

AN OVERVIEW OF THE NUCLEAR WASTE MANAGEMENT ORGANIZATION'S TRANSPORTATION PROGRAM 2016

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Abstract

The Nuclear Waste Management Organization's (NWMO) technical transportation program is preparing to safely and securely transport 4.2 million used nuclear fuel bundles from interim storage locations in Ontario, Manitoba, Quebec and New Brunswick to one repository located within one of 4 siting regions. Road and rail modes will be used in combination to accomplish this mission beginning in 2043 and lasting for fifty years.

The NWMO technical program has three principal components: transportation-logistics, packaging and safety-risk management. This paper describes the NWMO program to plan and implement this safe and secure transportation system. To be discussed are:

Completion of road and rail system assessments and selection of primary and alternative routes within Ontario and Manitoba, Quebec and New Brunswick. Additionally, identify where intermodal transfer between modes could take place to take advantage of the positive characteristics for each mode.

Development of a multi-criteria decision analysis model (Route Logistics Analysis Tool) to compare safety and operating criteria to identify relative route performance, potential impacts and opportunities for optimization.

A safety assessment for primary and alternative road and rail routes to evaluate the transportation safety characteristics, assist in describing the impact NWMO transportation could have on the routes and provide a basis for developing future operating protocols.

Three certified Type B (U) transportation packages make up the fleet for this program, the Used Fuel Transportation Package, the Dry Storage Container-Transportation Package and the Basket Transportation Package. Improvements to the first two packages are being reviewed and tested. The third package is a new design to transport used fuel stored in AECL designed round baskets by road or rail.

Keywords: Transportation logistics, package development, safety assessment, regulatory, integrated planning and large shipping campaign

1. Introduction

The mission of the Nuclear Waste Management Organization (NWMO) is to develop and implement, collaboratively with Canadians, a management approach for the long-term care of Canada's used nuclear fuel that is socially acceptable, technically sound, environmentally responsible and economically feasible. The NWMO transportation function is divided into two program elements, the Transportation Technical Program which is responsible for defining,

planning, developing and operating a safe and secure transportation system, and an Engagement Program which is working with the public to build social acceptance for the transport of used fuel. The NWMO Engagement Program is described on NWMO's webpage at: <https://www.nwmo.ca/en/A-safe-approach/Transportation> and is the topic of a second paper being presented to the CNS conference. The NWMO Engagement Program is taking this baseline system to the public as part of its Discussion Process to identify areas where safety and security can be enhanced.

The Transportation Technical Program's mission is to define, plan, develop and operate a transportation system for the safe and secure transport of 4.2 million bundles of used nuclear fuel from seven interim storage locations in Ontario, Manitoba, Quebec and New Brunswick to a deep geologic repository. There are nine communities clustered in 4 separate regions which are participating in a learning process related to Canada's solution to the long term management of used nuclear fuel. Figure 1.

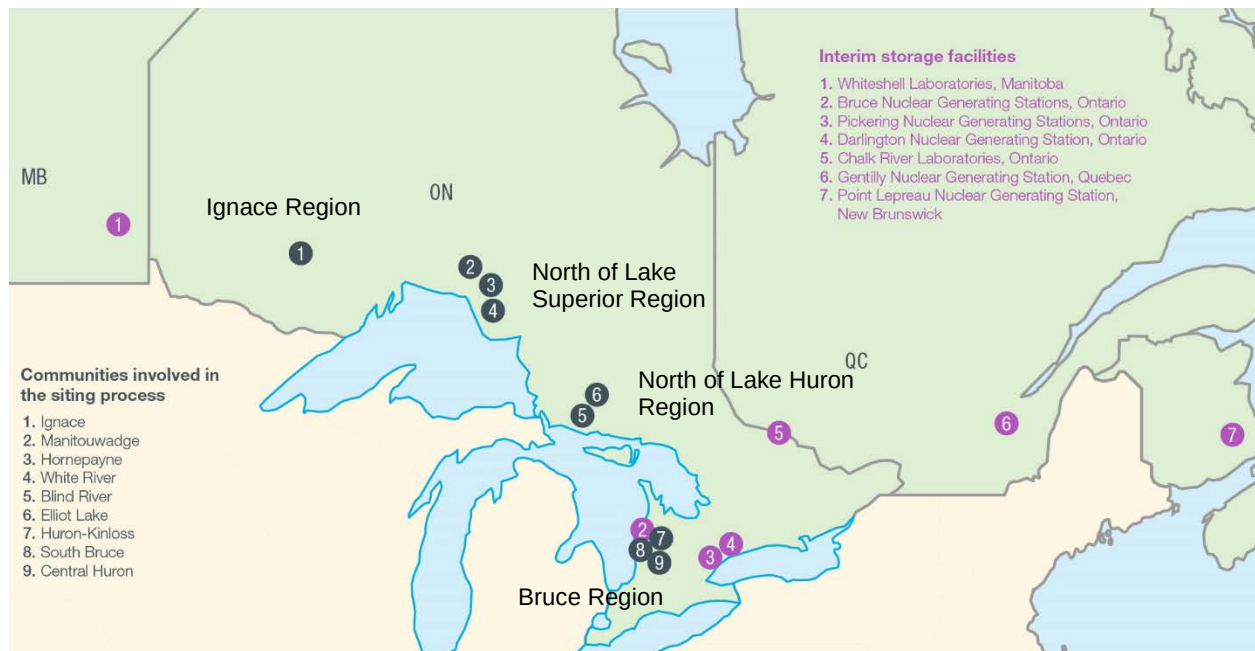


Figure 1, Points-of-Origin and Destination Sites

In 2012 NWMO assembled a technical team to develop the transportation technical program to plan, develop and operate a safe and secure transportation system. The Program's requirements come from the Canadian Nuclear Safety Commission (CNSC) Packaging and Transport of Nuclear Substances Regulations 2015 (PTNSR), the Transport Canada commercial vehicle and rail safety regulations and transport of dangerous goods regulations, and provincial highway traffic safety acts for driver qualifications and vehicle operation. These requirements provide the safety and security basis used in planning, developing and operating a used fuel transportation system.

NWMO is looking at international and North American experiences to identify the best practices for achieving these requirements and the highest level of safety. Programs, such as

those employed by Ontario Power Generation, Waste Isolation Pilot Plant Program, and Great Britain's used fuel transportation program provide examples for enhancing safety and performance. This international experience has been gained from the shipment of over 70,000 metric tons of uranium of used nuclear fuel during the past 30 years with no releases of nuclear material due to a transportation accident. (US Department of Energy).

This paper describes the Transportation Technical Program activities in support of NWMO's approach to used fuel transportation planning and how safety and security is built into all the planning, development and operating processes.

NWMO as it established the Technical Program defined 12 objectives:

- To describe the logistical system in support of the movement of used nuclear fuel from interim storage sites to a repository (including safety, security, support, maintenance and operational requirements and capital assets) in sufficient detail to prepare cost estimates, an environmental assessment and providing supporting documentation for a site construction license application.
- To identify and assess preferred and alternative road and rail routes between the seven interim storage sites and each of the four siting regions.
- To identify and design the necessary transportation equipment and facilities, including: local access infrastructure, transfer facilities and equipment, transportation packages (including the optimization of the DSC-TP, BTP and UFTP packages), trailers, vessels and rail cars.
- To maintain all licenses and certificates current for the NWMO fleet of packages and transport vehicles.
- To prepare a full transportation risk assessment, including public and worker dose assessments.
- To prepare a conceptual transportation emergency response analysis and approach for the seven point- of-origin to the four siting regions that addresses the requirements of CNSC and relevant authorities.
- To establish a conceptual approach for addressing first responder, law enforcement and emergency medical personnel risk and prepare emergency responders, law enforcement and emergency medical personnel to respond to transportation accidents involving used nuclear fuel.
- To ensure the lifecycle capital and operating costs have been quantified at a conceptual level.
- To prepare a conceptual security approach which addresses the requirements for road and rail modes and meets CNSC requirements as described in Regulatory Guide 208 and successor requirements.
- To prepare a transportation system description, development and operating plans that meet or exceed regulatory standards by relevant regulators and will serve as a basis for the environmental assessment process.
- To communicate and coordinate as appropriate with the transportation stakeholders and NWMO's Engagement and Site Selection to ensure they are informed and that all options remain available for the transport of used nuclear fuel by road, rail and water modes.

- To provide technical support to the NWMO siting team and engagement processes.

2. Elements of the NWMO Technical Transportation Program

The Technical Program established two planning timeframes based on the Repository Siting Program milestones leading to a site construction license (circa 2024) and activities leading to the testing and operation of a repository. The detailed list of project tasks are described in the Transportation Technical Program's Program Execution Plan (NWMO-PLAN-04200-0201).

Tasks supporting the site construction license application:

- Define system logistics by road and rail mode, identify primary and alternative routes, and prepare a capital asset management program
- Optimize and license transportation packaging
- Complete an assessment of transportation risks
- Develop an emergency response planning and preparation approach

Tasks to be completed prior to an application for a license to operate a repository:

- Complete security planning and preparations for submitting an application to CNSC for a license to transport
- Develop, test and implement operating practices and procedures
- Develop and implement communication and information safeguards
- Prepare a plan for worker protection and safety and conduct training
- Complete capital asset acquisition and management

3. Tasks supporting site construction license application

The technical program is currently working on those tasks to be completed prior to a site construction application and in building staff skills and capabilities. NWMO made a decision to build its internal capabilities given the continuing aging of experienced personnel in this area and the need to have a staff experience in all aspects of used fuel transportation. This approach will provide the skills necessary plan, develop and operate the NWMO transportation system well into the 21st century.

3.1. Logistics, modes, routes, equipment and infrastructure

The Technical Program as part of the Community Assessments identified existing road and rail routes accessing each of the communities involved in the NWMO siting process. Although access either exists or can be developed for each site it was evident that there was no comprehensive data base which could be used to support NWMO's logistics and routing planning. Information on road and rail logistics, infrastructure characteristics, system operations, and social, aboriginal, environmental and economic factors all had separate and unique data bases.

NWMO developed the Routing Logistics Analysis Tool (RLAT) to categorize and analyze the information and to assess potential primary and alternative routes using selected performance

and impact characteristics. The RLAT model utilizes a Multi-Criteria Decision Analysis approach to comparing different criteria, system characteristics and decision options. The system is designed to assist in identifying regulatory compliant routes, conducting social and environmental analyses.

The Technical Program is assembling available public data on road and rail routes linking the four Siting Regions with the seven points-of-origin. Data on existing road and rail infrastructure characteristics, planned improvements, logistical requirements, operating limitations, usage, traffic characteristics, accident data, environmental and social characteristics and traditional aboriginal knowledge are collected and then placed into an ArcGIS information system format.

Using the RLAT, NWMO for planning purposes identified baseline routes based on shortest route using time and distance. This baseline route complies with the safety requirement of limiting the dose received by the vehicle operators to “As Low As Reasonably Achievable.” Using the RLAT NWMO can compare routes based on such criteria as highest level of road designation available (Class A and Trans-Canada vs local streets). For rail, different classes of freight track can be selected. An additional criteria might include avoiding the use of ferries.

Routes can be subdivided into “First Mile, Primary Route Segment and Last Mile.” The First mile originates at the interim storage site and connects it to the nearest practicable access point of the Primary Route Segment. The Primary Route Segment connects the First Mile with the Last Mile and is generally the Trans-Canada for highways and transcontinental rail route for railways. This segment is often common for two or more origin/destination pairings. The Last Mile connects the Primary Route Segment to the repository (currently designated as the center of each siting region).

NWMO is updating the RLAT as new information becomes available for Ontario, Quebec, New Brunswick and Manitoba. When completed the RLAT will contain information on all primary and alternative routes between the pairings of shipping origins and destinations.

Selected preliminary outcomes from this research include:

1. All points-of-origin and Siting Regions can be accessed by road and many by rail.
2. Dry Storage Containers – Transportation Packages (DSC-TP) can be transported door-to-door by rail from Pickering and Darlington.
3. Utilizing a transfer facility approach DSC-TPs can be transported from the Bruce waste management facility to the Siting Regions thereby optimizing the comparative advantages afforded by road and rail modes. This is also true in reverse for the Last Mile serving the Siting Regions.

3.2. Optimizing Transportation Packaging

Based on the configurations for storing the CANDU fuel bundles NWMO is proposing to use a fleet of three transportation package designs, the Used Fuel Transportation Package (UFTP), the Dry Storage Container-Transportation Package (DSC-TP) and the Basket Transportation Package (BTP). The three transportation packages are shown in Figure 2. Work began early on

packaging due to the long lead times required for design, fabrication, testing and certification of Type B (U) packaging.

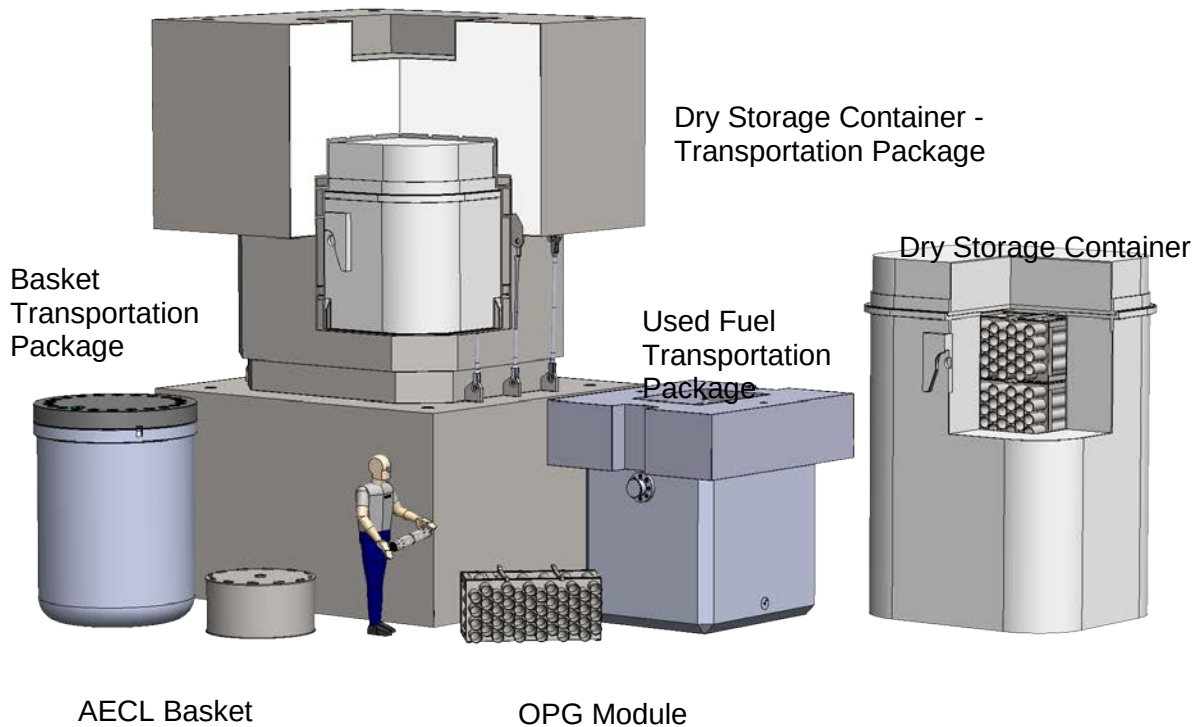


Figure 2 NWMO Transportation Packages

3.3. Used Fuel Transportation Package

The Used Fuel Transportation Package was designed by Ontario Power Generation to transport used fuel stored horizontally in modules. Each module holds 96 fuel bundles and the UFTP would transport two modules at a time.

In 2012 NWMO re-certified the UFTP with the Canadian Nuclear Safety Commission as meeting current safety standards. The performance standards are defined by the International Atomic Energy Agency in *SSR-6, Regulations for the Safe Transport of Radioactive Material, 2012 Edition*. The standards call for sequential physical testing using two drop tests and a fire test. Two water immersion tests are then used to test for water incursion and structural performance. These tests are used internationally for certifying all Type B (U) transportation packages.

The UFTP is a rectangular box which weighs 30 tonnes empty and 35 tonnes when loaded with 192 fuel bundles stored in modules. Figure 3 shows a breakout drawing of the UFTP. NWMO currently owns the design rights to the UFTP.

3.4. Dry Storage Container – Transportation Package

The Dry Storage Container is currently used by Ontario Power Generation for the interim storage of CANDU fuel after being removed from the cooling pools. The DSC - Transportation Package (DSC-TP) is essentially an over pack consisting of an inner package (the DSC), a body shield and two impact limiters (Figure 4). The two impact limiters are located at each end of the package and are constructed of steel shells filled with polyurethane foam. A steel proactive shield protects the DSC and cable rope assemblies holding the three parts together. The DSC-TP is transported in a horizontal position and is certified for rail transport (Figure 5).

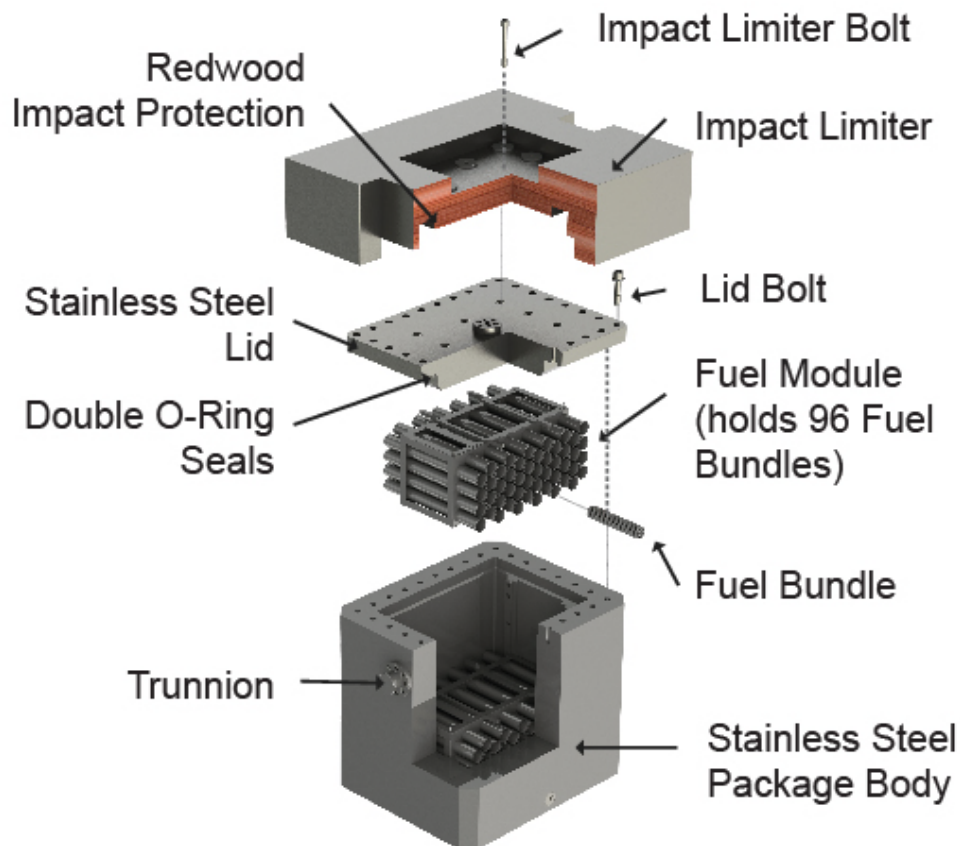


Figure 3, Used Fuel Transportation Package

The DSC can store four used fuel modules containing 384 CANDU fuel bundles. The DSC unit is made of carbon steel inner and out linings sandwiching a steel reinforce concrete body. Utilizing the DSC -TP for transport means that the container will not be opened at the interim waste management facility and will reduce the number of trips required since the DSC carrier twice the number of fuel bundles as the UFTP. This could reduce the safety risks to waste management workers and the public.

OPG owns the DSC-TP design and certification. NWMO is assessing the use of the DSC-TP and if it proves practicable would seek to acquire the rights to use the DSC-TP in 2021.

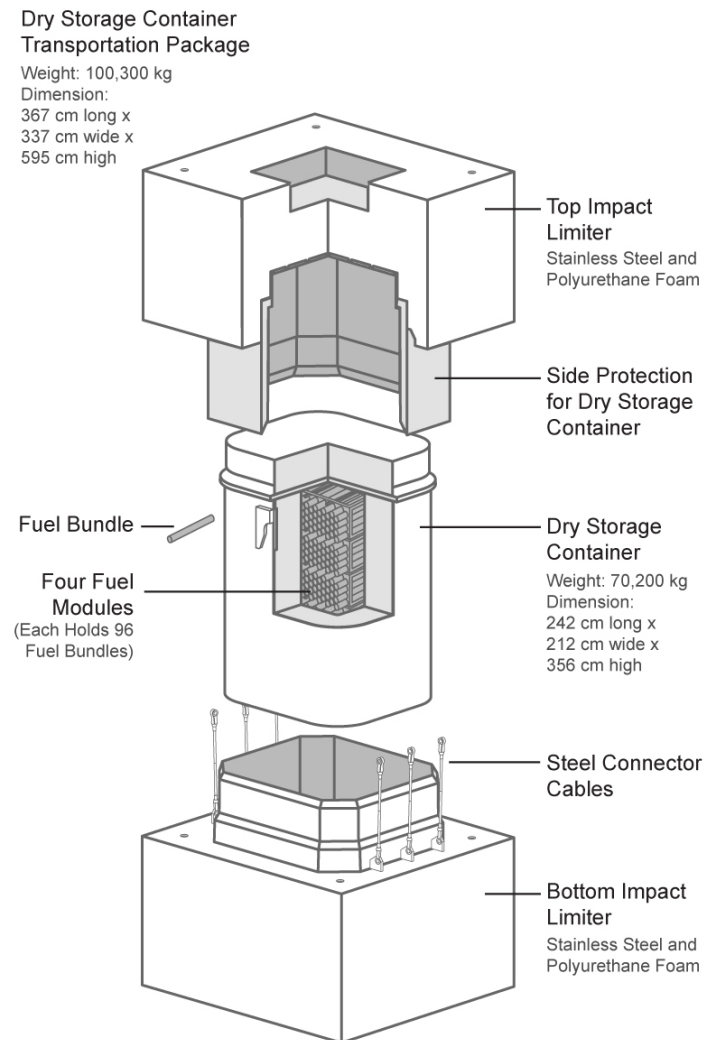


Figure 4, Dry Storage Container – Transportation Package

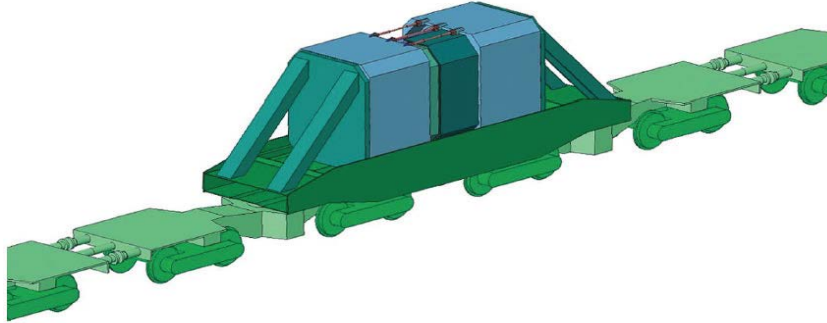


Figure 5, Stylized Picture Illustrating the DSC-TP Being Transported by Rail

3.5. Basket Transportation Package

Used CANDU fuel stored at Point Lepreau, Gentilly, and the Chalk River and Whiteshell National Laboratories use the AECL round basket configuration. The basket holds approximately 60 fuel bundles stored in a vertical position. The UFTP could be reconfigured to transport two AECL baskets in a horizontal position. For safety and efficiency reasons NWMO is designing a new transportation package, the Basket Transportation Package (BTP) specifically to carry the AECL baskets.

The BTP would carry three AECL fuel baskets. The BTP is a stainless steel cylinder weighing 20 tonnes empty and 25 tonnes when loaded Figure 6. NWMO is planning on completing testing and submit an application for certification to the CNSC in 2020. The BTP would be certified for transport by road, rail and water.

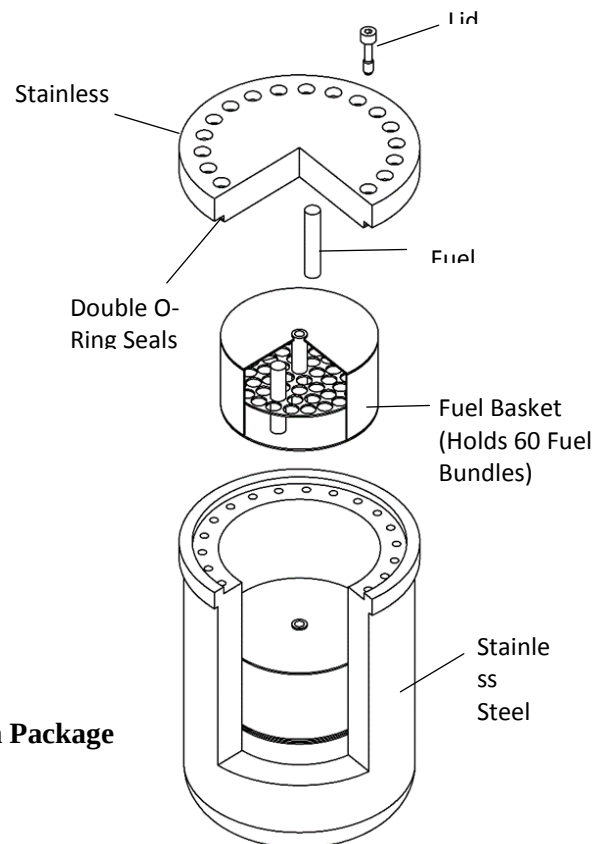


Figure 6, Basket Transportation Package (Conceptual Design)

3.6. Design, testing and certification of transport vehicles

NWMO is planning to own and operate the road and rail transport vehicles. Road trailers must meet each of the provinces' regulations and there are few uniform standards between the provinces through which NWMO will travel. The road trailer for the UFTP was originally designed by Ontario Power Generation for use solely in the province of Ontario. The basic format was used in fabricating the UFTP Exhibit Trailer which has required special permits to operate in other provinces. The current design will require optimization for both the redundant loadings and differing commercial vehicle regulations. This work is planned to be completed in 2022.

Road trailers for the BTP and the DSC-TP have not been designed. The current plan is to design the BTP trailer either as a join use trailer with the UFTP or at least to utilize the same basic design modified to incorporate the lower tied downs as a structural part of the trailer. The BTP as a cylinder would slip into a sleeve and stand up right with any required impact limiter slipped over the top.

The transport of the DSC-TP by road will require a truck and trailer designed for heavy hauling, since it weighs 100 tonnes loaded and is 3.6 meters tall. Standard designs exist for this type of unit, but it will require modifications for both the redundant application and unique features of the various provincial road systems.

Rail cars designed to carry used nuclear fuel are in use in Europe and the United States. The designs vary from standard flat cars to exclusive use cars designed around the transportation package. Given the railroads are privately owned they control the types of cars used on their systems, the testing and certification of those cars and the limitations on how those cars are moved on their system. NWMO has met the railroads, the American Association of Railroads and the Transportation Technology Center to begin the process for defining what standards will apply, the processes for design, testing and certification. The design process will begin in 2022 and is expected to require several years to reach a certified rail car. NWMO is also looking at car designs currently certified for used fuel transport to determine ownership and potential capability.

3.7. Risk assessment and dose studies

In 2012 NWMO published a *Generic Transportation Dose Assessment*(NWMO, 2012). Potential dose rates from the transport of used nuclear fuel were document using internationally accepted exposure factors. In 2014 NWMO commissioned Carleton University to drive a road route between Darlington Nuclear Generating Station and the Town of Ignace to identify exposure characteristics based on the Canadian road system.

The Carleton findings were used to prepare a *Generic Transportation Worker Dose Assessment*(NWMO, 2015) in 2015 and a Canadian specific dose assessment in 2016(NWMO, 2016). In all three assessments it was determined the dose received by the public and the transportation workers were significantly below CNSC regulatory limits.

In 2016 a transportation risk assessment was begun to determine types bounding accident scenarios representative of the types of accidents that could occur Canadian road and railways. The conditions produced during the bounding accident scenarios will be compared to package testing standards and illustrated for public education (see example: *Why the Nine Metre Drop Test Bounds the Impacts from Most Severe Accidents*, NWMO TR-2014-04, March 2014). The results of the risk assessment will be used to plan and develop the road and rail transportation systems and to prepare first responders.

3.8. Emergency response planning and preparation

NWMO in 2016 will begin the development of an emergency response approach for preparing first responders, law enforcement and emergency medical personnel using the “all hazardous approach.” The Transportation of Dangerous Goods (TDG) Act, 1992 identifies radioactive materials as Class 7 of 9 classes of dangerous goods (hazardous materials) in Canada. The approach will meet and exceed the principles identified in *CNSC HazMat Team Emergency Response Manual for Class 7 Transport Emergencies*. The initial work will review provincial and local emergency response plans to determine if Class 7 radioactive materials are addressed. Since it appears that few Class 7 shipments are made through communities a model plan section would be provided for consideration and guidance. The model plan section would be developed in cooperation with provincial governments, fire, first response, law enforcement and emergency medical professional associations.

4. Engagement support

The Transportation Technical Program provides technical support to the Siting and Engagement programs, including providing information on regulatory requirements, system development, technical plans and speakers for public meetings. The Technical Program designed and fabricated the UFTP Exhibit Trailer to demonstrate the robustness of the UFTP and the safety equipment built into the trailer.

The Technical Program prepared a public presentation demonstrating the greater forces experienced on a Type B (U) package during the regulatory drop test and those experience when a railroad locomotive strikes the package, as in the British demonstration Smash Hit (NWMO, *Why the Nine Metre Drop Test Bounds the Impacts from Most Severe Accidents*, NWMO TR-2014-04, March 2014).

To update this demonstration and to incorporate Canadian rail equipment and track NWMO is reviewing the idea of performing a second Smash Hit demonstration.

The Technical Program is currently working to model the thermal elements of the La Magentic accident which occurred in 2014. This information is being developed to answer the reoccurring question can NWMO’s transportation packages could survive a similar fire scenario. This project is scheduled to be completed in 2017 – 2018 time period.

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