nwmo
NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Transportation

Transportation of used nuclear fuel to a centralized facility is a necessary component of implementing Adaptive Phased Management (APM) for the long-term management of Canada's used nuclear fuel. The Nuclear Waste Management Organization (NWMO) acknowledges that people have concerns about transport of used nuclear fuel. However, Canadian and international experience demonstrates that used nuclear fuel can be transported safely.

Introduction

Used nuclear fuel is currently stored at the sites of the nuclear power reactors where it is produced, and at research sites. Figure 1 shows these reactor storage sites. In addition, small amounts of fuel are present inside university research reactors in Alberta, Saskatchewan, Ontario, Québec and Nova Scotia.

The Adaptive Phased Management approach for the long-term care of used nuclear fuel will ultimately include a centralized facility for the used nuclear fuel. Transportation to this facility from the current sites will therefore be needed. Options for transportation are road, rail or water (i.e. truck, train or ship). In the case of water transport, road or rail links would be needed, in addition to docking facilities.

At present, limited amounts of used nuclear fuel are transported in Canada. However, in other countries, in particular France, the United Kingdom and Sweden, shipments of used nuclear fuel take place routinely on a large scale.

Figure 1: Current storage locations of used fuel

Canadian National Railway (CN) estimates that 10% of their traffic is dangerous goods.

Transport Canada is responsible for regulating all dangerous goods that are transported within Canada. Responsibility for the regulation of transport of radioactive material is shared with the Canadian Nuclear Safety Commission (CNSC).

Other hazardous materials, such as gasoline, chlorine and propane, are routinely transported in Canada, including transport within heavily populated areas. There are approximately 30 million shipments of dangerous goods in Canada every year. Six million tonnes of hazardous waste are transported in Canada every year by road, rail, sea and air.

Transportation Concerns

In NWMO's public consultations, many participants expressed concerns about the potential risks associated with transportation of used nuclear fuel. During transport, the used nuclear fuel is in the public domain, exposed to traffic and not on a security and access controlled nuclear site. The transport routes could potentially be close to houses and schools.

Specific concerns expressed by the participants included:

- potential for radiation exposure as a result of an accident;
- potential contamination of water supplies;
- potential general contamination resulting in environmental damage and significant clean-up costs;
- potential inadequate maintenance of road and rail facilities, especially in rural and northern areas, and the possible increased likelihood for accidents;
- perceived lack of trained personnel and equipment required for emergency response in the event of an accident; and
- perceived target for terrorists seeking to either damage the shipment or acquire the used nuclear fuel for some undesirable purpose.

In fact, the transportation safety record for used nuclear fuel shipments around the world is excellent. Transportation packages are designed to withstand severe accident conditions. Robust national and international regulations specify stringent performance and operational requirements that include package testing, training, security and emergency response.

Other relevant issues are inclusion and transparency; involvement of communities along the transportation routes during the planning process; making information on risks and system performance readily available, and providing affected communities the opportunity to influence outcomes.

To address these concerns, both dialogue with the communities as well as specific provisions in the transportation program are needed. For example, community input to the design of the system, such as transportation modes, routes, sizes and timing of shipments, is needed to address specific concerns such as routes going near heavily populated areas. In addition, the safety and risk assessment has to include the issues of interest to citizens and communities.

Experience with Transportation of Used Nuclear Fuel and Other Radioactive Materials

REGULATORY FRAMEWORK

In Canada, the movement of radioactive materials, including used nuclear fuel, other nuclear wastes, industrial radiography sources and medical isotopes, is regulated by the Transport Dangerous Goods Directorate of Transport Canada and the CNSC.

For shipment of radioactive materials, Transport Canada is primarily responsible for:

- establishing and enforcing transportation requirements for the consignors and carriers;
- establishing requirements and undertaking compliance inspections for aspects such as training and documentation;
- setting and enforcing requirements for Emergency Response Assistance Plans.

The CNSC is primarily responsible for:

- setting transportation package performance requirements;
- certification of transportation package designs;
- establishing and enforcing the radiation protection program for carriers;
- investigating in the event of a dangerous occurrence;
- all aspects of physical security measures.

Transport Canada's regulations for the transportation of dangerous goods have been adopted at the provincial and territorial levels through administrative agreements.

The design of every used nuclear fuel transportation package must be certified by the CNSC to ensure that all regulatory requirements have been met. All users of the package must be registered by the CNSC. Additionally, a License to Transport requiring pertinent security and emergency response details must be obtained from the CNSC.

TRANSPORTATION PACKAGES

Used nuclear fuel transportation packages are massive structures, providing both protection and shielding of the used nuclear fuel.

For example, the package shown in Figure 2 currently certified in Canada for used nuclear fuel transportation consists of a solid stainless steel box, with walls nearly 30 cm thick and a lid attached by 32 bolts. This cask can carry about 4 tonnes of used nuclear fuel, and the overall package weighs about 35 tonnes.

Each package design must meet a series of severe performance requirements specified by the regulations to demonstrate the ability to withstand impact, fire and immersion in water. The test requirements for normal and accident conditions of transport are shown in Table 1.

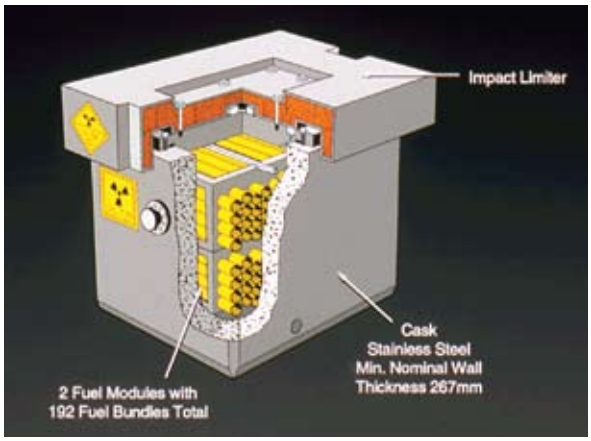

Figure 2: Transportation package licensed for used CANDU fuel

Table 1: **Test Requirements for Used Nuclear Fuel Transportation Packages**

CONDITIONS	TESTS
Normal transport conditions	» Free drop test: package is dropped 0.3 m onto an unyielding surface » Penetration test: a 6-kg bar is dropped 1 m onto the package » Stacking test: a compressive load equivalent to 5 times the mass of the package (packaging plus used fuel) is applied to the package » Water spray test: exposure to rainfall of approximately 5 cm/h for at least 1 hour
Accident transport conditions	» Free drop test: package is dropped 9 m onto an unyielding surface » Penetration test: package is dropped 1 m onto a rigid vertical bar » Thermal test: package is exposed for 30 minutes to a hydrocarbon fuel/air fire with an average temperature of 800°C » Water immersion test: package is exposed for 8 hours to a 15 m head of water

TRANSPORTATION EXPERIENCE

In Canada, about 1 million packages of radioactive materials are shipped each year. Most contain medical isotopes. Limited amounts of used nuclear fuel are transported in Canada. These have included the movement of demonstration reactor fuel to Chalk River Laboratories for storage, and the periodic movement of a few used nuclear fuel bundles each year from nuclear power stations to Chalk River Laboratories for research and examination purposes.

Transportation of radioactive materials takes place routinely around the world. Safety provisions are similar in all countries and are based on regulatory standards developed by the International Atomic Energy Agency (IAEA). The IAEA regularly reviews its model transport regulations, assessing both the adequacy of the provisions and level of compliance with the requirements. There have been no reported transport accidents with serious radiological consequences. The safety record established by the IAEA requirements over 40 years compares favourably with that of the shipment of all other hazardous materials.

It has been estimated by the IAEA that throughout the world, about 20 million shipments of radioactive material are made each year. Examples of the vehicles and equipment used for transportation of used nuclear fuel in Canada and elsewhere are shown in Figures 3 – 5.

In the United States, nearly 3,000 shipments of commercial used nuclear fuel have been transported over 2.5 million km in the last 40 years [US DOE 2005]. During that period, there were nine transport accidents involving packages of the type required for highly radioactive materials such as used nuclear fuel. In no case did any of these packages release their radioactive contents.

The United Kingdom and France transport a combined average of 650 shipments of used nuclear fuel or high-level waste per year, primarily by rail. Used nuclear fuel and high level reprocessing waste are also transported by sea between Europe and Japan, with 170 shipments in the last 30 years [PNTL 2008]. Sweden routinely ships used nuclear fuel between its nuclear power plants and interim storage facility, with 30-40 trips per year [SKB 2008].

Figure 3: Tractor-trailers for road transport of used nuclear fuel: OPG (above); Areva (right).

Figure 4: Rail car with a transportation cask used in Europe (left); the rail-to-road transfer facility near La Hague in France (below). Photos from Areva.

Figure 5: Ship for used nuclear fuel transport in Sweden (above); loading used nuclear fuel cask (right). Photos from SKB.

Serious accidents involving non-nuclear hazardous material have occurred. What if used nuclear fuel had been involved in a rail derailment or tunnel fire? Studies of 12 actual severe accidents, none involving radioactive material, showed that the integrity of used nuclear fuel casks would have been maintained if they had been present. This and similar studies have consistently shown that the levels of risk are very low regardless of whether used nuclear fuel is transported over land or by sea.

Implications for NWMO

The regulatory regime for regulation and oversight of used nuclear fuel transportation is well-established. There is practical experience in Canada and internationally. The NWMO believes that with sufficient effort, resources, preparation, oversight and continued vigilance, used nuclear fuel can be transported safely.

Technical work carried out as part of studies for the NWMO Final Study Report included examination of possible transportation systems based on road, rail or water. Because of the differing weight capabilities, the number of shipments varies between modes. In the study, road shipments were typically 192 used nuclear fuel bundles, for a payload of about 4 tonnes per truck. Rail shipments typically consisted of 10 road-weight casks, or five larger casks, per train, for a payload of about 40 tonnes. Shipments by water were typically 32 casks, or 15 larger casks, with a total payload of 128 tonnes.

For long-term management, the number of shipments of used nuclear fuel from the reactor sites to the central facility during the operating period would be:

- **Road:** about 53 road shipments/month, or
- **Rail:** about 5 rail shipments/month + about 36 road shipments/month, or
- **Water:** about 2 water shipments/month + about 36 road shipments/month.

The logistics of transportation would depend on the location of the centralized site. For some potential site locations, the options for transportation routes could be very limited, while for other locations (including most of the current storage sites), a number of alternatives might be explored. Multiple routes might be utilized. Seasonal conditions could affect the facilities needed (e.g. layover sites for use in unfavourable weather, and buffer storage facilities if shipments were made seasonally).

The NWMO acknowledges the need to demonstrate the safety of any transportation system to the satisfaction of citizens before beginning to transport used nuclear fuel to a centralized facility. APM facilitates this and includes the following considerations in designing the implementation plan:

- Monitoring of international practices, and updating the technology for transportation;
- Adopting an integrated approach to siting that includes the implications of transportation;
- Having a phased approach, which allows future generations to participate in decisions;
- Consulting interested and potentially affected communities, and developing implementation plans collaboratively, including factors such as mode, routes and rate of transportation, and emergency response training and equipment.

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