The experience of WNTI with Safety and Security Worldwide

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Abstract

This paper gives an industrial perspective on safety and security issues based on the experience of WNTI members.

It describes how safety is invested primarily in the package; not how the package is transported. Transport safety is therefore an engineering challenge, and all necessary technical information is available to enable this to be met.

Security in transport involves various measures to guard against intentional malicious acts. The paper describes the international instruments relevant to security in the transport of nuclear fuel cycle materials and how both safety and security regulations must be coordinated and simplified to avoid conflicts.

It considers potential risks, which must not be underestimated. However, the assessment of risks must be realistic and quantified, and the requirements placed on the industry appropriate. It is important to dispel exaggerated perceptions of danger in the minds of the public, politicians and regulators.

1. Introduction

The World Nuclear Transport Institute (WNTI) was formed in 1998 and comprises over 50 member companies covering all aspects of radioactive material packaging and transport. This paper gives an industrial perspective on safety and security issues based on the experience of its members gained over the past 13 years.

Nuclear fuel cycle materials come in a variety of chemical and physical forms and the potential safety and security hazards differ widely. It is important to keep these factors into account so that appropriate measures to ensure both safety and security can be implemented without imposing unnecessary operational and financial burdens on the transport industry. The main features of nuclear fuel cycle materials are as follows:

Uranium ore concentrate (UOC) is a material of low radioactivity and it does not present a large radiological hazard. There is a minor risk due to the toxicity of the powder if it is released and is ingested. In this respect, UOC is no different from many heavy metal compounds.

Uranium hexafluoride (Hex) also is a low specific activity material and the radiological risk from natural and depleted material is not great. However, there are hazards due primarily to the chemical toxicity. Enriched Hex is fissile and presents a potential criticality risk but, as it is with any packaging and transport of radioactive materials, this is prevented by the design of the package and the configuration of the packages during transport.

Uranium dioxide powder (UO_2), typically of less than 5% enrichment for the manufacture of new uranium fuel elements, is also classified as low specific activity material. The primary hazard is radiological in the event of a criticality incident. This is again prevented by the design of the package.

Uranium fuel assemblies typically consist of sintered ceramic UO2 pellets formed into assemblies. The fuel is refractory, stable and the radiological hazard is low. The design and configuration of the packages during transport ensures that criticality excursions could not occur.

Spent fuel and vitrified high-level wastes (VHLW*)* from reprocessing are intensely radioactive and need to be heavily shielded. However, they are inherently stable and refractory and difficult to disperse. These materials present a radiological risk. For spent fuel, criticality should also be considered. Other risks are negligible.

Mixed oxide fuel (MOX) fuel elements contain sintered uranium/plutonium oxide ceramic pellets and are very similar to uranium fuel elements. Due to the fact that MOX is transported in a Type B(U) package, the radiological hazard is not great except in the event of a criticality excursion and this is controlled in the same way as for enriched uranium fuel.

Plutonium's transport risks are due to toxicity if it is dispersed and ingested and criticality. They are controlled by the type and design of the package. When plutonium is transported as MOX, a stable refractory ceramic, it is not easily dispersed.

2. Safety in Nuclear Fuel Cycle Material Transport

Safety is vested primarily in the properties of the package and not in the manner in which the package is handled during transport. Safety standards for packages for the transport of radioactive materials are included in the International Atomic Energy (IAEA) Regulations for the Safe Transport of Radioactive Material, TS-R-1 (1). Appropriate tests are also specified which cover the transport accidents which can be realistically envisaged. These Regulations are prescriptive, well developed, stable, incorporated into international regulations (2) and form the basis of most National Regulations. Compliance with the IAEA Regulations insures safety in transport.

2.1 Test Requirements for packages

The test requirements ensure the integrity of the package under accident conditions such as impacts in crashes, fires or submersion in water. Type B packages are the main focus of this paper since they are of most safety and security significance.

The **impact tests** include a requirement for Type B packages (for the most radioactive nuclear fuel cycle materials) to survive a 9m drop test onto an unyielding surface without loss of shielding or giving rise to a significant release of radioactivity. This drop test is very severe because the objects which a package could impact in real-life situations, such as concrete roads and bridges, would yield to some extent and the 9m drop test is equivalent to impacts onto such real-life surfaces at very high speeds (3). Impact accidents which can be realistically envisaged are less severe than the IAEA drop test.

Fire also is a concern in the transport of nuclear fuel cycle materials. The IAEA **thermal test** specifies that Type B packages must be able to withstand a fully engulfing fire of 800^{0}C for 30 minutes without loss of shielding or significant release of activity. Studies have been carried out to investigate the ability of spent fuel casks to withstand long duration fires (4) and the results indicated that the casks would remain sound. The conditions generated in the regulatory test are more severe than in such realistic fire accidents. This also would be the case with packages for VHLW which are similar to those for spent fuel.

For Type B packages, the Regulations specify an **immersion test** equivalent to a water depth of 15m for 8 hours without loss of shielding or significant release of radioactivity. In addition, packages for spent fuel and VHLW have to withstand immersion for 1 hour at 200m.

If a cask containing spent fuel or VHLW were to sink due to the sinking of a ship, the rate of release of radioactive material into the sea would be very slow since the containment of the cask would be unlikely to have been completely lost and the materials are very refractory and insoluble. The radiation doses received by people who consume marine foods would be negligible compared with doses from the natural background due to the vast dilution which would occur in the sea (5). The same would apply to other nuclear fuel cycle materials, the activity of which is much less.

2.2 The safety record - Industrial experience

The IAEA Regulations for transport are sound and prescriptive. Ensuring safety therefore becomes an engineering challenge, and all the necessary technical information is available to enable this to be met. Compliance is the key to safety and this remains important and challenging as the industry expands and new entrants to transport emerge.

The safety record achieved by the transport industry is excellent - in the last 50 years there has never been an accident due to shortcomings in the regulations which caused significant damage to man or the environment.

The Regulations have therefore been successful in ensuring safety although there is still scope to comb out unnecessary features which result in operational constraints and increased costs without contributing to safety, and adapt the Regulations to new types of material to be transported, for instance to cater for wastes generated by decommissioning.

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3. Security in Nuclear Fuel Cycle Material Transport

Security in transport involves the various measures to guard against the consequences of intentional malicious acts. The main concern has been theft and diversion of material with a weapons' capability but in recent years, there has been heightened concern about the potential consequences of terrorist action on the transport of all radioactive materials.

The security challenge depends primarily on the probability and consequences of malicious acts and only national governments have the ability and information sources to assess the relevant factors within their region and some will be confidential. Whereas safety is governed by prescriptive IAEA Regulations which are stable and adopted by National Governments, appropriate provisions for security can vary both in time and place and cannot be prescribed. It is mainly the responsibility of individual Member States to set up the necessary regulatory framework.

Security measures

The United Nations (UN) and IAEA play a leading role in developing the international regulatory regime for the transport of radioactive materials and whereas the focus in the past has been on safety, an increasing interest for the security and physical protection of nuclear material during transport can be witnessed.

Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225) (5) which presents best practices which should be adopted by IAEA Member States covers security requirements (including transport) for materials with a potential use in weapons. The UN Model Regulations (2) now contain a basic security level for the transport of all dangerous goods, including some radioactive materials (classified as Class 7), as well as additional requirements for an enhanced security level for goods defined as '*high consequence dangerous goods'*, which have the potential to give rise to serious consequences. The International Ship and Port Facility Security Code (ISPS Code) and International Convention for the Safety of Life at Sea (SOLAS) of the

International Maritime Organization (IMO) amendments (7) give appropriate security plans for ship and port facilities. Other bodies including the IAEA, International Civil Aviation Organization (ICAO), United Nations Economic Commission for Europe who issued the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR), and National Jurisdictions, have also formulated requirements and recommendations. The security regime and requirements placed on the transport industry have been fragmented in the past but the transport industry has nevertheless been able to operate within this regime.

4. Implications of security requirements to the nuclear fuel cycle transport industry

4.1 The current regulations

Currently the five international instruments relevant to security in the transport of nuclear fuel cycle materials are:

(i) Convention on the physical protection of nuclear material is the overarching document for the physical protection of nuclear materials;

(ii) INFCIRC/225 (6) for the transport of *nuclear materials* which carry a potential risk of being used in nuclear weapons and which requires three categories of security depending on the risk;

(iii) Nuclear security recommendations on radioactive material and associated facilities" (IAEA Nuclear Security Series No 14);

(iv) Security in the transport of radioactive material" (IAEA Nuclear Security Series No9) [ref. 8]; and

(v)UN Model Regulations (2) for the transport of *high consequence radioactive materials* which require an enhanced security provision.

On this basis, all low enriched un-irradiated uranium nuclear fuel, typically less than 5% U_{235}, and its intermediates, including UOC, and natural and low enriched Hex, will therefore be exempt from the enhanced security requirements; normal prudent precautions should suffice. Large radioactive sources will normally be classified as *high consequence* materials and low activity sources will be exempt. Medical isotopes will also be exempt.

Hex could potentially give rise to a chemical hazard in the event of a severe accident because it produces corrosive products on exposure to moist air or water. This subsidiary hazard could be covered by the requirements of the Model Regulations for corrosive materials transported in bulk.

4.2 The IAEA Guidance on Security

The IAEA guidelines Security in the Transport of Radioactive Material (8) cover the transport of all radioactive materials, including nuclear fuel cycle materials in addition to those covered by INFCIRC/225. Although it cannot be prescriptive, the IAEA guidelines are sound and comprehensive and the transport industry is able to operate within these.

4.3 Safety and Security Regulation

Safety and security have many common features but the appropriate requirements are different in some important respects. However, it is important that the requirements for both are closely coordinated, simplified as far as possible and conflicts avoided. The current policy of the IAEA should achieve this objective. The IAEA Nuclear Safety Series coupled with the complementary IAEA Nuclear Security Series are likely to form the basis of National Requirements and this policy framework should be capable of being successfully implemented by the nuclear transport industry.

5. Perception of Risk

Whereas the potential safety and security risks associated with the transport of nuclear fuel cycle materials must not be underestimated, the assessment of the risks must be realistic and quantified, and the requirements placed on the industry appropriate. Exaggerated perception of potential risks resulting from transport incidents have serious consequences, such as the denial of shipments and the demonstrations to prevent spent nuclear fuel and VHLW transport, both of which give rise to significant operational problems, public disorder and high costs.

The nature of the materials and packages are relevant to this argument. Un-irradiated nuclear fuel cycle materials present a low radiological hazard. The terrorist threat is likely to be low and the radiological consequences of terrorist activity would not be severe. Highly radioactive materials, i.e. spent fuel, VHLW, and most large sources, are refractory, metallic, ceramic or vitreous materials, not easily dispersed and transported in very heavy robust containers. These are significant factors in ensuring not only safety but also security both from the point of view of theft and diversion of material and also from terrorist attack. It is highly relevant that the nuclear fuel cycle transport industry has had an excellent safety and security record over many years.

It is important to dispel exaggerated perceptions of the risk in the minds of the public, politicians and regulators. This depends on good communications based on sound science as well as continued improvement and updating of information briefs on safety and security issues written in a style which the public and media can readily understand. This is an important part of the role of the WNTI in its support of the nuclear transport industry.

6. Conclusions

Safety of radioactive material transport depends mainly on the integrity of the package. The design standards and tests for the packages for the transport of nuclear fuel cycle materials are intended to ensure safety under both normal and accident conditions.

There is a large body of evidence which demonstrates that the current IAEA Transport Regulations, properly implemented, are successful in ensuring the safety of nuclear fuel cycle transport. In the 50 years since the Regulations were first published, there has never been an accident which could be attributed to shortcomings in the regulations which has resulted in radiation damage to man or the environment. Compliance with the regulations is the key to success and this will remain important and challenging as new operators enter the transport business.

Security is a serious issue but it is important to project a realistic assessment of the threat and its potential consequences, based on the nature of the materials and package and the operating record of the nuclear fuel cycle transport industry. Uranium concentrates and uranium hexafluoride present a very low risk. Un-irradiated fuel, including mixed oxide fuel, and the more highly radioactive materials, i.e. spent fuel and VHLW, are very refractory ceramic or vitreous materials, not easily dispersed. They are transported in very heavy robust containers, which are designed to ensure safety but this is also a significant factor in ensuring security.

Safety and Security Regulations

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Public perception of risk

Whereas the potential dangers including those with a malicious intent now pose to nuclear fuel cycle transport must not be underestimated, the assessment of the risks must be realistic and quantified. The experience gained in the past needs to be taken into account.

It is important to dispel any exaggerated perceptions of the danger in the minds of the public, politicians and regulators.

References

(1) Regulations for the Safe Transport of Radioactive Materials, TS-R-1,, International Atomic Energy Agency, Vienna, 2009

(2) Recommendations on the Transport of Dangerous Goods, Model Regulations, 16th Revised Edition, United Nations, New York and Geneva, 2009

(3) D J Ammerman, "NUREG/CR-6672: Response of Generic Casks to Collisions", Proceedings, PATRAM 2001, Chicago, IL., USA, September 2001

(4) C Ito, H Yamakawa and T Saegusa, ''Demonstration of the Safety of Spent Fuel Transport Casks under Regulatory Tests and Realistically Severe Accidents', Proceedings, PATRAM 2001, Chicago, IL., USA, September 2001

(5) Tsumune, D. et al., "Dose Assessment for the Public by Packages Shipping Radioactive Materials Hypothetically Sunk on a continental shelf", International Journal of Radioactive Material Transport, Vol. 11, 00. 327-328, 2000

(6) Physical Protection of Nuclear Material and Nuclear Facilities INFCIRC/225/Revision5, International Atomic Energy Agency, Vienna, 2011

(7) International Ship and Port Facility Security (ISPS) Code, 2003 Edition and International Convention for the Safety of Life at Sea (SOLAS) Consolidated 2009 Edition, International Maritime Organization, London

(8) Security in the Transport of Radioactive Material, IAEA Security Series No.9, 2010, Vienna