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Fact Sheet

Safe Transport of Uranium Ore Concentrates

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Introduction

The World Nuclear Transport Institute (WNTI) is a Non-Governmental Organisation (NGO) that represents the radioactive materials transport industry, focusing on the needs of its members. One of the ways WNTI does this is via its Observer Status role at the International Atomic Energy Agency (IAEA). At the IAEA, WNTI actively participates in discussions on the content and meaning of the radioactive materials transport regulations, contributes to the development of IAEA Guidance documents, and helps develop IAEA Technical Reports. WNTI has Consultative status at the International Maritime Organisation (IMO) where is it the only NGO recognised as being an industry expert in radioactive material transports. The WNTI is also a Category A Liaison Organization to the International Organization for Standardization (ISO) delivering industry's opinions on various issues.

Whenever necessary, WNTI utilizes its extensive network of contacts to act on behalf of its membership to represent and advocate with the appropriate and applicable involved industry groups and regulators. WNTI endeavours to achieve resolution and suitable outcomes to various issues that affect those parties. The need for and subsequent development of this information sheet has resulted from one of those issues raised by its members.

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What is Uranium

Uranium is a naturally occurring element that is as common as tin, tungsten and molybdenum. Uranium is about forty (40) times as common as silver and five hundred (500) times more common than gold.

Uranium contributes to what is termed natural background radiation. Trace amounts of uranium occur in almost everything, living or otherwise. Found in rocks, soil, stream sediments, rivers and oceans; traces of uranium can also be found in food as well as in tissues within in the human body. A number of areas around the world have concentration levels of uranium within the ground that make it economically feasible to extract and process into Uranium Ore Concentrates (UOC), the raw feed material for the nuclear fuel cycle.

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Is Uranium hazardous?

Uranium is a radioactive material in its natural form consisting of a mixture largely of two isotopes, 99.3% 238-U and 0.7% 235-U by mass. The predominant 238-U isotope component decays very slowly, its half-life being equal to the age of the earth. The 238-U isotope is deemed to be non-fissile.

The 235-U isotope has a half-life one sixth of the 238-U isotope, and emits gamma rays as well as alpha particles. The smaller 235-U isotope component is the only naturally occurring isotope capable of sustaining a nuclear fission reaction yielding a lot of energy. The 235-U isotope component is therefore termed as being 'fissile', however it is not 'fissile' at concentrations found in nature.

Uranium is a heavy metal being the last naturally occurring element in the periodic table. Like any heavy metal including cadmium, manganese, lead, mercury and the broad range of radioactive metals, uranium is chemically toxic in sufficient quantities. However, the handling of uranium metal with the use of gloves will provide adequate protection from external radiation and good work and hygiene practices can protect against intakes of material.

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Uranium Ore Concentrate

The uranium ore (broken rock) is initially crushed, ground down and milled into a fine powder, then treated through a series of metallurgical processes to a point whereby the uranium is chemically separated from the treated ore using ammonia to form Ammonium Diuranate (ADU) in the form of yellow “cake” (sludge). An alternative method for extracting uranium from permeable orebodies (i.e. sands) is the In-Situ Leaching (ISL) method, whereby liquid is injected in the ore in order to dissolve and extract the uranium. The yellowcake is then either heated to around 650°C in a calcination process, forming U_3O_8, a dark green to greyish brown coloured powder. Alternately it can be dried to around 400°C, forming UO_3, a yellowish to orange powder.

The UOC is packaged into drums in powder form to be shipped to fuel conversion facilities in various countries around the world for further processing.

Uranium Ore Concentrate (UOC) is considered a “low level radioactive material” which means that it emits only small amounts of radiation at any given time, thereby presenting only a minor radiation hazard. UOC is non-flammable, it is non-explosive and more importantly, under normal conditions, UOC cannot trigger a nuclear reaction.

UOC possesses similar characteristics to any metallic concentrate (e.g. Lead, Zinc or Copper). However, due to its natural radioactivity, it should be handled and contained in a manner so as to protect people and the environment from inhalation, ingestion and the possibility of exposure from external radiation.

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Uses of UOC

While almost all uranium mined and processed today is used to produce electricity, small quantities are also used for other purposes. UOC has also been used in the past for glass colouring. Furthermore uranium which has been processed can be used in household smoke detectors and more importantly in producing other radioactive materials used for such purposes as nuclear medicine.

Depleted uranium (generated as a result of the UF_6 enrichment process) is used for specialised ballast applications (in the keels of yachts) and in medical radiation therapy machines for shielding from gamma rays etc.

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The front end of the Nuclear Fuel Cycle (NFC)

The front end of the NFC consists of Mining, Milling, Conversion, Enrichment and Fuel Fabrication.

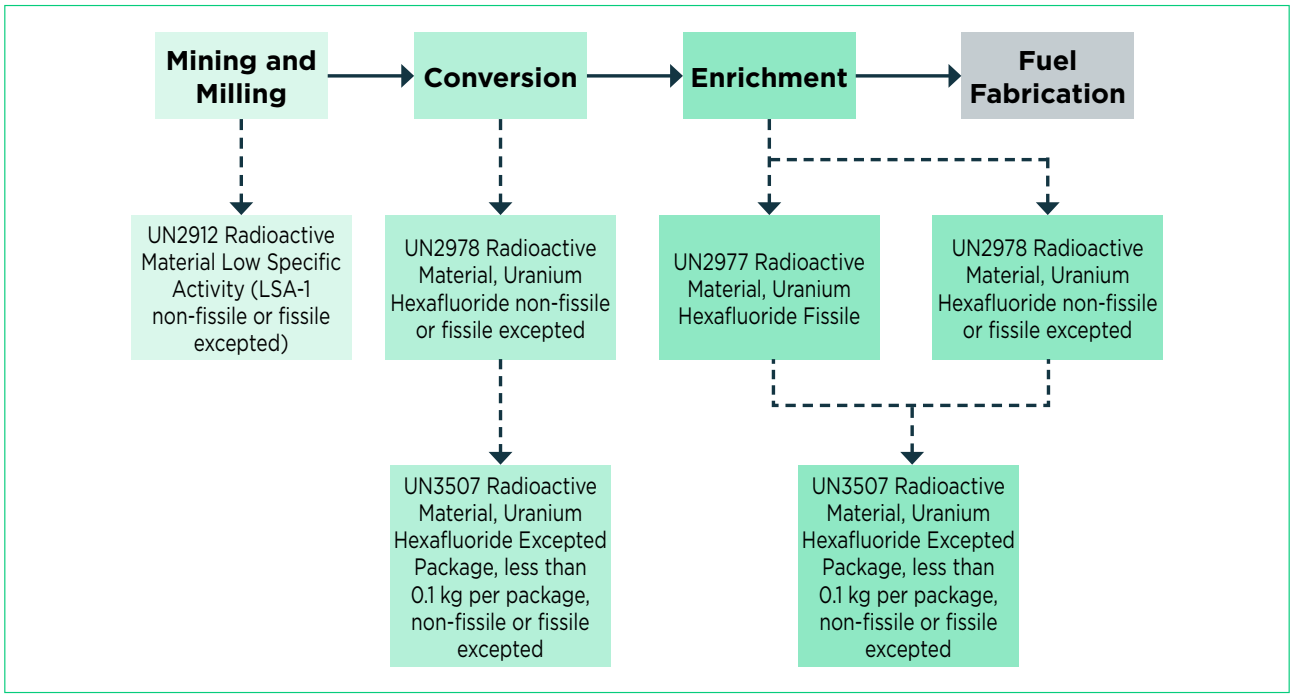

Figure 1: *The front end of the Nuclear Fuel Cycle*

The United Nations Recommendations on the Transport of Dangerous Goods, Model Regulations classifies the following materials with these specific UN numbers and proper shipping names:

- UN2912, RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-I), non-fissile or fissile-excepted
- Natural UF_6, UN2978, RADIOACTIVE MATERIAL, URANIUM HEXAFLUORIDE, non-fissile or fissile-excepted
- Fissile UF_6, UN2977 RADIOACTIVE MATERIAL, URANIUM HEXAFLUORIDE, FISSILE
- UN3507 URANIUM HEXAFLOURIDE, RADIOACTIVE MATERIAL, EXCEPTED PACKAGE, less than 0.1 kg per package, non-fissile or fissile excepted

After milling, the UOC needs to be converted into UF_6 at a licenced conversion facility. Here, the UOC, which is classified for transport as UN2912, RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-I), non-fissile, a naturally occurring radioactive material, is converted into UF_6, classified as UN2978 RADIOACTIVE MATERIAL, URANIUM HEXAFLUORIDE, non-fissile. UF_6 is a solid, liquid or gaseous natural uranium material, depending on the temperature and pressure, and is comprised of the 99.3% 238-U (non-fissile material) and 0.7% 235-U (fissile material) by mass.

The UF_6 then needs to undergo enrichment at an approved licenced facility, whereby the UF_6 is passed through a cascade of centrifuges or membranes in order to concentrate the U_{235} component of the UF_6 above its natural level.

The natural UF_6 is transported as a solid (UN2978) to a facility where it is enriched by means of centrifuges that concentrate the 235-U isotope component producing enriched (fissile) UF6.
The residual 238-U isotope with 235-U component below its natural level is classified as depleted uranium.

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Why the need for transport?

Uranium deposits are typically not located close to or nearby the other parts of the fuel chain, resulting in the need for safe, secure, effective and efficient transport.

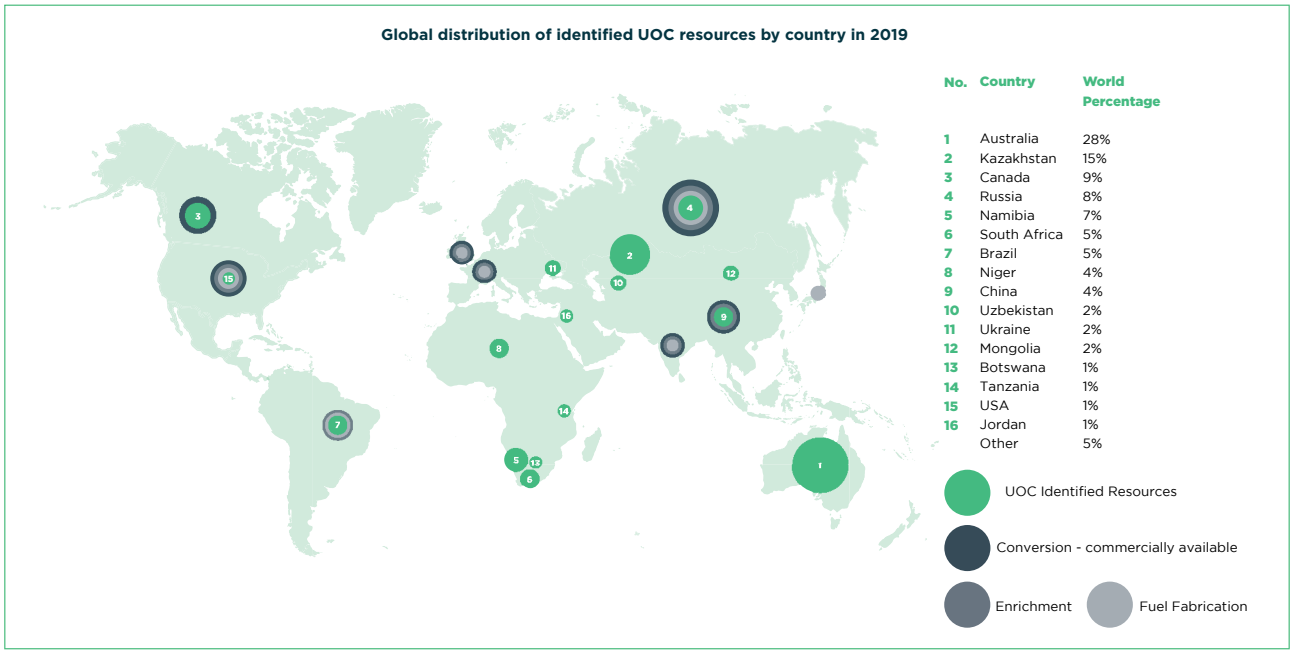

Figure 2: *Location of uranium deposits in relationship to other parts of the fuel chain.*

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The transport of UOC is a highly regulated activity across all Modes of Transport

UOC is safely transported worldwide by road, rail, sea, and air involving a structured, highly regulated and well-practiced activity. The maritime transport of UOC is regulated at the international level by the International Atomic Energy Agency (IAEA) via the IAEA Transport Regulations and the International Maritime Organisation (IMO) through the International Maritime Dangerous Goods (IMDG) Code, which incorporates the IAEA Transport Regulations. The movements of UOC by road, rail transport or inland waterways are regulated by the appointed government authority of the country in or through which the UOC is being transported. As for all dangerous goods that are shipped using maritime transport, a multi-modal dangerous goods form must be completed for each shipping container of UOC.

Radioactive materials are frequently transported by air, mainly for medical and industrial purposes, whereby the IAEA Transport Regulations (as per above) form the basis for instructions governing the transport of radioactive materials issued by the International Civil Aviation Organisation (ICAO). When UOC is transported by air it is generally in the form of small packages containing samples for testing and or analytical purposes.

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UOC is classified as being a Dangerous Good (Hazardous Material)

Under the United Nations (UN) international standards, all dangerous goods and hazardous materials fall into one of nine hazard classes. Class 7 covers radioactive materials such as UOC. For radioactive material, the IAEA Transport Regulations have established standards for safe transport and security, which have been adopted into international, modal and national regulations. These regulations are designed to protect people, the environment and property from the effects of radiation during transport.

The IAEA considers that transport comprises and encompasses all operations and conditions associated with and involved in the movement of radioactive material, including:

- the design, manufacture, maintenance and repair of packaging and packages,
- the preparation of the packages, consigning, securing within the shipping container, the carriage of the cargo including any in-transit storage
- the receiving and unloading of the radioactive material cargo at the final destination.

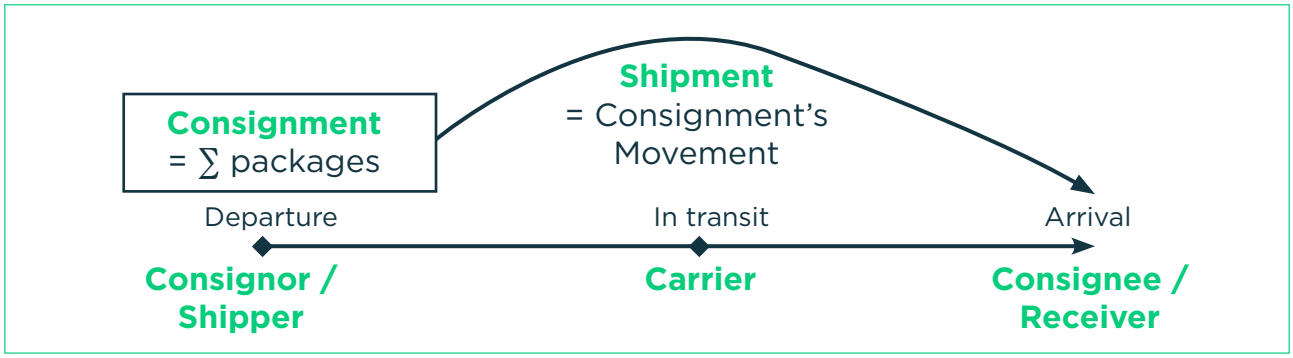

Figure 3: *The IAEA view of transport*

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Packaging and Shipping Containers

The packaging used for transporting any form of radioactive material must meet international standards. UOC is generally transported in sealed steel drums with tight-fitting lids meeting UN design requirements for stowage, handling, and package integrity. The drums of UOC are securely stowed inside general purpose shipping containers to prevent movement or load shifting during handling or transport activities. All shipping containers must be compliant with the international Convention for Safe Containers (CSC).

Figure 4: *Drums securely packed within a container*

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Markings, labels and Placards

Markings, labels and placards are an effective internationally recognised means of communicating information about radioactive materials that are being transported by road, rail, sea or air transport.

They provide important safety-related information indicating that there may be some danger and the need to take some precautions. Additionally, they contain hazard information (e.g. Class 7 or Radioactive), necessary for workers and public to be able to identify the precise hazards including the category and classification of the radiation hazard, providing indicative radiation levels likely to be encountered at the surface of or a 1 metre from the package.

UOC shipping containers must be labelled and placarded in accordance with the International Maritime Dangerous Goods (IMDG) Code.

Figure 5: *UN2912 Placard*

Figure 5a: *UN2912 Label with Marking*

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Shipping and Transport Documentation

The IAEA and IMO through the IMDG code sets out specific detailed mandatory information that must be declared on the Multimodal DG form, including a legally enforceable Shippers Declaration signed by the person having responsibility for packing the shipping container.

In addition to the mandatory requirements, it is recommended to include a copy of the Delivery Manifest (sometimes referred as a Packing List) relating to the cargo.

In overall terms, UOC is a fully declared, predictable, unitized cargo having a regular standardised documentation format, and reliable weights that ensure the Gross Container Weight (GCW) mass per container is being shipped in full accordance with all international standards and requirements.

Figure 5b: *Container (labels and placards)*

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What Are the Risks regarding Radiation and Contamination?

Packaged in steel drums, UOC will not present a health hazard to people handling or otherwise coming into contact with it. Due to its slight chemical toxicity, UOC can be harmful if inhaled or ingested. Skin contact should be avoided, and as with all powdered chemicals practicing personal hygiene habits such as washing of hands, not smoking and minimising the likelihood for exposure to dust are most important.

The low but measurable levels of radiation emitted from a drum or shipping container of UOC will not cause people or objects to become radioactive, just as receiving a dental or chest X-ray does not make a person radioactive.

Reducing exposure to radiation to an 'As Low As Reasonably Achievable' (ALARA) level should always be the objective. Everyone on the planet is exposed to some amount of natural background radiation from the sky, rocks, soil, food, commercial products, etc., as well as from medical procedures like x-rays. A US study[1] has placed some perspective on some of the health risks people impose on themselves through everyday lifestyles in comparison with those of background radiation. Generally background radiation is 2 or 3 times higher than doses allowed to the public from use of radioactive materials.

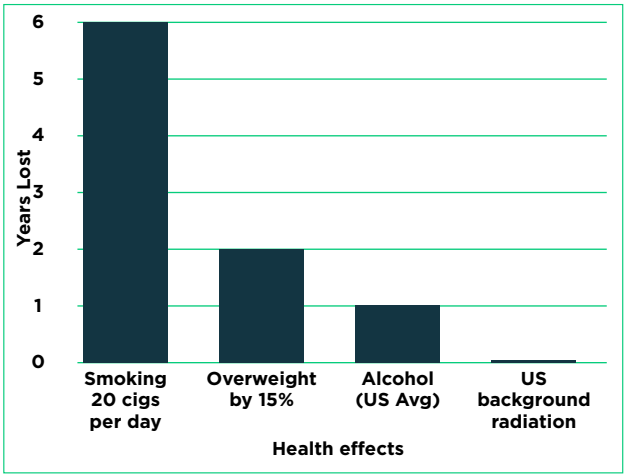

Figure 6: *Impact of lifestyle on life expectancy*

In the normal course of events, the total time involved in handling or transporting a shipping container of UOC, combined with the low levels of radiation emitted by the UOC itself, dramatically reduces the probability of receiving any significant exposure from the material. Indeed, exposure from this source is well below all regulatory limits for transport workers and does not contribute in any measurable way to the background doses received by non-transport workers.

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Protecting Your Health and Safety

As with any other dangerous good, the time and distance spent working around either a drum or shipping container of UOC should be optimized. Routine handling will not put anyone at risk of exceeding any regulatory limit for radiation exposure. In general, the necessary safety precautions are similar to those that should be employed when handling other dangerous goods in powder form.

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In the Unlikely Event of an Emergency

In the unlikely event that any leakage or spillage of UOC from either a drum or shipping container does occur, the main health consideration should be to prevent anyone from inhaling or ingesting any dust. The likelihood of this occurring is low due to the high density of the material, the drum packaging and secure stowage methods employed within the packed container.

There are several simple actions that need to be taken after the initial discovery of any leakage or spillage of UOC from either a drum or shipping container until the arrival of an emergency response team:

- mark and secure the area to prevent access by unauthorised personnel or other traffic. This will also help to prevent the spread of contamination,
- immediately locate shipping documentation and call the emergency response number to ensure the emergency response system has been activated,
- avoid contact with the spilt material as with any other dangerous goods,
- practice good personal hygiene by washing hands and avoiding smoking or eating in the affected area,
- stay upwind to avoid any wind-blown particles. It is important to cover manholes or grates and when feasible divert UOC from water bodies,
- leave potentially contaminated items (i.e. personal protective equipment) at the scene and dispose of them in accordance with the instructions of the emergency response team or the requirements of the appropriate regulatory authority.

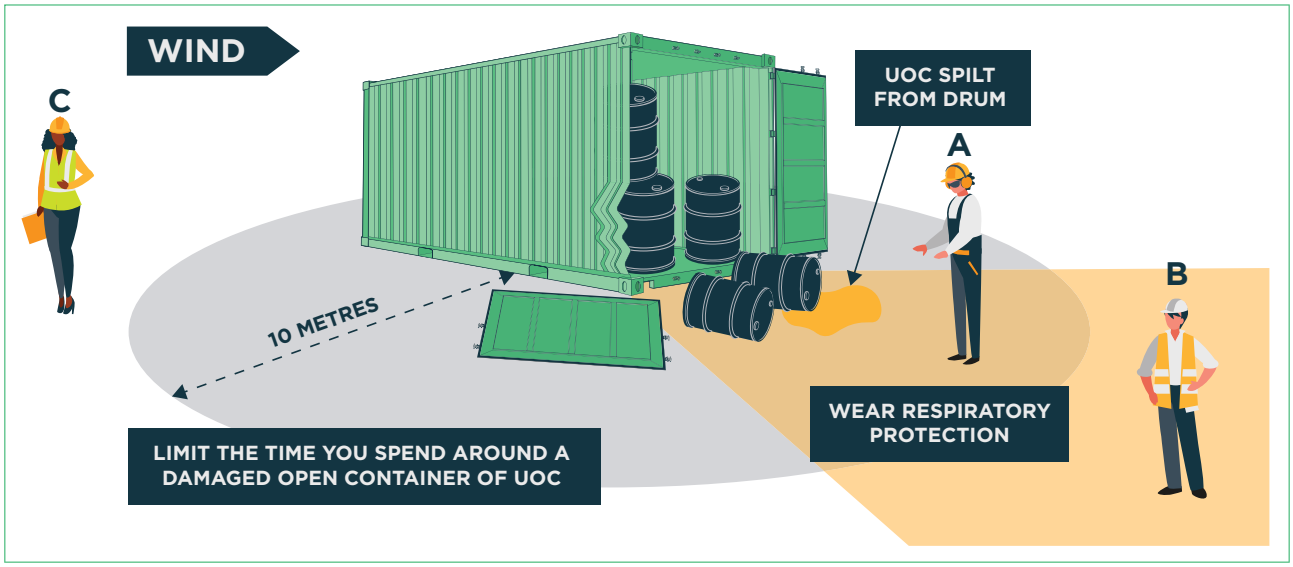

Figure 7: *Emergency Response*

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Incidents do happen

As is the case with any type of cargo, incidents involving the transport of radioactive material can occur. However, on the rare occasions that they do occur, the consequences have had minimal, if any, effect on members of the public, the community or the environment. Such outcomes reflect the effectiveness of the adoption of and application of the approach taken by the IAEA when setting the regulatory standards covering the transport of radioactive material.

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Conclusion

Each day thousands of shipments of radioactive materials of all kinds ranging from smoke detectors, cobalt sources for medical and industrial uses, to material such as UOC being associated with the nuclear fuel cycle for electricity generation are transported by road, rail, sea, air and inland waterways utilising international and national routes. The safety of such shipments is ensured by a stringent regulatory regime utilising a broad range of safety measures that have been developed to protect people, property and the environment against the potential hazards that could be posed by the cargoes. The safe transport of radioactive material is highly regulated on an international, national and regional basis through the implementation and application of a broad range of regulations that are well respected, understood and practiced by industry.

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Further reading

Further and more detailed information regarding the packaging and transport of UOC can be found within the WNTI Standard for Packaging and Transport of Uranium Concentrates Version 3.

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[i] Idaho State University, Radiation Network's 'Radiation and Risk', [www.physics.isu.edu/radinf/risk.htm]

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The WNTI offers the use of this fact sheet freely to members and non-members of the transport community. Where any interpretation of the information has been made, it has been done so with the interests of the wider transport community. Although the Fact Sheet has been extensively reviewed by industry experts, if you have any issues in use or content, please contact the WNTI so we can rectify the issues and conflicts in systems etc.

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