UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

June 6, 2025

MEMORANDUM TO: Josh Borromeo, Chief
Advanced Reactor Licensing Branch 1
Division of Advanced Reactors and Non-power
Production and Utilization Facilities
Office of Nuclear Reactor Regulation

FROM: Stephanie Devlin-Gill, Senior Project Manager ***/RA/***
Advanced Reactor Licensing Branch 1
Division of Advanced Reactors and Non-power
Production and Utilization Facilities
Office of Nuclear Reactor Regulation

SUBJECT: SUMMARY OF THE MAY 22, 2025, PARTIALLY CLOSED MEETING WITH ARC CLEAN TECHNOLOGY (EPID L-2023-LRM-0022)

Meeting Information:

Applicant: ARC Clean Technology (ARC)

Project No.: 99902103

Public Meeting Notice Agencywide Documents Access and Management System (ADAMS) Accession No.: ML25140A921

Presentation Slides Accession Nos.: ML25133A051

Meeting Attendees: See Enclosure 1 for a list of meeting attendees

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Meeting Summary:

The U.S. Nuclear Regulatory Commission (NRC) staff conducted the meeting in accordance with NRC Management Directive 3.5, “Attendance at NRC Staff-Sponsored Meetings” (ML21180A271). The NRC staff discussed with ARC its conceptual design for the ARC-100 sodium-cooled fast reactor.

The NRC staff began the public meeting with introductions and explained that a portion of the meeting would be closed to the public due to the discussion of export controlled and proprietary information.

During the public portion of the meeting, the NRC staff received a comment from one member of the public, which thanked the NRC and ARC for the information shared during the open portion of the meeting.

The main points of discussion during the meeting are described in Enclosure 2.

No regulatory decisions were made as a result of this meeting.

Enclosures:
1. List of Attendees
2. Meeting overview

cc: ARC Clean Technology ARC-100
via GovDelivery

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OFFICE	NRR/DANU/UAL1:PM	NRR/DANU/UAL1:BC	NRR/DANU/UAL1:PM
NAME	SDevlin-Gill	JBorromeo	SDevlin-Gill
DATE	06/06/2025	06/06/2025	06/06/2025

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LIST OF MEETING ATTENDEES

MAY 22, 2025, PARTIALLY CLOSED MEETING WITH ARC CLEAN TECHNOLOGY

(EPID L-2023-LRM-0022)

Name	Organization
Reed Anzalone	U.S. Nuclear Regulatory Commission (NRC)
Deion Atkinson	NRC
Josh Borromeo	NRC
Greg Chapman	NRC
Stephanie Devlin-Gill	NRC
Shawn Harwell	NRC
Candace de Messieres	NRC
Greg Oberson	NRC
Hakan Ozaltun	NRC
Hanh Phan	NRC
Wendy Reed	NRC
Cathleen Ridder	NRC
Alex Siwy	NRC
Amy Snyder	NRC
Walter Williams	NRC
Raymond Burski	ARC Clean Technology (ARC)
Robert Chiavaro	ARC
John DeBruin	ARC
Robert Iotti	ARC
Steve Marschke	ARC
Anton Moisseytsev	Argonne National Laboratory
Robby Christian	Idaho National Laboratory (INL)
Pavel Medvedev	INL
Kurt Vedros	INL
Darryn Fleming	Sandia National Laboratories
Adele Gryba	Public
Addison Hall	Public
Harley Hutchins	Public
Michael Lazar	Public
Ryan Marcum	Public
Paul Ouellette	Public
Spencer Toohill	Public
Zefeng Yu	Public

MEETING OVERVIEW

MAY 22, 2025, PARTIALLY CLOSED MEETING WITH ARC CLEAN TECHNOLOGY

(EPID L-2023-LRM-0022)

On May 22, 2025, ARC Clean Technology (ARC) presented slides entitled “Supercritical Carbon Dioxide Power Conversion System (PCC) (Recompression Closed Brayton Cycle)” (ML25132A304). The following bullets describe the main points of discussion during this presentation:

- On slide 7, the U.S. Nuclear Regulatory Commission (NRC) staff asked if there was a failure of this system would the plant shutdown. ARC stated it depends on what occurs and that not all failures would result in shutdown.
- On slide 30, the NRC staff indicated that the presentation on the power conversion system was informative and aided the NRC staff’s understanding of plant transient behavior. However, from a radiological safety perspective, the NRC staff's primary concern is the potential impacts of transients within the power conversion system, particularly at the sodium–supercritical carbon dioxide (sCO_2) interface on reactor systems. Of specific interest is how these effects, including possible sodium-sCO_2 reactions, will be addressed and mitigated. In response, ARC noted that Argonne National Laboratory has conducted studies on sodium–carbon dioxide interactions. ARC stated that these experiments demonstrated instances of self-plugging, however, the results were inconsistent, and further testing is required to fully characterize the reaction mechanisms. ARC stated that the plant will be conservatively designed to account for a large-break scenario and will incorporate appropriate protective measures.

ARC’s second presentation was entitled “Argon Gas Storage, Distribution and Purification System: Primary Sodium & Intermediate Sodium and [Sodium Potassium] Processing Systems” (ML25132A301). The following bullets describe the main points of discussion during this presentation:

- ARC stated that the argon (Ar) dewars would hold 200-pounds of Ar under 200 pounds-per-square-inch – a 30-day cover gas supply. The NRC staff asked if ARC had considered the Ar dewars and cylinders in the context of worker safety, specifically, if there was a container breach, could it pose an asphyxiation hazard. ARC went to slide 5 and stated that the reactor building (RB) is not usually inhabited. ARC stated that the RB is in an open space in the building and that the Ar dewars and cylinders are stored in an open space in the RB.
- The NRC staff asked about the cryogenic process and whether it is a continuous or a batch process. ARC went to slide 6 and stated that under normal operations it would be a batch process linked to the cover gas purification subsystem (CGPS) flow (orange lines). ARC stated that the cover gas would be constantly monitored by the impurity monitoring and analysis system (IMAS) (purple lines) and if there were issues, the isolation values on the orange lines would open and have the gas processed.

- The NRC staff asked what monitoring techniques ARC is planning on using in the IMAS. ARC stated that it would use a multi-channel ionizer so it can monitor specific isotopes, such as krypton (Kr) and xenon. After the meeting, ARC informed the NRC staff that it would not use a multi-channel ionizer but instead planned to use a mass spectrometer. ARC stated this monitoring would distinguish which aspect of the fuel failed.

- ARC stated it plans to separate noble gases. The NRC staff asked what ARC plans to do with the noble gases – store them under cryogenic conditions? ARC stated it has two options (1) pressurizer bottle, or (2) send it to stack. The NRC staff stated that ARC should look at Title 10 of the *Code of Federal Regulations* (CFR) Part 20, "Standards for Protection Against Radiation," and the U.S. Environmental Protection Agency regulation Title 40 CFR 190, "Environmental Radiation Protection Standards for Nuclear Power Operations," which contain specific limits for Kr-85. The NRC staff also mentioned that ARC may want to consider the decay of Kr-85 to Rubidium-85 and if there is a potential for reaction with the storage container.

- The NRC staff asked about the cover gas break analysis in the context of worker safety as draft 10 CFR Part 53, "Risk Informed, Technology-Inclusive Regulatory Framework for Advanced Reactors," has requirements to ensure worker safety. ARC stated they have not done the simulations yet. However, ARC stated that the atmospheric dispersion parameter, χ/Q, is low and therefore would expect worker dose to be low.

- The NRC staff asked about the cesium and cold trap, specifically how often do these need to be cleaned or replaced. ARC stated it depends on how much failed fuel occurs and it may or may not need to be linked to the refueling cycle.

- On slide 18, the NRC staff asked whether the doses assume any mitigation. ARC stated that no mitigation beyond pool scrubbing was assumed.

- At the end of the presentation, the NRC staff asked about ARC's proposed licensing strategy, anticipated schedule for technical report submittals, and planned interactions with the NRC, including future meetings. ARC stated its approximate timeline for submitting a licensing application to the NRC by using 10 CFR Part 53 is in January 2028. ARC requested planning of additional meetings with the NRC in summer 2025. The NRC staff asked ARC about the recent announcement "[ARC] and Nucleon Energy Sign [Memorandum of Understanding] to Explore Deployment of ARC-100 SMR in Alberta and Texas,"[1] where ARC stated it is exploring deployment in Texas. ARC stated it had no specifics to share about siting of the ARC-100 in Texas. The NRC staff suggested that ARC consider the submittal of white papers and topical reports more frequently during the pre-application process, ahead of ARC's planned submittal in 2028. ARC stated that they are thinking about submitting one topical report on fuel qualification to the NRC.

[1] https://www.arc-cleantech.com/news/88/39/ARC-Clean-Technology-and-Nucleon-Energy-Sign-MOU-to-Explore-Deployment-of-ARC-100-SMR-in-Alberta-and-Texas

ARC's third presentation was entitled "Decontamination and Decommissioning Plan" (ML25133A094). The following bullets describe the main points of discussion during this presentation:

- On slide 4, the NRC staff pointed out that confusion was caused by incorrect dates and typos on the slides. ARC said it had made corrections, and some additional corrections were made real time during presentation.
    - The NRC staff reiterated that the 60-year clock to complete decommissioning starts once the certificate of permanent fuel removal from the reactor vessel is issued. With correct dates, it appears it will not be an issue.
- On, slide 12, the NRC staff asked about moving the spent fuel. ARC said it will need to move fuel from where it is stored in the reactor vessel and that the reactor vessel works for 1st and 2nd core. ARC stated that when the fuel in the 2nd core needs to be stored, the in-vessel core needs to be moved to the other area. The NRC staff asked if the Independent Used Fuel Storage Installation (ISFSI) has enough space, because 12 appeared to be the max number of casks on ISFSI pad. The NRC staff explained typical spent fuel storage. ARC acknowledged it was departing because it does not have a spent fuel pool.
- On the last slide, ARC explained that the financials are site specific. The NRC staff stated that it agrees that financials are site specific and understands that cost points are subject to fluctuation. ARC asked the NRC staff if ultimate disposal, is that part of decommissioning, which is on 90-100 year timeline. The NRC staff explained that the ultimate disposal of both materials related to the radiological decommissioning of a facility, as well as any spent fuel, would be considered in the Radiological Decommissioning and Spent Fuel Management sections of a site specific decommissioning cost estimate, respectively.
- The NRC staff stated with regards to the milestones and timeline that ARC needs to consider a license amendment request that will incorporate a License Termination Plan submission, which should occur approximately 3 years prior to anticipated termination of license.
- The NRC staff stated with regards to preliminary considerations that what ARC showed in the presentations demonstrates pre-thought on how best to consider decommissioning prior to establishing the operating facility.

ARC's fourth presentation was entitled "Probabilistic Safety Assessment [(PSA)]" (ML25132A286). The following bullets describe the main points of discussion during this presentation:

- On slide 2, regarding the end-state categories, the NRC staff requested that ARC elaborate on how these categories were defined in future engagement.
- On slide 2, the NRC staff stated that the Standardized Plant Analysis Risk— Human Reliability Analysis (SPAR-H) method documented in NUREG/CR-6883, "The SPAR-H Human Reliability Analysis Method," (ML13074A165) is used only for modeling post-initiator human actions. The NRC staff further stated that for pre-initiator

actions, human failure probabilities could be calculated using the method documented in NUREG/CR-4772.[2] The NRC staff also mentioned the Type-B human-induced initiating events.

- On slide 3, the NRC staff stated that the estimated end-state frequencies seem low and that any values lower than 1E-7 per year would raise various uncertainties, and the staff anticipates requesting justification.

  On slide 4, the NRC staff inquired about the purpose of comparing the ARC-100 PSA to the NRC SPAR methodology, as included in the presentation materials. ARC explained that the comparison is intended to highlight any differences and provide additional insights.

- On slide 5, the NRC staff asked about the November 2024 (ML25013A109), meeting and the use of United States Geological Survey hazards curves. ARC stated that they have changed the base of its models to develop an envelope from the NRC-published Fukushima revaluations. Discussion occurred about holding a separate meeting on the topic of seismic hazard and ARC to get feedback on their use of Fukushima data to develop the envelope.

- On slide 5, the NRC staff asked about the High Confidence Low Probability of Failure calculation and ARC stated they would provide follow-up data to the NRC.

- On slide 6, the NRC staff stated that NUREG/CR-6850, “Fire [Probabilistic Risk Assessment (PRA)] Methodology for Nuclear Power Facilities,” (ML15167A396) only covers internal fires at full power and questioned why the presentation does not address fire events during low power and shutdown (LPSD). The NRC staff mentioned that NUREG/CR-7114, “A Framework for Low Power/Shutdown Fire PRA,” (ML13260A155) provides guidance for assessing internal fire events during LPSD. ARC stated that the current scope of its PSA is limited to full power.

- On slide 7:

  - The NRC staff asked about ARC’s plan for the self-assessment and peer-reviews, and the associated timeline and stated that if the application is planned for 2028, the peer review should be conducted ahead of that. ARC stated that the conceptual design completion will occur before December 2025, and that the earliest peer review will be completed by the end of 2026.

  - The NRC staff stated that the internal flooding PSA and internal events LPSD PRA were not mentioned in the presentation. ARC stated the design does not allow water in RB, so internal flooding is not expected to occur. ARC agreed that LPSD PRA needs to be developed. The NRC staff also asked about the potential of chemical flooding and ARC acknowledged they are looking at that.

[2] NUREG/CR-4772, “Accident Sequence Evaluation Program (ASEP) Human Reliability Analysis Procedure,” Sandia National Laboratories, 1987.

  - The NRC staff asked about the comprehensive list of postulated initiating events for the ARC-100 design, as well as the methodologies used to identify and select them.

Between the ARC's fourth and fifth presentations, the NRC closed the meeting to the public due to the discussion of export controlled and proprietary information.

ARC's fifth presentation was entitled "Fuel Qualification Update" (ML25132A303). The following bullets describe the main points of discussion during this presentation:

- The NRC staff asked about how scenarios in fuel performance modeling and simulation activities are generated for uncertainty and sensitivity studies.
- The NRC staff asked for clarification on the premise of the topical report, e.g., fuel qualification, methodology, informative, etc. ARC stated the resulting report may be limited on scope.
- ARC responded that the primary means of qualification will be to reexamine the available data from EBR-II and Fast Flux Test Facility database, perform additional sensitivity studies using modeling and simulation tools, and reassess the uncertainties to demonstrate fuel performance. No additional in-reactor demonstration tests are planned.
- In response to ARC's proposed use of modeling and simulation tools as their primary means for the demonstration of the fuel system, the NRC staff provided the clarification that BISON is not an NRC-approved code, particularly for mechanistic extrapolation. The NRC staff further clarified that although BISON has been validated for light-water reactor fuel, its history with metallic fuel is relatively brief. The code has not been submitted to the NRC staff for a review and approval, so its use to support licensing actions would involve additional evaluation efforts.
- The NRC staff also emphasized that ARC is using the code on a design that has significant changes to geometry and operational parameters. To date, the code has not been demonstrated to the NRC that its scalability is feasible or accurate. The NRC staff stated that scaling can be done a variety of ways that may or may not rely on 1:1 fuel testing. The NRC staff stated that Regulatory Guide 1.203, "Transient and Accident Analysis Methods," (ML053500170) is an example process that may aid in this effort.
- The NRC staff further clarified that the concerns are not isolated to a specific variable, such as time-at-elevated-temperature or fuel elongation. The NRC staff stated the example that fuel geometry may cascade through other phenomena such as constituent redistribution. The NRC staff stated that it is not necessarily an issue with the design, rather that these sensitivities must be explored, justified, and addressed in future submittals.
- The NRC staff clarified that the "time to extract" a surveillance pin is difficult as the potential mechanical fuel failure mechanism occurs in the first 5% of posed irradiation timeline. The NRC staff stated that should ARC seek to license under a surveillance program, the premise would be investigated by the NRC staff for

potential fuel failure modes, such as fuel-cladding mechanical interaction, and the likelihood of surveillance to be able to capture the performance in a core-leading manner.

- ARC stated that its fuel qualification topical report would be submitted to the NRC approximately during calendar year 2026, which depends on the contract from U.S. Department of Energy getting extended.
- NRC staff encouraged ARC to engage more frequently with the NRC and consider submitting additional reports before the final licensing application. The NRC staff noted several preliminary topics yet to be received.

The meeting on May 22, 2025, was adjourned at 3:02 PM eastern time.