

TRM-Transportation of Liquid Highly Enriched Uranium (HEU)- 21341

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ABSTRACT

From 1986 until 2003 U.S.-origin highly enriched uranium (HEU) fuel elements and targets were irradiated in the National Research Universal (NRU) research reactor located at Chalk River Laboratories, in Ontario, Canada, and then dissolved in a nitric acid solution to separate out Molybdenum-99 (Mo-99), an important medical isotope. Approximately 6,000 gallons of highly enriched uranyl nitrate liquid (HEUNL) target residue material (TRM) was left after the Mo-99 was separated out. The TRM was not waste, it was a valuable product that was shipped to the Savannah River Site's (SRS) H-Canyon to be separated. Moving the TRM to SRS took 115 individual truck shipments, covering ~150,000 highway miles of safe and secure transport. This paper will focus on the planning and execution of the TRM shipping campaign.

INTRODUCTION

In the 1950s, Technetium-99m (Tc-99m) was identified as a potentially useful medical tracer, as it is a pure gamma emitter with a 6-hour half-life making it ideal for diagnostic medical imaging. Tc-99m is used in approximately 80 percent of all nuclear medicine diagnostic procedures, and in roughly 40,000 diagnostic and therapeutic nuclear medicine procedures performed daily in the United States, including diagnosis of heart disease, treating cancer, and studying organ structure and function. However, the short half-life makes the distribution of the substance very challenging and means that it be produced continuously to meet the medical community's needs.

In 1957, what is now Canadian Nuclear Laboratories, Ltd. (CNL) began using the National Research Universal (NRU) reactor at the Chalk River site to produce Mo-99, the first reactor able to commercially produce medical isotopes. From 1986 until 2003, U.S.-origin HEU fuel elements and targets were sent to Canada for use in the production of medical isotopes. Until October 2016, CNL was one of the world's largest producers of medical isotopes used in the diagnosis and treatment of cancer and other serious diseases, producing approximately 60% (and at times 100%) of U.S. demand for Mo-99, as well as other isotopes such as Iodine-131, Xenon-133.

The HEU targets were irradiated for approximately 7 days in the reactors and then dissolved in a nitric acid solution in order to separate out the Mo-99 isotope. The HEUNL TRM that was left after the Mo-99 was separated by dissolution, was then transferred to a double-walled stainless-steel vessel

known as the fissile solution storage tank (FISST) located at the CNL facility in Chalk River, Ontario. There was approximately 6,000 gallons of TRM stored in the FISST.

In March 2012, the governments of Canada and the United States committed to work cooperatively to repatriate this material from Canada to the United States. The shipping campaign was part of the U.S.-origin Nuclear Material Removal Program conducted by the U.S. Department of Energy/National Nuclear Security Administration's (DOE/NNSA) Office of Material Management and Minimization (M3). M3 works with civilian nuclear facilities around the world to remove and/or confirm the disposition of excess HEU and plutonium to ensure it does not fall into the hands of terrorists or other malevolent actors. Each kilogram of this material that is eliminated reduces the risk of a terrorist acquiring it for use in an improvised nuclear device, thereby achieving permanent threat reduction.

Operational demands associated with maintaining isotope production, combined with constrained shielded facility capabilities at CNL precluded conversion of this material to a standard solid form (e.g. calcine). This necessitated the transport of the TRM in liquid form.

INITIAL AECL/NNSA COORDINATION

In 2008 Atomic Energy of Canada Limited (AECL) expressed interest in assessing alternative treatment processes that would permit this material to be transported to SRS for disposition. SRS conducted an engineering study that determined that SRS would need to develop a capability to remove and transfer the HEU liquid from the shipping cask to H-Canyon.

Discussions then began between AECL and DOE/NNSA. AECL would be responsible for transport activities from Chalk River to SRS. DOE/NNSA would be responsible for coordinating with organizations and states along the route in the United States. A contract was signed on September 28, 2012 to transport the material to SRS for disposition.

The material would be transported by truck and each shipment was planned to include two casks. Based on optimistic projections at that time, a total of 88 casks would be needed to make 44 shipments and it was expected to take approximately nine months to one year to complete all shipments.

HEUNL CANISTERS

Transporting liquid HEUNL material presented numerous first-time technical and regulatory challenges. To ship the liquid material AECL contracted with NAC International to design and license a canister to fit inside the NAC-LWT Type B package (LWT) for transporting the TRM directly to H-Canyon. These canisters hold approximately 15 gallons each, with four (4) canisters fitting inside an LWT cask.

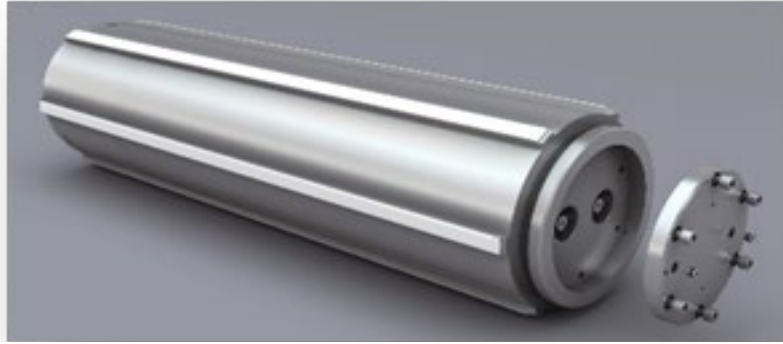


Figure 1 - HEUNL Container – NAC

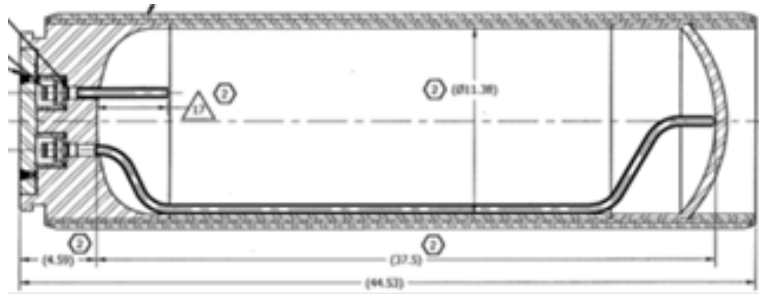


Figure 2 - HEUNL Container Internals - NAC

LWT TYPE B CASK CERTIFICATION

The LWT cask is a lead-lined package with a cylindrical cavity designed to enable shipment of HEU and various types of SNF by reconfiguring the internal components (baskets) which secure the shipped material within the cavity. On June 18, 2010, NAC submitted an application to the United States Nuclear Regulatory Commission (NRC) requesting the addition of HEUNL to the approved contents for the LWT. Several designs were developed for the inner canister. The final design consisted of four self-contained canisters that would be placed individually into the LWT.

For the shipment of TRM, the NRC reviewed a request for change of contents from NAC for the LWT and issued an amended Certificate of Compliance (COC). The United States Department of Transportation (DOT) is the competent authority in the U.S., and it issued a Competent Authority Certificate (CAC) for the package in consultation with and in consideration of the NRC's COC. The Canadian Nuclear Safety Commission (CNSC) is the competent authority in Canada and it validated the DOT-issued CAC for use of the LWT within Canada.

On December 24, 2014 the NRC issued Revision Number 61 of the COC for the LWT, certifying use of the cask for shipment of HEUNL. Under the revised Certificate of Compliance, each cask could ship up to 4 inner containers holding HEUNL, with up to 58.1 liters (15.35 gallons) within each container, or a total within the cask of 232.4 liters (61.4 gallons).

CNL CANISTER LOADING AND SRS CANISTER UNLOADING FACILITIES

Both CNL and SRS had to design, fabricate, and install specialized equipment and processes to handle the loading of the HEUNL at CNL and the unloading at SRS. Transfer hoses and fittings for all the equipment designed for use in Canada also had to work at SRS. To ensure this interoperability of loading and unloading processes and hose connections, engineers from the Savannah River National Laboratory (SRNL) worked in conjunction with CNL engineers to design the withdrawal and transfer systems as well as design the transfer system and processing equipment that would be used during the unloading operation at H-Canyon. Challenges in Canada included determining how to remove the material from FISST tank and safely transferring it to the canisters while accurately measuring what had been transferred, for material control and accountability purposes, and loading the filled canisters into the LWT. Challenges at SRS included determining how to safely remove the canisters from the LWT and then fully emptying the HEUNL from the canisters while accurately measuring volumes.

NEPA

The National Environmental Policy Act (NEPA) requires federal agencies to assess the environmental effects of their proposed actions prior to making decisions. A comprehensive Environmental Impact Statement (EIS), completed in 1996, addressed DOE's decision to accept and manage foreign research reactor spent fuel as well as certain target material. A NEPA Supplemental Analysis, completed in 2015, specifically evaluated the transportation of the TRM material from Canada to SRS.

On August 12, 2016, several U.S.-based environmental interest groups filed suit in Federal Court against DOE/NNSA in an effort to halt the TRM shipments. The Plaintiffs alleged that DOE/NNSA violated NEPA by not preparing an adequate supplemental or new EIS prior to the planned transportation. DOE/NNSA negotiated an accelerated path for resolution of this case by voluntarily refraining from undertaking any TRM shipments until the case was decided by the Court.

On February 2, 2017 the Court ruled in DOE/NNSA's favor, concluding that DOE met its NEPA obligations. The Court issued an Order dismissing the Plaintiffs' case. DOE/NNSA then began the TRM transport campaign with the first shipment conducted on April 15, 2017.

TRANSPORTATION PLANNING

DOE/NNSA closely coordinated with its Canadian partners, the shipping contractor, a Tribal Nation, and multiple U.S. federal and state agencies. These included the Department of Homeland Security and the Federal Bureau of Investigation to ensure the material would be transported safely and securely. DOE/NNSA also provided specialized training courses free of charge to prepare emergency responders for response to transportation accidents involving radioactive material.

NRC TRANSPORTATION OVERSIGHT

While DOE/NNSA is not an NRC licensee, and therefore not subject to enforcement actions, the decision was made to conduct all Foreign Research Reactor Spent Nuclear Fuel Acceptance Program shipments in compliance with NRC regulations. DOE/NNSA, through its management directives, Orders, and contractual agreements, ensured the protection of public health and safety by imposing on its transportation activities standards equivalent to those of the NRC.

All TRM shipments complied with NRC regulatory requirements for the specific highway routing that each shipment had to follow. Each chosen route was reviewed and approved by the NRC to ensure the met applicable security and safeguards requirements.

All information regarding shipping dates, times, and routes were secured and managed according to NRC 'Information Safeguards' regulations.

TRANSPORTATION COORDINATION

To ensure the successful, safe and efficient transportation of the TRM by truck, a transportation plan was developed that identified the responsibilities, requirements and procedures, transportation activities, organizational responsibilities, emergency preparedness guidelines, and other methods for achieving safe transport.

This plan was prepared under the direction of DOE/NNSA in cooperation with the states and tribe whose jurisdictions these shipments traveled through, the Southern States Energy Board, the Council of State Governments Northeastern Office, and the transportation contractor and commercial carrier.

TRANSPORTATION PARTICIPANTS

Numerous federal, state, tribal and commercial entities were involved in the supporting the TRM shipping campaign. Primary among those were:

DOE/NNSA: Overall responsibility for the TRM shipping campaign in the United States.

AECL: Overall responsibility for the TRM shipping campaign in Canada.

Secured Transportation Services, LLC (STS): Responsible for overall management of transportation in Canada and the United States.

Corridor States/Tribes: The corridor states/tribe had responsibility for providing security escorts and establishing procedures and providing personnel and equipment to take charge of emergency situations if necessary. These were the Seneca Nation of Indians, New York, Pennsylvania, West Virginia, Virginia, Maryland, North Carolina, South Carolina and Georgia.

Federal Bureau of Investigation (FBI): Provided threat assessments and coordinated with each state's Fusion Center regarding overall security planning.

INMM & ESARDA Conference, August 21-26, 2021, Vienna, Austria.

Savannah River Nuclear Solutions (SRNS): Established an integrated baseline planning schedule and provided logistical and administrative support to implement the TRM shipping campaign. Took responsibility for the TRM upon arrival at SRS.

CNL: Prepared all TRM shipments for departure in Canada.

Commercial Motor Carrier: The carrier was responsible for safely transporting the TRM from Canada to SRS and returning empty transport packages to the vendor or Chalk River Laboratories.

NRC: Approved the U.S. ports of entry (POE) and certified the routes of movement plan submitted by STS.

TRANSCOM: The DOE unclassified Transportation and Communications Tracking System used to monitor the progress of the TRM shipments. TRANSCOM utilized onboard satellite Global Positioning Systems (GPS) to track the truck shipments as they made their way from Chalk River to SRS.

Transportation Emergency Preparedness Program (TEPP): is a DOE wide program that integrates the transportation emergency preparedness activities under a single program to address the emergency response concerns of state, tribal, and local officials affected by the TRM shipments.

Commercial Vehicle Safety Alliance (CVSA): All equipment and drivers used to transport TRM received a Level VI inspection per the Enhanced North American Inspection Standards of the Commercial Vehicle Safety Alliance (CVSA) at Chalk River before the start of every shipment and prior to departure from the U.S. port of entry. Each state a shipment passed through had the option to conduct their own CVSA Level VI inspection. Several states did exercise this option at the beginning of the shipping campaign until they gained confidence in the Level VI inspections that were conducted before a shipment left the U.S. POE.

TRM ROAD SHOW

The TRM campaign was the first time irradiated HEUNL would be shipped internationally into the United States. Most jurisdictions had little experience in providing security escorts and responding to highway incidents involving radioactive materials in large quantities. To inform and educate local community first responders, state agency points of contact, and tribal representatives, NNSA, AECL, CNL, NAC and STS teamed up to conduct a “TRM Roadshow” with these stakeholders.

The roadshow consisted of setting up a static display of an actual LWT cask, TRM canisters, and the transport truck at each of the stakeholders’ locations. The stakeholders were given the opportunity to examine and learn firsthand of all the safety measures that would be in place during the transport of the TRM through their areas. Additionally, information seminars were conducted with the stakeholders to give them an accurate understanding of the makeup of the HEUNL. Over the course of two-weeks more than a dozen roadshows were conducted along the two interstate highway routes.



Figure-3 TRM 15-gallon canister

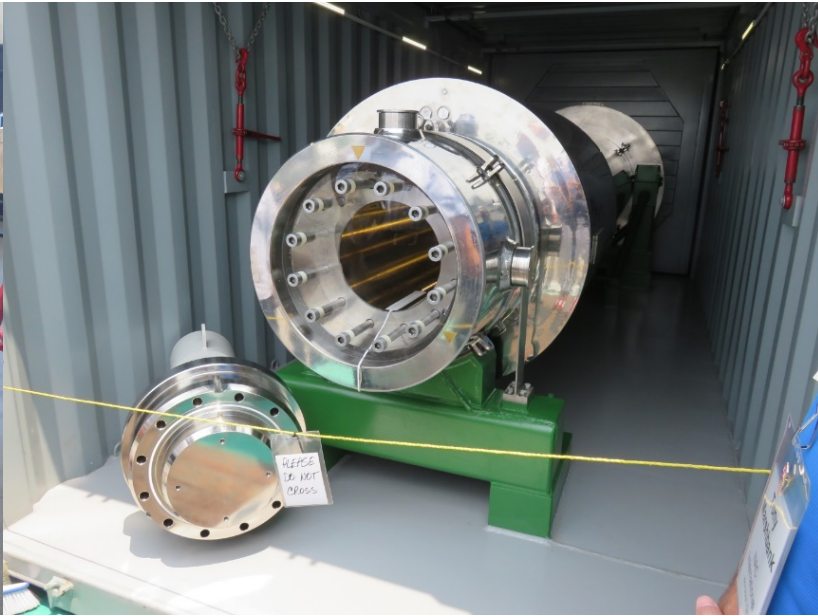


Figure-4 LWT: End view

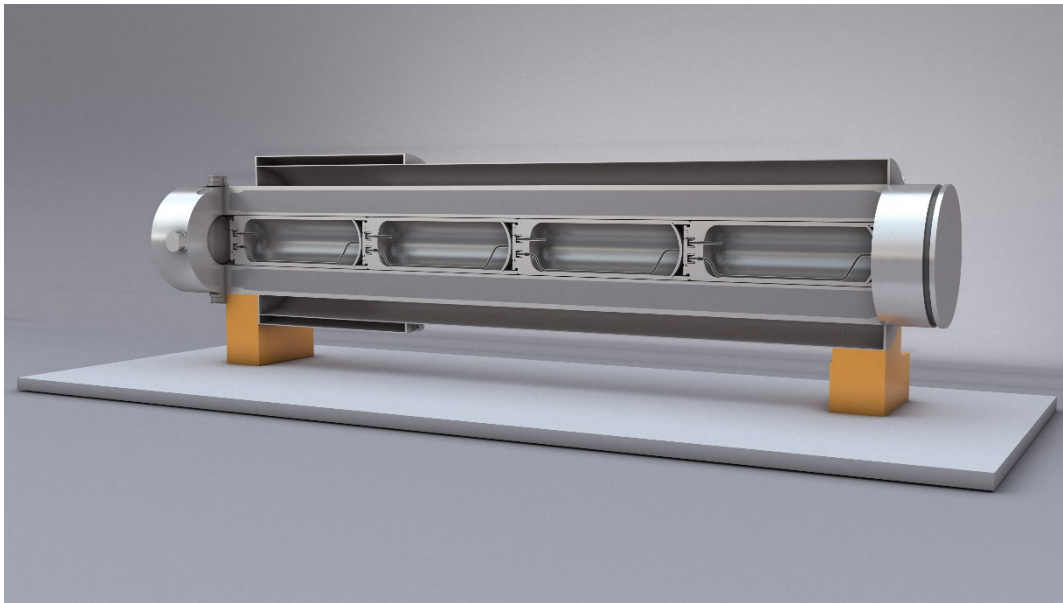


Figure-5 LWT cask with TRM canisters

TRIBAL NATIONS OUTREACH

Prior to the commencement of TRM shipments NNSA reached out to the tribal nations along the U.S. transportation corridors and conducted in person briefings with tribal leaders, including conducting a TRM Roadshow event. In addition, DOE/NNSA complied with the NRC's Advance Notification to Native American Tribes of Transportation of Certain Type of Nuclear Waste rule.

DOE/NNSA also used the National Transportation Stakeholders Forum (NTSF) to meet with the Tribal partners to share information about the TRM campaigns and extended the free Transportation Emergency Preparedness Program (TEPP) training along the highway routes to interested tribes.

FIRST RESPONDER TRAINING

DOE/NNSA provided free specialized TEPP training courses for emergency responders along the two highway routes for many years, even though the probability of an event was extremely low. A component of TEPP was the Modular Emergency Response Radiological Transportation Training (MERRTT) which provided first responders with training on the how to properly respond to a radiological incident. Over the course of the campaign, DOE/NNSA conducted more than 100 training classes in 7 states, attended by more than 2,000 participants.

SHIPMENT SCHEDULING

In January 2016 CNL and SRNS established an integrated baseline planning schedule. Shipments were scheduled in accordance with 10 CFR 73, which required written notification for the shipment to be sent to the Governor's designee in the corridor states, tribe, and the receiving facility not less than 7 days prior to the arrival of the shipment at the U.S. POE. These notifications were sent by the transportation contractor STS.

The baseline schedule was reviewed and revised on a continuing basis to reflect inclement weather, route restrictions, availability of LWT's, and scheduled outages at each site. If a planned shipment date could not be met, that shipping slot was skipped, and the next scheduled shipping date was used. This allowed the local law enforcement agencies to maintain a fixed schedule of when escort support was required for a shipment.

CONDUCTING SHIPMENTS

The TRM campaign began in April of 2017 and made quick progress with 17 shipments completed in the first 5 months. A core team of shipment planners conducted weekly calls to discuss near term shipments and to discuss long term plans for the campaign using the integrated baseline planning schedule. The TRM campaign was undertaken concurrently with a spent nuclear fuel shipment campaign from the NRU and National Research Experimental (NRU/NRX) reactors also located at Chalk River Laboratories. The NRU/NRX and TRM campaigns utilized the same cask, trucks and highway routes and were often conducted as joint shipments, moving two casks at one time, in order to streamline the campaigns and limit the impact on the corridor states and tribe.

Every shipment was tracked on DOE's TRANSCOM system and regular updates were communicated to the various security and programmatic organizations actively following its progress. Once the shipment arrived at SRS, the full cask was offloaded, and an empty cask was placed back on the truck for a return trip to Canada.

CONCLUSION

The U.S. Department of Energy, National Nuclear Security Administration and Atomic Energy of Canada, Ltd. collaborated closely to complete the removal of HEU liquid target residue material from Chalk River Laboratories in Ontario, Canada to the Savannah River Site in Aiken, South Carolina. The four-year shipping campaign involved 115 separate truck shipments and covered approximately 150,000 miles, equal to traveling around the earth six times. In the end the TRM removal team successfully completed all shipments without incident, despite loading, unloading, and shipping material year-round in all weather conditions from freezing Canadian winters to broiling southern summers in the United States. Over 161 kilograms of HEU were returned during this multi-year campaign and it marks another important step in the global effort to minimize the civilian use of HEU.