location of the aerobatic box if needed.

MEMBER HALNON: So, the whole aspect would take into consideration the higher risk of a nuclear facility and push the activity away, is essentially what I heard?

MS. KOLB: Right.

CHAIR BALLINGER: This is Ron Ballinger again. Did that consideration include thinking about making the air space over the facility an exclusion area?

MS. KOLB: We did not discuss that specifically.

MEMBER HALNON: Did it include the extra fuel and other chemicals that would be onsite based on the fact of the higher activity of the aircraft?

MS. KOLB: We did not consider increased fuel locations of the air show in the chemical hazard analysis, no.

MEMBER HALNON: Do you think that's appropriate? Clearly, they're going to have a tremendous amount more of flammable fuel there onsite probably in a bust or ground storage.

MS. KOLB: We can follow up perhaps later but the frequency of the air shows historically have only been once a year for a couple of days and we would not expect that to increase the total yearly probability by that much but we have not evaluated it.

MEMBER HALNON: I think you should at least understand how much more fuel and how long it's going to be there because even though the aircraft may only be there for a couple days, the fuel may be there for weeks.

So, that may be something to look at.

MS. KOLB: I understand. Next slide. This slide shows the results of our updates, things that we did to update the hazard analysis such as the PSAR.

We reevaluated the calculation using an updated number considering operations at the airport that generally decreased.

We used the forecasted values for commercial flights for civil and air taxis and air carriers and we've used the historical averages for military because the forecasted amounts for military aircraft was a static forecast in the days that we had.

Another update that we did is we used, instead of one of the largest aircrafts that was manufactured, a more typical aircraft that it was found at the Southern Wisconsin Regional Airport because the one we used previously, a very large Black Hawk, wasn't realistic.

And then this isn't directly part of the analysis but since the PSAR we added a second stage-related structure, a small structure to the east of the main production facility, our nitrogen purge system structure.

That was addressed qualitatively based on its location relative to the main facility and offsite power sources, where it was determined that any aircraft that impacted that small structure based on the location of the site would not also impact offsite power sources due to the degree of separation there.

The results where the small non-military aircraft did not meet the acceptance criteria of 1e to the -6 per year, so therefore, the main production facility structure is designed to withstand impact from this type of aircraft.

The other categories, large non-military or air carriers and military aircraft, did meet that criteria even considering increased traffic from the postulated air shows.

MEMBER HALNON: So, the question here is I understand the structure and I understand the impact. Can the facility withstand the impact? It's more than just a structure being able to withstand it if large-area fires have been looked at.

So, the question is did you look at it from an impact perspective or a large-area fire perspective?

MS. KOLB: We did not a large-area fire, no. We did not feel that evaluation of a large-area fire was required for the guidance that we had.

MEMBER HALNON: I'll explore that later, thanks.

MS. KOLB: Are there any other questions regarding the aircraft hazard analysis? This is my last slide.

CHAIR BALLINGER: That it?

MS. KOLB: Yes.

CHAIR BALLINGER: Next up is the NRC Staff and we're pretty much on schedule I think. So, Mike, you are presenting?

MR. BALAZIK: Yes, can you hear me loud and clear?

CHAIR BALLINGER: Loud and clear, thank you.

MR. BALAZIK: Let's go ahead and get started here. Good morning, everyone, my name is Michael Balazik, I'm the Project Manager in the Division of Advanced Reactors and Nonpower Production and Utilization Facilities.

And I'm within the Nonpower Licensing Branch so I'll be presenting some background information on the SHINE review and the information contained in Chapter 1 of the safety evaluation. Overall, it's just a general overview and of course, once we get to the --

In other chapters we'll be discussing more specific information. Next slide.

So, just to go over the apply to real quick, SHINE submitted an operating license back in July of 2019. SHINE has commenced construction at the facility starting in September of 2019.

What SHINE has requested is a commercial operating license, which is designated as a 103 license for a nonpower utilization and production facility that's located in Janesville, Wisconsin.

SHINE proposes to produce molybdenum-99 as well as other isotopes from the fissioning of target solution in eight irradiation units.

Next slide, please.

The molybdenum-99 is recovered through the irradiated target solution and the radioisotope production facility, which contains equipment that are located in the hot cells.

Recently, we have received a supplement to the license application earlier this year. This describes SHINE's phased construction approach to the facility so operations and construction will be occurring at the same time and the overall construction activities will consist of four phases.

SHINE plans on completing Phase 1 in May of 2023. Now I'll just go over our general licensing approach.

SHINE's requested a single operating license under Part 50 for their facility, which includes the eight irradiation units which will be licensed at 125 kilowatts each.

The hot cells will be licensed as production facilities and all these facilities will be located within a single building. The special nuclear material will be licensed under Part 70 and the source material will be licensed under Part 40.

The regulatory guidance that the Staff

used to review this application, it was mainly NUREG 1537, which provides guidance on reviewing applications for nonpower reactors.

The Staff did develop interim Staff guidance to NUREG 1537.

This includes guidance for the review of radioisotope production facilities, aqueous homogeneous reactors and it also includes guidance from NUREG 1537, which is the standard review plan for fuel cycle review.

For example, it includes addressing chemical hazards. Of course, other guidance that the Staff used was certain ANSI standards, engineering judgments, and finding and exhibiting permits.

So, next I just want to talk about some of the regulations that are required for the SHINE facility. For 10 CFR 5057 for issuance of an operating license, it must meet the following, that the construction has been substantially complete.

The facility will operate in conformance with the application and regulations.

Reasonable assurance that operation will not endanger public health and safety, that the Applicant is technically and financially qualified, and provisions of Part 140 satisfy the issuance of license will not be inimical to common defense of security.

Also, in 10 CFR 5034 which defines the information that needs to be included in the FSAR, the general description of the facility, the design basis, the kinds and qualities of radioactive material expected to be produced by the facility, proposed tech specs, description and plans for the operator requalification program, technical qualifications of chi to engage in the activities, the physical security plan for the facility.

Next slide, please.

The final analysis and evaluation of design and performance of structure systems and components, financial qualifications, the emergency plan, the relationship to design features to major processes in chemical or mechanical processes involved with the radioactive material.

Next slide, please.

Today, the Staff will be going over Chapter 1 which is the facility, which is basically an introduction, Chapter 2, site characteristics. We'll also be discussing Chapter 4, which is facility description, Chapter 5, coolant systems, and Chapter 6, engineering safety features.

As Member Ballinger said earlier, the Staff does not plan on presenting on SHINE's quality assurance plan description known as the QAPD because the plan was approved during the construction permit. And SHINE has made some revisions to the plan since then and the Staff can take any questions on the review if there's changes prior to going into closed session.

Next slide, please.

So, just a quick summary of Chapter 1, the applicable requirements of the Atomic Energy Act, if Commission regulations have been met. SHINE does not share any systems or equipment with other facilities.

I mentioned the guidance of NUREG 1537, it's used mostly for research reactors. There are some research reactors that share facilities such as ventilation and emergency power within a larger building.

So, SHINE is in a single building so there are no shared systems or equipment.

The production facility processes for the moly purification and uranium recovery are similar to other facilities, specifically the sintacin (phonetic) process, and SHINE does provide a general description of the facility and summarizes major operations.

Finally, the SHINE facility will not have any high-level waste or spent nuclear fuel, so the Nuclear Waste Policy Act of 1982 is not applicable to SHINE.

So, that's a quick overview of Chapter 1 and if there are no questions, we can start discussing Chapter 2.

Can you bring up the Chapter 2 slides? Ken, are you online?

MR. SEE: Yes, I'm online, found the mute button.

MR. BALAZIK: Thank you, Ken.

MR. SEE: My name is Ken See, I'm a hydrologist in the Office of Nuclear Reactor Regulation, and I'm going to be presenting the slides on site characteristics.

I do want to point out that I was not the technical reviewer for this section. I will be presenting the slides and will do my best to answer any questions. If we can't answer them, we can certainly take them back so we can adequately get you an answer.

Next slide, please.

For the geography and demography, the Staff reviewed using mapping information, databases, reviewed the information that was submitted by the Applicant, and basically found that the information was sufficient and acceptable.

The two bullet points there, where the high-level facilities are going to be located and the size and area of the site. And we found that all to be appropriately presented and an accurate description.

Based upon our review of FSAR Section 21, Staff did independent confirmatory review of these features, the topography, et cetera, of the facilities, we find the information that they presented to be accurate.

MEMBER HALNON: This is Greg. The population was largely based on the 2010 census and translated to today. Did you guys take a look at the 2020 census and see if the assumptions were even close?

MR. SEE: I looked for that and I didn't see anything regarding 2020.

MEMBER HALNON: I didn't either, maybe it's just the results were out too early. It would be interesting to see if the assumptions they made were --

MR. SEE: I'm not certain when the 2020

census results were actually available. I've seen some news headlines but other than that -- we can certainly go back and see if we can update.

MEMBER HALNON: I saw a report April of 2021. So, it may be out there by that time. When I looked at it, the assumptions seemed to be okay but I didn't take a hard look at it.

MR. SEE: We can see if we can go back and look at that number and see if it's close or reasonably close to the projection.

MEMBER HALNON: Thanks.

MR. SEE: Next slide, please. So, as the bullet says, we went out there and looked at all the facilities. We've already heard from the licensee about some of the airports and roadways, things of this nature.

We found that they are basically represented appropriately, they're accurate, we didn't see where the licensee missed anything.

We did a pretty comprehensive search and we found, basically, that the information they provided was accurate and reasonable and meets the requirements.

MEMBER HALNON: This may be for the SHINE folks but when I went to Google Maps because I had no idea where this place was, right in the middle of the acres was something called the Hughes Farm.

I never saw it mentioned and assumed it was subsumed into the SHINE facility from a property perspective. Would you guys verify that?

MR. SEE: No, but we can look into that if SHINE wants to --

MEMBER HALNON: Did you guys buy the Hughes Farm in this part of your facility?

MS. KOLB: This is Catherine Kolb. The Hughes Farm is still there so the Hughes Farm owns land around the facility. Before starting construction, they farmed the area where the site is.

That 91 acres they were doing is a lease agreement with the city, the city owned the property. But the Hughes Farm, right there is a building that is directly south of the main production facility site.

MEMBER HALNON: I didn't see that anywhere addressed in the tables of the nearby facilities. Did I miss it or is it there? Because I actually did a word search and couldn't find it.

MS. KOLB: I'm not sure we listed all farms in the listing of facilities. It's farm land around the facility owned by various people.

MEMBER HALNON: You listed the Walmart so

I had assumed that you would list the farms. I'm not sure why, that being the closest facility, you would leave it out.

MS. KOLB: We'll have to get back to you but I don't believe we listed farms as facilities.

MEMBER HALNON: There are some farms.

MS. KOLB: Yes, there are farms.

MEMBER HALNON: Go on.

MR. SEE: That's the last slide on manmade hazards I believe we have. Anymore questions on this? We'll look into that as well.

Next slide, please.

I guess I'm presenting this one unless Kevin --

MR. WHITE: No, this is Jason, I'm on the line.

MR. SEE: You're on the line, it says plus 47 and I don't know who those 47 people are. Jason, I'll hand it over to you.

MR. WHITE: Good morning, everybody, my name is Jason White and I'm a meteorologist in the External Hazards Branch in the Office of Nuclear Reactor Regulation.

Today I will be discussing the review of Section 2.3 of the application which addresses meteorology.

Section 2.3 consists of two subsections addressing the general and local climate, and Section 2.31, the site meteorology, and Section 3.2.

The Staff's review of Section 2.31 includes topics related to regional climate, regional data sources, extreme weather conditions, restrictive dispersion conditions, and air quality.

NRC Staff reviewed the description of the general climate of the region and meteorological conditions relevant to the design and operation of the facility. The Staff also reviewed the data resources and analytical approaches used by the Applicant to prepare the information.

The Staff concluded that the site characteristics associated with meteorology and general local climatology are acceptable and are reasonably representative of the proposed site region.

Next slide, please.

DR. SCHULTZ: This is Steve Schultz. I think this is the right place to put it because I don't see it coming further in your presentation.

My question is, and it may not be you that needs to answer this question, about the application by SHINE of the ALOHA methodology.

They've used that for a number of the evaluations that they discussed this morning and when I read the information in the SER, it wasn't clear to me the extent of review that the Staff did on those evaluations.

It indicated that the evaluations had been reviewed but the detail of the ALOHA evaluation by the Staff wasn't clear to me from the SER presentation.

MR. WHITE: This ALOHA review isn't part of the meteorology review. I'm not sure whose section that falls under, I don't know if they're on the line and are planning to address that later?

MR. SEE: This is Ken, that's a manmade hazards review. Like I mentioned earlier, I did not perform the review so we can take that back. Can you repeat your concern?

DR. SCHULTZ: My concern is the Staff's review of the evaluations that have been performed by ALOHA. Several detailed evaluations had been done by SHINE about the only indication in the SER is that the Staff looked at the evaluations.

But how that was done and the Staff's experience with the ALOHA code applications wasn't clear from the presentation in the SER.

MR. SEE: No mention of any confirmatory

analysis or ran the files and ran the code and came up with similar results or any discussion like that?

DR. SCHULTZ: No, that's why I'm asking and your description is correct. I appreciate any feedback on that.

MR. SEE: I'll go back and talk to the Staff and get an answer to you.

DR. SCHULTZ: That's fine, thank you.

MR. WHITE: I think we're onto the next slide. The Staff's review of Section 2.32 included topics related to local meteorology and topography, the data sources, the diffusion parameters, and the atmospheric dispersion.

The Staff reviewed the meteorological data in the description of the Southwest Regional Airport meteorological tower.

The Staff found the meteorological database was suitable for input to ARCAN and PAVAN dispersion models.

The Staff also reviewed the diffusion parameters for use in ARCAN and PAVAN dispersion models and found them acceptable.

The Staff evaluated the site topography and concluded that no unique topographic features preclude the use of ARCAN and PAVAN models for the

SHINE site at the site boundary.

And thus the Staff found the proposed chi over q values were acceptable for use in the SHINE FSAR because they are a conservative estimate of the atmospheric dispersion at the proposed SHINE site.

Next slide, please.

In summary, the Staff finds, based on a review of the application and supplemental information provided through the RAI response, that the Applicant's analysis of meteorological hazards and atmospheric dispersion are sufficient and acceptable as they followed the applicable local state and federal guidelines in accordance with 10 CFR 5035.

The Staff concludes that the site is not located where catastrophic meteorological events are likely, that the Applicant considered credible meteorological events in developing the design basis parameters for the facility, and the Applicant provided adequate site characteristics needed to evaluate uncontrolled release of radioactive materials.

Next slide, please.

That concludes the Staff's presentation.

MEMBER HALNON: Before you get off the meteorology, I was interested in the limited use of

HMR-51, HMR-52.

I'm sure you're aware that obviously after the Fukushima re-evaluation of flooding, that document was almost exclusively used to identify storms, transposition those storms to the site of interest, and come up with the maximum precipitations and lifts and all that.

The document they did use, which I think was a Department of Transportation document from Wisconsin, did you compare those with the HMR that we were so used to using in this flooding reevaluations to make sure that they were conservative in the use of the data?

MR. WHITE: Yes, in the review I think we did take a look at the document. I don't know that we documented it in the actual safety evaluation, we just said the Staff found the information suitable and representative.

But we can go back and double-check that and specifically outline that.

MEMBER HALNON: I know the Staff has really experienced now after the reevaluations and storms and storms transpositioning, you have to base that conclusion on something, some standard or some issue that you said was reasonable.

Not the fact that the W document said it makes it reasonable but something else has to be used. So, I would appreciate some feedback on the use of HMR-51.

And when I looked at the Byron, which is the nearby site, they used HMR-51, HMR-51, and if I transposition those storms and those values to pretty much the same type of topography and region, I don't see a great correlation of numbers.

As a matter of fact, I think Byron is more conservative than SHINE.

And maybe there's enough margin that doesn't matter but there certainly is a difference there, so that would be something to take a look at to see if the standards we got to -- used to using after the reevaluation process would change the conclusion.

MR. WHITE: The Staff can definitely take a look at that.

MEMBER BROWN: This is Charlie Brown. I'm going to backfit or backslide, this is meteorology but SHINE says they used the 2005 to 2010 meteorological data with their evaluation.

Did the Staff independently go look at the 2015 to 2020 to see if they were consistent?

That's the question.

MR. WHITE: One of my colleagues who actually took a look at the data --

MR. QUINLAN: This is Kevin Quinlan, I'm a meteorologist in NRR, Acting Branch Chief for the External Hazards Branch, and I performed that portion of the review.

No, I did not go back and compare it against other timeframes but what I did do is take the meteorological data set that they used for the Southwest Regional Airport for that time period, put it through a fairly rigorous internal QAQC process, created my own joint frequency distributions to use as input to the models so that when we compared it against the SHINE results, we had a level of confidence that what they did with the National Weather Service data was what's acceptable for the site.

But we did not go back and compare it against other time periods since the time period they used was already adequately long.

MEMBER BROWN: But not more current? 2015 to 2020, there's a more current period.

That's why I asked that question, just to see if the data, not necessarily the analysis but at least the data that was input was consistent relevant to what's been going on meteorologically.

A second question then, for the aircraft hazard did they state the period at which they evaluated aircraft activity? I don't remember that from their presentation a few minutes ago.

Was it 10 years ago or was it 5 years ago? Was it 20 years ago?

MR. SEE: I'll have to check this, I didn't do the review but I believe it was 2010.

MEMBER BROWN: So, 12 years ago and normally air traffic increases.

MR. SEE: SHINE's on the phone, maybe they can answer this question.

MS. KOLB: This is Catherine, Director of Plant Operations.

We did the aircraft hazard analysis for the FSAR and we used the forecasted data from 2019, which forecasted from 2019 through 2045, but the forecast was updated as of 2019 and that is the data set that we used for air carriers and other non-military aircraft.

That was the latest data set that was available and we submitted the FSAR in 2019. For military aircraft, I'd have to check the calculation but we redid that too that was using a historical average going back several years, I think 10 but I can't really specifically. But it was starting in 2019 also.

MEMBER HALNON: I saw some independent FAA numbers that made them look good. Yes, from several different sources I looked at it and they looked pretty consistent.

CHAIR BALLINGER: Dennis?

DR. BLEY: Thank you. I just want to raise an issue with the Staff. I think it's a small matter here but it's going to be a big matter in some other areas and previews of other applications.

And that is from some of the questions Greg raised and other Members, and back when the Committee participated in the review of the construction permit, questions by the Members pointed out areas where things hadn't been thought of and the Staff hadn't delved into them.

Greg's BLEVE missiles really come to mind because I know we're mostly nuclear engineers but if you know anything about BLEVES, when you first learn about them it's very surprising the amount of energy that gets generated in those kinds of accidents.

I'm rambling a bit but it seems the NRC Staff review is checking the details and seeing the

Applicant has done things right.

And for the things the Applicant has analyzed, they've gone back and checked the underlying data and the way calculations are done, which is excellent. But I don't see much evidence of the Staff thinking of things that might have been left out.

And like I said, the ones here are probably on the minor side but there's going to be other areas where that becomes really important. That's all I wanted to add, Ron.

CHAIR BALLINGER: We will continue.

MR. SEE: Next slide, please. This is hydrology, this is Ken See, I'm a hydrologist, I spoke earlier. I do want to start off by going back to have discussion on HMR-51 and HMR-52.

That typically falls under our area too but we're still going to be working with Jason. But for these types of reactors, typically the requirements are not as conservative, if you will, for large light water reactors.

You go back to Part 100-10, there's no requirement, whereas if you look at Part 100-20 for large light water reactors, they do specifically mention the probable maximum precipitation and you have much more reactors.

So, I went back and looked at other licensing documents for other research and types of reactors, things of that nature. And you'll find a lot of the precipitation requirements not to be as conservative.

So, in NUREG 1537, in my opinion it gives a lot of leeway. If I were the king of the NRC I would update that document, things like that.

MEMBER HALNON: It is an old document, there's no doubt.

My point is it wasn't written specifically for nuclear plants and we're licensing this under Part 50, which is what the other plants are licensed under and a storm doesn't know one nuclear plant from another.

So, the data is either good or it's not. If it's not good, we just spent a billion dollars on the rest of the industry for no reason. But nevertheless, I think it's an established well thought of standard and the updating of it I think would be a great idea.

That's why we look at the recent storms and we transposition them.

MR. SEE: They are currently doing an update at 5152 and they're going to be factoring climate change. I think one of the pieces of federal legislation gave NOAA a pot of money to do that work so I am happy to report that as being updated.

But for this review, other than the storms, as the slide says, we looked at all the patterns, we don't see any catastrophic hydrological events where they would be considered credible, dam failures, things of that nature.

I will say when I went back and looked at the construction permit application, they seemed to deal more with the larger storms there about diverting the flows away from the facility, things like that.

This application, I know they made changes to the footprint but they dealt more with the drainage system and things of this nature.

And I believe they used a 100-year event for that. I didn't do this analysis myself but they applied local building code-type standards and things of this nature for the local facility for drainage.

MEMBER HALNON: And my point, we've got a four-inch margin on the buildings over the grade and the grade has a couple feet here and there where I think it was at one point 51 feet from the river flooding.

I can't remember all the different things but you're right, the margins are high but it's also from a corrective perspective.

And as Dennis mentioned, down the road if the margins are not so high, are you just going to accept a state Department of Transportation document or are you going to go to something that's been tried and proven when you renew?

So, that's the decision you guys have to make and defend.

MR. SEE: Yes, I think the safety portion of the components inside the structure are given additional flood protection features, so if water enters the front door, quote, unquote, of the facility, I don't think that's going to be a safety issue, is my understanding as I read the SE.

So, that's why they feel like they can use a lower standard, but we're trying to do risk-informed reviews and looking at the requirements. And it takes some judgment to make that call.

MEMBER HALNON: And I couldn't assess the impact of the flooding because it's down the road on the systems chapters. It's either plus or minus, black and white, is it flooding or not? So, that's all I looked at.

That's what I mean. This facility is in

pretty good shape currently but another one may not be. So, it comes down to the technique and what the Staff can defend.

MR. SEE: Each review is unique absolutely. We can't just take what we did on this site and apply it to another necessarily.

MEMBER HALNON: Okay.

CHAIR BALLINGER: This is Ron, I would add that 1537 is indeed old but the ISUs are not and we are in kind of a gray area in that it's not a homogeneous reactor but it's homogeneous. So, you've got to be careful about that part.

MR. SEE: So, that's the only slide I have. I don't know what's next. Anymore questions on hydrology? If not, next slide, please. That may be the last one, I don't know.

Geology, this will be someone else so I'll step back and let them take over, thank you.

MR. HEESZEL: Good morning, this is David Heeszel, I'm a geophysicist in the External Hazard Branch of NRR.

For geology, the geologic characterization in the operating license hasn't changed from the construction permit and we didn't identify any new geologic hazards since the time of the construction permit.

So, our conclusion is there's no potential for surface deformation from tectonic or non-tectonic hazards. Next slide, please.

When it comes to seismic hazard, the design basis ground motion, they call it here the SSC, is Reg Guide 1.60 spectrum anchored at 0.2g. It's used in the seismic design of SSCs important for safety.

The seismic characterization in the operating license application is based on the U.S.G.S. National Seismic Hazard Map of 2008. We looked at the 2014 maps and the results are very similar.

In addition, we performed a confirmatory analysis using RO1 models and codes and used the site-specific subsurface profile provided during the desertion permit.

Next slide, please.

As you can see here on the left, the yellow line is the design basis ground motion and then the blue line and the orange line are for seismic design Classifications 3 and 4 under ASE, SEI-4305.

You see there's a lot of margin between the probabilistic analysis and the design basis ground motion. Based on that, the Staff finds that SHINE has adequately characterized seismic hazards at the site.

And that is it for seismology and geology.

MR. XI: Good morning, I'm Zuhan Xi, geotechnical engineer at the Civil and Geotechnical Engineering Branch, Division of Engineering and External Hazards of NRR. I'm the geotechnical reviewer for the site.

Geotechnical site characterization was based on the results of field investigation and the laboratory tests conducted for construction permit application.

Staff confirmed that field investigation and the laboratory tests were sufficient to determine the soil properties at the site. Staff confirmed that the soil properties used in the geotechnical evaluation and the soil structure interaction analysis are reliable and reasonable.

Staff verified the stability of the foundation and subsurface material on the information Applicant provided in the FSAR and II response, as well as detailed analysis through regulatory audit.

Staff reviewed the liquefaction analysis, Staff verified the soil underlying the site is not considered to be potential liquefiable.

In accordance with the guidance of Reg

Guide 1.198, Staff reviewed bearing capacity calculation and found that the applied method is widely acceptable and used by industry.

The assumption used in the calculation is conservative. The Staff confirmed that soil-bearing capacity is adequate for design structures. Staff verified that the conservative structure is designed to accommodate the potential differential and total settlement of the foundation.

The Staff reviewed analysis for static, active, and passive lateral soil pressure and verified that proper consideration of later soil pressure towards the soil wall has been given to the structure analysis and design.

In summary, Staff confirmed the geotechnical evaluation and analysis for shown site are reasonable and conservative and are therefore acceptable. Thanks.

MR. BALAZIK: This is Mike Balazik, that's the end of the presentation on Chapter 2. Are there any questions?

CHAIR BALLINGER: Okay, if there aren't any other questions, we can shift over to Chapter 5. SHINE folks are up and I'm not sure who's going to do the presentation.

MR. SODERLING: Good morning, my name is Ian Soderling and I'll be presenting Chapter 5. Are you pulling up the slides? Like I said, good morning, my name is Ian Soderling, I'm a mechanical engineer in the auxiliary systems group.

I'll be presenting the cooling systems here at SHINE. Next slide, please. Just as a basic outline, we'll be talking about the primary closed loop cooling system, PCLS, first and then we'll move on to the radioisotope process facility cooling system, RPCS.

Then the processed chilled water system, which is PCHS and then facility demineralized water system, which is FDWS. Next slide, please. So, the first system is the primary closed loop cooling system, and again, that's PCLS.

So some of the non-safety-related functions that PCLS performs, the biggest one is obviously cooling the water to the target solution vessel, the neutron multiplier, and then the light water pool as well using forced convection.

Just as an added note, the PCLS cooling itself is a non-safety-related function. It regulates water to a design temperature range uses RPCS as the cooling water to that system and PCLS itself cools the subcritical assembly and the components within it.

Two pumps are normally used for full-flow operation but you can operate with a single pump, just at a reduced capacity.

And then in Chapter 5 there's also details about a cleanup side stream for the PCLS, and that includes a deionizer bed and then free and post filters to maintain ESTM Type 2 water purity standards.

And that's to limit corrosion, product activation, any sort of contamination that you might get in the process stream. The other secondary function that PCLS has, one of the major ones, is to provide purge gas flow from confinement.

PCLS itself does not have any motive force, it's simply the flow path the purge gas takes. So, PCLS has an air separator that removes drained, dissolved, and free gases in the PCLS process stream and it sends it to an expansion tank.

And that expansion tank also collects air from the irradiation units and the TOGS cell atmospheres. And then from the expansion tank, there's piping that goes to the radiological ventilation Zone 1 exhaust.

Are there any questions on this slide? If not, we can move to the next one. Some of the safety-related functions that PCLS has is equipping the expansion tank with a flame arrester to preclude any sort of hydrogen degradation or detonation events.

There is closure of PCLS confinement isolation valves, there's three solenoid valves, there's one check valve, and it's for a variety of reasons. IU cell safety actuation will cause these valves to close.

One of the bigger events that is postulated is any sort of water intrusion into the TSV. And then you have several trips that can occur as a result of the PCLS instruments.

You have the high PCLS temperature so that's the applied temperature to the subcritical assembly. You also have low PCLS temperature, and again, that's supplied.

And then you have low PCLS flow and that flow is actually on the return, so it's downstream of the subcritical assembly.

Are there any questions?

MEMBER MARCH-LEUBA: There is a question, this is Jose. This might be a Chapter 4 question probably but eventually, you are going to have to calibrate -- the power of the facility is measured using ex-core neutron detectors.

And you are going to have to likely calibrate them with power on the PCLS, right? Is that done? How is the power for the facility measured?

MS. KOLB: This is Catherine Kolb.

We are not using a calometric method for a calibration, we're going to use an isotopic method by analyzing the fission products in the target solution for initial calibration of the neutron detectors.

And we could get into that more in later sessions if you would like.

MEMBER MARCH-LEUBA: I'll wait for Chapter 4. Was your answer there is no calometric measurement on the PCLS?

MS. KOLB: There is no calometric calibration for the PCLS.

MEMBER MARCH-LEUBA: We'll talk in Chapter 4 about that calibration.

MEMBER REMPE: This is Joy and I guess I have a follow-up on that because somewhere I thought I read that actually, as you start to come to power, you will make some changes as you try to calibrate things.

And I guess I would like to hear more how that's done. And I was real puzzled in the Staff's review of Chapter 4, and I went back to 1537 and it looks like Chapter 4 is kind of an inventory of information in the Staff's review.

And so I'm real curious where the Staff has information on determining how I wouldn't call them fudge factors but how changes to that calibration are determined accurately.

Because the Chapter 4 Staff review, and actually, it's allowed in 1537, is just to make sure information is complete and consistent with other places. But all of the evaluations, there's nothing in the SER about did they do independent calculations or anything like that.

It's an inventory. And I think that's what 1537 allows but I will be curious and I think I'd like to encourage Members to help me compile a list of questions that they want to follow up in other chapters for the review.

MEMBER MARCH-LEUBA: I'm glad to wait until the closed session for Chapter 4 this afternoon because probably we'll get into proprietary, but there is an implication that there is an MCMP calculation that gives you what the efficiency of those ex-core neutron detectors is.

MEMBER REMPE: And maybe there is but it's not in the SER for Chapter 4.

MEMBER MARCH-LEUBA: What I'm curious about is what's the uncertainty on the conclusion because that's a notoriously difficult calculation.

MEMBER REMPE: Anyway, it isn't the time to bring it up but I just was puzzling about that and finally came to my own conclusion. I may be wrong but --

MEMBER MARCH-LEUBA: I'm not the Applicant but I would suggest we wait until the closed session this afternoon.

CHAIR BALLINGER: This is going to come up later on as well probably more than a few times. It's the issue of deflagration detonation for a problem. This PCLS tank, can it survive a deflagration where you get a pressure increase of probably a factor of 2?

Whereas a detonation is more like a factor of 20.

MR. SODERLING: The flame arrester filter and the associated piping to and from the expansion tank is safety-related.

So, any air that enters that expansion tank goes through that flame arrester, which will preclude any sort of deflagration or detonation.

CHAIR BALLINGER: What if it doesn't work?

MR. SODERLING: I'm not sure I understand.

CHAIR BALLINGER: What I'm saying is you've got a component there that's containing things. If you get a deflagration in the expansion tank, what happens to the tank?

MS. RADEL: This is Tracy Radel with SHINE. The passive features there, the flame arrester is safety -related, as Ian said. We have no evaluated a deflagration or detonation in that system.

There is air flow through there to maintain the hydrogen concentration below the deflagration limits, so that system combined with the flame arrester is a sufficient ensurer of safety.

It was not evaluated for deflagration of that tank.

CHAIR BALLINGER: You've got two things going for you, you've got maintaining the concentration below the limit and then using the flame arrestor?

MS. RADEL: Correct.

CHAIR BALLINGER: Thank you.

MEMBER DIMITRIJEVIC: This is Vesna. I have a question about this isolation function of the PCSL. Does this reservation activate every time when you get the trip from the TSV protection system?

Yes is the answer?

MS. RADEL: I think safety actuation and using isolation valves would isolate every time.

MEMBER DIMITRIJEVIC: So, every time you open the valves that system isolates, right?

MS. RADEL: I think normal operation termination of irradiation and opening of the dump valves, you would not isolate the primary system boundary, the cooling loop would continue to run until it was no longer needed.

The isolation function is towards IU cell safety actuation so if the safety system determined there was a concern of release into the primary confinement boundary, it would initiate that isolation function, which is to prevent radionuclides from exiting the primary confinement boundary.

Because the PCLS did within the cooling rooms, the entire skid is not safety-related and so we have those isolation valves to maintain that primary confinement boundary.

MEMBER DIMITRIJEVIC: My question was if you're talking about operating valves, there is this post-irradiation, right, mode, I think it's Mode 3, where the TSV dump valves open and the solution starts.

And that happens on this protection signals listed here, the temperature, the low flow or whatever, the other thing initiates.

MS. RADEL: Yes, the unit will transition to Mode 3 and dump the solution on any of those signals.

MEMBER DIMITRIJEVIC: So, in that case the function of the cooling of the pool is never used in any abnormal conditions, right?

MS. RADEL: Correct, the light water pool provides sufficient cooling for any of those conditions.

MEMBER DIMITRIJEVIC: Thanks.

MR. SODERLING: The next system, the secondary loop in the 3-loop system here in SHINE is the radioisotope process facility cooling system.

And again, that's RPCS. It removes heat loads from around the IF, or the irradiation facility, as well as the radioisotope conduction facility, which is the RPF.

So, like I said, it acts as a secondary cooling loop. It removes heat from the PCLS heat exchanger and that next bullet point is a big list of heat exchangers and systems that it removes heat from.

So, just some examples are the target solution vessel off gas system, or TOGS, process vessel vent system, PVVS, neutron driver assembly system, NDAS, and then other heat exchangers that are listed there as well.

This is not performed or maintained in any safety functions in any capacity. By that I mean it doesn't perform any sort of safety-related cooling there in the safety-related trip signals. It's a wholly non-safety-related system.

And then ultimately, it rejects heat to the PCHS, the process chilled water system, through the RPCS heat exchanger, and we'll talk about this a little bit later but the RPCS maintains a pressure that's higher than the PCLS or any other system that it serves and that's to prevent any sort of spread of contamination around the system and facility.

Just as a last bullet point, there are three pumps in this system, it's configured as an N+1 type system. You'll always have two pumps running and then a third pump further down in NC.

MEMBER MARCH-LEUBA: This is Jose again. I'm curious, for the PCLS you have only two pumps and for the RPCS you have N+1. Is there any logic to that, any reason?

MR. SODERLING: Like I said before, the PCLS can run with a single pump, it's ideal to run with two but you can still run with one single pump. And that comes down to how much space is available in the cooling room.

We can comfortably fit two pumps on the cooling skid.

MEMBER MARCH-LEUBA: So, there's a logic to the madness. There are space requirements.

MEMBER HALNON: This is Greg. What's the cooling mediums of treated water or untreated water?

MR. SODERLING: If you want me come back with what the type of water in the future I can bring that back. There are certain standards we took from an IAEA tech doc and that's what's being applied to this system.

I don't have that information on hand but it is treated, yes.

MEMBER HALNON: What I was putting it to is if there was some contamination based on a whole-system trip and back leakage, would it be a mixed waste issue? Just a curiosity at this point.

MR. SODERLING: Sure.

MEMBER DIMITRIJEVIC: This is Vesna again, you have the one PCS and the PCLS per unit, right, per deviation unit? And RPSCS is common for facility, right?

MR. SODERLING: You have one PCLS unit per IU cell.

MEMBER DIMITRIJEVIC: So, you have eight of them, right?

MR. SODERLING: That's correct.

MEMBER DIMITRIJEVIC: And one RPCS, right?

MR. SODERLING: One single RPCS, that's correct. It sounded like there was another question.

MEMBER BROWN: Yes, you said something on the previous slide relative to the different terminology. I guess that's what I'm questioning. I can find the slide again now. It was Slide for where you talked about the closure of the confinement isolation valves.

MR. SODERLING: Yes, that's the slide that's currently up on the screen.

MEMBER BROWN: Let me finish my question and make sure you heard me. In looking at Chapter 6, is that the same as the primary system boundary?

MR. SODERLING: No, it is not.

MEMBER BROWN: If you look at that overall diagram, 6A2.2-1, the primary containment boundary of confinement, and then it talks about primary system boundaries in one of the others.

And I'm starting to get confused as to where the primary system boundary is relative to the confinement boundary?

MS. RADEL: This is Tracy, I can take that one. The primary system boundary is the boundary that directly contains the target solution and fission product gases during irradiation.

So, the process boundary directly, the primary confinement boundary is the irradiation unit cell, along with TSB off gas system cell, and so those confinement boundaries that contain the radionuclides in case of a breach of the primary system boundary.

MEMBER BROWN: You just lost me.

MEMBER MARCH-LEUBA: Yes, you don't have a cartoon of that, right?

MEMBER PETTI: Charlie, the confinement boundary is a hot cell.

MEMBER BROWN: It's an irradiation unit and a TOGs.

MR. BARTELME: This is Jeff Barnum. We have a figure in the Chapter 4 closed session slides that we might --

(Simultaneous speaking.)

MEMBER BROWN: I was ahead of you. I got

lost in Chapter 6 trying to figure out what was what on the computer with no paper. Go ahead, we'll wait, or I'll wait.

MR. SODERLING: The tertiary loop here at SHINE is the process chilled water system, PCHS. It removes heat from the RPCS heat exchanger and then rejects it to the environment with air-cooled chillers that are external to the facility.

It does not perform any safety functions either, there are three chillers and three chilled water pumps and that's the N+1 configuration applied to both the cooling and to the mode of force behind the system.

MEMBER MARCH-LEUBA: Are the chillers common to multiple units?

MR. SODERLING: Yes. There are elements or RPCS that are unit-specific and then parts of it that are unit zero or common. But the PCHS is common to the entire facility.

Sounds like we can go to the next slide. This is about the cooling system pressure cascade, so just to recap how the process works, you have heat that's generated in a subcritical assembly neutron multiplier.

And to some degree the light water pool

will have some heat added to it. The PCLS removes that heat from both systems and circulates it back to the primary cooling room which is where the SKID is.

RPCS water enters the PCLS heat exchanger and then removes heat from PCLS, which in turn the RPCS rejects heat to the PCHS, and then you have PCHS supply and return headers that are routed back and forth from the non-RCA, we call it the administrative annex, to the RPCS heat exchanger room, which is in the RCA.

And then that ultimately ends up outside the facility where the PCHS chillers are. And so like I detailed before, the pressure cascade prevents any contamination from the PCLS moving towards RPCS or PCHS.

So, you have PCLS which is at a relatively lower pressure, RPCS at a higher pressure, and then PCHS at a higher pressure than that.

MEMBER MARCH-LEUBA: You're using so many -- what's the RCA?

MR. SODERLING: The radiologically controlled area.

MEMBER MARCH-LEUBA: Thank you.

MR. SODERLING: The diagram to the right shows relatively where all the systems are. The PCLS is in the RCA, the radiologically controlled area, the RPCSs as well, and then PCHS is a system that goes back and forth between the RCA, the non-RCA, and outside the facility.

MEMBER DIMITRIJEVIC: You also have to prevent the contamination between the makeup, which is the demineralized water system, which reminds makeup for the PCLS, right? Because that is only direct. All other contact happens through the heat exchangers, right?

MR. SODERLING: We'll talk about the FTWS next, the mineralized water makeup but for PCLS specifically, there's a reduced pressure backflow preventer, so there's an actual air gap that exists between PCLS and demineralized water systems.

And that prevents contamination from getting into the makeup system.

I think we can move to the next slide. This system is a facility to mineralized water system, or FTWS. This system also performs non-safety-related function of providing makeup to the process systems.

You have reversed osmosis water that is used mostly in the administrative annex portion of the facility. It does also serve the QC and analytical lab sinks.

You also have deionized water, ASTM Type II, which is a primary source of makeup for a lot of the systems within the RCA or just the process systems in general I should say.

And then you have ultra-pure deionized water, which is ASTM Type I, and that's provided to the quality control of the QC and analytical labs as well as the MEPS hot water system and the molybdenum in the extraction purification system, that's what MEPS is.

And then the FTWS has a water to air heat exchanger and it's just simply there to reject some of the heat from pump operation and any other equipment that would create heat.

MEMBER HALNON: And is the molybdenum water the reverse osmosis?

MR. SODERLING: So, in the administrative annex to the non-RCA, you have potable water that's fed to an RO skid, a reverse osmosis skid. So, you have a reverse osmosis tank in that room as well.

And then you have a supply to the RCA where you have another skid that circulates water to the RCA to systems that are within it, and you purify it to these ASTM Type II and Type I deionized water using various polishers and systems throughout.

So, as an example, outside of each cooling room there's a deionizer polisher that cleans up water that's supplied to PCLS. So, before water is ever made up to PCLS, it goes through that polisher.

MEMBER HALNON: So, you don't have a pure molybdenum water tank that is the supply of potable water from city going to whatever processing institute to meet those standards?

MR. SODERLING: There are two storage tanks, one in the RCA and one in the non-RCA.

MEMBER HALNON: Approximate volume of those?

MR. SODERLING: I don't have that on hand.

MEMBER HALNON: Big, little, medium? I'm pretty easy.

MR. SODERLING: Relative to our facility, I would say they're big. I believe it's something like 200 gallons.

MEMBER HALNON: Hundreds of gallons versus -- thanks.

MR. SODERLING: If there aren't any other questions, I believe that concludes my slides.

CHAIR BALLINGER: Thank you then. By our agenda we're scheduled for a break and we're darn near on schedule. I'm sure that will change. So, we will take a recess until -- let's be specific -- 10:35 a.m.

(Whereupon, the above-entitled matter went off the record at 10:17 a.m. and resumed at 10:35 a.m.)

CHAIR BALLINGER: We're back online. The staff, where is the staff? Mike, are you up for this? Who? That looks good, except I can't hear anything.

MR. RAU: Hi, can you hear me?

CHAIR BALLINGER: Yes, thanks.

MR. RAU: My name is Adam Rau. I'm a technical reviewer in the Nuclear Systems Performance Branch in the Office of Nuclear Reactor Regulation and I'll be presenting the NRC Staff's review of the cooling systems.

So, I should also mention that although I'm presenting, I didn't perform the majority of this review. That was done by Muhammad Razzaque, my former coworker who retired at the end of last December.

Additionally, I'll be presenting systems review by the Nuclear Systems Performance Branch. There are additional systems that were reviewed by the Containment and Plant Systems Branch as well that are here to answer any potential questions.

Next slide, please. The systems I'll be discussing today include the target solution vessel, the primary closed-loop cooling system, target solution vessel dump tank and light water pool system, and the radioisotope process facility cooling system.

There's a bit to say about the thermal hydraulic and testing calculation as well as the safe shutdown thermal hydraulic analysis. I'll try to speed through the sections of this that SHINE have already discussed as well.

Next slide, please. So, for the review methodology, the NRC Staff used the augmented interim staff guidance for the radioisotope production facilities, the augmented guidance to NUREG 5037.2.

The NRC Staff reviewed docketed correspondence including the final safety analysis report response to request for additional information in addition to docket correspondence.

For understanding, NRC Staff also reviewed SHINE calculations by the reading room.

Journal publications that were referenced in these calculations and in the safety analysis report, and performed a few simple confirmatory calculations just to understand some of the sensitivities in the system.

Next slide, please. Moving through the systems, there's more nuance to the target solution vessel that I believe will be discussed in Chapter 4, but from the perspective of cooling systems, the target solution vessel is an annular vessel.

It's cooled by the primary closed-loop cooling system and multiple surfaces. The acceptance criteria for this design are intended to prevent boiling of the target solution and ensure the integrity of the primary boundary.

And these are that the bulk target solution temperatures should be less than 80 degrees Celsius and the peak target solution multiple should be less than 90 degrees.

I should mention that the second criterion listed on the slide, the bulk target solution temperature, applies to the main operation analysis and its initial condition to the safe shutdown analysis.

Next slide, please.

So, it's been discussed already but the PCLS is an irradiation-unit-specific system. I should also mention the light water pool system and the TSV dump tank are also irradiation unit-specific systems. And it's designed to remove 110 percent of TSV power during normal operation.

Next slide, please. SHINE's analysis, NRC

Staff found that SHINE's analysis demonstrated that overheating of the target solution was not expected for any anticipated operating conditions.

Additionally, departure from nuclide boiling is not expected either of the target solution or of the primary closed-loop cooling water.

I should last mention that the PCLS system also cools the neutron multiplier and SHINE has confirmed there's adequate margin to prevent departure from nuclide boiling on this surface as well.

Next slide, please.

The role of the TSV dump tank has already been discussed, it's a horizontal annular tank that's submerged within the light water pool system. Next slide, please.

The geometry of the tank facilitates decay heat removal from the target solution fluid because of the large heat transfer area associated here. SHINE's analysis shows that peak target solution temperature inside the dump tank does not exceed 90 degrees Celsius.

During a shutdown scenario, appropriate pool level is maintained and also to emphasize here that this analysis assumes that PCLS is lost too. Next slide, please.

MEMBER MARCH-LEUBA: This is Jose. This is lost and drained, so this a vacuum? What state are the PCLS tubes in and annulus?

MR. SODERLING: I can answer that question. When a PCLS shuts down, the water stays within the system so the cooling loop would just turn off whenever the operators turn it off. But the water stays in the tube and the subcritical assembly.

MEMBER MARCH-LEUBA: Maybe I'll hold my question for the closed session. I know you have some backup slides with some drawings, I'll wait until this afternoon. Thank you.

MS. RADEL: This is Tracy, I just want to clarify, the PCLS isn't credited for removal of any heat in that safety basis analysis. It just looks at the target solution dumping into the dump tank there so the PCLS would not factor into that analysis.

MEMBER MARCH-LEUBA: My concern is that if you drain some components you may prevent heat transfer but it's easier if you see the drawing in the screen so I'll ask you the question this afternoon again.

MR. RAU: Thank you. Next slide, please. The dump tank is submerged in the light water pool. The light water pool removes decay heat from the dump tank through natural convection, no forced cooling or heat exchanges.

And it achieves this without boiling of the target solution or the water from the light water pool. Next slide, please.

MEMBER BROWN: Is there makeup water? You're heating it, is it an enclosed pool? The pool sounds like it's open to the atmosphere, is that right?

MR. RAU: That's my understanding. If SHINE wanted to weigh in?

MEMBER BROWN: My question is if that's used to cool something, you're going to get evaporation and is there a makeup of that water based on some levels in the tank? I don't remember seeing that.

MS. RADEL: I think it's probably best to save the real detailed discussion on the safety basis so that we don't approach any of the proprietary information in that analysis.

MEMBER BROWN: I just thought having water go into the tank wasn't necessarily proprietary. But that's fine, I'll wait if I can remember that long. Go ahead.

MEMBER DIMITRIJEVIC: Will this pool also be covered in Chapter 4? Because it wasn't really included in Chapter 5, the cooling system. And I looked at that in Chapter 4.

So, would you have a discussion again of the pool when we go to Chapter 4?

MS. RADEL: This is SHINE, we will have a discussion on the pool in Chapter 4.

MR. BALAZIK: This is Mike Balazik from the NRC Staff. There is a discussion in the SE on Chapter 4 on the pool.

MEMBER DIMITRIJEVIC: Thanks, we can ask more questions about control of the level of instrumentation and the makeup to it. Okay.

MEMBER REMPE: This is Joy and at the beginning of this presentation you said Staff did some hand calculations to confirm the adequacy of some of the information related to this application.

There's nothing in Chapter 4 that I saw in the SE that identified what calculations were done.

Could you elaborate either here or in the closed session what exactly the staff did to confirm that the information like the instrumentation would give the appropriate signals to ensure the safety of the facilities operation?

MR. RAU: I can absolutely elaborate in

the closed session on the confirmatory analysis that was done.

MEMBER REMPE: I'm sorry I interrupted you, go ahead.

MR. RAU: I can't speak to other technical reviewers, I know that myself I didn't perform any confirmatory analysis on the instrumentation to confirm that was adequate.

MEMBER REMPE: When I looked at Chapter 4 and the importance of some of the instrumentation, I'm worried about the calibration and have they considered the cycling and all the environmental things?

And I think I mentioned that in our overview discussion whenever we had that a while back here, and I was told that'll come in Chapter 7.

So, again, I'm just trying to understand and make sure everything got done with the questions that folks are thinking are going to get answered in 4 because I don't think we're going to get answers for calculations done to support information in 4.

I think it's going to have to be done in other chapters when I looked at what I saw in Chapter 4. Is that a true assumption on how this review was done? And maybe I should ask the Chapter 4 reviewers instead of you.

MR. RAU: If they're here and they wanted to?

MR. STAUDENMEIER: This is Joe Staudenmeier, I worked on the Chapter 4 review and the instrumentation is really Chapter 7 so we did not review the instrumentation in Chapter 4 other than if they have instrumentation that appears functional to measure what they need to measure.

MEMBER REMPE: Right, and I think that's true for the analysis too, that it's done in other chapters.

But anyway, let's hear what Chapter 5 folks did for analysis in the closed session, but I just wanted to give Vesna a heads-up that if there's something that's got a question that's technical about the adequacy of the design, this is the chapter to ask the questions.

MR. STAUDENMEIER: Yes, for Chapter 4 I did some simple hand calculation-type analysis but yes, nothing in great detail.

MEMBER REMPE: Thank you, go ahead.

MR. RAU: Thank you. Next slide, please. Here, this is just to mention that the light water pool does receive some heat during normal operation.

Not all of the fission heat is deposited in the target solution vessel, some of it travels and heats the light water pool directly. The credit for removal of this heat is from the submerged PCLS components within the pool.

So, the expectation is that the pool temperature would rise slightly above the PCLS temperature during normal operation. And so the temperature and the water level are monitored as well and there's also a technical specification limit on the water level in the pool.

Next slide, please.

Just to talk a little bit about the SHINE calculations, there were some heat transfer and other correlations used in the SHINE safety-related calculations.

These were derived from public literature and where an applicable correlation was not valuable in the literature, SHINE did perform some specific tests. And so NRC Staff reviewed these correlations and found they're valid and applicable to the SHINE facility in the way they're used.

Next slide, please.

I'll discuss a bit more about the safe shutdown thermohydraulic analysis. The NRC Staff finding on this was based in part on the number of conservative simplifying assumptions in this analysis.

And due to this and the simplicity of the system, NRC Staff found the safe shutdown of long-term cooling can be achieved passively for any anticipated operating condition.

MEMBER MARCH-LEUBA: This is Jose. Remind us again, the ultimate heat sink is the pump or is there any heat transfer through the environment?

MR. RAU: I don't believe the safe shutdown analysis assumes any heat transfer to the environment.

MEMBER MARCH-LEUBA: So, it's just the pool is so large and the power is so small that it doesn't get to heat up in the allowed time, correct?

MR. RAU: Right, and it's a time-limited analysis if I'm remembering correctly.

MEMBER MARCH-LEUBA: 72 hours or longer?

MR. RAU: I think it's longer than that. I should probably look and make sure so I'm not giving you false information but yes.

MEMBER MARCH-LEUBA: Thank you.

MEMBER DIMITRIJEVIC: They said five days in the calculation. So, there are eight pools, they're all separate per unit, right?

MR. RAU: Right. Next slide, please.

MEMBER DIMITRIJEVIC: They're not so big, they're corrected to the -- I mentioned in the beginning some big pool but they're actually just in deviation unit pools limited by unit size.

Next slide, please.

So, I won't go into much more detail than SHINE did about the radioisotope process facility cooling system. I think they've described the purpose of the system already.

Next slide, please.

NRC Staff findings were related. This is not a safety-related system, not credited with preventing or mitigating any design basis events. And if active cooling for the radioisotope process facility cooling system were lost, then irradiation of the target solution would be suspended through other means.

Additionally, the pressure cascade that SHINE discussed to maintain and prevent the spread of contamination is consistent with the interim Staff guidance for aqueous homogeneous reactors.

Next slide, please.

Finally, the review of the phased approach is underway. This review is partially simplified because the component design for many of the cooling systems are irradiation-unit-specific, so unaffected by the phase approach.

But SHINE has submitted information on how these irradiation-unit-specific components and non-irradiation-unit-specific components are isolated from each other as well.

MEMBER PETTI: I have a question on that. I remember reading that they're all independent but there were some geometrical discussion about installing the N+1 unit, showing yourself that you're not causing an interference with the other operating units.

I can't remember what chapter that was in but I'm assuming we're going to get into that a little bit? I'm just not sure this is the right chapter.

MR. RAU: Yes, I wouldn't have considered that for the cooling systems chapter.

MEMBER PETTI: So, I recall there's a figure that shows the physical location of the cells and how they're going to build them out.

So, the concern is things are being moved, somewhat heavy equipment, how do you make sure the operating ones aren't affected when you're installing the next unit, the sixth one, the seventh one.

I know I read it, it's in one of the

chapters, I just don't remember what chapters it was.

MEMBER MARCH-LEUBA: Even some units in real life, I have Internet connection in my neighborhood and the other neighborhood, next time when they connect Internet to the other neighborhood they disconnect me.

That's what you're saying?

MEMBER PETTI: Yes.

MEMBER HALNON: We talked about this at another meeting because I questioned the sequence as well and the answer I believe was that the heavier components were already installed, they were in place, just not totally there.

I think that was the answer. Maybe we can talk more in closed session about how that worked. Because we were talking about the missile shields, what I call missile shields they called floor plugs.

And they were all in place before the first operation.

MEMBER REMPE: I remember your asking the question that responds to that too but in the schedule that we have for reviewing, Ron, are we going to talk at all about phased construction?

The Staff said they're reviewing it so this is coming up in a subsequent session?

We'll have an opportunity?

MEMBER PETTI: There will be a focus on that specific topic.

MR. ANDERSON: This is Shaun from the Staff. I know this is one area that has been discussed amongst the Staff in terms of movement of equipment. So, we can make sure we address that.

MR. RAU: Thank you. Should I resume?

CHAIR BALLINGER: Yes.

MR. RAU: Next slide, please. That actually covers my slides here. I can go over the conclusions again.

The NRC Staff review found that adequate cooling capacity exists for the primary closed-loop cooling system to cool the TSV without boiling of the target solution or departure from nuclide boiling.

Next slide, please.

Review of the thermal hydraulic calculations found the contained and adequate number of simplified and conservative assumptions still included safety margin and doubted expected operating scenarios.

During a shutdown decay heat would be passively removed from the target solution inside the dump tank by the large thermal mass of the light water pool. Next slide, please.

The pressure cascade is maintained between cooling systems to prevent spread of potential contamination and review of the phased approach as it relates to cooling systems is still underway.

MEMBER REMPE: This is Joy, and, again, when I look at these conclusions, they imply that some calculations were done independently by the Staff, not just that you did what I think you're allowed to do in Chapter 4 about reviewing the assumptions and the adequacy of the information.

And I've looked ahead at the closed slides, I don't see anything that tells me what the Staff did. Is there something you can say in the open session about your calculations that gave you the confidence to say that adequate cooling capacity exists?

Did you just review what they did and said, okay, the inputs are good, they said they had bounding assumptions? Nobody took their calculator out and wrote some equations and did some analysis?

What was done?

MR. RAU: I'm not sure what I can say about it in the --

MEMBER REMPE: Okay, that's fine in the

closed session, but you did some calculations, you can say that at least in the open session, that gave you this confidence, right?

MR. RAU: Right, and part of it was also based on the conservatisms of the assumptions in the calculations as well.

I think from a cooling system perspective, some confirmatory analysis was done to rule out issues that might otherwise have been looked into more, if that helps.

MEMBER REMPE: We'll explore it more in the closed session, I just was puzzled.

MEMBER MARCH-LEUBA: And before you go, for the long-term cooling, I assume you assumed that all the solution had been dumped into the dump tank, is that correct?

MR. RAU: That's right.

MEMBER MARCH-LEUBA: This is not Chapter 5 or 4, this is more the old Chapter 19, what happens if the damp valves fails to open? It's very low probability event but the solution remains in the TSV.

Very low probability event, did you evaluate if that is a safe configuration?

MR. RAU: No, I don't believe this was evaluated, I think that SHINE has redundant dump valves if I'm remembering correctly so a single failure wouldn't cause that to occur.

MEMBER MARCH-LEUBA: One way to handle this situation is to say the frequency, the probability frequency, is so low that we don't need to look at it. Another way is to look at it and say even if it fails we handle it.

So, I don't know, I would have preferred to make sure that -- because I think we can handle it.

MEMBER DIMITRIJEVIC: My question here is again, the cooling here is not a safety function, right? Because the cooling system is not a safety system, so the main safety function is defined in the SHINE slides, maintaining valve, that is whatever, containment pressure, system boundaries.

And controlling the H2 concentration. So, did you guys concentrate on those, reviewing this? You said there is the pressure cascade maintained but I'm not sure, let's say that takes care of integrity or maintaining integrity.

But did you analyze these other functions, the H2 function, chemistry quality control function, to prevent corrosions, things like that? Did you review those things too?

Because you concentrate your presentation just on the cooling and cooling is not a safety function of this system.

MR. RAU: I myself didn't review those items.

MEMBER DIMITRIJEVIC: They're covered in the SER, I was just wondering because they're not covered in your presentation, so I was just curious about it.

CHAIR BALLINGER: Okay.

MR. RAU: Thank you very much, that's all I have.

CHAIR BALLINGER: Thank you. Are there any questions from the Members? As the lady once said, strap yourself in, we're now on Chapter 4. So, are the SHINE folks ready to go?

MS. RADEL: Before we start Chapter 4 here, I just wanted to make a quick clarification on something that was mentioned earlier.

I did want to note that we did a comparison of the atmospheric meteorological data from 2000 to 2010 against the 2007 to 2017 data and showed there is no significant difference between the distributions of wind speed or the Pasquill stability class.

So, I just wanted to note that before we jump in Chapter 4 here.

CHAIR BALLINGER: Thank you. That closed us out with questions.

MS. RADEL: I'm going to turn it over here to Eric Edwards, our clinical process systems manager, to cover Chapter 4.

MR. EDWARDS: This is Eric Edwards, as she said. For Chapter 4 we're going to go through the radiation facility site for 4A and then we'll go through the radioisotope production facility for this outline.

So, go ahead to the next slide.

This slide shows the interaction of the various systems in the irradiation facility in a block diagram format.

The irradiation unit contains a light water pool and accelerator neutron driver, the subcritical assembly, the neutron multiplier, the dump tank and then other support equipment.

So, the main equipment that supports the irradiation unit outside of the irradiation unit cell concludes the target solution vessel off gas system and the primary closed-loop cooling system, which we just discussed.

And then Tracy?

MS. RADEL: Yes, before we move to the next slide, I just wanted to try to clarify the difference between the primary system boundary and the primary confinement boundary, as was asked earlier.

The primary system boundary would be -- I don't know if you can see the mouse there but the lines that run from the target solution vessel through the TOGS condensers to the TOGS skid and back around into the dump tank and back into the TSV as well.

So, that's the primary system boundary, piping and component boundary for the primary confinement boundary, which is made up of the irradiation unit cell, the TOGs shielded cell, as well as the recirculation RVZ, radiological ventilation zone and recirculation subsystem here.

So, that's a secondary boundary in case of a release. Are there questions on the difference between those two?

MEMBER HALNON: This is Greg. We have the confinement boundary going through white space there just below the IU cell supplemental cooling subsystem. What is that? Is that a wall there, or what is that?

MS. RADEL: The confinement boundary there is the actual components within the RVC 1R system itself, so the piping, those units, that unit is seismically qualified in the farthest part of the boundary.

MEMBER HALNON: Thank you.

MEMBER MARCH-LEUBA: What does that supplemental cooling unit do?

MS. RADEL: That's just a closed system that maintains the temperature and humidity within the IU cell and TOG cell within a range for optimum equipment time. It is not safety-related, it performs no safety-related functions other than confinement.

MEMBER MARCH-LEUBA: So, would you call it the air conditioning system?

MS. RADEL: Yes.

MEMBER MARCH-LEUBA: And another question, the primary confinement, there is one for each unit cell so we have eight of those?

MS. RADEL: Correct.

MEMBER BROWN: Is the dotted red line the confinement boundary?

MS. RADEL: Correct.

MEMBER BROWN: And this other thing called the system boundary is an invisible line going around through TSV up through the TOGS and out to the off gas?

MS. RADEL: The primary system boundary is made up of the actual piping and components that directly contain the target solution and off gases for the system. So, it's represented by the lines between the boxes and the boxes themselves.

MEMBER BROWN: The purple boxes?

MS. RADEL: Correct, purple boxes and the lines between the purple boxes.

MEMBER BROWN: Including the ones in the bottom? There are five purple boxes so it's all those that are the primary system boundary?

MS. RADEL: Correct.

MEMBER BROWN: And the lines going in and out?

MS. RADEL: Correct.

MEMBER BROWN: That's interesting because when you read Chapter 6 there's references to the PSB and it's very difficult to tell what's being isolated or not.

So, it would be nice to define that a little bit better than what you've done. Something similar to the red line would be very nice, a green line going around the purple items to show the system boundary.

It's tough when you're reading to try to figure out what you're talking about. That's all, just a comment.

MS. RADEL: And as we move into the Chapter 6 slides, we can definitely clarify wherever there is anything confusing about what we're referring to there. I'm going to turn it back over to Eric for the remainder of the Chapter 4 discussion.

MR. EDWARDS: This is Eric again. Next we're going to talk about the Neutron Driver Assembly System, or NDAS. The neutron driver creates deuterium ions that are accelerated into a tritium gas that creates fusion events, which creates helium, neutrons, and releases energy.

These other neutrons drive the subcritical assembly, where the molybdenum is created.

Components of the accelerator go through the accelerator stage on top that creates that ion beam, a pumping stage in the center that pumps out low pressures and puts that into higher-pressure areas for transport of the ion beam.

And then the target stage where the tritium gas is and diffusion occurs.

MEMBER MARCH-LEUBA: Do you have an estimate of the lifetime of these accelerators, an experience that will last several years?

MS. RADEL: We can discuss that during

closed session.

MEMBER MARCH-LEUBA: Sorry about asking that.

MS. RADEL: It's okay.

MR. EDWARDS: As I said, the accelerator drives the Subcritical Assembly System, specifically the target solution vessel. So, the target solution vessel contains the target solution which creates the moly in the reaction that was driven by the accelerator.

That's part of the Subcritical Assembly System, which also includes the neutron multiplier, the target solution dump tank, and the structure. The TSV drains to a geometrically favorable tank and that's how the system is shut down.

And it sounds like we are talking a bit about the passively cooling of that dump tank in the light water pool previously. Actually, this slide was covered a bit so I'm just going to go quickly over it.

Heat is created in the fission process which is removed by the primary closed-loop cooling system using force convection to cool a target solution. The size to remove all the heat produced are 10 percent over license power.

And then the whole subcritical assembly

sits in the light water pool and that's where we have the heat capacity to cool the target solution vessel dump tank.

The target solution vessel off gas system is used to maintain the hydrogen gas concentration, which is formed by water radiolysis at an acceptable level.

As we discussed a little at the beginning, TOGS is part of the primary system boundary and also has a function to provide iodine gas to control dose.

TOGS runs slightly below atmospheric and is designed to minimize the water hold-up in its own system and element material in its own system.

MEMBER MARCH-LEUBA: Can you say that again? Is this to minimize the hold-up?

MR. EDWARDS: Yes, it's designed to minimize the hold-up.

MEMBER MARCH-LEUBA: I think you have some drawings in the closed session? You can tell us where the water holds and how much of it and how long does it take to fill up? I'll ask this later.

MR. EDWARDS: We do talk a little bit about how this affects our activity management. All equipment in the irradiation facility that produces radiation is shielded by the irradiation cell biological shielding or ICBS.

That includes the IU irradiation unit cells, the target solution vessel off gas system cells, primary cooling rooms, and the Neutron Driver Assembly System service cell.

In that analysis of our shielding, geometry is explicitly modeled to mean that we would explicitly model penetrations and voids that are not scenario materials, as they call it, in most cases at least.

Dose rates are limited in occupied area in the analyses and then we have also shown in our analysis that the shielding material itself is not damaged over the lifetime from the radiation that it's protecting from.

That's the end of the irradiation facility.

So, moving onto the radioisotope production facility, this is where isotope separation is performed with molybdenum by extraction of moly with the purification system and the iodine and xenon, and separated in the iodine and xenon purification and packaging system.

Those are MEPS and IXP. There are three MEPS processing lines in the super cell, which is a series of hot cells and moly is separated from the target solution there.

Following separation, the target solution is staged for subsequent irradiation in a system called the target. The teachable lessons, we'll have a subsequent slide here.

Purification is performed on manipulators of a large scale in a separate hot cell so there's actually three extractions and three purifications. And then iodine and xenon are also separated in a separate hot cell by using some of the confinement systems.

Next, the TSSS, which is the target solution staging system, is a series of below-grade tapes. There are eight whole tapes, one for each radiation unit, and then you have two target solution storage tanks which are essentially spare tanks.

Any of the MEPS processing, once the extraction is complete, it can go to any of the TSSS tanks or subsequent irradiation so we don't have to keep going back to the same tank we got it from.

It's for operational flexibility. The moly isotope production path system, or MIPS, is an additional two hot cells where the product is put into fission containers and exported for shipping offsite.

And then some other process systems, these will be covered more heavily in Chapter 9 but the process vessel event system, I want to cover this because it interacts with some of the other systems, this is the system that mitigates the formation of hydrogen and the RPF tanks.

This is significantly less hydrogen than the irradiation unit cell so we don't see the system that is target solution vessel off gas system. And then this system also captures iodine and delays the release of radioactive gases reportedly harmful at least to the environment.

Radio-elective liquid waste storage, or RLWS, collects liquid waste from different systems where it can be sampled, blended, and then transferred to the radioactive liquid waste and mobilization system, where it's solidified for disposal.

And then the radioactive liquid waste mobilization system, or RLWI, receives the waste from RLWS and solidifies it.

It also has the ability to remove classification-driving radioisotopes, meaning it can separate cesium and strontium, for example, so that the waste can meet the system's lower classification level for exclusion.

That is the end of the Chapter 4 open session slides. Are there any questions on the open session slides?

CHAIR BALLINGER: Hearing none, let's continue.

MR. NEWELL: My name is Alexander Newell, I'm the criticality safety lead. I'm going to be going over the Chapter 6 presentation.

In the presentation we're going to cover confinement systems and combustible gas management and the IRF and RPF, as well as process vessel event isolation.

The purpose of confinement systems is to limit the release of radiological material to the occupied or uncontrolled areas during and after design basis accidents in order to mitigate radiological consequences to the facility staff, the public, and the environment.

The principal objective of SHINE's confinement systems is protection of onsite personnel, the public, and the environment with a secondary objective to minimize reliance on the administrative or active engineering controls.

The confinement systems were designed with the goal of as simple and fail-safe as reasonably possible.

I want to begin, as we had discussed earlier, by noting that each IU cell is independent of the other IU cells, and the primary confinement boundary utilizes passive and active features and consists primarily of the IU cell, the TOG cell, and the IU and TOG cell HVAC enclosures.

The RVZ1e subsystem is a credit to redundant dampers or valves that close on the confinement actuation signal. The piping systems penetrating the primary confinement boundary, and capable of excessive leakage or equipped with one or more isolation valves.

This satisfies SHINE design criteria in 33. Lines from outside the confinement that penetrate the primary confinement boundary and are connected directly to the primary confinement boundary are provided with redundant isolation capabilities.

This satisfies SHINE design criteria in 34. Note that isolation valves outside of the confinement are located as close to the confinement as practical and state acquisition providing greater safety to the parts of actuating power.

The N2PS and PVVS are equipped with appropriate isolation capabilities and to take the position of greater safety on the parts of actuating power.

CHAIR BALLINGER: This is Ron Ballinger, these design criteria are in Chapter 3 and we're not --

MR. NEWELL: Yes, that's correct.

CHAIR BALLINGER: We're not reviewing that chapter here but might it be appropriate for you to tell us what design criteria 33 is as well as design criteria in 34?

MR. NEWELL: Let me pull that up for you, just one second. I have them in front of me now. SHINE design criteria in 33 is piping systems penetrating confinement.

Piping systems penetrating confinement boundaries that have the potential for excessive leakage are provided with isolation capabilities appropriate to the potential for excessive leakage.

Piping systems that pass between confinement boundaries are equipped with either one, a locked closed manual isolation valve, or two, an automatic isolation valve that takes the position that provides greater safety upon loss of actuating power.

Manual isolation valves are maintained and locked shut for any conditions requiring confinement valve drain integrity.

And then Criterion 34 is confinement isolation. Lines from outside confinement that penetrate the primary confinement boundary and are connected directly to the primary system boundary are provided with redundant isolation capabilities.

Ventilation, monitoring, and other systems that penetrate the primary process, level locks, or hot cell confinement boundaries are connected directly to the confinement atmosphere and are not normally locked closed, have redundant isolation capabilities, or are otherwise directed to structures, systems, and components capability of handling any leakage.

Isolation valves outside the confinement boundaries are located as close to the confinement as practical. And upon loss of actuating power, automatic isolation valves are designed to take the position that provides greater safety.

Manual isolation valves are maintained to locked shut for any conditions requiring confinement boundary integrity. All electrical connections from equipment external to the confinement boundaries are sealed to minimize air leakage.

CHAIR BALLINGER: Thank you.

MR. NEWELL: No problem.

MEMBER BROWN: Can I ask a question? It's Charlie Brown again.

Going back to your Chapter 4 picture, based on what you define as the primary system boundaries, it looks like there's only one valve associated with that and all the rest of them are general confinement penetration, excuse me, two valves.

So, does your block diagram accurately represent what you just said with these? I'm trying to differentiate between confinement and system again to make sure I understand that.

MS. RADEL: This is Tracy, there are significantly more valves than representative in that block diagram. That's a simplified diagram showing some of the key isolation valves.

MEMBER BROWN: So, there's more. Okay, thank you.

MR. NEWELL: Okay, picking up, the N2PS, I believe I already said this but I'll just repeat myself, and PVVS are equipped with appropriate isolation capabilities and take the position of greater safety on locks of actuating power.

Moving on to the tritium confinement boundary, similar to primary confinement boundary, each TPS train is independent of the other two. The tritium confinement boundary is comprised of passive and active components.

The passive components include the TPS flow boxes, the secondary enclosure cleanup process boundary and the TPS to NDAS interface lines to the interface with the primary confinement boundary.

The active components include the isolation of the helium supply, the glove box pressure control exhaust, the vacuum and impurity treatment subsystem process vent, and process connections to the NDAS.

Active components are initiated to the safe configuration via the SFAS which initiates either a TPS train isolation on detection of high TPS glove box tritium concentration or high target chamber supply or exhaust pressure, or a TPS process vent actuation on the detection of high TPS exhaust to facility staff tritium.

And active components take their safe state on a loss of actuating power. So, here is a slide demonstrating the efficacy of our safety features.

I'll hold for a minute to give you time to digest the slide and ask any questions.

CHAIR BALLINGER: I have one, this is Ron Ballinger. I'm sure there's an obvious answer to this but if you look at Column 1, the public TEDE, versus Column 2, the worker TEDE, the public dose is higher than the worker dose.

I'm sure there's an obvious answer but I just don't know what it is.

MR. NEWELL: That would be because the worker dose in the unmitigated and mitigated cases are accounted for ten minutes based on our calculation of evacuation time.

CHAIR BALLINGER: Okay, thank you.

MR. NEWELL: Any other questions?

Moving on, the principal objective of combustible gas management in the IF is to prevent the conditions required for a hydrogen deflagration within the primary system boundary piping that results in over pressure exceeding the pressure safety limit of the primary system boundary.

Hydrogen gas is monitored and maintained below the LFL using the TOGS and if the TOGS becomes unavailable the N2PS is actuated to limit the build-up of hydrogen gas.

The N2PS provides passive, pressure-driven nitrogen sweep gas in the event of a loss of normal combustible gas management function.

The system utilizes both primary system boundary and PVVS piping to perform its hydrogen mitigation function and is actuated based on a loss of normal sweep gas flow 180 seconds after a loss of power, and on additional inputs that indicate a loss of TOGS functionality.

The capacity of the N2PS is sufficient to provide at least three days of flow to maintain hydrogen concentration within acceptable limits with additional margin.

CHAIR BALLINGER: This is Ron Ballinger, I'll pick up on the first bullet again, deflagration versus detonation. If you have an event where you get a deflagration, will the system handle that pressure jump?

I know you're not supposed to have one and you're preventing one, but what happens if you get one?

MS. RADEL: This is Tracy. Our founding deflagration analysis does -- we do exceed the LFL in our bounding combustible gas management analysis there. The pressure that is generated does not exceed the pressure of the primary system boundary.

The primary analysis is done in an

extremely conservative way, assuming that dump valves don't open, assuming we lose blowers, maximum response times.

CHAIR BALLINGER: Thanks, and I'm assuming the physical design of the system prevents detonation?

MS. RADEL: Yes, I'd have to look at the analysis to confirm whether that maximum over pressure event was classified as a deflagration or detonation. But we can confirm. The over pressure generated though was not sufficient to exceed the primary system boundary.

CHAIR BALLINGER: Thank you.

MEMBER MARCH-LEUBA: On the gas management system, you have active instrumentation, you're mentioning all these concentrations, correct?

MS. RADEL: Correct, we have instrumentation measuring hydrogen as well as oxygen. The hydrogen measurement is not safety-related but the oxygen one is.

MEMBER MARCH-LEUBA: And does it have safety-related power or do you dump the TSV before it becomes an issue of used power?

MS. RADEL: For the instrumentation the monitoring is on the uninterruptible power supply system. We do dump in the case of if any of the readings exceed the set points, so both of those are true.

MEMBER MARCH-LEUBA: And can you go into details in the open session about why is the oxygen safety-grade and not the hydrogen?

MS. RADEL: For the hydrogen, it was determined there was no degradation mechanism that would cause a set change in performance on the recombiners because they are pretty passive in their function so they're sitting there.

We do have the heaters that heat those re-combiners on the safety system just to make sure they maintain the temperature needed.

So, with no identified mechanism to cause a step change in their ability to recombine the nitrogen and the oxygen, it was determined that flow and other parameters were sufficient to ensure safety.

The oxygen is a safety-related measurement and early on within the radiation cycle, oxygen will be held up within the solution from the radiolysis. Some of the oxygen early on does not escape the solution at the same rate the hydrogen does and so you need to ensure there's sufficient oxygen for that recombination.

And we do have an oxygen system that

injects oxygen early on in the irrigation cycle.

MEMBER MARCH-LEUBA: And the safety action is if the oxygen gets too low to compensate for the hydrogen production or the other way around?

MS. RADEL: Correct, if the oxygen gets too low it will trip the unit.

MEMBER MARCH-LEUBA: Okay, thank you.

MR. NEWELL: Okay. Next slide. Thank you. Moving on to the supercell confinement in the RPF now. The supercell confinement is also made of passive and active components. Passive components include the stainless steel box that provides confinement of materials and process equipment. The active components include the supercell ventilation that during normal operations keeps the supercell at a negative pressure relative to the general area and has filtration on both the inlet and the outlet.

Upon detection of high radiation by the induct radiation monitors, isolation dampers or valves close on the ventilation system inlet and outlet of the affected cells. And a MEPS heating loop isolation and VTS safety actuation are initiated. All active components required to function to maintain the confinement barrier are actually ESFAS.

MEMBER PETTI: This is Dave. Just a

question on the steel boxes. It's not the hot cells aligned with steel. But there's actual boxes so things are separated, different processes.

MS. RADEL: This is Tracy. Each of the cells has their own confinement box that sits within the supercell structure. So there's a framework that supports each of the ten boxes. But it's that steel box or steel -- it's called -- we refer to it sometimes as a liner, but it's a steel box within that structural framework.

MEMBER PETTI: So there's ten boxes?

MS. RADEL: Correct, ten boxes.

MEMBER PETTI: And so like many hot cells, both steel boxes separate the different operations to prevent cross contamination and the like?

MS. RADEL: Yes, so there are --

(Simultaneous speaking.)

MEMBER PETTI: Okay.

MS. RADEL: -- between some of the cells. But the doors are the pass-throughs are designed to maintain the integrity of the individual boxes.

MEMBER PETTI: Right. Thank you.

MEMBER MARCH-LEUBA: And this might be because of my ignorance. But tritium is very easy to handle by itself. It's just hydrogen. But when it leaks into a large volume of light water, then it becomes a problem because you cannot distinguish it from the other hydrogen. Are there paths for the tritium to leak into light water which then will become contaminated? What happens with confinement then?

MS. RADEL: So this is Tracy again. There is no tritium on the radioisotope production facility side. The tritium is all located within the radiation facility side. One interface where tritium is adjacent to water with a single boundary between would be the target chamber -- the tritium target chamber. And that does have a dedicated loop to it to minimize the amount of contamination that would occur in that case.

(Simultaneous speaking.)

MEMBER MARCH-LEUBA: Yeah, so if some corrosion or hole or break or something happened, you could contaminate the PCLS.

MS. RADEL: No, the dedicated cooling for the target chamber isolates it from the PCLS.

(Simultaneous speaking.)

MEMBER MARCH-LEUBA: So it's a smaller volume? Okay.

MS. RADEL: Correct.

(Simultaneous speaking.)

MEMBER MARCH-LEUBA: Yeah, that's a good design.

MS. RADEL: We also changed the target chamber between the PSAR stage and the FSAR to stainless steel to minimize permeation of tritium through the target chamber.

MEMBER MARCH-LEUBA: Thank you.

MR. NEWELL: Moving on to the below grade confinement in the RPF, the below grade confinement is primary comprised of the structural components of the boundary. Each part of the subgrade is equipped with a concrete cover plug and gaskets or other non-structural features already used as necessary to provide ceiling where components meet. The pipe trench, annular tank vaults, and valve pits with equipment containing fissile material are equipped with drip pans and drains that lead to the RDS. Where process equipment processes the confinement boundary into non-confinement, appropriate isolation capabilities are provided.

And again, we'll pause for a minute so you can take a look at this table and ask any questions.

DR. SCHULTZ: This is Steve Schultz. Could you describe briefly the unmitigated versus mitigated dose values that you have? What is meant by unmitigated here? And these are shown in Chapter 11. Is that correct?

MR. NEWELL: No, these are shown in Chapter 6.

DR. SCHULTZ: All right. I got you. Thank you.

MR. NEWELL: Yeah, do you still want me to describe the difference between the unmitigated and mitigated?

DR. SCHULTZ: Yes, thank you.

MR. NEWELL: Yeah, so the unmitigated consequence is essentially a release of the corresponding material, quote-unquote, and then the open field. So it's only considered to have the most bounding chi of q applied to it. There's no kind of credit taken for any kind of holdup on the gases that may occur as it leaks out of the confinement into the general area and then from the general area out to the environment.

DR. SCHULTZ: And for the worker, is that the same type of definition?

MR. NEWELL: That is correct, yes. There assumed to stand in the cloud or the release of material for ten minutes. And then that's where the analysis stops so we can get a one-to-one comparison between the unmitigated dose and the mitigated dose to demonstrate the efficacy of the safety features.

DR. SCHULTZ: Okay. Thank you.

MR. NEWELL: So moving on to the RPF Combustible Gas Management. The principle objective of the combustible gas management and the RPF prevents the conditions required for a hydrogen declaration in the gas spaces of the RPF tanks. During normal operations, the PVVS provides sweep gas to the tanks and the RPF and provides an outlet path for gas generated in a primary system boundary.

If the PVVS becomes unavailable, the buildup of hydrogen gas is limited using the N2PS to establish sweep gas flow through the process vessels, process system piping, and PVVS piping. The capacity of the N2PS is sufficient to provide at least three days of flow to maintain hydrogen concentration within acceptable limits with additional margin. And finally, we'll discuss the process vessel vent isolation.

During normal operations, radioactive components of the PVVS gas stream are removed or delayed via condensation, acid adsorption, mechanical filtration with HEPA filters, and adsorption in the carbon beds. SHINE utilizes two types of carbon beds, guard and delay beds. The PVVS guard and delay beds are equipped with isolation valves that isolate the affected guard bed or group of delay beds and extinguish a fire. The isolation values also serve to prevent the release of radioactive material to the environment.

Note that the guard bed isolation is a nonsafety-related function. The PVVS is equipped with instrumentation that detects fires and provides indication to ESFAS. Redundancy in the beds and the ability to isolate individual beds allows the PVVS to continue operating following isolation. And that's the last slide of Chapter 6.

CHAIR BALLINGER: Thank you. Any questions from the members before we -- we have scheduled for lunch between 12:00 and 1:00 and we're a bit early. I think we have to meet that schedule.

MEMBER PETTI: We still have the staff.

CHAIR BALLINGER: Huh?

MEMBER PETTI: We still have the staff.

CHAIR BALLINGER: Yeah, but the staff is --

MEMBER PETTI: Oh, okay.

CHAIR BALLINGER: The staff is --

(Simultaneous speaking.)

MEMBER PETTI: I had a question.

CHAIR BALLINGER: Oh, okay.

MEMBER PETTI: How often do you anticipate having to replace your carbon beds?

MR. EDWARDS: This is Eric Edwards. The beds are the life of plant.

MEMBER PETTI: Oh, okay. Thanks.

CHAIR BALLINGER: Any other questions?

Okay. I think we really need to recess until 1:00 o'clock because of our schedule. So we will recess for lunch and be back here at 1:00 o'clock.

(Whereupon, the above-entitled matter went off the record at 11:45 a.m. and resumed at 1:00 p.m.)

CHAIR BALLINGER: Okay. It's 1:00 o'clock, and we're ready to reconvene. And the staff is up for Chapter 4 and 6. Mike, are you up? You are.

MR. BALAZIK: This is Mike Balazik, and we'll be presenting Chapter 4A. Joe Staudenmeier is going to start off the presentation. Joe, are you on?

MR. STAUDENMEIER: Yeah, I'm here.

MR. BALAZIK: Yeah? Okay.

MR. STAUDENMEIER: Okay. Chapter 4A, the

irradiation facility description, at some point in the slides, I'm going to hand it over to Nate Hudson to talk about the final slides. Let's move on to the first slide. Okay. Just this is while I work on the facility description, if there's any questions about it, feel free to ask.

But I think we're short on time for the amount of slides we have. So maybe we can move on. And also the review standards have been presented before. So let's go to the SHINE system overview.

MEMBER REMPE: So this is Joy. And before we breeze past the review standards, could you talk a little bit about -- because I kept looking through the SER to kind of try and understand what exactly the staff did. Because throughout the SER in Chapter 4, it talks about the staff evaluated, the staff assessed.

And finally, I got curious and I went back 1537. And it said really all that the staff does on Chapter 4 is make sure the background information is complete and is available for other -- they want to make sure it's consistent with what's in other chapters. But it's background information used by others. Is that -- am I right or are there some calculations you did --

(Simultaneous speaking.)

MR. STAUDENMEIER: Yeah, I mean I've done calculations. We've done more than that. I guess my history in these AHRs, I started working on them back when we put together the interim staff guidelines which I think was -- I don't remember -- back in, like, 2009 or 2010. And then there was another company that was in for pre-application review that ultimately decided not to come in with a licensing application that a lot of actually the interim staff guidelines were based on some things and their conceptual design for what they were going to have.

That was an actual reactor, not a subcritical facility. But I guess through that time, I've gone through lots of calculations, read lots of background material. And as part of the review, I did some simple calculations, checking on things. At one point, I had a TRACE calculation looking at the cooling system to check on some numbers they had for that. So there's --

MEMBER REMPE: So where is that documented that you did a TRACE calculation in Chapter 4 in the SER?

MR. STAUDENMEIER: Nowhere. I mean, I didn't write up a report on it. I did some calculations just to check that their numbers looked okay with an independent calculation. So I did not document that. And the cooling system actually -- review actually got handed over to NRR during Chapter 5 for the cooling of the TSV. But I can talk a little bit about it when we get to that slide if you'd like.

MEMBER REMPE: So again, like, I mean, there was a place you talked about that you had -- you were concerned about or someone was talking about they were concerned about the stagnant flow location --

MR. STAUDENMEIER: Yeah.

MEMBER REMPE: -- and different things like that. It'd be good to understand. But again, when I asked the folks in Chapter 5 how they had confidence that there was a lot of margin, and we'll be talking about it in the closed session, I kind of thought that the calculations would be more a Chapter 5 thing is what I came away with after looking at the guidance that you didn't have to do stuff.

And now you're saying, well, yeah, I did stuff. But I didn't document it. I'm wondering if ACRS is curious about things, where do we bring it up?

Like, the instrumentation should be brought up in Chapter 7. Should we be bringing up the concerns about the coolant system and the heat transfer or the reactivity and heat transfer response combined? Should that be a Chapter 4 issue or should it be a Chapter -- some other chapter issue?

MR. STAUDENMEIER: I think it should be Chapter 4.

MEMBER REMPE: Oh, really? Okay.

MR. STAUDENMEIER: I can answer those questions.

MEMBER REMPE: Okay.

MR. STAUDENMEIER: Yeah, I mean, the stagnant flow, I mean, you just have to look at a drawing of the facility and you can see that there's going to be a stagnant flow region. And I can present a picture like that because it's proprietary. But you can examine it and know that there's not going to be a flow sweeping in a certain area, so --

MEMBER REMPE: But yeah, as you go through -- again, in a closed session because I don't want to get into proprietary stuff -- be very specific and tell us exactly what calculations you did. Okay?

MR. STAUDENMEIER: I was going to say the cooling system isn't very challenging. It's sub-cold water and single phase heat transfer and fixed flow rate. I mean, you look at CHF, there's one other thing related to the cooling systems that you have to look at since there's these parallel flow channels. You have to make sure that there isn't vapor generation in one of the channels because if you do that, then it will starve that channel a flow because they're connected in parallel across two plenums essentially.

So that's something beyond CHF that you have to be concerned about because if that did happen, again, if it didn't go in the CHF and you're a standalone calculation, that would possibly cause things to go into CHF. But I mean, the outside of the TSV, the temperatures are too low to even generate vapor. They're below the onset of nuclear boiling. So there's -- I mean, if you look at temperatures involved in the system, you don't have to --

MEMBER REMPE: Then sometimes --

MR. STAUDENMEIER: -- worry about that stuff. And I discuss that stuff with Adam Rau, their reviewer that presented Chapter 5. So he was aware of that situation also.

MEMBER REMPE: If you get through, let us know what kind of calculations you did and where. And then also a lot of times I saw things about, well, this is whatever instrumentation and it gives you competence that there's adequate time to do stuff.

And I just would like to know how that all worked.

And I'll try and look for those locations too or ask you at the end. But I was puzzled in what I was given to review and how I was going to review it. So thank you.

MR. STAUDENMEIER: Okay. Yeah, I mean, probably, yeah, I could discuss more calculations in the proprietary session because I wouldn't trust myself not to spit out a number that's not proprietary because there's a lot of numbers that are, so --

MEMBER MARCH-LEUBA: This is Jose. Isn't the TSV at the lower pressure than the ECLS, the cooling channel?

MR. STAUDENMEIER: It is. It is at a lower pressure. So --

(Simultaneous speaking.)

MR. STAUDENMEIER: -- if you have a leak, water would leak into it, yeah.

MEMBER MARCH-LEUBA: I'm thinking about in order for the cooling channel to boil, the TSV, the solution would have to boil first to reduce the pressure, right -- the temperature?

MR. STAUDENMEIER: Yeah, that's correct. Yeah, that's correct. The temperature inside the TSV is below what the onset of nuclear boiling temperature would be in the cooling system.

MEMBER MARCH-LEUBA: It's physically impossible to have CHF on the cooling channel.

MR. STAUDENMEIER: Right. On the cooling channel, you couldn't. The neutron multiplier, it could be possible if there was enough power going into the neutron multiplier, if there would be a possibility there I guess. But --

(Simultaneous speaking.)

MR. STAUDENMEIER: --- you have to get that surface cold also.

MEMBER MARCH-LEUBA: Thank you.

MR. STAUDENMEIER: Okay. Let's move on. Well, let's see. Let me see if there is any point I forgot that I didn't say. Yeah, I think -- the facility is described enough, all the major components, design basis for the equipment and how they're going to control it during normal operation and items that relied upon for safety.

And a lot of these details will make it into things forming the accident analysis in Chapter 13. Okay. Next slide. Okay. Yeah, it's a low power pressure and temperature system that's driven -- it's subcritical driven by a neutron source. Can't talk about the multiplication factor. That's proprietary.

But you get a gain over the neutrons you're putting in through the multiplication. It has a lot in common with aqueous homogeneous reactors. I guess the main difference is you're driving the neutrons with your accelerator here as a neutron source where in AHR, you would get the neutrons for free, I guess.

You'd also have a reactivity control system you'd have on as part of that. But that's the main difference. But both would have to have to have, like, a system to handle the offgases and otherwise they'd be similar.

The solution properties are similar. The solution composition in power density are within the existing experience base for solution reactors. If you go -- the reference I have in parenthesis is kind of the bible of solution reactors.

But if you go back and look, you can see people have tried all sorts of solutions, just about any kind of acid you can think of that will dissolve uranium. That is the basis for solution reactors. And there's actually quite a bit of operating experience and experimental work showing the feedback characteristics from small and large reactivity insertions and AHRs would bound anything that happens in this facility.

And as I said, the unique feature to this system is the accelerator driven neutron source. Okay. Next slide. Major systems and components, I have arranged in a little bit different order than it was in the SAR to try to think, I guess, logically about it. And the first components I listed are the ones inside the primary system boundary.

And that's what contains the solution and the radioactive gases and off gases that are generated. So in the target solution vessel, there's a surveillance and inspection for radiation, damage, and corrosion. There's overflow lines to the TSV dump tank that keeps a clear gas space so the TOGS can keep operating, that you don't cover up the TOGS in the lines. The dump tank is criticality safe.

It's substantially lower k-effective than what the TSV is. So there is a big shutdown margin in the TSV dump tank. And that's really the scram system. You have two dump flow paths, and there's two overflow paths from the TSV to the dump tank.

Like, the drain rate to the TSV dump tank is something that will be tested. It has to meet certain criteria. The TOGS, the TSV offgas system, the main function of that is to keep hydrogen concentrations below flammability limits.

And the TSV and TSV dump tank, there's two trains of TOGS. Only one of the trains provides a sweep gas to the dump tank. The hydrogen concentration, it's not a safety measurement. But there is an alarm associated with that that goes off at a certain concentration to alert the operator that it's on the rise.

And if you see the -- once you get to see the accident analysis, there were hydrogen ignition events that the pressure limits says quite a bit below what the design limit is on the primary system boundary. In normal operation, it maintains pressure within the operating limit. So there's an operating band that you're trying to maintain the pressure within, hence the limit water hold up because taking water out of the system --

(Simultaneous speaking.)

DR. BLEY: So this is Dennis. I got knocked off for a while and didn't hear anything. Did that happen to everybody?

MEMBER REMPE: No, Dennis. We can hear you.

MR. STAUDENMEIER: Okay. Can everyone hear me?

Okay. And also removes iodine to try to keep a limit on the source term for iodine release. Next slide.

MEMBER REMPE: Okay. So on this prior slide is I guess a good place. Again, I'm curious again. The staff and I, when I read this, like, do we have confidence that the instrumentation is going to provide enough of an indication, whether it's the hydrogen concentration or the flex levels and all these other things?

Did you just read it and say, yeah, they put the instrumentation in a good place? Or did you do any sort of analysis? And again, if you want to talk about the analysis in the closed session, that's fine. But that's one of the -- again, when I was reading it, I was puzzled why you had the confidence.

MR. STAUDENMEIER: Okay. So yeah, I don't know. Maybe I might keep it to the proprietary session. But there are -- I mean, there's instrumentation. And I don't know if you've looked at the instrumentation and the safety trip system.

But there's things related to flow and oxygen concentration for the TOGS system. In the TSV, there's a bunch of thermocouples that are used to get a temperature. That's also there's high temperature limits. And essentially, anything exceeding limits, you'll end up shutting off the neutron driver and dumping the solution into the dump tank.

MEMBER REMPE: So some things I can understand why the instrumentation is placed at a good place. And I don't know what I can say here. But other things because of data that was cited and testing. But other things I wasn't sure.

And so did you think about, yeah, where they've put it is a good place. I don't have to worry about stratification in this particular location for this particular sensor. I'm just kind of kicking the tires to say did you ask those kind of questions when you were going through the review? Or you just, again, I've got a sensor and I assume they put it in the right place?

MR. STAUDENMEIER: I mean, I guess I thought about the processes going on there. Like, in the TSV, there's going to be circulation of the fluid because, I mean, you're going to get higher buoyance in the high power region for more generation of gas. So there's going to be some natural circulation flow pattern keeping it mixed.

And there's also some experiments that were run, Wisconsin by Professor Corradini. There used to be a YouTube video up of him presenting it as a seminar. I don't know if that's still on --

(Simultaneous speaking.)

MEMBER REMPE: Yeah, that one, I got. But I'm thinking, like, hydrogen. Did you think about stratification and where it might accumulate?

MR. STAUDENMEIER: Well, the hydrogen, the flow rate in the loop I think is high enough to keep it from accumulating or stratifying. So there's a force flow going around the TOGS loop. It's not natural circulation going around the TOGS loop.

So there's forced blow or flow going around the TOGS loop that should keep it from being stratified. And if you look at the hydrogen concentration compared to the sweep gas that's going around, it's going to be small, I guess. So it's a small fraction of the total sweep gas flowing around. But I don't want to say numbers. So I --

(Simultaneous speaking.)

MEMBER REMPE: That's fine.

MR. STAUDENMEIER: -- numbers are proprietary or not. Okay.

MEMBER REMPE: Thanks.

MR. STAUDENMEIER: Okay. Next slide. Okay. Then moving beyond the primary boundary of a secondary confinement boundary, and that's the Subcritical Assembly Support Structure. And that's where the cooling water flows through to cool off the TSV and the neutron multiplier. It's a higher pressure than the TSV.

So if the TSV got a leak, you would have water flowing into the TSV. And that is a negative reactivity insertion when that happens. And you've already seen the review of the ECLS from Chapter 5.

But it's a closed loop cooling system which is -- that's one of the, I guess, fairly big changes from the re-application -- or the PSAR version of this which PSAR version had the TSV open to the pool where an accident could dump the TSV into the pool. But now a leak in the TSV would put it into another confinement system which also has a fairly substantial pressure boundary -- peak pressure. Okay. Detection for -- there's detection for leakage from the TSV or the neutron multiplier.

And the neutron multiplier also has a [redacted] in it for any [redacted] in the neutron multiplier. That uranium metal and aluminum cladding. And there's a [redacted].

I don't know if you've seen a picture of it. Okay. Next slide. Okay. Light water pool, each light water pool has about 19,000 gallons of water, I think, somewhere in that. I think that's the number. And I'm sure that's not proprietary.

And so if you figure out what the heat capacity of that and the decay heat from 125 kilowatts, can figure out pretty quickly that the temperature rise over many days is going to be low. So that's one of the two functions is to provide decay heat cooling for the dump tank under normal operations and for the whole system under emergency operations. So you can dump it in there, leave it in the pool for a very long time and not get much of a temperature rise.

There's a minimum pool level that's required for shielding. That minimum level is a controlled number. And then there's -- the cooling was evaluated at actually a much lower level than a shielding minimum level. And so there's a lot lower number needed for provide for the cooling and the long term and limit heat ups.

And there's -- yeah, there's just still a lot of water and even after you lower it to that level. And water has a high heat capacity and the power is not very high for the amount of water that's there. Okay. Next slide. Okay. Neutron driver assembly systems, so this is the source of the neutrons. They use DT fusion reaction to provide the neutron source for the subcritical assembly. There's trips to shut down --

(Simultaneous speaking.)

MEMBER DIMITRIJEVIC: Sorry, before you go to there, I wanted to ask you. Couldn't find my microphone. This control level for shielding, so what happening that is alarm connected to that level? I mean, what happens the water goes below that shielding level --

(Simultaneous speaking.)

MR. STAUDENMEIER: I think you would have to shut down if you couldn't make it up.

MEMBER DIMITRIJEVIC: Shut down but don't dump it in the tank. Is that --

(Simultaneous speaking.)

MR. STAUDENMEIER: Well, dump it in the -- shut down means turn off the accelerator and dump it in the tank.

MEMBER DIMITRIJEVIC: So dump it in the tank even there is a low level?

MR. STAUDENMEIER: I'd have to go back and look at the control system for that. I don't want to say yeah. I would need to go back and confirm the details on what it is. There's probably some time that's allowed for that. But there's a tech spec for minimum pool level.

MEMBER DIMITRIJEVIC: And I assume that activates the makeup system, right, which is also non-safety system, right?

MS. RADEL: So this is Tracy with SHINE. The pool heights are proprietary. And so it'd probably be best to discuss in closed session. But there is no active makeup system and there is none required for safety. So we can talk about more the details of the scenarios with the light water pool in closed session.

MEMBER REMPE: Since we kind of interrupted you, I was just thinking about the Wisconsin tests a bit more. Were they subject to some sort of QA, like, a real reactor or large reactor would be if there were testing that came into play?

MR. STAUDENMEIER: Okay. Could you repeat that again?

MEMBER REMPE: Well, I know that you -- and I did read the paper given about the Wisconsin tests. And I was just curious about QA on something like that. If you're relying on a heat transfer coefficient from a university experiment, it's subjected to the same kind of QA that you would for, like, NQA-1 or something? What kind of QA do you require on something like this where it's just in IMBA?

MR. STAUDENMEIER: We did not check on any QA requirements put in place for that test. I guess the one thing is I guess safety is not really important to that specific correlation. If you look at the heat transfer coefficients that come out of that. I mean, they're not very high.

You can look at other related correlations and look at differences between them. And if they are off on that heat transfer correlation, if they were too low and it caused the temperature to get higher, then it would just trip and dump the system. So I would say that heat transfer correlation is not safety-related.

MEMBER REMPE: Thanks.

MR. STAUDENMEIER: Okay. So yeah, there's trips to shut down the neutron driver. There's an interlock to prevent operation during maintenance activities. And there's a system to detect tritium leakage. So next slide.

Okay. Target solution, the target

solution parameters are controlled to prevent precipitation of uranium out of the system, temperature limit to prevent boiling, and natural convection cooling enhanced by bubble buoyancy. Evaporation cooling is not credited in this system when they're doing the heat transfer correlations, even though if you look at the vapor pressure associated with the temperature it's at, there's going to be -- it's not insignificant I'd say. So you could get some more margin if you took that into account. Next --

CHAIR BALLINGER: This is Ron. I'm assuming that if you got precipitation, it would go to the bottom of the tank and you'd see it right away?

MR. STAUDENMEIER: Well, you can't really see the precipitation.

CHAIR BALLINGER: I don't mean see it. Notice it --

MR. STAUDENMEIER: Okay.

CHAIR BALLINGER: -- on some instrumentation.

MR. STAUDENMEIER: Well, I mean --

CHAIR BALLINGER: I don't mean you have a gremlin down there.

MR. STAUDENMEIER: Yeah, I mean, the

boundary to precipitation, they stay well below the precipitation boundary when they're doing start up. So it's by controlling the system parameters to keep it away from the precipitation boundary. But you would probably notice it in the neutron signal, I think, because that would change the reactivity in the system if you precipitated some of it to a different location.

You would probably indirectly notice it through that. But it's really prevented by keeping operating parameters away from the known precipitation boundary. And that's power density and temperature are the two main parameters for that.

MEMBER REMPE: What about fouling of surfaces? I vaguely remember this was brought up in the construction permit review or at least I think I remember that. And I thought we were told that somehow rather that the surfaces are monitored. Did that come up in your review this time?

MR. STAUDENMEIER: There is inspection of the surfaces periodically. So there is visual inspection. In terms of -- there are some fouling assumptions in the heat transfer resistance that's included for that. But there will be visual inspections periodically.

MEMBER REMPE: And if they see something, can they clean off what they see? Or what would they do?

MR. STAUDENMEIER: I guess they would have -- I do not know how they would clean it. But maybe SHINE could answer that question if they have a way that they would clean it. But I think the tanks are also maybe periodically rinsed out.

MS. RADEL: Hi, this is Tracy. Based on the chemistry of the solution, we don't expect significant fouling. So fouling is considered in the thermal hydraulics safety basis, thermal hydraulics analysis. We have not yet developed any procedures related to how we -- if it did happen, how we may go about cleaning the surfaces, that's not been evaluated at this point. Based on the chemistry, we would not expect that.

MEMBER REMPE: But if you would, then I guess you stop things and discuss it with the NRC and do something about it?

MS. RADEL: We would stop operation in that unit and assess what the next action -- correct actions would be on that.

MEMBER REMPE: So then the question is, how much is enough to stop? I mean, I guess, is this discussed anywhere with the NRC that, yeah, if you see a little bit, it's not a big deal. Or if you're off on your heat transfer assumption, somehow or other by some percent, you know there's a trigger to this is too much? How do you decide what to do?

MS. RADEL: So we would compare it to our safety basis analysis. And if we're outside of our -- or approaching our safety basis analysis, that would be when we would consider next steps and reevaluate. Yes, we did include margin in our analyses or following other considerations. So we would evaluate against those.

MEMBER REMPE: So let me put words in your mouth. If you ever were approach -- exceeding -- or reducing your safety margin that's allowed in your FSAR, then you would shut down. So there is a trigger point. It's the margin, right?

MS. RADEL: Yes.

MEMBER REMPE: Thanks.

MR. STAUDENMEIER: Okay. Next slide. Okay. This is where Nate is taking over.

MR. HUDSON: Thanks, Joe. Hi, good afternoon. This is Nate Hudson, NRC Research. I redo the biological shield for the irradiation facility. It's a thick concrete shield. It's designed to limit exposures within the standard 10 CFR 20 limits and ALARA considerations.

There are obviously radiation sources in the TSV, the dump tank if there's a trip, activation products and the TOGS and the ECLS. The shielding is designed to shield. It's a concrete shield that's the water shields the neutrons and gammas to the concrete.

And it was constructed an analyzed for NRC and concrete standards, NUREGs, standards that define the criteria for flux and temperature and a cumulative dose to the concrete to make sure that the shielding function is maintained and the concrete stays -- the integrity stays. It doesn't collapse or getting embrittled with coolant. Next slide, please.

Nuclear design reactivity control, with the information that's been presented so far, it's a subcritical system. No excess reactivity, so no need for chemical and mechanical shim or reactivity control, no control rods. The introduction of solutions controlled by the reactor -- the operator, excuse me.

The lift tank is a limited capacity, and the flow rate is limited by an orifice. All the physical properties that I the staff could see in the relationships, the reactivity balance were described, calculated, analyzed, and supported in the text with tables and figures. The TSV can be shut down through a trip, reactivity protection system, into the dump tank which is designed to be an annular dump tank and subcritical.

And the flow rate, there's two redundant dump valves in parallel that passively open. Be energized on a trip. So the flow rate is greater than the fill rate for the TSV. So the variables that influence reactivity are clearly understood, and some are monitored and controlled with tech specs or monitoring a solution prior to irradiation. And obviously, the neutron multiplication is monitored on startup with the flux detectors we have out.

MEMBER MARCH-LEUBA: Nate, this is Jose. Did the staff perform any confirmatory calculations on criticality, k-effective, or reactivity coefficients?

MR. HUDSON: No, we didn't. Based on -- I mean, based on everything that's presented and in the reading room and SAR and historical references I reviewed, it was -- we didn't -- I didn't see a need to do confirmatory for the MCNP.

MEMBER MARCH-LEUBA: Okay. Thanks.

MR. HUDSON: I was satisfied based on what -- I mean, my reading of everything, I was satisfied there was a negative temperature, negative fuel solution coefficient. And I wasn't confident that it would add too much to the finding to do a confirmatory calculation for the reactivity.

MEMBER MARCH-LEUBA: Well, in this case, it would've added confidence if you had reviewed the input decks for MCNP to make sure they didn't make a mistake.

MR. HUDSON: True. We could've -- I could've done that.

MEMBER MARCH-LEUBA: Okay, thanks. Not complaining.

MR. HUDSON: Like, in the case of the dunk tanks, there were a lot of MCNP models that were put in the reading room for dose calculations and criticality of the dump tanks. So there were some analysis there. I can't remember if the account notebooks are supplied in the reading room. But I mean, we perhaps could've found in there --

MEMBER MARCH-LEUBA: It's clear what you did. I have concerns about the temperature treatment on the MCNP models because I haven't seen the models either. So I will ask more details on the closed session.

MR. HUDSON: Okay. Next slide. Yeah,

with their MCNP analysis, they calculated a bounding -- like, all the contributors to the power coefficient were calculated and analyzed to indicate that it was, like a self-damping system with a negative void and temperature coefficient and a solution. The kinetics parameters at the beginning of life, end of life for the fuel solution were calculated and understood, like, the beta effect. The uncertainties on the neutron multiplication and reactivity coefficients with respect to uncertainties and state parameters calculated within confidence intervals.

And the reactivity coefficients with solution multiplier were evaluated at nominal and limiting conditions. And they also did reactivity additions and static changes in the core components, like, during startup and irradiation. I think, like, at the head space and the multipliers supplied it or if there's water in the dump tank that can overmoderate the criticality.

So a lot of criticality calculations are considered things that would bound the calculation and demonstrate if the k-effective was critical in the TSV or in those components external to the TSV. Subcritical margins were calculated in several different scenarios. And a limiting core configuration in terms of thermohydraulic limits was calculated for the solution volume and uranium concentration was determined. Next slide, please.

MEMBER REMPE: Well, I guess I have --

MR. HUDSON: I'm sorry.

MEMBER REMPE: -- a question too. We talked about earlier today about when you're starting up this device. And I've forgotten now where it was -- what chapter it was. But I thought that again they realize that there's a different between what they think would be critical as they approach criticality versus what their models predict.

Or a difference in the instrumentation versus the models that things will adjusted. Is there any interaction that would occur with the staff if that happened? And again, if their margin is reduced significantly and how much is significant before they would go back to the regulator and say, well, it was a bit more off than what we expected?

And again, I mean, I saw in your SER that the staff again said that there was reasonable competencies that if there are oscillations that they would be small and self-limiting due to low power density and negative void and temperature coefficients. Again, you're basing it on some data as well as prior experience with other devices. And I'm just wondering when there's always some uncertainty and when this uncertainty becomes significant and people need to think about it.

MR. HUDSON: So as far as the detectors being calibrated, I didn't personally review that. But that is a good question. I hadn't thought about it in a year, if there are tech spec limits on uranium concentration and I think lower volume of the TSV. So if the system is not behaving during start up testing, if it departs from what's controlled, then I would think there'd be some interaction during the startup program for this system it's outside what was analyzed and determined what's on the docket.

MEMBER REMPE: So again, if I were a regional inspector and I was cognizant of those tech specs that I would know that this is a trigger point and the licensee will know this is a trigger point where we need to stop and have some discussions with NRC. Is that what you're telling me?

MR. HUDSON: There were uncertainty bands on the startup detector, so -- the three detectors. So if it's outside those uncertainty bands, I would assume a regional inspector would note that.

MR. BALAZIK: Yeah, this is Mike Balazik

from the NRC staff. Also, this information I believe is in the FSAR. And the licensee would have to evaluate any changes under 5059. And there's the possibility that they would have to notify us if they were wanting to make a change to that.

MEMBER REMPE: Thank you.

MR. BALAZIK: And also in 5059 is also inspected by the inspectors, any evaluations they do.

MEMBER REMPE: Thank you.

MEMBER MARCH-LEUBA: This is Jose. While we're talking about detectors, I want to do it in the open session. My concern is it feels to me -- feel because I haven't seen the exact wording anywhere -- that we are calibrating the detectors at least for the first startup just on a calculation using MCNP.

I mean, it's the only way I know how to do it. And detectors age. Their efficiency changes with time. You don't know what the efficiency of that detector is, and you don't know the exact location because it can be a couple of millimeters off.

It's a calculation that has a very large uncertainty. And we -- at least on the startup in cycle one, we are going to the one over M, upper case M, measurement to ensure we don't go over a critical k-effective. But without knowing efficiency of the detectors, it's hard to do.

I mean, we can be off significantly. The beauty of M is it goes to infinity when you hit M equal one. So you can be off a little bit and still be okay.

I'm just putting that on the record that maybe -- I'm sure SHINE already knows that for the first startup, they have to go very easily and very slowly. And if they're trying to go to a k-effective or XXX, they'll probably for the first cycle go to XXX minus two or something like this. That's my concern that predicting the response of a detector especially in the next core detector with any accuracy is not easy.

MS. KOLB: This is Catherine Kolb from SHINE. I appreciate the points, and that is part of our startup testing plans as we have them written out to do low power, very short runs and for the express purposes of calibrating the detectors. So we can talk more about that. I believe that will be in Chapter 7 to be specific.

MEMBER MARCH-LEUBA: My concern of the power, you can always turn off the accelerator. My concern is that where you filling the tab you go over k-effective of one or get very close to it, much closer than you thought, because you're measuring your one over M and you overshoot. Because, of course, it requires two failures.

It requires a failure of calculating k-effective accurately with MCNP, the level at which you have to stop. And then a failure of the calibration of the tape.

It requires two failures to have an accident -- not an accident, an event. But I would recommend that for the first startup, you fill it up, I don't know, 20 liters less than what you were expecting to and live with a lower multiplication factor for a while. That's -- yes --

(Simultaneous speaking.)

MS. RADEL: This is Tracy with SHINE. Part of our startup plan is to start with low concentration, significantly lower than the expected nominal concentration. Also, the one over M process stopping five percent by volume below critical is always going to ensure a certain margin to critical because you're mapping out that ratio. And the detector -- parameters on the detector will cancel out in that ratio as you're doing that individual startup.

MEMBER MARCH-LEUBA: The point I'm trying to make is that you have a five percent margin to the critical value you calculated with MCNP before you run any experiment. Or on the startup, I will go with a 15 percent margin instead of 5 percent just in case your MCNP calculation was off. Don't go with a margin with power. Go to a margin to k-effective.

MS. RADEL: Right, yeah. Our margin, yeah, is relative to k-effective. And our first two steps are below which we could go critical. And so we'll be comparing every step.

MEMBER MARCH-LEUBA: My point is your margin is the k-effective that you pre-calculated, not --

(Simultaneous speaking.)

MEMBER MARCH-LEUBA: Yeah, I leave you with that concept in mind so you're careful when you start. Thanks.

MR. EDWARDS: This is Eric Edwards. We're going to talk a little bit about fill, too in this closed session here. I do just want to stress that we're not filling to the MCNP predicted height. We're filling based on the one over M. And we can talk about that in more detail in the closed session too.

MEMBER REMPE: I'm sorry. I couldn't quite hear. You said you were basing it on, what was the phrase?

MR. EDWARDS: The one over M plot is where we would --

(Simultaneous speaking.)

MR. EDWARDS: -- based on, not -- we're not going to fill to a level predicted by MCNP.

MEMBER MARCH-LEUBA: Correct. And that's what my previous comment about the efficiency of the detectors. You're going with a shut off on the one over M that MCNP calculated for you. I'm trying to be a little kind of insulting to see if I make the point that the first time we startup cycle one.

We have a safety level that is based on the k-effective calculation with MCNP and a safety level which is based on the one over M using the efficiency of detectors calculated by MCNP. Everything is calculations. One over M is a really good measurement or the same, M goes to infinity and k goes to one. So you cannot be very wrong. But this says be careful, an extra margin on the first step. That's all I'm saying.

MS. RADEL: Understand. Thank you for the feedback, though. We will consider it. Thank you.

MR. HUDSON: Okay. Next slide. So based on our findings and conclusions, based on what we reviewed, the irradiation facility systems have been described on principle design according to -- and the principle design criteria were listed and described in the criteria for reviewing the SAR was known and the principle design criteria for whether the system is safe are known.

We didn't have to search for anything. The biological shield analysis with reasonable assurance, the dose would be known and it'll maintain its function and limit radiation exposures and reasonable assurance that the facility will operate -- be operated safely without undue risk to the public as far as Chapter 4. Next slide. I don't know if that was the last slide.

MR. STAUDENMEIER: Yeah, that's the end of the presentation. I guess one thing I meant to say is I think earlier somebody asked a question or made a statement about that it wasn't clear that the staff will look into any ideas of their own or probe things. And I think the place you would have to look for that to see what was probed or questions that were asked or things that come up with by staff would be the RAIs. I don't know if you were given access to the RAIs that were asked.

But the old style of writing SERs used to be you would discuss the RAIs and resolution with the licensee. But the new standard for SERs is that is not part of it. They want to limit discussions of RAIs and back and forth with the licensee and write it like there was a clean final SAR that included all the RAI answers. So that's just a comment that if you really wanted to see where the staff probed or looked for things or brought up issues that they thought needed to be addressed, it would be in the RAIs and the RAI answers.

MEMBER REMPE: So I'll go back and look at the RAIs. But it'll say, hey, I did an independent TRACE calculation and I got something different. It'll talk about the calculations that the staff did.

MR. STAUDENMEIER: The RAI, it could have that if the RAI was based on some independent calculation the staff did. But in general, that would not be the case. It would be the staff asking a question of something they didn't think was addressed fully in the SAR and asked the licensee to provide or the applicant to provide more information of that.

MEMBER REMPE: Thank you.

CHAIR BALLINGER: Is that the right presentation?

MR. BALAZIK: Yes, this is Mike Balazik from the NRC staff. Yeah, so now Section 4B which is for the --

(Simultaneous speaking.)

CHAIR BALLINGER: Oh, I get it.

MR. BALAZIK: Yeah, all right. Yawar, are you online?

MR. FARAZ: Yes.

MR. BALAZIK: Okay.

DR. BLEY: Hey, Ron. Ron, this is Dennis. Before you go ahead, can I sneak something in?

CHAIR BALLINGER: Sneak in whatever you want.

DR. BLEY: Well, that last comment is certainly true. And I didn't realize that was the way you're supposed to do the SEs these days. But when the staff comes to the committee giving us some of those areas where, in fact, they probed and found things would be most appropriate. And I hope they would do that in the future. That's all.

CHAIR BALLINGER: Yeah, I think what he means is what we're reviewing is no open items. So all these chapters have no open items. So it's one step beyond the process of the so called earlier standard review process. But the RAIs are all available.

MEMBER REMPE: So I guess I probably

motivated the comment. But the problem I had was the SE basically regularly says the staff assessed and the staff evaluated. And I could not figure out how the staff did that. And I went back to 1537, and it said, well, all you have to do is make sure the information is complete and it's consistent with what's found elsewhere.

And now today I'm hearing, well, we did some evaluations. And it would be nice to know exactly. And I'm hoping in a closed session I'll learn more what exact calculations were done. An undocumented TRACE calculation doesn't always give one confidence, I guess.

CHAIR BALLINGER: Okay. If there are no other questions, can we continue?

MR. FARAZ: Okay. So my name is Yawar Faraz. I'm a senior PM in NMSS. I replaced the primary reviewer for Chapter 4B several months ago. And I have other staff that are available who might do a better job at responding to any specific questions that the ACRS may have.

The slides that I'll be presenting pertain to the Radioisotope Production Facility, or the RPF. The description is in Chapter 4B. As was mentioned before in the morning, the main functions of the RPF is to extract, notify, package, and ship medical isotopes and to prepare target solution. Next slide, please. So these are the regulatory requirements that apply to Chapter 4B, and Mike Balazik went through those in the morning. So I'll just go to the next slide.

And then the regulatory guidance that applied in 1537, Parts 1 and 2. Next slide. And then the ISGs to NUREG 1537, so ISG Part 2 would be the primary guidance document used in Chapter 4B. Next slide. So the areas of review for Chapter 4B include the design of the facility and its operation.

We looked at schematics to understand the RPF's physical features and processes. Then we review the biological shielding of the RPF, the radioisotopic structure and clarification process, and then the irradiated and unirradiated SNM, Special Nuclear Material, processing and storage. Next slide. So Nate Hudson provided this slide and the four in one. And I'll be presenting them on the biological shield. So the staff reviewed the engineer features to support the ALARA requirement.

So the staff reviewed the biological shield and material and its thickness, below grade solution transfers, access plugs, and minimization of streaming paths due to penetrations with the engineered features, those gates. Next slide, please. The staff found SHINE's use of MCNP to conduct shielding calculations adequate. Reg Guide 1.69 was used as guidance to ensure that the dose and the RPF reduce adequately and that the structure requirements of the shielding will be maintained. Specifically, ENS and ACI standards referenced in Reg Guide 1.69 were used for shielding and dose determination and structural integrity of the shield.

And you had used NUREG-7171 as guidance to address the potential impacts of gamma rays on the structural integrity of the concrete shielding. The NRC staff also determined the adequacy of the ventilation system and its associated tech spec for ensuring confinement to negative pressure. Do you have any questions on the biological shielding?

Okay. Next slide, please. So here are the primary systems that pertain to the RPF that were described in Chapter 4B. They were described in the morning, their functions were described. And so I won't go through all of them, but basically that's the lesson there.

There are a couple more that apply to both the RPF and the radiation units. These are the main ones. Next slide. So in terms of SNM processing and storage, the staff reviewed the process descriptions by included the controls, the criticality, and chemical protection. Next slide.

And then you have the same for the unirradiated SNM processing. Next slide. And that's our findings and conclusions. The staff has determined that Chapter 4B acceptably provides the staff a general understanding of the RPF processes. With regards to biological shielding, the staff concludes that the described designs, supporting analysis, and proposed tech specs offer reasonable assurance that exposures would be within power -- any limits and ALARA guidelines.

And then with regard to MEPS which is the extraction of moly -- the process of extracting moly, the staff concludes that the descriptions provide the staff confidence that the SNM and fission products can be controlled. And then finally, the staff includes as described in 4B and in conjunction with the staff's reviews and for the rest of the application that the processing of irradiated and unirradiated SNM will be done safety in the RPF. So that's the end of my presentation. Any questions?

CHAIR BALLINGER: Thank you. I guess

we're now -- oh, we have to do Chapter 6.

MR. KARIPINENI: Hello. Can you hear me?

CHAIR BALLINGER: Yes.

MR. KARIPINENI: Okay. Next slide, please. My name is Rao Karipineni. Rao is my middle name. It's the easiest way for me. I'm a safety and plant systems engineer in the containment and plant systems branch. Next slide, please.

Engineer safety features is the previous licensee was saying there are reactive or passive features designed to mitigate the consequences for accidents to keep the radiological exposures to the public, to facility staff, and the environment within acceptable values. This concept in general from the nuclear industry evolved from the defense-in-depth philosophy of multiple layers of design features to prevent or mitigate the release of radioactive materials to the environment during accident conditions. However, in the case of SHINE, the need for a (audio interference) is really determined by the SHINE severe accident analysis. Next slide, please.

Listing of some regular requirements and the acceptance criteria. You heard it so many times, so I'll skip this slide. Next slide, please. We can start the design criteria in Chapter 3 of the FSAR and came up close to four or five criteria in one way or another and reply to the various systems we were reviewing. And they doing the safety evaluation when they are done.

A couple new ones that were in there that were not in the previous slides you saw about the SHINE and design criteria 929, about the barrier, hot cells, glove boxes, and everything. Maybe it was included in the top, but I didn't remember seeing it on the slide. And then we also have included hydrogen mitigation for Criteria 39 as one of the requirements also. It was one of the criteria that we would look at. Next slide, please.

Hold on. Go back. Go back. Go back. Yeah, actually, this is the one that I was going to discuss a little bit more after the discussion this morning. We have -- the engineer safety features is not really limited to any one system. It's really a conglomeration of many systems that you would have to review in all the chapters and go to the discussion contained therein to write a safety evaluation.

But it was only one person was the allocator for this job and I did what I could. I reviewed all those chapters and then compared the discussion in the chapter's analysis with the remaining chapter such as the instrumentation and controls in Chapter 7, accident analysis in Chapter 13, et cetera, to see that there is some consistency and get a feeling for what is being included and see if anything is missing and to the best of my ability. Finally, we also reviewed the technical specifications.

There were, like, four or five them we came up with and reviewed the -- what they were doing, what ELCO (phonetic), and what -- how much time they're taking to fix the problem and the surveillance requirements, et cetera. Next slide, please. So the Irradiation Facility ESFs is broadly divided into three categories: primary confinement boundary, tritium confinement boundary, and combustible gas management. It's truly speaking, the RPF is also the same way, except there is no -- there is a little bit of tritium confinement there but mostly combustible gas management with the PVVS and the N2PS nitrogen purge.

And also there is some confinement boundary. We can call it primary also because there's some target solution there. The way the review was done is -- rather the way the licensee has presented the ESF features is they came up with the broad diagrams to indicate what are the active, what are the passive features that are considered. If they're active features, which parts of those active features are actually included in the assessment in ESF.

And finally, it also includes the components and systems names that come for that particular ESF. And then we would go into those discussions contained for those systems and determine if they are complete in the sense -- in addition to what they have should there be something more there or not. And that's the way I proceeded with the analysis.

And I did not come up with any new items that needs to be included there. In the discussion this morning, we had the feature irradiation facility boundary drawing that we saw which was a little confusing for me. And I decided that the HVAC unit that was there that was shown as part of the confinement -- the boundary.

It kind of extends this wall really, around that unit basically. I still don't understand the drawing because the drawing is -- the dotted lines we saw was far from the HVAC units. The way I saw it -- I heard this morning was that the unit extension is just part of the IF boundary. I don't know if everybody understood the same way I did or if I'm missing something. I'm not too sure.

But if that is so, one thing I didn't really consider is if this is an extension of that boundary, should this whole HVAC unit where the leakage possibilities from these units, how are they construed into the design and those things are not fully clear. So that's one thing that we may be discussing this later on this closed session to make it more easily understandable for somebody like me. So combustible gas systems and PVVS systems, they're pretty elaborate discussion of those two systems in the USAR and separate sections, more details and all those things.

So I only look at the confinement features of those systems and insert into the design. But when we get to the point of ACRS presentations for those systems, a lot more details can be discussed in my opinion at that time. So when I consider all of these things, both for the IF, irradiation facility, and the RPF, the design that were submitted were clearly understandable for me.

It was -- in my opinion, it is complete to the extent I could determine. And it kept giving me the basic information needed to see that these confinements were effective to perform as they were intended to. This is basically my presentation, because I made it at a slot (phonetic) -- because after the discussion this morning, I revised my discussion. And I'm open for any questions now.

DR. SCHULTZ: Ron, this is Steve Schultz. And I don't know if this is the right place to ask this question or not or to bring this up. The staff finds that the mitigated doses meet the targets that are set by SHINE and that they are acceptable in the discussion in Chapter 6, SER.

Then the staff also remarks that the staff finds that the dose consequences in some cases would be unacceptable without the mitigation by the engineer and safety features. And my question, when I look at the tables that were presented by SHINE this morning, in each of those cases, I don't see any of the results in the unmitigated cases which would be acceptable. So I'm concerned about that phase, in some cases. Perhaps there's other design basis accidents where they might be acceptable without the mitigating features of the engineer and safety features. So it's just really a comment there, something that --

(Simultaneous speaking.)

MR. KARIPINENI: Yeah, I did look into

that. And I had to make sure that the pages say exactly same what you are looking at.

DR. SCHULTZ: Yes.

MR. KARIPINENI: And I had a little difficulty. And I finally understood how that table came up when I talk to the Chapter 13 folks and confirm what I was saying. And I looked at it again because I'm not in a position to exactly explain to you right away. But I had to look at the table again, and --

(Simultaneous speaking.)

MR. KARIPINENI: -- I can do that. And I will take that as an open item and let you know.

DR. SCHULTZ: There is -- as you know, there's a large difference between the mitigated and the unmitigated results, a factor of 100 about. And so therefore, there's a large benefit. It demonstrates the benefit and the necessity of the engineer and safety features. Was there any look either by the staff -- well, actually, we ask SHINE too -- trying to -- not trying to, but identifying the benefit of the passive features verses the active features?

MR. KARIPINENI: No, I did not do any look in that manner.

DR. SCHULTZ: It's just a question I would ask myself given the benefit of unmitigated features. But that hasn't been --

MS. RADEL: This is Tracy with SHINE. We did not evaluate failure or taking away one or the other. The active and passive components together really they act together to create the confinement boundary. So --

DR. SCHULTZ: Okay.

MS. RADEL: -- we didn't see that it would make sense to evaluate those separately. And so there's a single evaluation. We're not crediting any of the confinement.

DR. SCHULTZ: Okay. I understand your comment. Thank you.

CHAIR BALLINGER: Are there other questions from the members?

MR. BALAZIK: Sorry, Professor. This is Mike Balazik from the NRC staff. Rao, I just wanted to make sure. Are those all your slides, or do you have more slides in the presentation?

MR. KARIPINENI: I have more slides. But really the information is pretty similar to the other presentations. I can do that if you want. You want to go to the next slide?

MR. BALAZIK: Well, can you just summarize it really quickly so we can go through the rest of the presentation?

MR. KARIPINENI: Yeah, the summary, the application has provided information necessary to conclude that the, you know, the requirements we have about the -- that's in front of the SERs are reasonably satisfied in our opinion. And the operating license 257, all the information is there.

As far as how we -- how together would perform for different analysis that were done in all the accident analysis, et cetera, that would be there in Chapter 13. I took a look at it, and I was okay with what was done. I was satisfied with what was done.

CHAIR BALLINGER: Are we now complete?

MR. KARIPINENI: Unless Mike, you want me to the other slides, I will. But that's the basic information we're talking about.

MR. BALAZIK: Rao, if you're done -- this is Mike Balazik from NRC staff. If you're done, then let's go ahead and we can wrap this up.

MR. KARIPINENI: Okay.

CHAIR BALLINGER: Okay. So now we're about to transition to the closed session. And before we do that, we need to ask for public comments. So given our team's scheme of doing things, I presume that anybody that wants to make a public comment already is online.

So if you have a public comment, you're a member of the public and you'd like to make a comment, please state your name and make your comment. I don't do five minutes. I do five seconds.

Okay. I guess hearing none, then what we need to do then is to rely on staff and SHINE folks to verify that there isn't anybody present on the Teams that does not belong there. And I guess it'd have to be up to the staff and the applicant to do the checking.

MR. BROWN: No, we're going to transition to the other Teams number.

(Laughter.)

MR. BROWN: Yes, I will come over. I will come over and do that.

CHAIR BALLINGER: Okay. Well, I've been chastised roundly. We need to end this session and then have a new line. So we'll take a ten-minute break to get this to happen.

(Whereupon, the above-entitled matter went off the record at 2:17 p.m.)

Chapter 1 – The Facility
Chapter 2 – Site Characteristics

TRACY RADEL, VICE PRESIDENT OF ENGINEERING
CATHERINE KOLB, DIRECTOR OF PLANT OPERATIONS

Outline

- Chapter 1
  - Facility Overview
- Chapter 2
  - Chemical Hazard Analysis
  - Aircraft Hazard Analysis

SHINE

Facility Overview

- The SHINE site is located on the southern edge of the city of Janesville, Wisconsin
- The radiologically controlled area (RCA) within the main production facility is divided into two regions
  - Irradiation facility (IF): contains eight accelerator-driven subcritical assembly irradiation units (IUs) and their supporting equipment
  - Radioisotope production facility (RPF): contains target solution preparation, target solution storage, three processing lines for isotope extraction, and waste handling processes
- Seismically qualified structures, geometrically favorable equipment, and gravity drain of solutions are passive safety features used reduce risk
- Structures, systems, and components (SSCs) whose intended functions are to prevent accidents that could cause undue risk to health and safety of workers and the public, or mitigate the consequences of such accidents, are classified as safety-related SSCs

Facility Overview

- The major operations to be performed in the SHINE facility are as follows:
  - Target solution preparation from raw feed material
  - Irradiation of target solution
  - Molybdenum (Mo) extraction from irradiated target solution
  - Mo purification
  - Target solution adjustments
  - Solidification of radioactive liquid waste
- An IU Cell Safety Actuation automatically transitions the unit to a safe state in the case of upset conditions, without the need for operator action
  - De-energizes the neutron driver
  - Opens redundant target solution vessel (TSV) dump valves to drain target solution to geometrically favorable TSV dump tank
  - Isolates the primary system boundary

SHINE

Chemical Explosions

- Accidents involving detonations of chemicals or fuels were considered for facilities and activities on-site and off-site.
- Allowable (standoff) and actual distances of hazardous chemicals transported or stored near the facility were determined in accordance with Regulatory Guide (RG) 1.91 (1 psid of peak overpressure).
- Two types of explosions are considered: stationary explosion at the source, and a vapor cloud explosion.
  - Stationary explosion evaluation uses the TNT equivalence method described in RG 1.91.
  - Vapor cloud explosion evaluation uses the ALOHA computer program.
- Where a postulated explosion has a standoff distance greater than the actual distance from the source of the chemical to the nearest safety-related building, a probabilistic analysis is used.
  - These analyses show “the rate of exposure to a peak positive incident overpressure in excess of 1 psid (6.9 kPa) is less than 1E-6 per year, when based on conservative assumptions, or 1E-7 per year when based on realistic assumptions.”
- No chemical explosion hazards were found to pose an unacceptable risk to the SHINE facility.

Toxic Chemicals

- Chemical hazards within 5 miles of the SHINE site, including on-site, were evaluated for their potential toxicity and ability to affect control room personnel in the event of an accident.
  - Some chemicals were screened out from quantitative evaluation.
- Chemical hazards not screened are evaluated using ALOHA against the chemical's National Institute for Occupational Safety and Health (NIOSH) Immediately Dangerous to Life and Health (IDLH) value, or Protective Action Criteria (PAC)-2 value if no IDLH value is available, or against qualitative toxicity information if quantitative information is unavailable.
- If concentration in the facility control room for a chemical release exceeds evaluation criteria, a probabilistic evaluation is performed.
  - The acceptance criteria for releases evaluated in this manner is 1E-6 releases per year.
- A simple probabilistic analysis is not sufficient to eliminate ammonia from consideration as a hazard to the site. However, in the most limiting case, facility control room operators will have 2 minutes to take self-protective actions.

SHINE

Fires

- Fires in adjacent industrial plants and storage facilities, oil and gas pipelines, and fires from transportation accidents were evaluated as events that could lead to high heat fluxes.
- Three types of fires are analyzed for high heat flux: boiling liquid expansion vapor explosion (BLEVE) fireballs, pool fires, and jet fires.
- Fires evaluated as to whether they can cause damage to a SHINE building
- All three types of fires are analyzed using ALOHA
- Limiting fire scenario (i.e., pool fire from gasoline truck on U.S. Highway 51) resulted in a temperature rise on the facility’s concrete wall of 44°F.
    - This is an insignificant temperature rise compared to American Concrete Institute (ACI) 349-13 standards for short- and long-term maximum concrete temperatures.

Site Wind and Atmospheric Stability

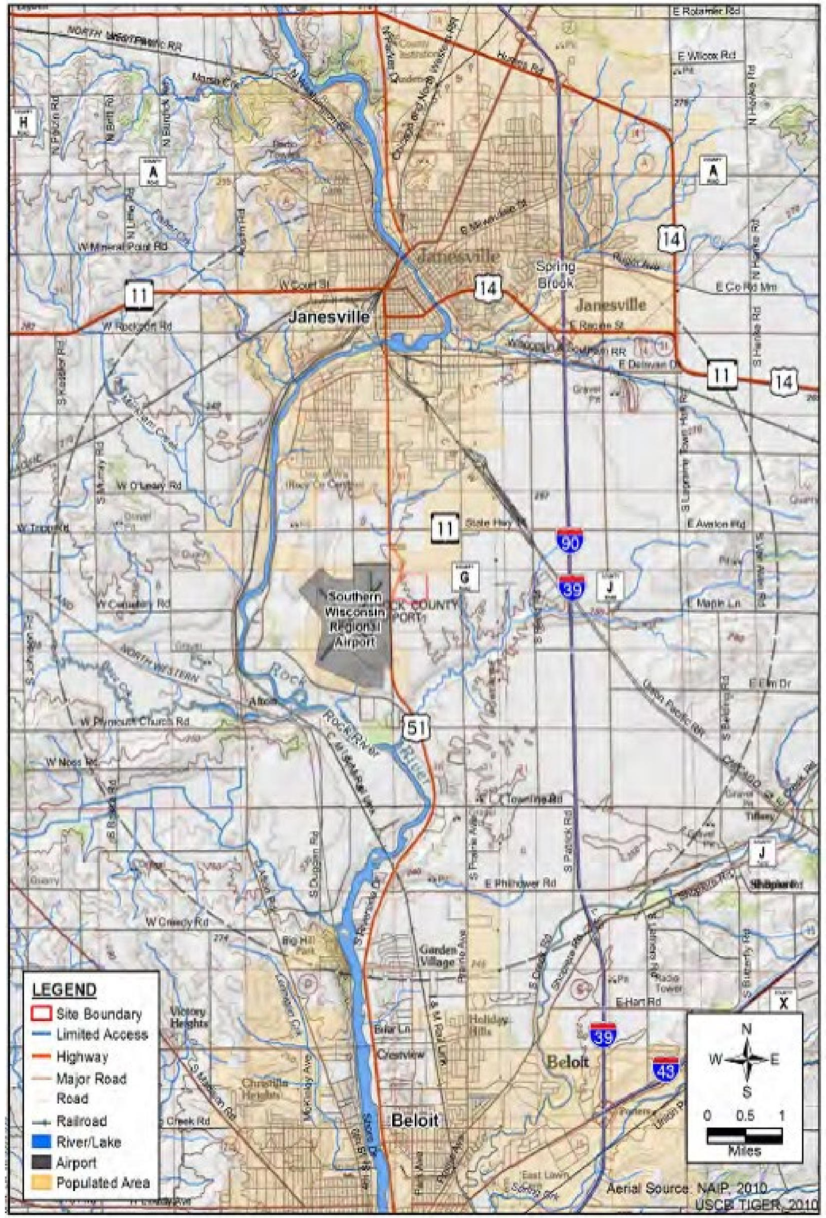
- Site meteorological data set covering the period 2005-2010 was developed to support relative atmospheric concentration (χ/Q) and radiological dose assessments.
- Surface met data taken from automated weather station at Southern Wisconsin Regional Airport (National Oceanic and Atmospheric Administration [NOAA] station identifier KJVL).
- Data taken includes hourly dry bulb temperature, humidity, wind speed, and wind direction.
- Pasquill stability class is calculated from hourly wind speed, ceiling height, and sky cover measurements.
- Annual wind rose shows winds at the site predominantly westerly and southerly, but there is significant seasonal variation.

Atmospheric Dispersion

- Joint frequency distributions of wind speed, direction, and Pasquill stability class are used to calculate χ/Q values at the site boundary and at the nearest residence.
- PAVAN used to calculate short-term χ/Q values used in radiological accident dose calculations.
- XOQDOQ module of NRCDose used to calculate long-term χ/Q values used in normal radiological dose calculations.
- ARCON96 used to calculate χ/Q values for control room habitability (between facility release point and control room ventilation intake).
- Chemical concentration calculations using ALOHA do not take χ/Q values; rather, 95^{th} percentile values for wind speed and atmospheric stability are used directly as inputs.

Aircraft Hazard

- Site is located approximately 0.4 mi east of the Southern Wisconsin Regional Airport (KJVL)
- Same methodology as PSAR
  - DOE Standard DOE-STD-3014-96 crash probability methodology used for airways
  - NUREG-0800 methodology used for crashes from nearby airports
  - Non-frequent airport events (air shows) considered based on increased number of airport operations (originally addressed in PSAR request for additional information [RAI])
  - Acceptance criteria for total crash probability (airways + airports) established as 1E-6 per year (based on DOE-STD-3014-96)



SHINE

Aircraft Hazard

- Aircraft hazard analysis updates since PSAR:
  - Number of operations at airports (decreased)
  - Largest typical military helicopter used at KJVL considered for crash probability (vs. largest manufactured)
  - Nitrogen purge system (N2PS) structure addressed qualitatively, based on location relative to main facility and off-site power sources

	Large Non-Military Aircraft	Small Non-Military Aircraft	Military Aircraft
Total Probability	1.10E-7	3.92E-4	1.99E-7
Total Probability Considering Air Shows	1.90E-7	N/A	5.37E-7

- Small non-military aircraft crash probabilities do not meet the 1E-6 acceptance criterion; therefore, the main production facility structure is designed to withstand impact from this type of aircraft.

Chapter 4 – Irradiation Unit and Radioisotope Production Facility Description (Open Session)

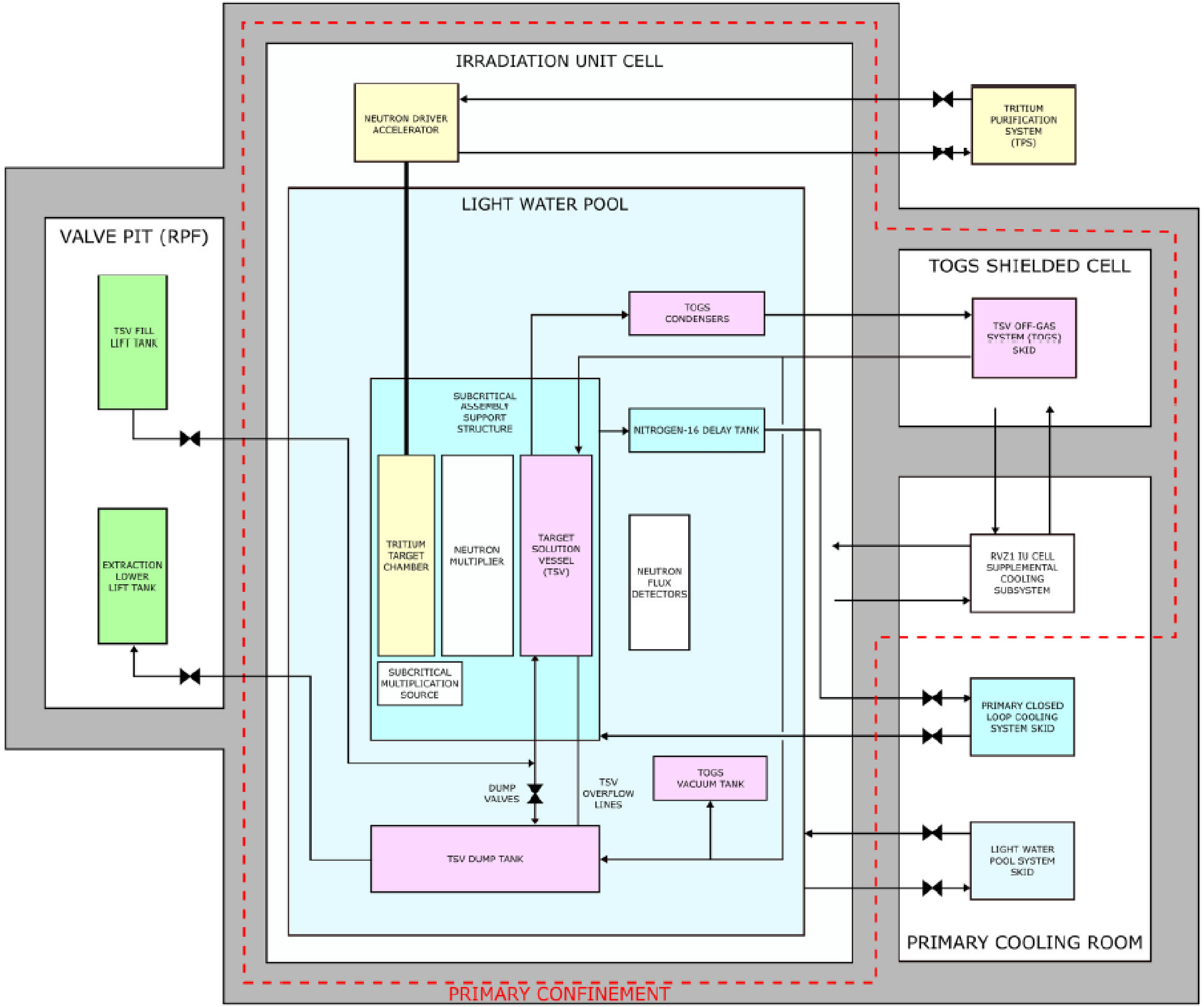
ERIC EDWARDS, CHEMICAL PROCESS SYSTEMS MANAGER

Outline

- Irradiation Facility (IF)
  - Irradiation Facility Overview
  - Neutron Driver Assembly System (NDAS)
  - Subcritical Assembly System (SCAS)
  - Heat Removal Systems
  - Target Solution Vessel (TSV) Off-Gas System (TOGS)
  - Irradiation Cell Biological Shielding (ICBS)
- Radioisotope Production Facility (RPF)
  - Isotope Separation
  - Other Process Systems

Irradiation Facility Overview

IRRADIATION FACILITY

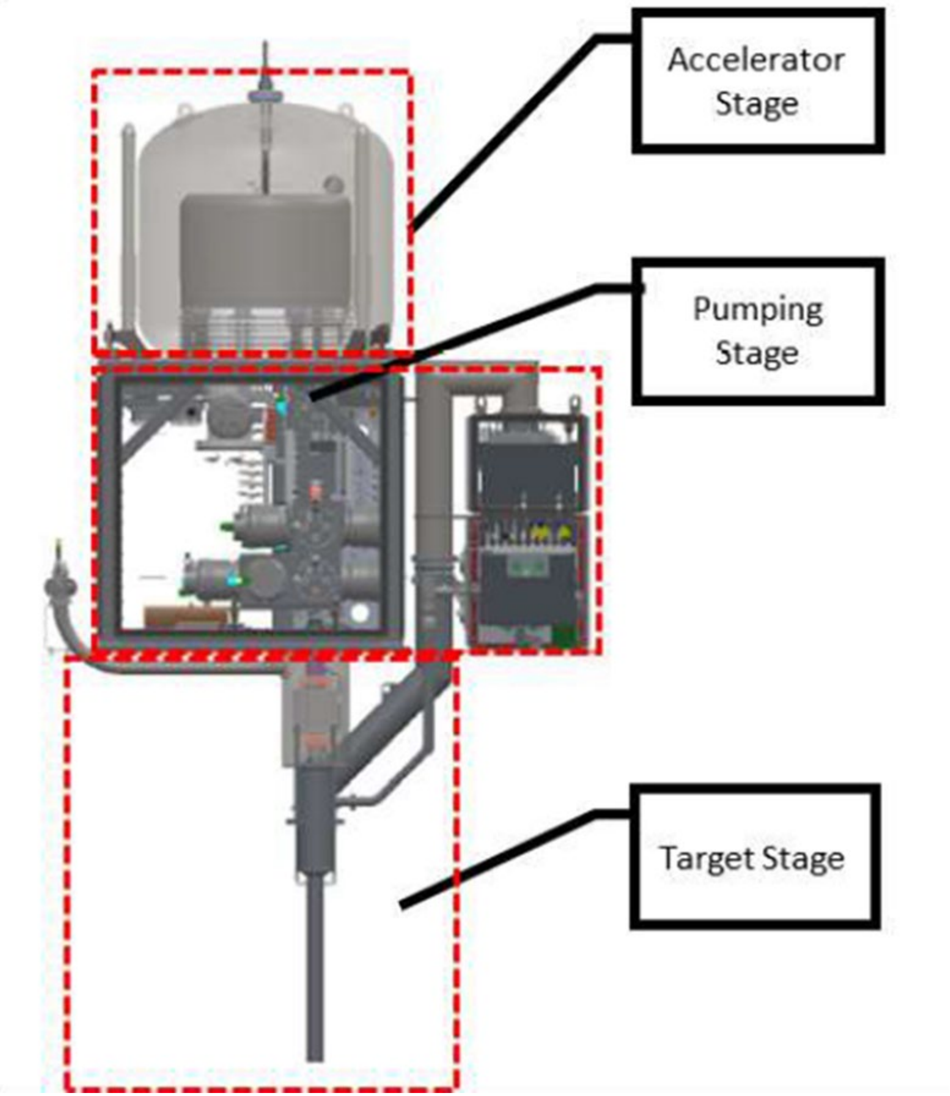


SHINE

Neutron Driver Assembly System (NDAS)

IRRADIATION FACILITY

- Basics
  - Creates fast neutrons using a deuterium (D or ^{2}H) ion beam incident upon a tritium (T or ^{3}H) gas target
  - $D + T \rightarrow\ ^{4}He + n + 17.6\ \mathrm{MeV}$
  - Neutrons delivered to subcritical assembly system (SCAS) where medical isotopes are produced
- Components
  - Accelerator Stage: Creates deuterium ion beam
  - Pumping Stage: Keeps pressures low to allow formation and transport of ion beam
  - Target Stage: Location where fusion occurs



SHINE

Subcritical Assembly System (SCAS)

IRRADIATION FACILITY

- SCAS major components:
  - TSV
  - Neutron multiplier
  - TSV dump tank
  - Subcritical assembly system support structure (SASS)
- TSV maintains fissile solution in a subcritical, but highly multiplying configuration during the irradiation process.
- TSV dump tank holds fissile solution in a geometrically favorable configuration as it is passively cooled by the light water pool.

Heat Removal Systems

IRRADIATION FACILITY

- Primary closed loop cooling system (PCLS)
  - Cools the TSV and multiplier by forced convection with water through annular channels
  - Circulates deionized water upward from the lower plenum, through the TSV, and out of the upper plenum
  - Capacity to remove the maximum multiplier and TSV thermal power (137.5 kW from TSV, 20 kW from multiplier)
- Light water pool
  - SCAS sits in a light water pool
  - Cools the annular TSV dump tank by natural convection
  - Sufficient to remove 100% of thermal power from TSV dump tank
  - Contact area with PCLS piping rejects heat, in addition to conduction through concrete

SHINE

Target Solution Vessel Off-Gas System (TOGS)

IRRADIATION FACILITY

- Safety functions:
  - Maintains hydrogen concentrations below values which could result in an overpressure capable of rupturing the primary system boundary (PSB)
  - Provides confinement of target solution and fission products as part of the PSB to prevent release of radioactive material
  - Removes a portion of the iodine from the sweep gas to mitigate the dose consequences of accidents involving loss of PSB integrity
- Additional functions:
  - Maintains the pressure within the PSB slightly sub-atmospheric during normal conditions
  - Captures target solution droplets entrained in the sweep gas and returns them to the TSV to minimize buildup of fissile material in TOGS
  - Condenses water vapor generated by the target solution in the TSV and returns the condensate to the TSV to limit water holdup in TOGS to less than 3 liters

Irradiation Cell Biological Shielding (ICBS)

IRRADIATION FACILITY

- Comprised of the following concrete enclosures:
  - IU cells (including light water pools)
  - TOGS shielded cells
  - Primary cooling rooms
  - Neutron driver assembly system (NDAS) service cell
- Analysis includes
  - Neutron and gamma dose rates to areas that could be occupied
  - Penetrations and voids
  - Radiation effect on shielding materials

Isotope Separation – Molybdenum and Iodine

RADIOISOTOPE PRODUCTION FACILITY

- Molybdenum extraction and purification system (MEPS) and iodine and xenon purification and packaging (IXP) separate fission products from irradiated target solution.
- Three MEPS processing lines are provided in the supercell.
  - Molybdenum is separated from irradiated target solution.
- Following isotope separation, target solution is staged for subsequent irradiation cycles via the target solution staging system (TSSS).
- Manual process with laboratory glassware is used to finish purification of molybdenum prior to packaging in the molybdenum isotope product packaging system (MIPS).
- Iodine is separated from target solution and purified.
- Xenon isotopes are collected on a cryotrap.

Other Process Systems

RADIOISOTOPE PRODUCTION FACILITY

- Target solution staging system (TSSS)
  - Below grade storage tanks – 8 target solution hold tanks, 2 target solution storage tanks
  - Any MEPS processing line can drain to any TSSS tank
  - Provides an area for target solution storage, staging prior to transfer into TSV, and allows sampling of target solution
- Molybdenum isotope product packaging system (MIPS)
  - Product bottle, secondary container, and type B shipping container
  - Product is loaded in the hot cell and shipping containers exported using the drum transfer system

Other Process Systems

RADIOISOTOPE PRODUCTION FACILITY

- Process vessel ventilation system (PVVS)
  - Mitigates radiolytic hydrogen generated in RPF tanks
  - Captures radioiodine and delays release of radioactive noble gases in off-gases to the environment
- Radioactive liquid waste storage (RLWS)
  - Collect liquid radioactive wastes from MEPS, IXP, vacuum transfer system (VTS), PVVS, and non-routine operations
  - Wastes are sampled and blended together prior to transfer to the radioactive liquid waste immobilization (RLWI) system
- Radioactive liquid waste immobilization (RLWI) system
  - Receives liquid wastes from the RLWS for immobilization in cementitious mixture
  - Selectively removes classification-driving isotopes (e.g., Cs, Sr)
  - Located in an above-grade shielded enclosure in the RPF

SHINE

Chapter 5 – Cooling Systems

IAN SODERLING, AUXILIARY SYSTEMS ENGINEER

Outline

- Primary Closed Loop Cooling System (PCLS)
- Radioisotope Process Facility Cooling System (RPCS)
- Process Chilled Water System (PCHS)
- Facility Demineralized Water System (FDWS)

Primary Closed Loop Cooling System (PCLS)

- Nonsafety-related functions of the PCLS:
  - Provides cooling water to target solution vessel (TSV), neutron multiplier, and light water pool for a single unit
    - PCLS cooling is a nonsafety-related function
    - Regulates water to design temperature range and rejects excess heat from the subcritical assembly system (SCAS) to the RPCS
    - Two pumps are used for full-flow operation, but a single pump may be used to allow the unit to continue operating at a reduced capacity
    - Deionizer bed and filters maintain ASTM Type II water purity standards to limit corrosion, product activation, and radiological contamination of the process stream
  - Provides purge gas flow from confinement
    - The PCLS includes an air separator that removes dissolved, entrained, and free gases from the irradiation unit (IU) cell and TSV off-gas system (TOGS) cell atmospheres
      - Air separator routes gas to the expansion tank for purging
      - Gases from IU cells and TOGS cells are drawn into the PCLS expansion tank by radiological ventilation zone 1 exhaust (RVZ1e)

Primary Closed Loop Cooling System (PCLS)

- Safety-related functions of the PCLS:
  - Installation of the PCLS expansion tank with a flame arrestor to preclude hydrogen deflagration/detonation
  - Closure of PCLS confinement isolation valves to prevent PCLS water intrusion into the TSV in the event of a leak
  - Closure of PCLS confinement isolation valves to maintain confinement boundary during abnormal conditions
  - Generate a TSV reactivity protection system (TRPS) signal on high PCLS temperature
  - Generate a TRPS signal on low PCLS temperature
  - Generate a TRPS signal on low PCLS flow

Radioisotope Process Facility Cooling System (RPCS)

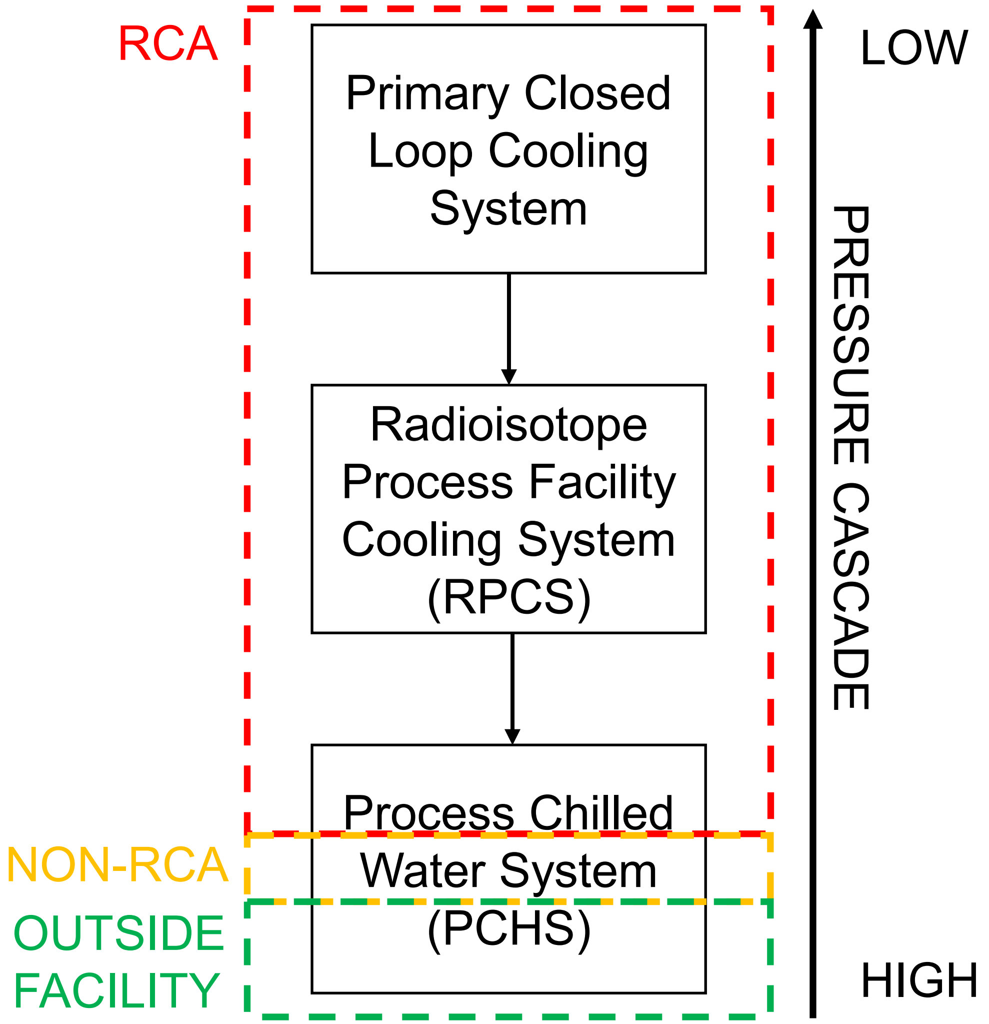
- Removes heat from loads around the irradiation facility (IF) and radioisotope production facility (RPF)
  - Acts as the facility secondary cooling loop by removing heat from the PCLS heat exchanger
  - Target solution vessel off-gas system (TOGS), Process vessel vent system (PVVS), neutron driver assembly system (NDAS), target solution preparation system (TSPS), molybdenum extraction and purification system (MEPS), radiological ventilation zone 1 recirculation unit (RVZ1r), and radiological ventilation zone 2 recirculation unit (RVZ2r) heat exchangers within the radiologically controlled area (RCA) and non-RCA areas
- Does not perform or maintain safety functions in any capacity
- Rejects heat to the PCHS through the RPCS heat exchanger
- RPCS pressure is maintained higher than serviced systems to prevent the spread of contamination around the system and facility
- Three pumps are provided in an N+1 configuration to maintain normal operations during a complete loss of a pump

Process Chilled Water System (PCHS)

- Removes heat from the RPCS heat exchanger and rejects it to the environment by air-cooled chillers that are external to the facility
- Acts as the tertiary cooling loop in the facility
- Does not perform or maintain safety functions in any capacity
- Three chillers and three chilled water pumps provide design redundancy to maintain normal operations with a complete loss of chiller and/or pump

Cooling System Pressure Cascade

- Heat generation occurs in the SCAS and neutron multiplier of the SCAS during and post-irradiation
- The PCLS removes heat from the SCAS and light water pool through forced convection
- RPCS provides cooling to the PCLS via the PCLS heat exchanger on the PCLS cooling skid
- PCHS removes heat from the RPCS via the RPCS heat exchanger (within the RCA)
- PCHS supply and return headers are routed through the non-RCA (administrative annex) and to the PCHS chillers (outside facility)
- Pressure cascade prevents contamination from the PCLS onward by maintaining the RPCS pressure higher than the PCLS pressure and the PCHS pressure higher than the RPCS pressure



Facility Demineralized Water System (FDWS)

- The nonsafety-related FDWS provides makeup water to process systems
  - Reverse osmosis water is provided to systems with lower water quality requirements such as the facility chilled water system, process chilled water system, and facility ventilation zone 4 (FVZ4)/radiological ventilation zone 2 (RVZ2) humidifiers
  - Deionized water (ASTM Type II) is provided to systems around the facility that require higher purity water to maintain system cleanliness and to preclude product activation for systems that are exposed to radiation
  - Ultrapure deionized water (ASTM Type I) is provided to the quality control (QC) and analytical labs as well as the MEPS hot water system
- The FDWS uses a water-to-air heat exchanger to reject heat from pump and equipment operation and to the RCA atmosphere

Chapter 6 – Engineered Safety Features

ALEXANDER NEWELL, CRITICALITY SAFETY LEAD

Outline

- Irradiation Facility (IF)
    - Confinement Systems
    - Combustible Gas Management
- Radioisotope Production Facility (RPF)
    - Confinement Systems
    - Combustible Gas Management
- Process Vessel Vent Isolation

Purpose of Confinement Systems

- Confinement systems are designed to limit the release of radiological material to occupied or uncontrolled areas during and after design basis accidents (DBAs) to mitigate consequences to the facility staff, the public, and the environment.
- Principle objective of confinement systems is to protect on-site personnel, the public, and the environment.
- Secondary objective of confinement systems is to minimize reliance on administrative or active engineering controls.
  - Goal of as simple and fail-safe as reasonably possible

Primary Confinement Boundary

IRRADIATION FACILITY – CONFINEMENT SYSTEMS

- The boundary for each irradiation unit (IU) is independent of other IUs
- Utilizes active and passive features
- Consists primarily of:
  - IU cell
  - The target solution vessel (TSV) off-gas system (TOGS) cell
  - IU cell and TOGS cell heating ventilation and air conditioning (HVAC) enclosures (radiological ventilation zone 1 recirculating [RVZ1r] subsystem)
- Connection to radiological ventilation zone 1 exhaust (RVZ1e) subsystem is equipped with redundant dampers or valves that close on a confinement actuation signal

Primary Confinement Boundary

IRRADIATION FACILITY – CONFINEMENT SYSTEMS

- Piping systems penetrating the primary confinement boundary and capable of excessive leakage are equipped with one or more isolation valves. (Design Criterion 33)
- Lines from outside confinement that penetrate the primary confinement boundary and are connected directly to the primary system boundary are provided with redundant isolation capabilities. (Design Criterion 34)
  - Isolation valves outside confinement boundaries are located as closed to confinement as practical and take the position providing greater safety upon the loss of actuating power.
  - The nitrogen purge system (N2PS) and process vessel ventilation system (PVVS) are equipped with appropriate isolation capabilities and take the position of greater safety on a loss of actuating power.

SHINE

Tritium Confinement Boundary

IRRADIATION FACILITY – CONFINEMENT SYSTEMS

- Each tritium purification system (TPS) train is independent of the other two
- Passive components:
  - TPS gloveboxes
  - Secondary enclosure cleanup process boundary
  - TPS-neutron driver assembly system (NDAS) interface lines (up to interface with primary confinement boundary)
- Active components:
  - Isolation of:
    - Helium supply
    - Glovebox pressure control exhaust
    - Vacuum/impurity treatment subsystem process vent
    - Process connections to NDAS
  - Active components are initiated to their safe configuration via the engineered safety features actuation system (ESFAS)
    - Engineered safety features actuation system (ESFAS) TPS Train Isolation occurs on detection of high TPS glovebox tritium concentration or high target chamber supply or exhaust pressure
    - ESFAS TPS Process Vent Actuation occurs on detection of high TPS exhaust to facility stack tritium

Engineered Safety Features Effectiveness

IRRADIATION FACILITY – CONFINEMENT SYSTEMS

Representative DBA	Unmitigated Public Dose (rem)			Mitigated Public Dose (rem)		
	Public TEDE	**Worker TEDE**	**Worker Limiting Organ**	**Public TEDE**	**Worker TEDE**	**Worker Limiting Organ**
Mishandling or Malfunction of Target Solution *(Primary Confinement Boundary – IU Cell)*	5.3E+01	3.7E+01	8.6E+02	4.5E-01	1.2E+00	2.3E+01
Mishandling or Malfunction of Equipment *(Primary Confinement Boundary – TOGS Cell)*	5.3E+01	3.7E+01	8.6E+02	7.3E-01	1.9E+00	4.2E+01
Facility-Specific Events *(Tritium Confinement Boundary)*	2.5E+01	8.6E+01	8.6E+01	8.0E-01	1.4E+00	1.4E+00

Irradiation Facility – Combustible Gas Management

TOGS AND N2PS

- Principal objective: prevent conditions required for hydrogen deflagration within the primary system boundary (PSB) piping that results in overpressure exceeding the pressure safety limit of the PSB
- Hydrogen gas is monitored and maintained below the lower flammability limit (LFL) using the TOGS.
- If TOGS becomes unavailable, the buildup of hydrogen gas is limited using the N2PS.
- The N2PS provides passive, pressure-driven nitrogen sweep gas flow in the event of a loss of normal combustible gas management function.
  - N2PS utilizes both PSB and PVVS piping to perform its hydrogen mitigation function
  - Actuation occurs on a loss of normal sweep gas flow, 180 seconds after a loss of power, and on other additional inputs that indicate loss of TOGS functionality
  - Capacity of the N2PS is sufficient to provide at least three days of flow to maintain hydrogen concentration within acceptable limits with additional margin

SHINE

Supercell Confinement

RADIOISOTOPE PRODUCTION FACILITY – CONFINEMENT SYSTEMS

- Passive components:
  - Hot cells are fitted with stainless steel boxes for confinement of materials and process equipment
- Active components:
  - Supercell ventilation is fitted with radiation monitoring instrumentation to detect off-normal releases
    - Upon indication, isolation dampers or valves close on both the inlet and outlet to isolate the affected cells from the ventilation system, as well as a molybdenum extraction and purification system (MEPS) heating loop isolation and vacuum transfer system (VTS) safety actuation
  - Active components required to function to maintain the confinement barrier are actuated by ESFAS

Below Grade Confinement

RADIOISOTOPE PRODUCTION FACILITY – CONFINEMENT SYSTEMS

- In the event of radiological release, material is confined primarily by structural components of the boundary.
- Passive components:
  - Each part of the subgrade is equipped with a concrete cover plug
  - Gaskets and other non-structural features are used, as necessary, to provide sealing where components meet
  - The pipe trench, annular tank vaults, and valve pits with equipment containing fissile material are equipped with drip pans and drains that lead to the radioactive drain system (RDS)
- Active components:
  - Where process equipment crosses the confinement boundary into non-confinement, appropriate isolation capabilities are provided

SHINE

Engineered Safety Features Effectiveness

RADIOISOTOPE PRODUCTION FACILITY – CONFINEMENT SYSTEMS

	Unmitigated Public Dose (rem)			Mitigated Public Dose (rem)		
Representative DBA	**Public TEDE**	**Worker TEDE**	**Worker Limiting Organ**	**Public TEDE**	**Worker TEDE**	**Worker Limiting Organ**
Critical Equipment Malfunction *(Process Confinement Boundary - Supercell)*	8.0E+00	1.7E+01	2.5E+02	4.2E-02	7.6E-02	5.2E-01
Critical Equipment Malfunction *(Process Confinement Boundary - Below Grade)*	8.0E+00	1.7E+01	2.4E+02	2.4E-02	4.2E-02	2.9E-01

Radioisotope Production Facility – Combustible Gas Management

PROCESS VESSEL VENTILATION SYSTEM (PVVS) AND NITROGEN PURGE SYSTEM (N2PS)

- Principle objective: prevent the conditions required for a hydrogen deflagration in the gas spaces in the RPF process tanks
- During normal operation, the PVVS provides sweep gas to tanks in the RPF and provides an outlet path for gas generated inside the PSB.
- If PVVS becomes unavailable, the buildup of hydrogen gas is limited using the N2PS to establish sweep gas flow through process vessels.
  - The flow path also uses the process system and PVVS piping
- Capacity of the N2PS is sufficient to provide at least three days of flow to maintain hydrogen concentration within acceptable limits with additional margin.

Process Vessel Vent Isolation

- Radioactive components of the gas stream are removed or delayed via condensation, acid adsorption, mechanical filtration with high efficiency particulate air (HEPA) filters, and adsorption in carbon beds.
  - Two types of carbon beds are used: guard beds and delay beds
- The PVVS guard and delay beds are equipped with isolation valves that isolate the affected guard bed or group of delay beds and extinguish a fire.
  - The isolation valves also serve to prevent the release of radioactive material to the environment.
    - Guard bed isolation is a nonsafety-related function
  - The PVVS is equipped with instrumentation that detects fires and provides indication to ESFAS.
  - Redundancy in the beds and the ability to isolate individual beds allows the PVVS to continue operating following an isolation.

Advisory Committee on Reactor Safeguards
Non-Power Production or Utilization Facility Subcommittee

SHINE Medical Technologies, LLC
Operating License Application Review

Michael F. Balazik, Project Manager
Non-Power Production and Utilization Facility License Branch
Division of Advanced Reactors and Non-power Production and Utilization Facilities
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
March 17, 2022

SHINE Operating License Application

- SHINE Medical Technologies LLC (SHINE) submitted operating license application on July 17, 2019

- SHINE commenced construction of the facility in September 2019.

- SHINE has requested a commercial operating license for a non-power utilization and production facility (RPF)located in Janesville, Wisconsin

- SHINE proposes to produce molybdenum-99 (^{99}Mo) and other isotopes from the fission of low enriched uranium target solution in an Irradiation Facility consisting of 8 irradiation units

SHINE Operating License Application (cont.)

- ^{99}Mo is recovered through irradiated target solution processing in a Radioisotope Production Facility consisting of hot cells
- SHINE submitted a supplement to the license application on January 27, 2022, providing information on phased construction and operation of the facility
  - Operations and construction occurring simultaneously
  - Consists of four phases
- SHINE plans to complete Phase 1 in May 2023

SHINE General Licensing Approach

- SHINE requested a single operating license under 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities"
  - Irradiation units licensed as utilization facilities
  - Hot cells for separation of irradiated target solution as production facility
  - Housed in a single building
- Special nuclear material will be licensed under 10 CFR Part 70, "Domestic Licensing of Special Nuclear Material"
- Source material is licensed under 10 CFR Part 40, "Domestic Licensing of Source Material"

Regulatory Guidance and Acceptance Criteria

- Safety reviews for operating license applications conducted in accordance with Commission's regulations
- NUREG-1537, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors"
- Interim Staff Guidance Augmenting NUREG-1537
  - Radioisotope production facilities
  - Aqueous homogeneous reactors
  - Incorporates relevant non-reactor guidance from NUREG-1520, "Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility, Rev. 1"
- Other guidance (e.g., regulatory guides and ANSI/ANS standards) and engineering judgment used, as appropriate, to make construction permit findings

Basis for Issuing Operating License

- The findings of 10 CFR 50.57, “Issuance of operating license,” must be made to issue an operating license.
  - Construction has been substantially complete
  - Facility will operate in conformity with application and regulations
  - Reasonable assurance that operation will not endanger public health and safety
  - Applicant technically and financially qualified
  - Provisions of 10 CFR Part 140 satisfied (Financial Protection Requirements)
  - Issuance of license will not be inimical to common defense and security

Additional Regulatory Requirements

- 10 CFR 50.34, “Contents of applications; technical information,” requires the contents of the final safety analysis to include:
  - the general description of the facility;
  - the design bases, the limits on facility operation, and the safety analysis of the structures, systems, and components and of the facility as a whole;
  - the kinds and quantities of radioactive materials expected to be produced in the operation of the facility and the means for controlling and limiting radioactive effluents and radiation exposures within the limits in 10 CFR Part 20 and as low as is reasonably achievable;
  - the proposed technical specifications for the facility;
  - the description and plans for implementation of an operator requalification program;
  - the technical qualifications of SHINE to engage in the proposed activities;
  - the physical security plan for the facility;

Additional Regulatory Requirements (cont.)

- 10 CFR 50.34 requires the contents of the final safety analysis to include:
  - the final analysis and evaluation of the design and performance of structures, systems, and components with respect to assessing the risk to public health and safety resulting from operation of the facility;
  - the financial qualifications;
  - the emergency plan for the facility;
  - the relationship of specific facility design features to the major processes
  - the major chemical or mechanical processes involving licensable quantities of radioactive material.

NUREG-1537 Review Areas

1. **The Facility/Introduction**
2. **Site Characteristics**
3. **Design of Structures, Systems, and Components**
4. **Facility Description**
5. **Coolant Systems**
6. **Engineered Safety Features**
7. **Instrumentation and Control**
8. **Electrical Power Systems**
9. **Auxiliary Systems**
10. Experimental Facilities
11. **Radiation Protection and Waste Management**
12. **Conduct of Operations**
13. **Accident Analyses**
14. **Technical Specifications**
15. Financial Qualifications
16. Other License Considerations
17. Decommissioning
18. Uranium Conversions
19. Environmental Review

BOLD – Chapters presented to ACRS Subcommittee

Summary of Chapter 1 Review

- Applicable requirements of Atomic Energy Act and Commission regulations have been met
- SHINE facility does not share any systems or equipment with other facilities
- RPF processes, such as ^{99}Mo purification and uranium recovery, are similar to other facilities
- SHINE provides a general description of the facility and summarizes major operations
- SHINE facility will not have high-level nuclear waste or spent nuclear fuel, so Nuclear Waste Policy Act of 1982 is not applicable

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Advisory Committee on Reactor Safeguards Meeting on SHINE Medical Isotope Production Facility Operating License Application

Chapter 2
Site Characteristics

U.S. Nuclear Regulatory Commission
March 17, 2022

Geography and Demography

- The NRC staff finds, based on the review of the application and supplemental information provided, that the applicant's analyses of geography and demography are sufficient and acceptable
  - The SHINE facility is located in the city of Janesville, Rock County, Wisconsin. The SHINE site boundary encloses approximately 0.37 km^2 (91acres). All safety related structures, systems, and components of the SHINE facility are centrally located in a square area, in order to minimize distance to the site boundary.
  - Based on its review of the information in the FSAR Section 2.1 and independent confirmatory review of prominent, natural, and manmade features of the area as found in publicly available documentation, the staff finds the information provided by the applicant with regard to the SHINE site location and description adequate and acceptable.

Nearby Industrial, Transportation, and Military Facilities

- The NRC staff finds, based on the review of the application and supplemental information provided that the applicant's analyses of man-made hazards are sufficient and acceptable
- The staff's review covered:
  - Locations of transportation facilities and routes in relation to the SHINE site, including airports and airways, roadways, railways, pipelines, and navigable bodies of water
  - The presence of military and industrial facilities
- The staff reviewed the information provided and, for the reasons discussed in the SER, concluded that the SHINE applicant has provided adequate and reasonable information that established site characteristics and design parameters acceptable to meet the requirements of 10 CFR 50 and all applicable guidance provided in determining the acceptability of the SHINE site.

Meteorology – General and Local Climate

- The review of this section included the following topics:
  - Regional Climate
  - Regional Data Sources
  - Extreme Weather Conditions
  - Restrictive Dispersion Conditions
  - Air Quality
- NRC staff reviewed the description of the general climate of the region and meteorological conditions relevant to the design and operation of the facility.
- NRC staff reviewed the data resources and analytical approaches used by the applicant to prepare the information.
- The staff concluded that the site characteristics associated with meteorology, and general and local climatology are acceptable and reasonably representative of the proposed site region.

Meteorology – Site Meteorology

- The review of this section included the following topics:
  - Local Meteorology and Topography
  - Data Sources
  - Diffusion Parameters
  - Atmospheric Dispersion (χ/Q values)
- The staff reviewed the meteorological data and the description of the Southwest Regional Airport (SWRA) meteorological tower. The staff found the meteorological database suitable for input to the ARCON and PAVAN dispersion models.
- The staff reviewed the diffusion parameters for use in the ARCON and PAVAN dispersion models and found them acceptable.
- The staff evaluated the site topography and concluded that no unique topographic features preclude the use of the ARCON and PAVAN models for the SHINE Site at the site boundary.
- Thus, the staff finds the proposed χ/Q values acceptable for use in the SHINE FSAR because they are a conservative estimate of the atmospheric dispersion at the proposed SHINE Site.

Meteorology – Summary

- The staff finds, based on the review of the application and supplemental information provided through the RAI response, that the applicant's analyses of meteorological hazards and atmospheric dispersion are sufficient and acceptable as they followed the applicable local, state, and federal guidelines in accordance with 10 CFR 50.35. The staff concludes that the site is not located where catastrophic meteorological events are likely, that the applicant considered credible meteorological events in developing the design basis parameters for the facility, and that the applicant provided adequate site characteristics needed to evaluate uncontrolled release of radioactive materials.

Hydrology

- The NRC staff finds, based on the review of the application, as supplemented, that the applicant's analyses of hydrologic hazards are sufficient and acceptable
- Staff finds:
  - The NRC staff determined that the hydrologic descriptions in FSAR Section 2.4 are adequate to understand the local hydrology and drainage patterns for the proposed site.
  - SHINE site is not located where catastrophic hydrologic events are credible
  - The applicant considered credible hydrologic events in developing the design basis flood parameters for the facility
  - The applicant provided adequate site characteristics needed to evaluate an uncontrolled release of radioactive materials in the event of a credible hydrologic occurrence.

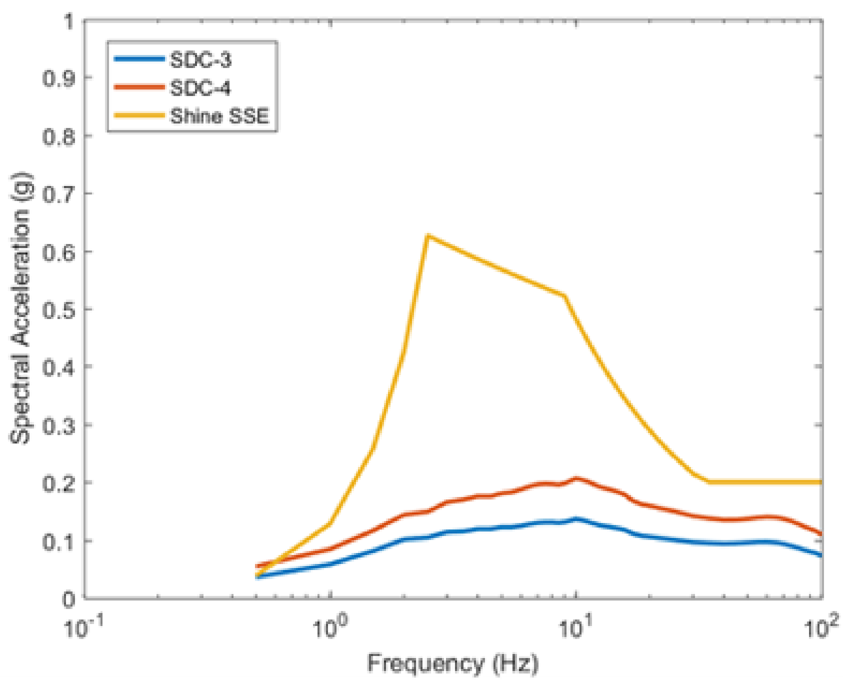
Geology

- The geologic characterization is unchanged from the Construction Permit Application
  - NRC staff confirmed that there are no new geologic hazards identified since the CP review
- No potential for surface deformation from tectonic or nontectonic hazards

Seismology

- Design basis ground motion (SSE) is RG 1.60 spectrum anchored at 0.2 g
  - Used in seismic design of SSCs important to safety
- Based on USGS National Seismic Hazard Mapping project results (2008)
  - Staff confirmed that 2014 NSHMP results are consistent
- Staff performed confirmatory PSHA
  - Used up-to-date NRC approved methods and models
  - Used site-specific subsurface profile

Seismology



- Shine SSE envelopes site-specific PSHA results for both seismic design classification (SDC) 3 and 4 facilities using guidance in ASCE/SEI 43-05
- NRC staff finds that SHINE adequately characterized seismic hazards at site

Geotechnical Engineering

- Geotechnical site characterization based on the results of field investigations and laboratory tests conducted for Construction Permit Application
  - Staff confirmed that soil parameters used in the geotechnical evaluation and SSI analysis are reliable and reasonable.
- Staff verified the stability of the foundations and subsurface materials
  - Staff verified that the soil underlying the site is not considered to be potentially liquefiable in accordance with the guidance of RG 1.198
  - Staff verified that the soil bearing capacity is adequate for designed structure
  - Staff verified that facility structure is designed to accommodate the potential differential and total settlements of the foundation
  - Staff verified that lateral earth pressure to the subgrade walls are properly considered in the structural analysis and design

Advisory Committee on Reactor Safeguards Meeting on SHINE Medical Isotope Production Facility Operating License Application

Chapter 4a
Irradiation Facility Description

U.S. Nuclear Regulatory Commission
March 17, 2022

Facility Description

- Addresses the primary operations at the irradiation facility (IF), the description of the IF, design descriptions of major systems and components, biological shield, and operating processes

- The design description includes the design basis, equipment design, process control strategy, and items relied upon for safety

- The design description provides details important to accident analysis and parameters controlled through technical specifications.

SHINE System Overview

- Low power, pressure, and temperature neutron source driven, liquid fueled sub-critical system.
- The system has a lot in common with Aqueous Homogenous Reactors (AHRs).
  - Solution composition and power density are within existing experience base for solution reactors. (see Fluid Fueled Reactors, Part 1 Aqueous Homogenous Reactors, James A Lane, Editor, ORNL).
  - The feedback characteristics after small and large reactivity insertions in AHRs are understood from testing.
- Unique feature is accelerator driven neutron source.

Major Systems and Components

Primary System Boundary

- Target Solution Vessel (TSV)
    - surveillance and inspection for radiation damage and corrosion
    - overflow lines to TSV dump tank
- TSV Dump Tank
    - criticality safe
    - 2 dump flow paths and 2 overflow paths from TSV
- TSV Off-Gas System
    - keep hydrogen concentrations below flammability limits in TSV and TSV Dump Tank
    - maintains pressure within operating limits
    - limit water holdup
    - remove iodine

Major Systems and Components

Secondary Confinement Boundary

- Subcritical Assembly Support Structure (SASS)
  - aligns and contains the TSV, neutron multiplier, and provides the cooling channels for them
  - subcooled liquid cooling
  - higher pressure than TSV
- Primary Closed Loop Cooling System (PCLS)
  - Part of Chapter 5 review
- Detection for leakage from TSV or neutron multiplier

Major Systems and Components

Light Water Pool

- Provides shielding
  - minimum level controlled
- Cooled by heat exchange to SASS cooling system piping inside pool during normal operation
- Provides emergency cooling
  - large thermal capacitance to absorb decay heat

Major Systems and Components

Neutron Driver Assembly System

- Uses deuterium-tritium fusion reaction to provide neutron source for the subcritical assembly
- Trips to shut down neutron driver
- Interlock to prevent operation during maintenance
- System to detect leakage

Major Systems and Components

Target Solution

- Solution parameters are controlled to prevent precipitation
- Temperature limit to prevent boiling
- Natural convection cooling enhanced by bubble buoyancy (evaporation cooling not credited)

Major Systems and Components

Biological Shield

- Thick concrete shield designed to limit radiation exposures to within 10 CFR Part 20 limits and meet ALARA considerations
- Radiation sources are TSV, TSV Dump Tank, TOGS, and PCLS
- Light Water Pool reduces radiation load from TSV and TSV Dump Tank to inside of biological shield
- TOGS and PCLS in separate enclosures

Nuclear Design – Reactivity Control

- Subcritical -- No excess reactivity or chemical/mechanical reactivity control
- Introduction of solution controlled by operator (the lift tank has a limited capacity, and the fill rate is limited by an orifice)
- Physical processes and their relationships to reactivity balance are described, calculated, and supported with tables and figures
- TSV can be shut down through the TRPS and dump tank (the dump flow rate is greater than the fill rate)
- Variables that influence reactivity are understood and some are monitored and controlled
- Neutron multiplication monitored on startup with flux detectors and subcritical neutron source

Nuclear Design – Properties

- Kinetics parameters calculated with solution life
- Power coefficient negative over range of expected system conditions – self damping effects
- Calculated uncertainties on neutron multiplication factor and reactivity coefficients with respect to uncertainties in state parameters
- Reactivity coefficients for solution and multiplier evaluated at nominal and limiting conditions
- Reactivity additions induced by drastic changes to core components are studied for startup and irradiation
- Subcritical multiplication margins were calculated with several different scenarios
- Limiting Core Configuration (for power density) in terms of solution volume and Uranium concentration was determined

Evaluation Findings and Conclusions

Accordingly, SHINE has met the following requirements for issuance of an operating license for Chapter 4a:

- Irradiation facility systems have been described, including the principal design and operating criteria
- Biological shield analysis offers reasonable assurance that design will limit radiation exposures to within 10 CFR Part 20 limits and meet ALARA considerations
- Reasonable assurance that the proposed facility can be constructed and operated without undue risk to the health and safety of the public

Advisory Committee on Reactor Safeguards
Meeting on SHINE Medical Isotope Production Facility Operating License Application

Chapter 5
Cooling Systems

U.S. Nuclear Regulatory Commission
March 17, 2022

Introductions

- Presenter:
  - Adam Rau, Ph.D
    Nuclear Systems Performance Branch
    Division of Safety Systems
    Office of Nuclear Reactor Regulation

- Primary Reviewer:
  - Muhammad Razzaque, Ph.D (Retired)
    Nuclear Systems Performance Branch
    Division of Safety Systems
    Office of Nuclear Reactor Regulation

Review Scope

- Target Solution Vessel (TSV)
- Primary Closed Loop Cooling System (PCLS)
- TSV Dump Tank
- Light Water Pool System (LWPS)
- Radioisotope Process Facility Cooling System (RPCS)
- Thermal-hydraulic Testing & Calculation
- Safe Shutdown TH Analysis

Review Method

- Cooling systems were evaluated against the acceptance criteria delineated in ISG to NUREG-1537, Part 2

- NRC staff reviewed FSAR, RAIs, SHINE calculations (via reading room), journal publications, and performed simple confirmatory calculations

Target Solution Vessel (TSV)

- TSV is an annular vessel cooled by PCLS flow on multiple surfaces

- TSV cooling designed such that:
  - Peak target solution temperature < 194°F (90°C)
  - Bulk target solution temperature < 176°F (80°C)

- These criteria prevent boiling of target solution and ensure integrity of the primary system boundary

Primary Closed Loop Cooling System (PCLS)

- There are 8 Irradiation Units (IU) in SHINE Facility
- Each PCLS is separate and independent for an IU
- Each PCLS can remove up to 137.5 kW of heat by forced convection from each TSV during normal operation (Licensed power is 125 kW)

PCLS (contd.)

- Heat flux at any cooling surface does not exceed Critical Heat Flux (CHF) in worst-case scenario

- Adequate margin exists to prevent Departure from Nucleate Boiling (DNB)

- Overheating of target solution not expected for anticipated operating conditions

TSV Dump Tank

- If PCLS not available, target solution is dumped from TSV into Dump tank

- Dump tank is a horizontal annular tank completely submerged in water inside the light water pool system (LWPS)

TSV Dump Tank (contd.)

- Tank geometry facilitates decay heat removal with large heat transfer area
- Peak target solution temperature inside dump tank does not exceed 194°F (90°C) provided that appropriate pool level is maintained

Light Water Pool System (LWPS)

- LWPS has no forced cooling or heat exchangers

- Performs passive cooling of Dump tank by natural convection

- Pool’s large thermal mass serves as heat sink

- Designed to remove decay heat from Dump tank without boiling target solution
  or pool water

LWPS (Contd.)

- Temperature is maintained between 50°F (10°C) and 95°F (35°C) during normal operation
- Radiation heating from TSV heats pool slightly above PCLS temperature
- Pool heat is removed through submerged PCLS piping
- Pool water temperature & level are monitored

Thermal-Hydraulic Testing & Calculation

- Correlation-based methodology used for safety-related calculations
- Heat transfer correlations were derived from published literature & SHINE-specific tests
- Tests performed at University of Wisconsin to develop correlation for the TSV
- Published correlations are valid and applicable

Safe Shutdown TH Analysis

- Adequate conservatism built into calculational methodology for passive decay heat removal during shutdown
- Calculated temperatures are bounding
- Safe shutdown & long-term cooling is achieved passively from any anticipated operating condition

Radioisotope Process Facility Cooling System (RPCS)

- RPCS is an intermediate closed loop forced liquid cooling system
- Removes heat from PCLS and within radiological control area (RCA)
- Rejects heat to process chilled water system (PCHS)

RPCS (contd.)

- Not a safety-related system and not credited with preventing or mitigating design basis events

- If active cooling to TSV and neutron multiplier not available due to loss of RPCS, irradiation of target solution is suspended

- Pressure cascade maintained between cooling systems to prevent contamination

Phased Approach

- Review underway

- IU-specific component design unaffected by phased approach:
  - Target Solution Vessel (TSV)
  - Primary Closed Loop Cooling System (PCLS)
  - TSV Dump Tank
  - Light Water Pool System (LWPS)

Conclusions

- Adequate cooling capacity exists for PCLS to cool TSV
- DNB in any cooling surface and/or overheating of target solution leading to loss of PSB integrity is not expected to occur during anticipated operating conditions or shutdown

Conclusions (contd.)

- Thermal-hydraulic calculations and assumptions are adequately conservative, include adequate safety margin and are bounding
- Decay heat is passively removed from target solution inside Dump tank by large thermal mass of pool water

Conclusions (contd.)

- Pressure cascade maintained between cooling systems to prevent potential contamination

- Review of phased approach underway

Advisory Committee on Reactor Safeguards
Meeting on SHINE Medical Isotope Production Facility
Operating License Application

Chapter 6
Engineered Safety Features

U.S. Nuclear Regulatory Commission
March 17, 2022

Introductions

- **Nageswara (Rao) Karipineni** – Safety and Plant Systems Engineer, Containment and Plant Systems Engineer, Division of Safety Systems, Office of Nuclear Reactor Regulation

Facility Descriptions

- Addresses the engineered design features (ESFs) of the irradiation facility (IF) and radioisotope production facility (RPF), designed to mitigate the consequences of accidents and events to keep radiological exposures within acceptable limits.

Regulatory Basis and Acceptance Criteria

- Regulatory Requirements
  - 10 CFR 50.34, “Contents of applications; technical information,” paragraph (b), “Final safety analysis report.”
  - 10 CFR 50.36, “Technical Specifications.”
  - 10 CFR 50.40, “Common Standards.”
  - 10 CFR 50.57, “Issuance of operating license.”
  - 10 CFR 20.1201, “Occupational dose limits for adults.”
  - 10 CFR 20.1301, “Dose limits for individual members of the public.”

- Acceptance Criteria
  - NUREG-1537 and ISG, Part 2, “Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors, Standard Review Plan and Acceptance Criteria.”

Areas of Review

- Applicable SHINE design criteria considered in the design
- Confinement features included in the design, as described in the applicable figures and tables included in the FSAR
- Actuation of the isolation features and consistency with I&C portions of isolation descriptions in Chapter 7
- Inclusion of the features in the technical specifications

Summary of Application

Irradiation Facility ESFs

Broadly divided into three categories (FSAR figure 6a2.1-1):

- primary confinement boundary
- tritium confinement boundary
- combustible gas management

Description of the design features and the SSCs that are part of the confinement, passive and active.

Drawings, block diagrams and tables included in the FSAR to allow a clear and general understanding of the confinement features.

Summary of Application

Irradiation Facility ESFs

Confinement:
- IU cell, TOGS shielded cell, HVAC system enclosure cell.
- PCLS and expansion tank design to vent radiolysis gases to RVZ1 system.

Tritium confinement boundary:
- TPS glove boxes.
- Secondary enclosure cleanup system
- Isolation valves

Combustible gas management:
- PVVS and nitrogen purge (N2DS)

Summary of Application (cont.)

Radioisotope Production Facility ESFs

Broadly divided into three categories (FSAR Table 6b.1-1):

- supercell confinement
- process vessel ventilation system (PVVS)
- combustible gas management

Description of the design features and the SSCs that are part of the confinement, passive and active.

Drawings and block diagrams included in the FSAR to allow a clear and general understanding of the confinement features.

Summary of Application (cont.)

Radio Isotope Production Facility ESFs:

Confinement:
- Supercell confinement.
- Below grade confinement.

PVVS:
- Captures or provides holdup for radioactive particulates, iodine, and noble gases.
- HEPA filters, carbon beds, guard and delay beds.

Combustible gas management:
- PVVS and nitrogen purge (N2DS)

Summary of Application (cont.)

Technical Specifications:

- LCO 3.4.1 addresses primary confinement boundary or primary system boundary valves.
- LCO 3.4.2 addresses check valves.
- LCO 3.4.3 addresses confinement boundary valves for TPS glove boxes.
- LCO 3.4.4 addresses supercell confinement dampers.
- LCO 3.4.5 addresses shiel plugs.

Review Procedures and Technical Evaluation

The staff compared the design features with the descriptions in Chapter 7 and Chapter 13 and determined they were consistently applied.

The staff performed an evaluation of the technical information presented in Chapter 6 of the SHINE final safety analysis report (FSAR), including the tables and block diagrams, to assess the sufficiency of the final design and the description of the engineered safety features in support of the issuance of an operating license.

Evaluation Findings and Conclusions

- Accordingly, SHINE has met the following requirements of 10 CFR 50.57 for issuance of an operating license:

   1) Irradiation facility and radioisotope production facility ESFs have been described, including the principal design criteria

   2) Reasonable assurance, based on Chapter 6 review, that the activities authorized by the operating license can be conducted without endangering the health and safety of the public.