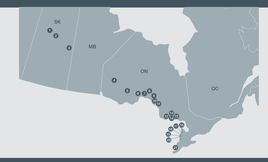
Safe and Secure Transportation of Canada's Used Nuclear Fuel

NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Introduction

This provides an overview of the transportation activities associated with Canada's plan to manage the used nuclear fuel that is created through electricity generation. The focus is on the transportation package that will help ensure the safe and secure transport of used nuclear fuel, both now and when it will be relocated to a deep geological repository. In Canada, the safe, secure movement of radioactive materials is jointly regulated by the Canadian Nuclear Safety Commission (CNSC) and Transport Canada. The Nuclear Waste Management Organization (NWMO) will need to demonstrate to regulatory authorities and citizens the safety and security of a transportation system before the shipments of used nuclear fuel can begin.

The NWMO was established in 2002 by Canada's nuclear electricity producers in accordance with the *Nuclear Fuel Waste Act (NFWA)*. Its mandate 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's responsibility includes the design and development of a transportation system for the safe, secure delivery of used nuclear fuel from current interim storage locations *(see map on the left)* to a centralized deep geological repository. Currently, the NWMO is working with 21 communities *(see map on the right)* that are interested in learning more about being a potential host for this national infrastructure project.



What is Canada's Plan?

Canada's plan for the long-term management of used nuclear fuel is called Adaptive Phased Management (APM). This Plan emerged from a three-year dialogue which engaged 18,000 Canadians across the country, including 2,500 Aboriginal people and 500 specialists. APM is specifically designed to be responsive to the expectations and values expressed by Canadians throughout the ongoing public engagement.

The NWMO's primary goal is safety – to protect people and the environment from highly radioactive used nuclear fuel. Used fuel will need to be contained and isolated from people and the environment essentially indefinitely. Planning is underway to provide safe, centralized containment and isolation of Canada's used nuclear fuel in a deep geological repository situated in a suitable rock formation.

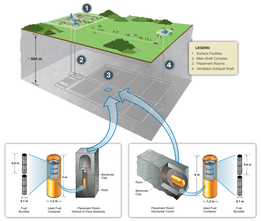
In accordance with Canada's plan, the NWMO is seeking an informed, willing community to host the facility. This facility will include the repository and a centre of expertise that will be a hub for national and international scientific collaboration.

The NWMO initiated a site selection process in May 2010 to identify a suitable location for the repository. The siting process involves extensive community engagement and technical assessments before a site is selected.

Construction and management of Canada's used nuclear fuel repository is a large, national infrastructure project that will offer jobs in the host community, region and province for many decades.

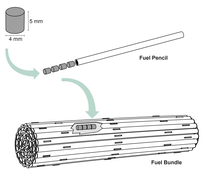
Project implementation will involve a long-term partnership among the community, the larger region in which it is located, and the NWMO. Fostering community well-being is an important part of the project.

The facility could begin operation as early as 2035. Transportation of used fuel from seven interim storage facilities to the repository will require the CNSC to issue a licence to transport used nuclear fuel and to operate the facility. For more information about APM and the project, see www.nwmo.ca/implementing_apm.



What is used nuclear fuel?

Used nuclear fuel is a by-product of the generation of electricity by nuclear power plants. It remains radioactive for a long period of time, and the material must be contained and isolated from people and the environment essentially indefinitely. Although its radioactivity decreases with time, chemical toxicity persists and the used fuel will remain a potential health risk for many hundreds of thousands of years. For this reason, used fuel requires careful management.



The nuclear fuel pellet
Fuel pellets are made from uranium dioxide powder, baked in a furnace to produce a hard, high-density ceramic. Ceramics do not readily dissolve in water and are resistant to wear and high temperatures.

The fuel pencil
Fuel pellets are contained in sealed zircaloy metal tubes, called pencils. These are welded together into a cylindrical fuel bundle.

The fuel bundle
Each bundle is composed of fuel pencils and is made of a strong, corrosion-resistant metal, called zircaloy. Fuel bundles are roughly the size of a fire log and weigh approximately 24 kilograms. The radiation hazards associated with new fuel bundles are relatively minor. Radiation dose from unirradiated fuel bundles is in the order of 0.05 mSv/h. When operational in a nuclear reactor, each fuel bundle emits sufficient electricity to power up to 100 homes for a year.

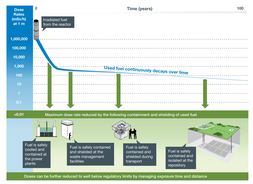
Safely managing the hazard during all phases of the nuclear fuel cycle

As shown in the illustration to the right, when used nuclear fuel is removed from a reactor, it is highly radioactive. Although the radioactivity decreases with time, used fuel will remain a potential health risk for many hundreds of thousands of years. This hazard needs to be appropriately managed.

The radioactivity of used fuel initially drops quickly once it is removed from the reactor. More than 99% of the radioactivity decays after 10 years. It continues to decay with time.

In Canada, used fuel has been safely managed for several decades in many types of nuclear facilities. At the reactor sites, fuel is safely cooled, contained and shielded in storage pools. At the interim waste management facilities, this containment and shielding is achieved using large storage containers made of concrete and steel. Both water and concrete are effective barriers to radiation. In transit, the robust transport package is designed to contain and shield the used fuel. And eventually, it will be safely contained and isolated in a deep geological repository with multiple natural and engineered barriers.

The measures used to protect people and the environment from radiation hazards are to limit exposure time, maximize distance and provide adequate shielding. These measures are incorporated into all stages of the management of used fuel, including transportation.

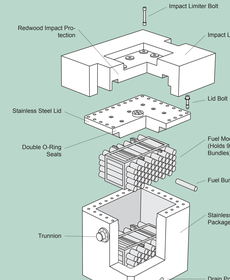


The key to ensuring safety: The used fuel transport package

The basic approach to planning and conducting a nuclear transport program is that safety is built into every element of the system, beginning with the transportation package design. The used nuclear fuel transport package is designed and tested to ensure it will protect the public during normal operations, as well as during accident conditions. The Canadian Nuclear Safety Commission (CNSC), using internationally tested standards, has the responsibility for evaluating the NWMO's transportation package and for certifying its design, the registration of individual packages, and the monitoring of the package maintenance process.

There are several used nuclear fuel transport packages certified for use in Canada, including the Used Fuel Transportation Package (UFTP) shown in the figure below. Before a transport package can be used in Canada, the design must be certified by the CNSC as meeting Canadian and international safety standards.

The current package is made of a solid stainless steel box with walls nearly 30 centimetres thick and a lid attached by 32 bolts. It has been designed to meet a series of challenging performance requirements – specified by CNSC regulations and based on international standards, to demonstrate the ability to withstand severe impact, fire and immersion in water. The package can contain 192 used fuel bundles and weighs almost 35 tonnes when loaded.



Cutaway view of used fuel transport package. The container is specifically designed to protect the public by withstanding severe accident conditions without releasing its radioactive contents.

Transport Regulations and Package Testing

The UFTP is designed specifically to contain used nuclear fuel during normal transportation and accident conditions. The CNSC uses a three-part process for ensuring this goal is met:

1. **the package design must pass four tests simulating accident conditions in order to receive a certificate for the design;**
2. **the CNSC registers users for the package; and**
3. **the CNSC issues a licence to transport.**

The certificate for the design requires that a design withstand a series of hypothetical accidents to demonstrate its ability to withstand extreme conditions without releasing its contents. The regulations *(Packaging and Transport of Nuclear Substances Regulations and IAEA Regulations for the Safe Transport of Radioactive Material)* allow computer-simulated, scale-model or full-scale-model testing to demonstrate a transportation container's suitability for certification. The scale-model test was used for the UFTP. To gauge the cumulative effects on the transportation container design, the first three tests are conducted in the following sequence:

Free-Drop Test
The UFTP was dropped from 9 metres (30 feet) onto a flat, unyielding surface (such as a steel-reinforced concrete pad), striking the surface at the container's weakest point.

Puncture Test
Second, the UFTP was subjected to a 1-metre (40-inch) free drop onto a 15-centimetre (6-inch) diameter steel bar at least 20 centimetres (8-inch) long.

Burn Test
The UFTP is then drenched with petroleum fuel and ignited, subjecting it to a temperature of 800 degrees Celsius (1,475 degrees Fahrenheit) for 30 minutes.

Immersion Tests
The only independent test is the immersion test. Using specialized analyses, a separate transportation container of the same design is subjected to external pressure equivalent to being immersed under 200 metres (650 feet) of water.

When all the requirements for design and testing are met, the CNSC issues a certificate for the package design. The certificate specifies procedures for the manufacture, operation and maintenance of the transportation container. It also defines the authorized contents which may be carried in the UFTP. The certificate is valid for five years. At the end of this period, the NWMO will have to apply for recertification and renewal of the UFTP's certification.


Free-drop test from 9 metres (30 feet) onto a flat, unyielding surface


Burn test at 800 degrees Celsius (1,475 degrees Fahrenheit) for 30 minutes

Managing risks

The NWMO has an overall objective of ensuring public health and safety while transporting used nuclear fuel from an interim storage location to the final repository site.

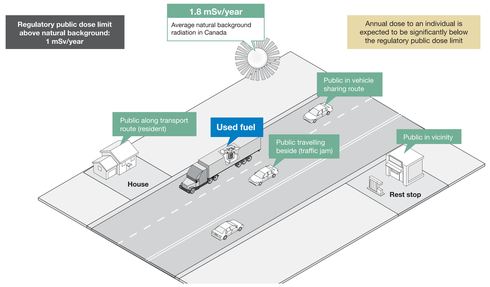
Radiation dose to the public during transportation

Radiation is found in many forms. People are exposed to natural background radiation every day from the ground, building materials, air, food, outer space (cosmic rays), and even from elements occurring naturally in the body. The CNSC *Radiation Protection Regulations* have set an annual radiation dose limit of 1 milliSievert (mSv) per year for members of the public to limit exposure from nuclear-related activities. This radiation dose is about half of the average background radiation dose received by Canadians (1.8 mSv/year).

As part of the certification and licensing process, and before any shipment of used nuclear fuel is authorized by the regulatory authorities, the NWMO will have to demonstrate that potential exposure to members of the public along the transportation routes is well below the regulatory limit (1 mSv/year). A generic study with a range of scenarios was conducted to determine the potential exposure to individuals along transportation routes.These scenarios include residents living along or in the vicinity of the transport route, persons sharing the transport route, and persons at rest stops along the route.

Based on the shielding provided by the current design of the transportation package, it is expected that the potential exposure to individuals along the transportation routes will be significantly below **(several orders of magnitude)** than the regulatory limit of 1 mSv per year.

Annual dose due to road transport



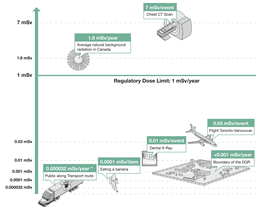
The CNSC uses epidemiology studies and the international understanding of the risks from radiation to ensure its regulations appropriately protect Canadians. Knowing what the risks are helps the CNSC and other regulatory bodies set dose limits and regulations that limit exposure to an acceptable or tolerable risk. The following table shows limits and possible health effects from radiation that guide the CNSC in establishing these limits.

Epidemiological evidence

Dose	Limit or health effect
More than 5,000 mSv	Dose which may lead to death when received all at once
1,000 mSv	Dose which may cause symptoms of radiation sickness (e.g. tiredness and nausea) if received within 24 hours
100 mSv	Lowest acute dose known to cause cancer
30–100 mSv	Radiation dose from a full-body computed axial tomography (CAT) scan
50 mSv	Annual radiation dose limit for nuclear energy workers
1.8 mSv	Average annual Canadian background dose
1 mSv	Annual public radiation dose limit
0.1–0.12 mSv	Dose from lung X-ray
0.01 mSv	Dose from dental X-ray
0.01 mSv	Average annual dose due to air travel
What is a mSv?	**A milliSievert is one thousandth of a Sievert, a unit of dose that reflects the relative biological effects of various types of radiation.**

Source: CNSC website – Radiation Health Effects
www.nuclearsafety.gc.ca/eng/readingroom/radiation/radiation_health_effects.cfm

Comparisons



* The calculated dose to a member of the public along the route is 0.000032 mSv per year for a person located at 30 m from the route experiencing all 605 shipments.

The NWMO's roles and responsibilities

The NWMO will have overall responsibility for the safe transportation of used nuclear fuel from the current interim storage locations to the selected host site for the deep geological repository. The CNSC and Transport Canada are responsible to ensure regulations are followed.

Communication

A central command centre operated by the NWMO will provide a single point of contact for all agencies involved in transportation-related communications. This will allow for quick access to shipment information, including vehicle driver location, weather, traffic and routing activities. As planned, the centre will communicate with emergency responders, Transport Canada, CANUTEC and the CNSC as required.

Communication will be in place throughout the transport of the used fuel in accordance with the Transportation Security Plan. This includes communication among the:

- Transportation command centre;
- Security escort accompanying the used fuel;
- Sites from which the shipment originated;
- Repository site; and
- All emergency response command centres of provinces through which the shipments will transit.

In the event of an incident, the transport command centre would be notified. Upon notification, the transport leader on duty would contact the emergency response command centre of the province involved.

Emergency response

2012 Emergency Response Guidebook

The NWMO will provide an emergency response plan to the CNSC, Transport Canada and the provinces, ensuring that information is correct and available to relevant public emergency response agencies. The NWMO will also assist response agencies with developing their emergency plans for used nuclear fuel, as required.

The purpose of the emergency response plan is to enhance the coordination among the NWMO, provincial and local first responders, leaders of affected communities, and federal agencies. According to the Emergency Management Framework for Canada (2nd edition – January 2011), all levels of government may be asked to participate in emergency management. Provincial governments and local administrations and authorities will be responsible for the response services. Federal organizations may provide additional resources at the request of the province/municipality.

In collaboration with the provinces, the NWMO will coordinate its planning, provide used fuel specific training, and conduct exercises along the designated routes. Exercises are a tool to train, enhance communications, and coordinate, as well as improve emergency response programs. Exercises may include full-scale, as well as desktop exercises, to evaluate the integrated performance of the system. In the interest of ensuring maximum safety in transportation incident conditions, the NWMO is committed to robust emergency preparedness with response plans and procedures being rigorously tested through multi-layered training, inter-agency communications, process and joint exercises.

In Canada, the emergency management community has adopted an all-hazards approach for responding to major disasters or emergencies, regardless of cause. Federal, provincial and local governments have adopted a comprehensive approach to emergency management, which includes balanced efforts across prevention, mitigation, preparedness, response and restoration activities. The NWMO will follow this process as it plans and prepares along routes for the shipment of used nuclear fuel.

Security considerations

The NWMO is responsible for the development of the transportation security plan. The primary purpose of the plan is to ensure that the used nuclear fuel will receive adequate physical protection against any credible threats that may arise during transport. Risks are continually reassessed by planning, preparing, exercising, evaluating and improving emergency preparedness and security plans.

Security measures are aimed at preventing diversion or sabotage of the transport package; and consist of a combination of engineered, physical and monitoring measures to protect the cargo, and provide for detection, alarm, recording and communication, in the event of an occurrence. Security provisions during transportation are designed to ensure that used fuel will receive adequate protection against credible threats and will comply with Section 5 of the *Nuclear Security Regulations* as prescribed by the CNSC.

Transportation Security Plans will be maintained current and may be subject to periodic review by the CNSC to ensure they address current threat levels.

CNSC regulations require that specific security measures be addressed for the transport of used fuel, including:

- Shipments must have a security escort and constant surveillance;
- A Transportation Security Plan for shipments of used fuel must be submitted. A plan is prepared to detail the proposed security measures and arrangements for the shipment;
- Security measures, such as escort personnel, communication arrangements to contact response services, safety inspections prior to shipment, contingency arrangements in case of delay or mechanical breakdown, and procedures to be followed during scheduled stops or unscheduled delays, must be included;
- A safety, threat and risk assessment must be carried out by competent public and private organizations in order to identify potential risks and areas for improvement, as well as possible mitigation measures, and in order to identify any credible risks; and
- The CNSC has provided guidance related to what information is to be safeguarded for the security and safety of shipments. All information pertaining to security measures and arrangements for this type of shipment is considered sensitive information and would not be disclosed to the public. Prescribed information would be provided only to persons or agencies with a valid need to know, such as police response forces.


Regulatory Guide on Transportation Security Plans for Category I, II or III Nuclear Material (G-208)

International experience

Many countries are developing plans for or are proceeding with programs for the long-term management of used nuclear fuel or radioactive materials. There is a great deal of experience, both domestically and around the world, in their safe movement.

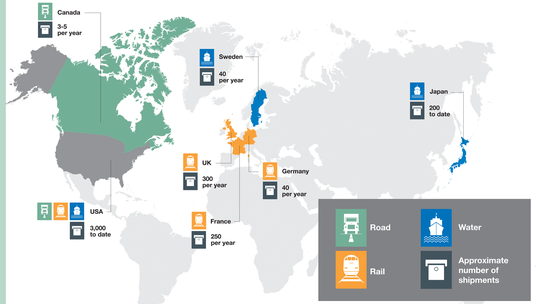
In over 45 years, internationally and in Canada, there have been no serious injuries, overexposure, fatality or environmental consequences attributable to the radioactive nature of the used nuclear fuel being transported.

Radioactive material transport is a well-established practice in Canada. Canada transports about one million packages of radioactive materials each year. Since the 1970s, Canada has transported approximately five used fuel shipments annually from nuclear generating stations to AECL's Chalk River Laboratories for research and post-irradiation examination.

Governments, regulators and commercial organizations in Canada and around the world have extensive experience in the safe, secure transportation of radioactive materials. The International Atomic Energy Agency, government agencies, and independent experts in many countries, most notably the United States, United Kingdom, Europe and Japan, have regularly examined and researched safety issues concerning radioactive substance transport.

In the United States, nearly 3,000 shipments of commercial used fuel have been moved over 2.5 million kilometres in the last 40 years,primarily over roads, and some by rail. The United Kingdom and France transport a combined average of 550 shipments of high-level radioactive waste every year, primarily by rail.

A demonstrated history of safe nuclear shipments in Canada and other countries



Summary

SAFE AND SECURE TRANSPORTATION OF USED NUCLEAR FUEL IS A PRIORITY

The transportation system is an important component of Canada's plan for the long-term management of used nuclear fuel. For a potential host location for Canada's used fuel repository to be considered technically feasible, it must be accessible by safe and secure routes for the transportation of used nuclear fuel from interim storage facilities in Canada.

TRANSPORTATION IS SUBJECT TO ROBUST REGULATION AND OVERSIGHT

Stringent regulatory requirements must be met before used nuclear fuel is transported. Transportation of used nuclear fuel is regulated by the CNSC and Transport Canada. Used nuclear fuel shipments will meet the IAEA's safeguard requirements to ensure they are secure. Transportation operations will meet federal, provincial and local safety legal requirements, and will be inspected for compliance. The NWMO will need to demonstrate to regulatory authorities the safety and security of a transportation system before the shipments of used fuel can begin.

TRANSPORTATION PLANS WILL BE DESIGNED TO REFLECT THE INTERESTS OF CITIZENS

As part of the site selection process for the used nuclear fuel repository, the NWMO will identify preferred transportation modes and potential routes associated with each interested community under consideration. Decisions regarding the appropriate transportation routes and modes will require engagement and input from all groups who are potentially affected by future transportation and have questions or concerns to be addressed in the process.

THERE IS A STRONG INTERNATIONAL TRACK RECORD IN TRANSPORTING USED NUCLEAR FUEL SAFELY

Transportation of radioactive material is a well-established practice. Over 45 years, worldwide there have been 20,000 shipments of used nuclear fuel, using road, rail and water transport. Canada has proven, and continues to demonstrate, its ability to safely transport used fuel, with hundreds of shipments made since the 1960s. Internationally and in Canada, there have been no serious injuries, overexposure, fatality or environmental consequences attributable to the radioactive nature of the used nuclear fuel being transported.