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

February 1, 2016

MEMORANDUM TO: Mark Lombard, Director
Division of Spent Fuel Management
Office of Nuclear Material Safety
and Safeguards

FROM: Christina J. Leggett, Ph.D., Nuclear Engineer **/RA/**
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SUBJECT: SUMMARY OF NOVEMBER 3-5, 2015, U.S. DEPARTMENT OF ENERGY ANNUAL FUEL CYCLE TECHNOLOGY MEETING IN IDAHO FALLS, ID

PURPOSE:

To discuss the current status and ongoing research and development activities of the U.S. Department of Energy's (DOE's) Fuel Cycle Technologies (FCT) program.

ATTENDEES:

U.S. Nuclear Regulatory Commission (NRC): Christina Leggett and Yawar Faraz

Other attendees (~100-110) included officials from the DOE and its national laboratories, the Nuclear Waste Technical Review Board, industry representatives, and university professors and students.

SUMMARY:

This memorandum summarizes the proceedings of the sixteenth annual meeting arranged by DOE on Fuel Cycle Technologies. Each year, DOE representatives, researchers from DOE national laboratories, and professors and students from various universities convene to present the results of their research funded by the FCT program. The agenda for the meeting is enclosed. Meeting presentations have been compiled and will be forwarded to NRC staff upon request.

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The inaugural presentation of the 16th Annual Fuel Cycle Technologies meeting was presented by Mr. John Herczeg, Deputy Assistant Secretary for the DOE Fuel Cycle Technologies program. He began his presentation by providing an update on the DOE Office of Nuclear Energy (DOE-NE) organizational structure. Notably, he informed the audience that Pete Lyons' replacement, John Kotek, had become the Acting Deputy Assistant Secretary for DOE-NE and that Raymond Furstenau had been promoted to Associate Principal Deputy Assistant Secretary of DOE-NE. In addition, William McCaughey currently serves as the Acting Director of the Office of Fuel Cycle Research and Development for the FCT program. In this capacity, he oversees fuel development programs and the Material Protection, Accounting and Control Technologies (MPACT) campaign. Lastly, Melissa Bates had replaced Jeff Williams as Acting Team Lead for the Nuclear Fuel Storage and Transportation Project. After summarizing the near- and long-term objectives and focus areas for the FCT program, Mr. Herczeg presented the key fiscal year 2015 (FY15) results and outlined the FY16 budget and FCT program priorities. He identified FCT's top three priorities for 2016 as continuing (1) the Joint Fuel Cycle Study with the Republic of Korea to advance electrochemical reprocessing, (2) the development of more accident-tolerant fuels and cladding, and (3) near-term activities associated with waste storage and transportation, which include the storage of high burn-up spent fuel and deep borehole disposal of DOE-owned waste materials such as cesium and strontium capsules stored at Hanford. Mr. Herczeg concluded his presentation by highlighting some of the diverse research activities conducted in FCT campaigns, recognizing outstanding individuals in his divisions, and applauding the NRC's role in DOE's joint effort with industry concerning the high-burnup cask demonstration project.

After Mr. Herczeg's presentation, several presentations were given on topics that may be of interest to NRC employees in the Offices of Nuclear Material Safety and Safeguards, Nuclear Regulatory Research, Nuclear Reactor Regulation, and New Reactors. These topics include (1) fuel cycle options, (2) reprocessing (aqueous and electrochemical), (3) material control and accountability, (4) spent fuel disposition (including spent fuel storage, transportation and disposal), and (5) accident-tolerant fuels. The following paragraphs summarize the research being done in the aforementioned subject areas.

Fuel Cycle Options

Dr. Roald Wigeland, National Technical Director for the Fuel Cycle Options (FCO) campaign, provided an overview of the mission and long-term objectives of the campaign. Research carried out in this campaign during FY15 included further analyzing potential fuel cycle options such as those that include the use of small modular reactors, extended storage, and minor actinide recycle and, additionally, exploring the effects of and potential approaches to transitioning to those fuel cycles. The results of the FCO evaluations were published in the report, "Nuclear Fuel Cycle Evaluation and Screening Report", which is available at https://fuelcycleevaluation.inl.gov/SitePages/Home.aspx. In the FCO campaign, the two most promising options are (1) continuous recycle of U/Pu and (2) the continuous recycle of U/TRU, both of which would include the use of thermal and fast reactors. Small modular reactors do not play an important role in his analyses other than being a potential source, along with other future commercial power reactors, of spent nuclear fuel (SNF) for recycle. Subsequent presentations given by members of the FCO campaign addressed strategies for transitioning from the current U.S. once-through fuel cycle to a fast reactor continuous recycle system and the potential for nuclear energy to address climate change.

Reprocessing

Dr. Terry Todd, National Technical Director for the Materials Recovery and Waste Form Development (MRWFD) campaign, discussed the benefits of having a closed fuel cycle and summarized the work done in the various campaign areas to support its development. This work includes research on aqueous and electrochemical reprocessing, off-gas treatment, and advanced waste forms. Significant research accomplishments during FY15 included (1) demonstration of Am(IV) co-crystallization with uranyl nitrate for the first time as part of a group actinide separation concept, (2) development of an advanced ceramic waste form for salt waste generated from electrochemical reprocessing, (3) the first demonstration of the electrochemical oxidation of Am(III) to Am(VI) in a non-complexing acidic aqueous medium, and (4) synthesis of a new molecular organic framework (MOF) for use in off-gas treatment with twice the Xe capacity of the previous best MOF. It is noted that the last two accomplishments were published in two prominent journals, *Science* and *Nature Materials*, respectively. Research in this campaign was further highlighted in four presentations on (1) electrochemical oxidation of Am(III), (2) the use of MOFs for Kr capture, (3) tritium separation from aqueous solutions, and (4) the development of titanate-based ceramic waste forms. Additional presentations on electrochemical reprocessing research and safeguards were also presented by members of the Joint Fuel Cycle Studies campaign. The safeguards model being developed for reprocessing could also be applied to other fuel cycle facilities.

Material Control and Accountability

Dr. Michael Miller, who is the National Technical Director for the MPACT campaign, could not attend the meeting. As a result, his presentation was given by a coworker. The presentation involved an overview of the diverse activities carried out in this campaign. The overall mission of the MPACT campaign is to develop innovative tools and technologies that will enable effective material control and accountability at existing and future fuel cycle facilities, thereby mitigating terrorism- and proliferation risks at these facilities. These activities include the development of an integrated safeguards and security system for electrochemical reprocessing facilities and for dry storage of SNF, and also include the development of advanced instrumentation for nuclear materials management. A majority of the funding for the campaign is devoted to development of integrated safeguards and security for electrochemical reprocessing and dry storage of SNF.

A number of significant accomplishments for FY15 were presented in Dr. Miller's presentation, including (1) development and/or testing of sensors (e.g., level/density- and actinide sensors) for electrochemical process monitoring experiments, (2) development of the Safeguards and Security Performance Model (SSPM) for a generic electrochemical reprocessing facility, and (3) successful continued development of a super high-resolution gamma spectrometer and a neutron counter capable of withstanding very high gamma doses. In addition, the Multi-Isotope Process (MIP) monitor began a series of tests at H-Canyon at Savannah River National Laboratory in FY15. These accomplishments were further highlighted in two additional presentations about the MIP monitor deployment at H-Canyon and about the SSPM. Application of the SSPM to other fuel cycle facilities was also being explored. Near the conclusion of the presentation, it was noted that, in addition to a maintaining a number of international collaborations, MPACT has also been integrating several Nuclear Energy University Program projects into the campaign.

Spent Fuel Disposition Including Storage, Transportation and Disposal

The Used Fuel Disposition (UFD) campaign overview was presented by Dr. Peter Swift, National Technical Director for the UFD campaign. The mission of the UFD campaign is to conduct research and develop technologies that enable safe storage, transportation, and disposal of SNF and wastes generated by existing and future fuel cycles. To that end, their focus is to develop the technical bases for the extended storage of SNF, fuel retrievability and transportation after extended storage, and transportation of high-burnup SNF. There is an additional focus on developing disposal options. Presentations by researchers in this campaign covered research on deep borehole disposal, modeling of spent fuel storage and transportation loads, development of sensors and robotics for inspection of dry storage cask containers, and international collaboration activities.

The UFD campaign collaborates fully with the Nuclear Fuels Storage and Transportation (NFST) project. The mission of the NFST project is to lay the groundwork for implementing interim storage and transportation of spent nuclear fuel. Activities in this campaign are diverse, ranging from evaluating a number of currently-available dry storage design concepts for consolidated interim storage, designing a large-scale transportation system, and evaluating options for an integrated waste management system. Presentations were given that (1) highlighted the NFST's cask railcar development activities; (2) summarized the work completed by NFST contractors on the generic design alternatives for dry storage of SNF[1] and on the development and loading considerations of Standardized Transportation, Aging, and Disposal (STAD) canisters; and (3) discussed model development for storage, transportation, and disposal systems.

Accident-Tolerant Fuel

Dr. John Carmack, National Technical Director for the Advanced Fuels Campaign (AFC), began the closing session of the FCT meeting with an overview of current and proposed AFC activities. The objectives of the AFC are to develop accident-tolerant LWR fuel (ATF) and cladding and to develop long-term advanced reactor fuel options. Key FY15 activities as outlined in Dr. Carmack's presentation include successful collaborations with Areva, GE, and Westinghouse to explore new cladding concepts; execution of ATF capsule and loop irradiation tests; rapid progress toward the start of the Transient REActor Test (TREAT) facility; and development of metallic fuels and alloys. These activities were further highlighted in a series of subsequent presentations by researchers in the AFC campaign. A report summarizing the AFC's efforts toward the development of accident-tolerant fuel can be found online at https://nuclearfuel.inl.gov.

Enclosure: Agenda

[1] It should be noted that although a number of dry storage concepts are being evaluated, the concept(s) that may be employed in a future consolidated interim storage system are unlikely to be significantly different from those currently being used in the U.S. and elsewhere. The challenge when evaluating these storage systems is the identification of a storage system that can accommodate transfer from currently distributed storage systems and from which future transport to permanent disposal can most easily be facilitated. This is further complicated by the recent change from a single future repository for commercial and defense waste to two separate repositories, one exclusively for commercial waste and the other for government-owned spent fuel and high level waste.

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Agenda
Fuel Cycle Technologies Annual Meeting
November 3-5, 2015
Idaho National Laboratory

Attendance is by invitation only. For the consideration of others and to optimize the effectiveness of the meeting, attendance is required for all three days.

Meeting Objectives

1. Review significant program accomplishments in FY 2015.
2. Review FY 2016 R&D, including goals and objective for that year, and 3 years forward.
3. Highlight the work of early-career researchers from the national labs and universities.
4. Showcase the Student Innovation award winners.

Meeting Facilitator: Bill McCaughey, DOE, NE-52

Tuesday, November 3, 2015

Time (MST)	Subject	Lead
8:00 am – 8:30 am	Introductory Remarks	Mark Peters Director Idaho National Laboratory
8:30 am – 9:00 am	Introductory Remarks Recognitions	John Herczeg, Deputy Assistant Secretary for Fuel Cycle Technologies, DOE
9:00 am – 10:10 am	Fuel Cycle Options • Campaign Overview—Roald Wigeland, INL • Ed Hoffman, ANL: "Fuel Cycle Transition Analysis: Evaluating the Transition from Current U.S. Nuclear Energy System to Fast Reactor Continuous Recycle System" • Sonny Kim, PNNL: "The Potential of Nuclear Energy for Addressing Climate Change"	Roald Wigeland National Technical Director, INL
10:10 am – 10:25 am	Break • Visitor Badging—Please meet in the lobby at EIL	

Enclosure

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10:25 am – 12:25 pm	Material Recovery & Waste Forms Development (MR &WFD) • Campaign Overview—Terry Todd, INL • Chris Dares, Univ. of North Carolina-Chapel Hill: "Electrochemical Oxidation of Am(III)" • Praveen Thallapally, PNNL: "Room Temperature Separation of Krypton and Xenon using Metal Organic Frameworks" • Ramesh Bhave- ORNL: "Tritium Separation from Dilute Aqueous Solutions" • Jake Amoroso, SRNL: "Development and testing of titanate based ceramic waste forms for HLW immobilization"	Terry Todd National Technical Director, INL
12:25 pm – 2:25 pm	Lunch	
2:25 pm – 3:35 pm	Material Protection, Accounting, and Control Technologies • Campaign Overview—Mike Miller, LANL • Dave Meier, PNNL, Jamie Coble, UTK: " Multi-Isotope Process (MIP) Monitor: H-Canyon Deployment" • Ben Cipiti, SNL: "Safeguards and Security Performance Modeling"	Mike Miller National Technical Director, LANL
3:35 pm – 4:45 pm	Fuel Resources • Campaign Overview—Stephen Kung, DOE • Dr. Carter Abney, ORNL: "Engineering Uranyl Selectivity through Polymer Design and Advanced Spectroscopy" • Dr. Slava Bryantsev, ORNL: "Computational Ligand Screening and Design for Extraction of Uranium from Seawater"	Stephen Kung Program Manager, DOE
4:45 pm – 5:00 pm	Break	

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5:00 pm – 6:30 pm	Student Innovation--Awards and Poster Session 2nd Place, Advanced Fuels • Andrew Dykhuis, Massachusetts Institute of Technology 2nd Place, Energy Policy • Andrea Gardiner, Vanderbilt University 2nd Place, Materials Protection, Control, and Accountancy • Matthew Marcath, University of Michigan 2nd Place, Nuclear Science and Engineering • Kimberly Mullane, University of Pennsylvania 2nd Place, Separations and Waste Forms • Jonathan Wormald, North Carolina State University 2nd Place, Used Fuel Disposition • Remy Devoe, University of Tennessee Competition for Students Attending Universities with Less than $600M in 2012 Science and Engineering R&D Expenditures • Samantha Cary, Florida State University • Ryan Collette, Colorado School of Mines • Charles Folsom, Utah State University • Elizabeth Krahn, Washington State University • Christopher Morrison, Rensselaer Polytechnic Institute Undergraduate Competition • Amanda Lewis, Rensselaer Polytechnic Institute	Patricia Paviet DOE, NE-51

Agenda
Fuel Cycle Technologies Annual Meeting
November 3-5, 2015
Idaho National Laboratory

Wednesday, November 4, 2015

Time (MST)	Subject	Lead
8:00 am – 8:30 am	Introductory Remarks	Andy Griffith Associate Deputy Assistant Secretary for Fuel Cycle Technologies, DOE
8:30 am – 9:50 am	Used Nuclear Fuel Disposition Research & Development • Campaign Overview—Peter Swift, SNL • Nick Klymyshyn, PNNL: "Modeling Used Fuel under Transportation and Storage Loads" • Cliff Lissenden, Penn State University: "Multi-Sensor Inspection and Robotic Systems for Dry Storage Casks"	Peter Swift National Technical Director, SNL
9:50 am – 10:05 am	Break	
10:05 am – 10:45 am	Used Nuclear Fuel Disposition Research & Development, continued • Jens Birkholzer, LBNL: "International Collaboration Activities in Disposal Research" • David Sassani, SNL: "Deep Borehole Field Test Overview"	
10:45 am – 12:15 pm	Modeling and Simulation Panel Discussion	
12:15 pm – 2:15 pm	Lunch	
2:15 pm – 3:25 pm	Joint Fuel Cycle Studies • Campaign Overview—Mike Goff, INL • James King, INL: "Processes for an Integrated Study of Electrochemical Recycling" • Magdalena Tylka, ANL: "Interfacial Kinetic Studies of Actinides in Electrochemical Systems"	Mike Goff Joint Fuel Cycle Studies, INL
3:25 pm – 4:25 pm	Nuclear Fuels Storage & Transportation • Campaign Overview—Mark Nutt, ANL • Pat Schwab, DOE: "Transportation Hardware/Railcar" • Rob Howard, ORNL: "Task Orders Completed in FY 2015" • Josh Jarrell, ORNL: "NFST Modeling Tools" • Casey Trail, ANL: "NFST Integrated Waste Management System Architecture Analysis"	Mark Nutt National Technical Director, ANL
4:25 pm – 4:40 pm	Break	
4:40 pm – 5:40 pm	Nuclear Fuels Storage & Transportation, continued	

Agenda
Fuel Cycle Technologies Annual Meeting
November 3-5, 2015
Idaho National Laboratory

Thursday, November 5, 2015

Time (MST)	Subject	Lead
8:00 am – 10:00 pm	Advanced Fuels • Campaign Overview—Jon Carmack, INL • K. G. Field, ORNL: "Design of FeCrAl alloys with Enhanced Accident Tolerance through Targeted Irradiation Programs" • A. Nelson, LANL: "High Density Ceramic Fuels for LWR Accident Tolerant Applications" • K. Metzger, University of South Carolina: "U3Si2 Fabrication and Testing for Implementation into the BISON Fuel Performance Code" • J. Harp, INL: "Recent AFC Experimental Post-Irradiation Examination Results"	Jon Carmack National Technical Director, INL
10:00 am – 10:15 pm	Break	
10:15 am – 11:45 am	Panel Discussion—" Advanced Instrumentation That Transforms How We Conduct R&D"	
11:45 am – 12:15 pm	Wrap Up	John Herczeg Deputy Assistant Secretary for Fuel Cycle Technologies, DOE