INL/MIS-24-81004

MPACT
Materials Protection Accounting and Control Technologies

U.S. Department of ENERGY | Office of Nuclear Energy

Materials Protection Accounting and Control Technologies (MPACT)

Quarter 1 Newsletter FY 2025

In This Issue:

Program Manager Note

We hope you all had very Happy Holidays! In our FY24 Q4 newsletter, I highlighted the MPACT mission statement: The Materials Protection, Accounting, and Control Technologies (MPACT) program supports the U.S. advanced fuel cycles technology developers to effectively and economically address nuclear Material Control and Accounting (MC&A) requirements. In this newsletter, I would like to expand on this a bit by explaining more about what MPACT does, and how we decide on what activities to pursue.

First and foremost, MPACT is an R&D program in DOE/ NE-43 (Office of Nuclear Energy Office of Materials and Chemical Technologies). We are primarily tasked to develop new tools and technologies to address MC&A challenges for U.S. nuclear fuel cycle facilities. We focus on the front and back-end of the fuel cycle, and coordinate with other NE programs. Additionally, we have further emphasis on the back end of the U.S. fuel cycle to better coordinate within NE-43 on recycling technologies. While our focus is on R&D, we do make significant investments in both industry cooperation as well as domestic safeguards education. Cooperation with industry moves our R&D products from a laboratory proof-of-principle Technology Readiness Level (TRL) to a facility application TRL. Lessons learned during this process are critical to the development of effective MC&A tools. And our work in domestic safeguards education is an investment in America's future nuclear safeguards practitioners.

MPACT continuously engages with U.S. Government-led nuclear fuel cycle R&D through national laboratory staff, university staff, and industry working on nuclear fuel cycle technologies. We pull our priorities from the DOE/ NE mission and objectives and develop R&D activities based on opportunities to develop tools and techniques following the safeguards and security by design principle alongside the nuclear fuel cycle technology developers. We welcome new ideas at any time and are happy to discuss the funding mechanisms (direct MPACT activities, Small Business Innovation Research / Small Business Technology Transfer (SBIR, Consolidated Innovative Nuclear Research (CINR) Nuclear Energy University Program (NEUP), Funding Opportunity Announcements (FOAs), etc.) to explore these ideas. We also encourage ideas that fall outside of traditional MC&A tools (gamma and neutron-based techniques) but still support MC&A implementation. We are in a very exciting time for new fuel cycle facility development, and these new fuel cycles facilities will likely require new MC&A approaches and new tools to meet those approaches. We'd love to hear your ideas!

Tansel Selekler –
MPACT Federal Program Manager

Principal Investigator Profile:
Lakshmi Soundara Pandian, Ph. D – RMD, Inc.

Lakshmi holds a B.S. and M.S. in Physics from Madurai Kamaraj University, India, and earned her Ph.D. in Nuclear Physics from the Tata Institute of Fundamental Research in Mumbai, India, in 2005. Following her doctoral studies, she was a Feinberg post-doctoral fellow at the Weizmann Institute of Science in Israel and as a post-doctoral scholar/research scientist at the University of Massachusetts, Lowell. Between 2009 and 2012, she taught Nuclear Instrumentation and Nuclear Physics as an Adjunct Assistant Professor at the University of Massachusetts Lowell. In 2012, Lakshmi joined Radiation Monitoring Devices, Inc. as a staff scientist in the Scintillation Detectors Group, and in 2023, she became the director of the Imaging Sensors and Application Group. She has extensive expertise in radiation detection, nuclear physics, and materials science, particularly in the development of novel scintillation materials. Her work has focused on creating new scintillators for gamma, neutron, and gamma/neutron detection, including both inorganic crystals and ceramics. Currently, Lakshmi is leading efforts to develop advanced dense scintillators for high-energy physics, high-temperature scintillation detectors, and innovative x-ray and neutron imaging technologies.

Principal Investigator Profile: *Nathaniel Hoyt, PhD*

Dr. Nathaniel Hoyt is manager of the Process Chemistry, Simulations, and Safeguards Group in the Chemical and Fuel Cycle Technologies Division at Argonne National Laboratory. As manager, he leads a team of researchers in the development of molten salt and aqueous technologies applicable to nuclear fuel reprocessing, molten salt reactors, electrometallurgy, and industrial decarbonization. His group specializes in the development and deployment of monitoring and control technologies to enable advanced high-temperature processes and flow systems. Toward that end, his group has developed key sensors for the in-situ monitoring of thermochemical and thermophysical properties of fluids. His group also possesses several high-temperature testbeds and flow systems that leverage automation and digital twins to enable the development, assessment, and optimization of advanced processes.

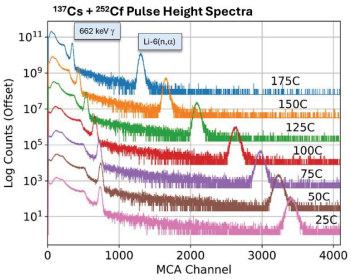
Dr. Hoyt received his PhD in aerospace engineering from Case Western Reserve University in 2013. Since starting work at Argonne in 2015, Nathaniel has worked on projects relevant to the safeguarding of nuclear materials within pyroprocessing vessels such as electrorefiners. Under MPACT, he has led the development of voltammetry sensors capable of measuring salt composition and actinide content. The sensors have been operated extensively in Argonne's pyroprocessing equipment and have been successfully deployed to hot cells at INL.

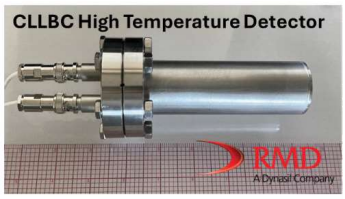
Program Update

In the Program Manager Note for this quarter's MPACT newsletter, Tansel describes the MPACT activity decision process. As an example of this process, we cite our FY25 MPACT MC&A for advanced reactor fuel fabrication facility activities. MPACT began looking into advanced reactor fuel fabrication MC&A four years ago following the creation of the DOE Advanced Reactor Demonstration Program. We started with an internal study to understand potential MC&A issues associated with fuel fabrication facilities for the new generation of advanced reactors. Many of these reactors will be cored with HALEU in fuel form factors unlike our current LWR reactor fleet. TRISO fuel, metallic fuel, and molten salt fabrication facilities are all being explored to support future advanced reactors. MPACT used this internal report to develop a prioritized approach to explore potential MC&A challenges following a safeguards and security by design methodology. This approach includes safeguards performance modeling, conceptual material accountancy plans, and material measurement technology assessments. MPACT has assembled a multi-laboratory team with consultations from industry and regulatory experts to comprehensively study these issues and make ongoing recommendations to focus MPACT R&D efforts.

In FY25, MPACT will release several advanced reactor fuel fabrication facility MC&A publications. These will include a publicly releasable version of our internal potential MC&A challenges report, a report outlining potential technologies to address the challenges, and two safeguards practitioner's guides. The first safeguards practitioner's guide was developed to assist potential licensees who are involved in the design of facility nuclear material accounting and control (MC&A) systems and licensing/inspection representatives from the Nuclear Regulatory Commission who are involved in their review. The document introduces the MC&A regulations and guidance; presents the purpose and history of MC&A; describes the basic elements of an MC&A program as it pertains to both safeguards and nuclear security; and summarizes the requirements (based on the regulations) and recommendations (based on the guidance documents) for the different nuclear material categories and facility types. The second safeguards practitioner's guide is focused on developing MC&A plans. This guide, specifically tailored to the practical needs of nuclear field safeguards practitioners, is meant to be a valuable resource for those integral to developing and implementing the facility's MC&A program. Its objectives are to provide a functional model and a systematic tool for designing an overall MC&A program, adopt applicable MC&A program elements, and prepare an adequate MC&A plan for any nuclear facility applying for a U.S. Nuclear Regulatory Commission (NRC) license to possess and use nuclear materials. All four of these publications will be posted to the MPACT website (https://mpact.lanl.gov/) for download.

We hope that you find this MPACT activity development process and products example informative. In this and future newsletters we highlight some of the technologies being explored for advanced reactor fuel fabrication facility MC&A as well as all other fuel cycle MC&A technologies. As always, please reach out to us with any questions or to discuss any ideas to support MC&A for U.S. nuclear!





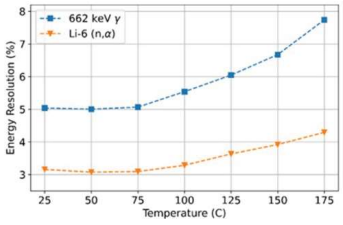


Photo of the high temperature detector and Gamma/neutron pulse height spectra and energy resolution measured with the detector at different temperatures.

MPACT Technical Update Highlight – *Detector Development for MC&A*

Material Control and Accountancy (MC&A) for advanced nuclear fuel cycles is a complex task, as operational conditions are often challenging. High radiation doses and elevated temperatures pose significant difficulties for most commercial instruments, which are typically designed for low radiation exposure and room-temperature operation. In recent years, under the MPACT SBIR funding, Radiation Monitoring Devices (RMD) has been developing a detector capable of performing under these harsh conditions, simultaneously detecting gamma and neutron radiation to provide quantitative results.

To achieve this, RMD evaluated and demonstrated the high-temperature performance of a dual-mode scintillator, Ce-doped Cs2LiLa(Br,Cl)6 (CLLBC). RMD's CLLBC-based high temperature detector can operate at temperatures up to 180°C (limited by the photodetector) and delivers 8% energy resolution at 662 keV, with the ability to separate gamma and neutron events. Jefferson Laboratory (JLab) and Oak Ridge National Laboratory (ORNL) have developed a GEANT4 model for the high temperature detector and tested few scenarios within the nuclear fuel cycle where the detector could be applied. Currently, RMD is working on a second revision of the detector and optimizing custom CAEN-based electronics to collect data at high count rates (1 Mcps) while maintaining good energy resolution and gamma/neutron separation. The system is expected to undergo evaluation at the Hot Fuel Examination Facility (HFEF) at Idaho National Laboratory (INL) in 2025.

MPACT Technical Update Highlight – *Molten Salt Sampling*

Material Control and Accountancy (MC&A) of special nuclear materials is essential for the successful licensing and operation of pyrochemical reprocessing. While off-line samples can be used to establish the quantities of uranium and plutonium within process vessels, in-line monitoring tools such as voltammetry sensors can potentially play a similar role without the need for complex and time-consuming sample preparation and analysis. However, to achieve this outcome, the sensors must be proven to have sufficient longevity, stability, and accuracy. As such, MPACT has sponsored the development of Argonne's voltammetry sensors through early-stage demonstrations up through deployments where the tools have been exercised in real-world conditions.

Argonne's voltammetry sensors make use of a unique multielectrode array that enables quantitative measurements of actinide concentrations and the salt level. These two values enable determination of the total quantity of species within process vessels. These sensors have been operated over years-long durations at Argonne and within the Hot Fuel Examination Facility at INL. During FY24, additional capabilities for automated analysis were implemented to improve the rate at which information can be provided to users of the equipment. Capabilities for simultaneous measurements of transition metals within the salt were also added. Further exercising of the sensor within operational process equipment will be performed in FY25 using new instrumentation and control software to further improve the quality of the measurements.

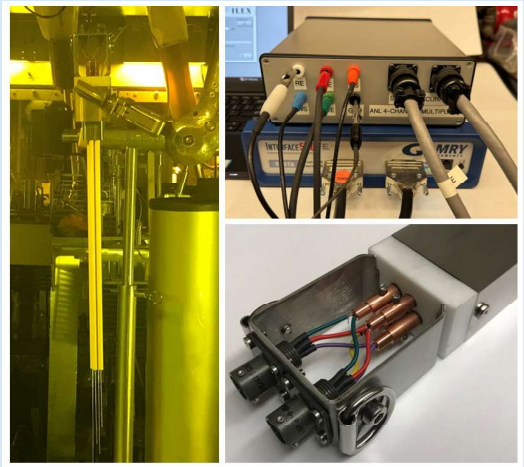


Photo showing the voltammetry probe and update instrumentation.

MPACT Contacts

TANSEL SELEKLER
Federal Program Manager
tansel.selekler@nuclear.energy.gov

MICHAEL BROWNE
National Technical Director
mcbrowne@lanl.gov

COLIN CARROLL
Deputy National Technical Director
ccarroll@bnl.gov

JACKI WALSH
Control Account Manager
jacquelyn.walsh@lanl.gov

The MPACT newsletter is prepared by INL in coordination with all MPACT labs.

Idaho National Laboratory, Pacific Northwest National Laboratory, Sandia National Laboratories, Argonne National Laboratory, Oak Ridge National Laboratory, Brookhaven National Laboratory, Los Alamos National Laboratory.