WNTI

World Nuclear Transport Institute

FACT SHEET

Quick facts on the transport of Nuclear Fuel Cycle Transport

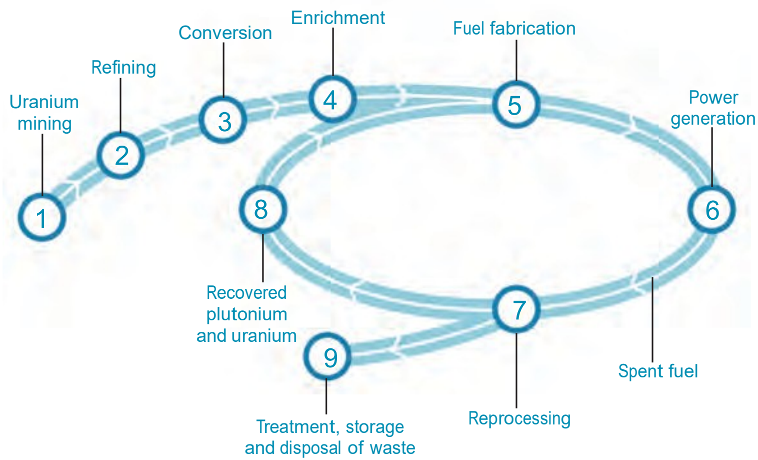
Dedicated to the safe, efficient and reliable transport of radioactive materials

Quick facts on the transport of Nuclear Fuel Cycle Transport

The nuclear fuel cycle

Today, nuclear power provides around 14% of global electricity, making affordable, clean, carbon-free energy available to people the world over. To sustain this important source of energy, it is essential that nuclear fuel cycle materials continue to be transported both safely and efficiently.

Nucear fuel cycle



The transport of nuclear materials is strictly regulated and has an outstanding safety record spanning several decades.

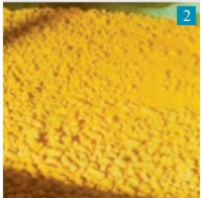
The fuel cycle can be broken down into what is generally known as the front end and back end operations.

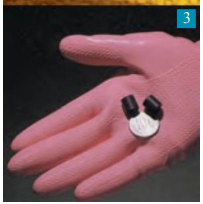
Front end operations

The front end of the nuclear fuel cycle encompasses the following operations:

- mining of uranium ore;
- conversion to uranium hexafluoride;
- enrichment;
- fuel fabrication;

  enriched uranium pressed into pellets;
  pellets assembled into fuel rods.





Fuel fabrication

A fuel pellet weighs about 10 grams and produces the equivalent energy of around 30 tonnes of coal or 20,000 litres of oil. The fuel pellets are stacked into zirconium alloy tubes that are then made up into fuel assemblies for transport from the fabrication plant to the reactor site. They are transported in specially designed robust steel packages. The design and configuration of packages during transport ensures that a nuclear chain reaction cannot occur.

Back end operations

The back end of the nuclear fuel cycle covers all the operations concerned with the spent fuel that leaves the reactors, including the shipment of spent fuel assemblies from nuclear power plants to reprocessing facilities for recycling, and the subsequent transport of the products of reprocessing. Alternatively, if the once-through option is chosen, the spent fuel is transported to temporary storage facilities pending its final disposal.

Reprocessing

Fuel used in a nuclear power plant generates electricity for about five years. After this time it becomes less efficient and needs to be replaced. The spent fuel is highly radioactive; it still contains 96% of the original uranium, but also about 3% of waste products, and 1% of plutonium. At this stage, spent fuel can either be sent for storage pending final disposal, or reprocessed to recover the uranium and plutonium.

The residual uranium can be recycled. The plutonium which is produced in the reactor is fissile, i.e. it can support a nuclear chain reaction. It can be combined with uranium to produce Mixed Oxide (MOX) fuel. The 3% of high-level waste products are transformed into a solid, insoluble glass form by a process called vitrification and returned to the country of origin for disposal.

The solid nature of back end materials – spent fuel, MOX fuel, and vitrified high-level waste – is one of the most important safety factors. The materials are characterised by long term stability and low solubility in water and would stay in a solid form after any accident.

Transport packagings for back end materials

Back end materials are transported in specially designed transport packagings, known as casks or flasks.

Casks containing nuclear materials have been safely transported internationally for over half a century. They are designed for the particular radioactive material they contain. They provide protection to people, property and the environment against radiation and are designed to withstand severe accidents.


4


5


6

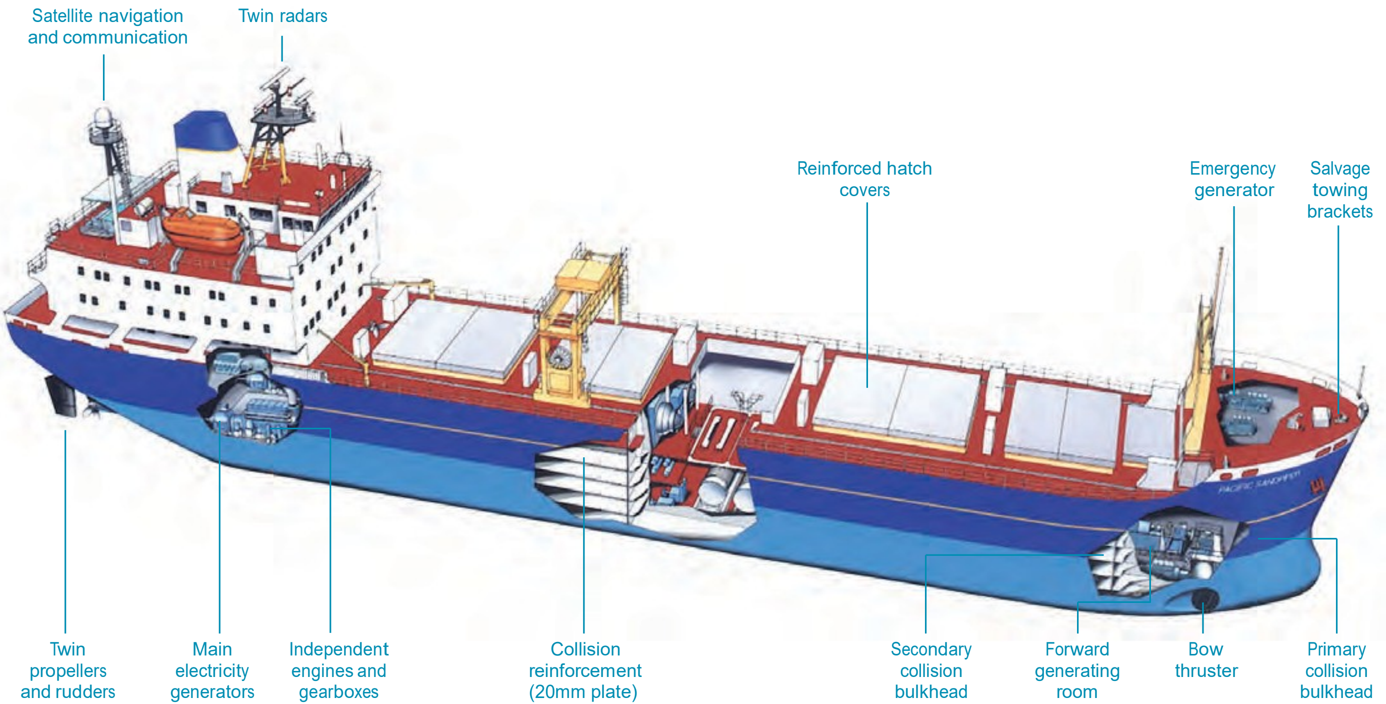
The casks are built to standards established by the International Atomic Energy Agency (IAEA). The philosophy of the regulations is that safety is ensured primarily by the special packagings no matter what mode of transport is used. The regulations cover both normal and accident conditions of transport. Under these regulations the cask design has to successfully meet a series of rigorous fire, impact and immersion tests.

- Prior to the transport cask receiving approval it must be proven that the design meets the IAEA test requirements which include:
  - a minimum of two drop tests – a 9 metre drop onto an unyielding surface and a 1 metre drop onto a steel punch bar;
  - a subsequent fire test in which the package is subjected to a fully engulfing fire of 800°C for 30 minutes;
  - an immersion test where the cask is then subjected to conditions equivalent to 15 metre submersion for 8 hours. For casks designed for the more highly radioactive materials, there is an enhanced immersion test of 200 metres for 1 hour.

After these tests the containment, shielding and criticality control must remain efficient. Once the cask design has been approved, it can be used for surface transport by truck, rail or ship.

Regulations have also been introduced for the transport of back end radioactive materials by air. The requirements for this type of packaging include additional tests to ensure that it can maintain its integrity under air accident conditions. This type of packaging has not yet been developed.

Safety features of a purpose-built vessel



Sea transport - purpose-built vessels

In 1993, the International Maritime Organization (IMO) introduced the voluntary Code for the Safe Carriage of Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes in Flasks on Board Ships (INF Code), complementing the IAEA Regulations. These complementary provisions mainly cover ship design, construction and equipment. The INF Code was adopted in 1999 and made mandatory in January 2001. It introduced advanced safety features for ships carrying spent fuel, MOX fuel and vitrified high-level waste.

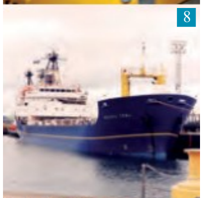
INF3 is the highest IMO safety rating for ships carrying nuclear cargoes. The safety features of these ships include:

- double hull construction around the cargo areas with impact resistant structures between hulls;
- at least two sets of safety-related equipment such as navigation, communication, cargo monitoring, electrical and cooling systems so the ship can use the second system if a fault develops;
- satellite navigation and satellite tracking so that the ship automatically transmits its position back to a manned control centre in the UK;
- extra fire detection and fire fighting equipment including a hold flooding system. All the holds could be completely flooded with the vessel remaining in a stable attitude;
- twin propellers and engines which operate entirely independently;
- powerful bow thrusters to provide greater manoeuvrability at slow speeds.

For more than 25 years, purpose-built vessels have been used to transport back end materials between Europe and Japan. The ships are owned by Pacific Nuclear Transport Limited (PNTL), a subsidiary company owned by International Nuclear Services (INS), TN International and a Japanese consortium. PNTL is the most experienced company in the world for the sea shipment of nuclear materials having covered over 5 million miles without an incident involving the release of radioactivity.

The ships typically carry a crew approximately two to three times larger than that found on chemical tankers of a similar size. Navigating and engineering officers hold certificates of competence for a higher rank than the one they serve.

All PNTL ships meet the international standards and requirements of the IMO, and comply with the requirements of the relevant competent authorities.



The future

In 2009, PNTL had the first delivery of a second generation purpose-built vessel, with delivery of two further similar vessels in 2011. They replaced three vessels from the previous fleet which were decommissioned and recycled, continuing the service PNTL offers between Japan and Europe.

Emergency response

Sea transport operations are carried out according to applicable international regulations. A full worldwide emergency response system is operated, including a 24-hour standby team and salvage cover. In the event of a serious incident, this team would be dispatched to the ship and would direct and manage all remedial operations.

In the unlikely event of the loss of a PNTL ship, the emergency team is equipped with a sonar search system for locating the vessel. All the vessels are fitted with a sonar location system capable of automatic operation in depths of water in excess of 6,000 metres and with a range of up to 20 km. The sonar can relay back vital information on the status of the vessel, including:

- the depth and angle of the vessel;
- whether the vessel is distorted or broken;
- whether the hatch covers are in place;
- what the radiation level is in each hold;
- the temperature.

The equipment is self-powered by high-grade lithium batteries with a working life of over seven years.

Emergency response exercises are a requirement of international radioactive material transport regulations and form an essential part of any contingency planning system. Regular exercises are carried out to test the communication systems, the expertise of team members and ships' crews as well as the performance of the emergency equipment. These exercises involve the call out of trained and qualified personnel (e.g. health physics and engineering), their transport to the incident scene and the necessary remedial actions to resolve a simulated radiological cask incident.

Security

For transports of nuclear material, security is a top priority. Shipments must comply with State requirements, as well as the physical protection measures developed by the IAEA, and the security requirements of the IMO.

Environmental

The transport system for these shipments involves a series of independent barriers – solid cargoes, casks, ships - between the material and the environment ensuring a high level of safety.

Several well-supported studies have concluded that even in the event of a cask being damaged in a maritime accident, the level of effect to the public or the environment would be insignificant compared to natural background radiation.

IAEA Transport Safety Appraisal Service (TranSaS)

In June 2002, a TranSaS appraisal of the UK's implementation of the IAEA Regulations identified 15 areas of good practice that can serve as a model for other competent authorities with special reference to maritime transport. The same appraisal took place with similar results in France in 2004, and in Japan in 2005.

Industry experience

The international transport of nuclear fuel cycle materials has played an essential role in bringing the benefits of nuclear power to people the world over. These transports have supported all stages of the nuclear fuel cycle including uranium mining, fuel manufacture, reprocessing, spent fuel management and waste storage. The safety record of nuclear transport is impressive; in over half a century there has never been a single transport incident which has resulted in significant radiological damage to mankind or the environment. This is due in part to the strict regulatory regime, but credit is due also to the professionalism of those entities performing packaging and transport activities.

Photographs

1 Uranium ore – raw material
2 Uranium ore processed and turned into powder – 'yellowcake'
3 Fuel pellets
4 Purpose-built vessel
5 Spent fuel cask
6 Sea transport of vitrified high-level waste
7 MOX fuel cask
8 Purpose-built vessel, Barrow Port, UK
9 Unloading operations

World Nuclear Transport Institute

Remo House
310-312 Regent Street
London W1B 3AX
United Kingdom
Tel: +44 (0)20 7580 1144
Fax: +44 (0)20 7580 5365
Web: www.wnti.co.uk
Email: wnti@wnti.co.uk

FS6_EN_MAR13_V2