



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

September 22, 2022

MEMORANDUM TO: Richard Chang, Chief  
Licensing Projects Branch  
Division of Operating Reactor Licensing  
Office of Nuclear Reactor Regulation

FROM: Stephanie Devlin-Gill, ATF Lead Project Manager /RA/  
Plant Licensing Branch II-1  
Division of Operating Reactor Licensing  
Office of Nuclear Reactor Regulation

SUBJECT: SUMMARY OF THE AUGUST 24, 2022, HIGHER BURNUP  
WORKSHOP III

On August 24, 2022, the U.S. Nuclear Regulatory Commission (NRC) staff held the Higher Burnup Workshop III, an observation meeting, with the nuclear industry and other stakeholders. This workshop included presentations by the NRC staff and representatives from the Nuclear Energy Institute (NEI), the Electric Power Research Institute (EPRI), Southern Nuclear Operating Company (SNC), Constellation Energy Corporation, the U.S. Department of Energy's (DOE) Idaho National Labs (INL), and the DOE Oak Ridge National Laboratory (ORNL). The meeting had three purposes: (1) provide all stakeholders with updated information about the current NRC and industry activities for higher burnup (HBU) and increased enrichment (IE) fuel, (2) exchange of information between the NRC staff and industry stakeholders on HBU IE activities, and (3) provide an opportunity for members of the public to ask questions of the NRC staff. The meeting notice can be found in the Agencywide Documents Access and Management System (ADAMS) at Accession No. ML22235A740. The NRC and industry meeting slides can be found at ADAMS Accession Nos. ML22230D012 and ML22235A640, respectively. A recording of the meeting can be found at:

<https://youtu.be/GQZKZitYPYk>

Joe Donoghue, Director of the Division of Safety Systems (DSS) in the Office of Nuclear Reactor Regulation (NRR), made opening remarks and Aladar Csontos from NEI provided the industry's opening remarks. The first presentation given by the NRC staff provided an overview and status update on the IE Rulemaking, required by Staff Requirements Memorandum (SRM)-SECY-21-0109. The IE Rulemaking staff provided schedule updates and discussed impacts of the June 22, 2022, public meeting. The SRM-SECY-21-0109 and the public meeting summary can be found in ADAMS at Accession Nos. ML22075A103 and ML22208A001, respectively. The next NRC staff presentation provided an overview of the Regulatory Framework Applicability Assessment (RFAA), available at ADAMS Accession No. ML22014A112. The presentation provided examples from the RFAA table and described how the table's applicability analysis assesses the NRC's regulatory framework to identify regulations and guidance that could be impacted by the licensing of ATF-concept, HBU, and IE fuels, whether pertinent regulations and guidance do not speak to phenomena unique to HBU, IE, or near-term ATF concepts, and how those could be addressed.

Next, the NRC staff provided a presentation regarding the Office of Nuclear Regulatory Research associated Research Information Letter (RIL) on fuel fragmentation, relocation, and dispersal (FFRD). The presentation described RIL 2021-13, available at ADAMS Accession No. ML21313A145, and how it summarized the NRC interpretation of recent FFRD research in: (1) fine fragmentation burnup threshold, (2) strain threshold for fragmentation, (3) dispersible mass fraction, (4) transient fission gas release, and (5) fuel packing fraction. The NRC staff emphasized intentions of continued participation in experimental programs and review of industry research.

Next, the EPRI representatives presented an overview of EPRI's HBU Alternative Licensing Strategy (ALS), specifically the objective, approach, and scope planned for the ALS topical report (TR). EPRI representatives stated that the objective of the ALS TR will be to address loss-of-coolant accident (LOCA)-induced FFRD in pressurized water reactors using a generically applicable method. EPRI plans to submit the TR in the fourth quarter of calendar year 2023. The SNC representatives then presented on the utility perspectives on EPRI's ALS, focusing on the industry's goals to achieve fuel licensing infrastructure to support burnup and enrichment extensions (LEU+) beyond legacy limits in the mid-2020s and safely and economically enable 24-month cycle operation for the entire fleet of existing light water reactors.

After these presentations, an NRC/industry discussion was held. The NRC staff asked about EPRI's ALS, specifically how leak-before break (LBB) prevents the dispersal within the phenomenon of FFRD. EPRI representatives stated crediting LBB, and operator response times limit transient temperature, thus preventing fuel cladding rupture in large-break LOCAs. EPRI representatives stated that the specific FFRD analysis is detailed in LOCA methods and analysis outlined in EPRI's ALS, for a variety of LOCA sizes and locations. The NRC staff then commented that EPRI's ALS relied on an interpretation of the Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants" (GDC), specifically Criterion 4, "Environmental and dynamic effects design bases" (GDC 4) from 1987. GDC 4 provides a criterion for environmental and dynamic effects design bases, which ALS relies on expansion of current interpretations of local dynamic effects for cladding rupture in a LOCA. The NRC staff and EPRI representatives both affirmed such interpretation would require additional information and NRC review. The NRC staff then questioned EPRI's bounding behavior in the provided extremely low probability of rupture (xLPR) code example, specifically emphasizing uncertainties in the model. The EPRI representatives provided a background in xLPR, a probabilistic tool, emphasizing conservative uncertainties support current Technical Specification requirements regarding operator response times. Further discussions regarding EPRI's ALS and xLPR are expected at a partially closed pre-submittal meeting on August 30, 2022, details are available under ADAMS Accession No. ML22249A002. The NRC staff then asked the industry representatives about its intent for submissions of license amendment requests (LAR) regarding HBU up to 75 gigawatt days per metric ton of uranium (GWd/MTU). Representatives from SNC answered that incremental or mid-range increases in burnup would rely on vendor specific methodologies coupled with plant specific applications. Of note, the industry representatives emphasized mid-range or intermediate burnup increases do not rely on EPRI's ALS, only burnup above 74 GWd/MTU would rely on the ALS TR. The NRC staff then commented that a risk exists in submitting a LAR, while the vendors associated TR is under review. After that question, a short break was held.

After the break, the NRC representatives provided a presentation on performing transportation evaluations of ATF with IE and HBU. The National Environmental Policy Act evaluations, aligned with 10 CFR Part 51.52, Environmental Effects of Transportation of Fuel and Waste - Table S-4 were discussed, for IE above 5 weight-percent U-235 and burnup higher than 62 GWd/MTU.

Next, the NRC staff presented on HBU and IE spent fuel transportation, dry storage research, and licensing. Updates were provided on ATF High-Assay Low-Enriched Uranium (HALEU) research and associated licensing activity, in conjunction with DOE ORNL. The NRC is actively reviewing and certifying transportation packages for ATF and continuing to proactively maintain front and back end regulatory readiness for the nuclear fuel cycle. The next presentation was provided jointly by representatives of EPRI, Constellation, DOE INL, and DOE ORNL. It provided an update on the Collaborative Research on Advanced Fuel Technologies for Light-Water Reactors (CRAFT), the Issue Tracking Matrix, and the Consensus LOCA Test Plan.

After these presentations, an NRC/Industry discussion was held. The NRC staff asked DOE and industry representatives how CRAFT supports licensing timelines industry proposed for ATF. DOE emphasized its role is to prioritize and develop technology for stakeholder use, however, defers licensing to the NRC. The industry representatives then explained the Consensus LOCA Test Plan specifically schedules and prioritizes activities to support current industry ATF licensing timelines. Then a representative from Framatome inquired about the NRC staff's perspective on the 10 CFR 50.46c emergency core cooling system performance during a LOCA rulemaking. The NRC staff confirmed awareness of the proposed rule, its implications, and the NRC's readiness for licensing applications. Of note, the NRC representatives emphasized that the rule has not yet been finalized. After that question, a public comment period was held.

There were nine public comments received during the public comment period. First a member of the public asked the NRC staff about maintenance timing requirements at operating reactors. The NRC staff answered that maintenance effectiveness is the subject addressed by the Maintenance Rule, 10 CFR 50.65, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants." Working toward public understanding of the regulation, the industry provides its guidance to NRC licensees, and then the NRC provides regulatory guides that may endorse the industry guidance, but additionally may take exceptions. A member of the public then asked a series of questions regarding potential nuclear proliferation of HALEU fuel for weapons and international intentions for enrichment supply. The NRC staff acknowledged all comments and questions for consideration; however, such topics were beyond the scope of the meeting. Then a member of the public asked the NRC staff for a means to convert megawatt days per metric ton of uranium (MWD/MTU) to months or years. The NRC staff provided clarification that MWD/MTU conversion to time depends on various factors, such as: core power level, position of fuel assembly, fuel power level, and rod position in core. Thus, no direct conversion can be made without providing additional factors for consideration. Members of the public then noted concern for HALEU fuel coefficient of criticality, emphasizing the need for transparency. Further, members of the public then noted concern with assumptions within EPRI's ALS, specifically xLPR and leakage LBB assumptions. The NRC staff acknowledged both comments from the public and will take them into consideration.

Next, a member of the public asked the NRC staff to discuss potential consequences of storing and transporting FFRD, focusing on damaged fuel canisters. First, the NRC staff indicated that FFRD is an accident phenomenon discussed for consideration of unlikely hypothetical accident scenarios. Further, the NRC staff provided information on damaged fuel canister requirements, design, and associated package approval. A member of the public then asked how many operating reactors are utilizing HBU fuel. The NRC staff indicated no NRC regulated reactors are operating with loads that have burnups exceeding current limits. Then, a member of the public asked for clarification on the confirmatory codes utilized for ATF technology, and the associated selection process. The NRC staff answered that the confirmatory code is based on research collected at a variety of facility and projects, specifically the Studsvik Cladding Integrity

Project was mentioned. Identified independent confirmatory calculation code for fuel performance, thermal hydraulics, neutronics, and severe accidents can be found at:

<https://www.nrc.gov/reactors/atf/independent-confirm-calc.html>

Joe Donoghue, Director of DSS in NRR made closing remarks and Aladar Csontos from NEI provided industry's closing remarks.

No regulatory decisions were made in the meeting.

Enclosure:  
List of Attendees

## List of Attendees

Higher Burnup Workshop III  
August 24, 2022

U.S. Nuclear Regulatory Commission (NRC)	
First Name	Last Name
Donald	Algama
Noushin	Amini
Brent	Ballard
Andrew	Barto
Philip	Benavides
Andrew	Bielen
Mark	Blumberg
Perry	Buckberg
Richard	Chang
Alice	Chung
James	Corson
Stephanie	Devlin-Gill
Elijah	Dickson
Joseph	Donoghue
James	Dunavant
Blaylock	Dwayne
Kenneth	Erwin
Hossein	Esmaili
Mike	Franovich
James	Hammelman
Nicholas	Hansing
Kevin	Heller
Kevin	Hsueh
Tara	Inverso
Lios	James
Stacy	Joseph
Daniel	King
Andrea	Kock
Scott	Krepel
Lucus	Kyriazidis
John	Lehning
Ekaterina	Lenning
Michael	Mahoney
Sean	Meighan
Nicolas	Mertz
Joseph	Messina
Ed	Miller
Tony	Nakanishi
Ngola	Otto
Donald	Palmrose
John	Parillo
Bo	Pham
Jason	Piotter
April	Pulvirenti
William	Rautzen
Carla	Roque-Cruz
David	Rudland
Michael	Salay
Fred	Schofer
Neil	Sheehan

Enclosure

<b>U.S. Nuclear Regulatory Commission (NRC)</b>	
<b>First Name</b>	<b>Last Name</b>
Zachary	Stone
Edward	Stutzcage
Rao	Tammara
Brian	Wagner
Kimberly	Webber
Sunil	Weerakkody
Bernie	White
Josh	Whitman
John	Wise

<b>Non-NRC</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Affiliation (if provided)</b>
Adam	Stein	Breakthrough Institute (BTI)
Rich	Augi	GE Power Portfolio
Aylin	Kucuk	Electric Power Research Institute (EPRI)
Jenner	Baker	
Elijah	Balltrip	
Kevin	Barber	
David	Barrientos	GE Power Portfolio
Bob	Baxter	Framatome, Inc. (Framatome)
Michael	Boone	
James	Breuninger	
Brain	Mount	
Nathan	Capps	Department of Energy (DOE) Oak Ridge National Laboratory
Cecile	Dame	MPR Associates
Johnathan	Chavers	Southern Nuclear Company (SNC)
Rachel	Christian	Westinghouse Electric Company
Christopher	Canniff	Excel Services Corporation
Colby	Jenson	DOE Idaho National Labs
Connie	Kline	
Aladar	Csontos	Nuclear Energy Institute (NEI)
Robert	Daum	EPRI
Peter	Diller	GE Power Portfolio
Steven	Dolley	
Dwayne	Blaylock	
Fred	Smith	Framatome
Jeff	Gabor	
Shane	Gardner	GE Power Portfolio
William	Gassmann	Constellation Nuclear
Lisa	Gerken	Framatome
Michelle	Guzzardo	Framatome
Kent	Halac	GE Power Portfolio
Robert	Hall	
Zachary	Harper	
Stanley	Hayes	
Feinroth	Herb	
David	Hindera	GE Power Portfolio
J.	Phillips	
Jason	Schulthess	
Jim	Anderson	
Ryan	Joyce	
Julianna	Duarte	
Kalene	Walker	
Zeses	Karoutas	
Thomas	Kindred	SNC
Jeffrey	Kobelak	

<b>Non-NRC</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Affiliation (if provided)</b>
Leigh	Lloveras	BTI
Matthew	Leonard	
Guangjun	Li	GE Power Portfolio
Alan	Meginnis	Framatome
Michael	Keegan	
Kurshad	Muftuoglu	GE Power Portfolio
Carole	Naugle	Framatome
Kari	Osborne	
Frances	Pimentel	
Ian	Porter	GE Power Portfolio
Kevin	Quick	Framatome
Deann	Raleigh	
Robert	Fortner	
Robert	Armstrong	
Baris	Sarikaya	Constellation Nuclear
Tyler	Schweitzer	GE Power Portfolio
Scott	Stanchfield	Entergy
Lawrence	Svetlana	
Jennifer	Uhle	
Yong-Joon	Choi	

Note: Attendance list based on Microsoft Teams participant list and in person attendee sign in sheet. This list does not include individuals who did not provide their last name either in registering for the meeting or by a follow-up email.

SUBJECT: SUMMARY OF THE AUGUST 24, 2022, HIGHER BURNUP WORKSHOP III  
DATED SEPTEMBER 22, 2022

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RidsNrrDssSfnb	JWise, NRR	JPiotter, NMSS
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RChang, NRR	JTsao, NRR	KErwin, NMSS
DHarrison, NRR	DDijamco, NRR	DPalmrose, NMSS
SDevin-Gill, NRR	KBucholtz, NRR	DBarnhurst, NMSS
DKing, NRR	Rlyengar, RES	EDickson, NRR JCorson,
LJames, NRR	JMcKirgan, RES	RES LKyriazidis, RES
ELenning, NRR	MHumberstone, RES	ACoggins, OGC
CRoque-Cruz, NRR	MHomiack, RES	DRoth, OGC
JDonoghue, NRR	AGilbertson, RES	NMertz, OGC
MRoss-Lee, NRR	CSallaberry, RES	KRoach, OGC
SKrepel, NRR	SHelton, NMSS	RWeisman, OGC
BParks, NRR	CRegan, NMSS	
JLehning, NRR	TInverso, NMSS	
JMessina, NRR		

**ADAMS Accession Nos.:**

**ML22256A017 (Meeting Summary)**

**ML22244A071 (Package)**

OFFICE	NRR/DORL/LLPB PM	NRR/DORL/LPL2-1 PM	NRR/DORL/LLPB LA	NRR/DORL/LLPB BC
NAME	DKing	SDevin-Gill	DHarrison	RChang
DATE	09/13/2022	09/13/2022	09/13/2022	9/14/2022
OFFICE	NRR/DSS/SNSB BC	NMSS/REFS/RRPB BC	NMSS/DFM/NARAB BC	NMSS/REFS/ERNRB BC
NAME	SKrepel	IBerrios	DMarcano	KErwin
DATE	9/14/2022	9/14/2022	9/22/2022	9/21/2022
OFFICE	RES/DSA/FSCB BC	NRR/DORL/LPL2-1 PM		
NAME	HEsmaili	SDevin-Gill		
DATE	9/20/2022	9/22/2022		

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