Waste and Spent Fuel Transport

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ABSTRACT
Various kinds of radioactive waste are generated from nuclear power and fuel cycle facilities. These materials have to be treated, stored and eventually sent to a repository site. Transport of wastes between these various stages is crucial for the sustainable utilisation of nuclear energy.

The IAEA Regulations for the Safe Transport of Radioactive Material (SSR-6)[1] have, for many decades, provided a safe and efficient framework for radioactive materials transport and continue to do so. However, some shippers have experienced that in the transport of certain specific radioactive wastes, difficulties can be encountered. For example, some materials produced in the decommissioning of nuclear facilities are unique in terms of composition or size and can be difficult to characterise as surface contaminated objects (SCO) or homogeneous.

One way the WNTI (World Nuclear Transport Institute) helps develop transport methodologies is through the use of Industry Working Groups, bringing together WNTI members with common interests, issues and experiences. The Back-End Transport Industry Working Group focuses on the following issues currently:

- Characterisation of Waste: techniques and methods to classify wastes
- Large Objects: slightly contaminated large objects (ex. spent steam generators) transport
- Dual Use Casks: transportable storage casks for spent nuclear fuels, including the very long term storage of spent fuel
- Fissile Exceptions: new fissile exceptions provisions of revised SSR-6

The paper gives a broad overview of current issues for the packaging and transport of radioactive wastes and the associated work of the WNTI.

INTRODUCTION
The WNTI was founded in 1998 by British Nuclear Fuels plc (BNFL) (now International Nuclear Services (INS)) of the United Kingdom, COGEMA (now AREVA) of France, and the Federation of Electric Power Companies (FEPC) of Japan. The WNTI's principal aims are to foster the development of safe, efficient and reliable radioactive material transport and to represent the collective interests of the radioactive materials transport sector and also generally those who rely on safe, effective and reliable transport.

Over the past few years, the WNTI has grown substantially with member companies drawn from a wide range of industry sectors, including utilities, fuel producers and fabricators, transport companies, lawfirms and package producers and currently comprises around 50 companies all over the world.

With its small secretariat staff, and drawing on a large pool of industry expertise from among its members, the WNTI is committed to ensuring that transport, essential to bringing the benefits of radioactive materials to where they are needed the world over, is conducted safely, efficiently and reliably.

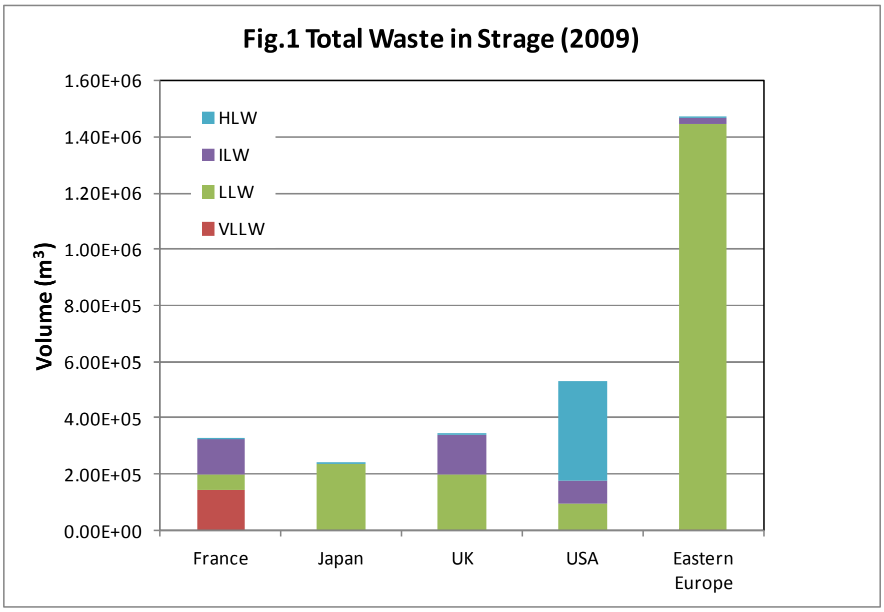
Over the past 15 years, the WNTI has established itself as an authoritative voice for the industry in key international organisations including: the IAEA (International Atomic Energy Agency), the IMO (International Maritime Organization), and the various national authorities:

- The WNTI has been granted observer status in the IAEA and is routinely represented at meetings of the Transport Safety Standards Committee (TRANSSC).
- The WNTI also has consultative status in the IMO, and registers industry positions in the appropriate committees and working groups.
- World-wide, members of the WNTI are engaged with national authorities in most aspects of radioactive materials transport.

As well as fulfilling its stated aims, the WNTI provides a "conduit" for the industry to exchange information, views and potential issues.

RADIOACTIVE WASTE MATERIALS

The nuclear industry has been in existence for about 60 years and has created considerable quantities of waste materials – though the volumes are small in comparison to those created by other industries. Some of the radioactive materials have been disposed of but there are still significant amounts in storage. Waste radioactive materials are still being created, but at a lower rate because of the greater efficiencies of modern processes.



Recent (2009) figures compiled by the IAEA, and displayed in the "Net-Enabled Radioactive Waste Management Database" [2], show a total of approximately 6 million m^3 of waste all over the world[1]. Fig.1 shows the storage volumes of VLLW (Very Low Level Waste), LLW (Low Level Waste), ILW (Intermediate Level Waste) and HLW (High Level Waste) for major countries using nuclear energy. For example, it shows that East Europe, which consists of Belarus, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Lithuania, Romania, Slovakia, Slovenia and Ukraine, shares around quarter of total radioactive waste storage.

In the near term, continuing on-site storage is likely in many countries, but in the longer term, it is probable that most of these wastes will be transported through the public domain to facilities for either further processing or disposal in a repository. Whatever strategies are adopted, these volumes of waste in storage imply a large number of transports which means that substantial costs for waste transport will be needed. Therefore, it is very important to transport the radioactive waste efficiently.

[1] The database doesn't include some countries (ex. Russia and China).

BACK-END TRANSPORT INDUSTRY WORKING GROUP (BETWG)

Clearly, given the probable scale and costs of these activities, the efficiencies and safety of waste transport are important issues. Consequently, in 2008, the WNTI decided to establish the WSFTWG (Waste and Spent Fuel Transport Industry Working Group) of specialists and interested parties to promote the development of the safe, efficient and reliable transport of radioactive waste and spent fuel. The WSFTWG was later renamed the BETWG (Back-End Transport Industry Working Group, Chairman: Gary Jones (INS)) to clarify the targets in 2011. In broad terms, the aims of the group can be expressed as:

- identifying issues with the potential to adversely affect the safety or efficiency of radioactive waste transports,
- using the knowledge and experience of its members to obtain a full understanding of these issues, and to develop an industry position,
- disseminating the learning to shippers and regulators.

The working group meets twice a year, in between communicating by email, and to date, has concentrated on the following four areas that were considered to be of importance to the WNTI community.

Characterisation of wastes

A large variety of process wastes arise in the nuclear fuel cycle industry, from mining, conversion, enrichment and fuel fabrication, reactor operations, reprocessing and more recently from decommissioning a wide variety of nuclear facilities. These wastes vary greatly in their chemical, physical and radioactive properties and the degree of homogeneity is sometimes difficult to assess. Furthermore, according to Fig.1, the breakdown of waste level (VLLW, LLW, ILW and HLW) for each country is quite different. It's thought that one of the reasons is the difference of the definition of the level and term for characterisation of wastes between countries.

Traditionally, waste management has been mainly focused on the need to ensure safe storage of waste, either interim or long term, in the raw or conditioned state. However, it is important to note that all these waste streams will have to be transported eventually in some form or another and the IAEA Transport Regulations SSR-6, must be able to cater for these materials without imposing unjustified constraints which could result in significant operational difficulties and economic penalties. The inventory forecasting is an important process because it determines the number of packagings, transport vehicles, personnel, etc that will be required over the coming years. It may also influence requirements for capital investment and work programmes for inter-related facilities. Nevertheless, wide discrepancies between the forecasting and actual demand of the waste transport are reported in some countries[3]. They cause inefficiency and strains for the waste transport.

Internationally, many techniques and methods are used to characterise and classify wastes and to forecast waste inventories. The BETWG currently has a project underway to collect, collate and share the knowledge and experience in these areas and under discussion on a good practice for the inventory forecasting.

Large Objects

Some wastes consist of large surface contaminated objects (SCO), such as reactor pressure vessels, or steam generators. It would often be advantageous to transport them directly as Type IP-2 packages; however, while there is no safety issue, it is often difficult to meet all of the requirements of the SSR-6 because of their large scale, for example in respect of impact tests.

Therefore, some of those large components have been transported under "special arrangements" approved by competent authorities according to the SSR-6 (para. 310). Fig. 2 shows an example of the transport of a large object (spent steam generator) in Germany.[4] Furthermore, it is expected that the demand to transport contaminated large equipments from the decommissioning of various nuclear fuel cycle facilities for recycling or treatments will increase rapidly. For example, a large number of diffusers (ex. height: over 12 m, weight: over 80 ton) in an enrichment plant may need to be transported for recycling.[5]

Fig. 2 Transport of Spent Steam Generator[4]

However, the approval for "special arrangements" from competent authorities may be difficult and time-consuming to obtain because some competent authorities do not have enough expertise to approve it or the requirements for the special arrangements in the national regulations may not be specific. Furthermore, such high-profile transports are sometimes faced by strong opposition from the public even when the relevant competent authorities have approved it. Recently the Canadian Bruce Power's plan to transport 16 spent SGs (SCO-1) from Canada to Sweden for recycling (Fig. 3) was forced to be cancelled due to strong opposition from the public people and local communities in Canada and the U.S. while the transport had been approved by the Canadian Nuclear Safety Commission (CNSC).[6] In contrast, Southern California Edison in the U.S. transported several spent SGs (SCO-2) to the disposal site in Utah without major oppositions.[7] In addition, the two spent boilers (weight: approx. 310 ton) of the Berkeley power plant in the U.K. were successfully transported to Sweden in March 2012. [8]

Fig. 3 Cancelled transport plan from Canada to Sweden[6]

With the support of WNTI experts to the revision process of the Transport Regulations, a "Guidance for Transport of Large Components under Special Arrangements" will be incorporated to Appendix VII of the new Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material (TS-G-1.1).[9] It provides basic concepts, recommended criteria and specific examples. A common understanding on the special arrangements for large components transport by both competent authorities and the industry will enhance this kind of transport.

The BETWG continues to monitor and evaluate development in this area and is developing a document for such transportation.

Dual Use Casks
With the shortage of reprocessing plant capacity or the lack of repository site, large amounts of spent fuels are accumulated in nuclear power plants. An option for the management of spent fuel is to use dual purpose casks which are designed to meet the requirements for both transport and storage (interim and/or long term). Some interim storage facilities have already been installed or planned in some countries. For example, Fig.4 shows an example of the Dukovany Interim Spent Fuel Storage Facility (ISFSF) in the Czech Republic.[10] Similarly, high level waste or residues can also be stored in dual purpose casks before an appropriate repository has been commissioned.


Fig.4 ISFSF Dukovany I [10]

According to the increase of the importance of interim storage and dual use casks, international research programs have extended or newly established and some international conferences have been held. Furthermore, the Blue Ribbon Commission in the United States issued their final report in January 2012 and proposed to establish one or more consolidated interim storage, independent of the schedule for opening a repository.[11] And the US NRC published a draft report for comment regarding to the long storage of spent nuclear fuel, "Background and Preliminary Assumptions For an Environmental Impact Statement - Long-Term Waste Confidence Update" in December 2011.[12] It concludes that commercial spent fuel can be stored safely without significant environmental impacts for at least 120 years and evaluate the impacts of extended storage and associated transportation for an analysis period of approximately 200 years. However, the Court of Appeals for the District of Columbia invalidated the waste confidence rule in June 2012. NRC staff submitted to the NRC Commissioners a draft rulemaking for Commission concurrence regarding Waste Confidence and Continued Storage of SNF along with a draft Waste Confidence Generic Environmental Impact Statement (DGEIS) in June 2013. In the DGEIS, the NRC staff has analysed the environmental impacts of continued storage of SNF at nuclear power plant sites for extended time periods (beyond 60 years).

As dual use casks are paid wide attention recently, an issue arises because of the different time scales for which the approvals for storage and transport are valid (long for storage and relatively short for transport). [13] Whilst the storage facility needs to be licensed for a middle term (potentially several decades), package design approvals for transport are issued with a limited period of validity (typically 3 to 5 years). The issue is then the maintenance of the package design approval for transport. What happens if after a certain period of time the approval cannot be renewed / prolonged (or re-issued if there was no need for a transport approval during the storage period), either because of a revision in the Transport Regulations or because of a new safety review? Is it possible to synchronise the expiration dates of the transport approval (short term) and of the storage facility license (middle term)?

The IAEA established the "Joint Working Group on Guidance for an Integrated Transport and Storage Safety Case for Dual Purpose Casks for Spent Nuclear Fuel" in 2011 and started the discussions internationally to provide guidance to Member States for integrating the safety cases for storage and transport in a holistic manner. Some BETWG members have participated in the activities and the draft TECDOC "Dual purpose cask safety case for transport/storage casks containing spent fuel" was finalised during the last meeting in April 2013. The contents are based on the "Technical Guide – Package Design Safety Reports for the Transport of Radioactive Material (PDSR)" issued by the European Association of Competent Authorities. The final version will be issued in 2013.

The BETWG continues to monitor the activities and participate in the discussions in the IAEA.

Fissile Exceptions

In 2007, the IAEA initiated a review of the criteria used to except fissile materials from the requirements of the then Transport Regulation (TS-R-1[14]). Several issues with the criteria had been identified and subsequently a number of IAEA Consultants Meetings were held in order to devise a better set of criteria. Members of the WNTI were involved in every stage of this process, generating ideas for new criteria to critically evaluating suggestions for new "fissile exceptions". The role of the WNTI in this process has been to add an industry perspective, making sure that new provisions for "fissile exceptions" would work well in practice.

As a result, the new provisions are incorporated in the present Transport Regulation (SSR-6). All provisions in regards to "fissile exceptions" have been completely reviewed, restructured and introduced new concepts for the enhancement of both safety and efficiency.[15,16] From the industrial point of view, major targets of the revised provisions are as follows;

- Para. 222(c): Material with fissile nuclides less than a total of 0.25g is excluded from the fissile material
- Para. 417(c) - (d): These are new provisions for small samples including UF_6 or Pu.
- Para. 417(f): This is a powerful concept to allow competent authorities to except specific fissile materials especially for radioactive waste because the nature of waste is miscellaneous physically and chemically and it is difficult to regulate in advance.[17] For example, large volume waste with very low fissile material concentration could be allowed according to the para. 417.8 in the new TS-G-1.1. [18]
- Para. 674(a) - (c): The new fissile mass limits depend on the enrichment are determined for reasonable transport. The new concept using CSI is introduced to satisfy with both safety and practical managements.
- Para. 674(d): The exception for Be-Cu alloy in this provision is introduced for practical materials. [19]

As the new "fissile exceptions" has been changed drastically, the BETWG disseminates the details and practical influence of the new provision to our members. We share the members' experience [20] for the new provisions, especially for new Para. 417(f) and will feedback our experience to the IAEA and competent authorities where necessary.

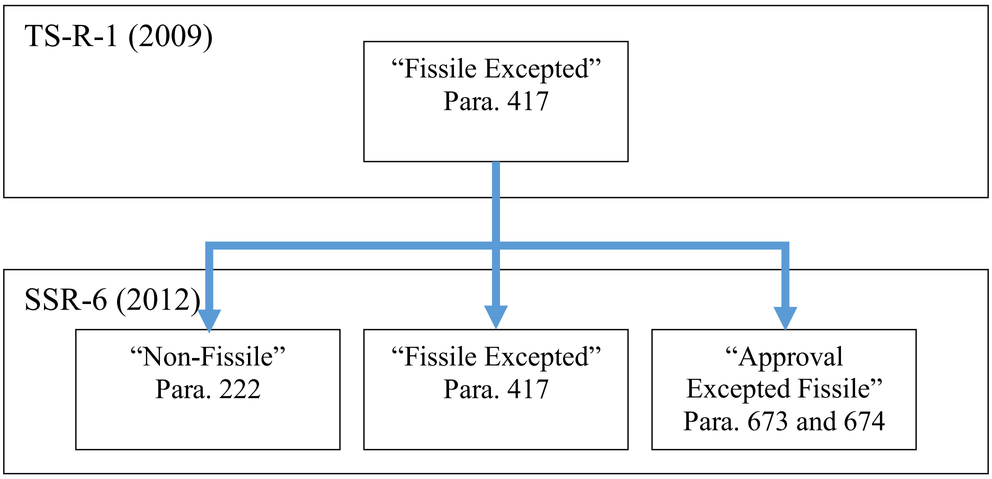


Fig.5 Basic Changes of New Fissile Exception Provisions

CONCLUSIONS

The WNTI established a working group in 2008 to promote the developments in the safe, efficient and reliable transport of waste radioactive and spent fuel. The BETWG has focused on four fields, Characterisation of Waste, Large Objects, Dual Use Casks and Fissile Exceptions. The activities contributed to the revision of the regulations SSR-6 and advisory material TS-G-1.1, and discussions in the IAEA through the members' expertise and practical experiences.

The importance of the transport of radioactive wastes and spent fuels will be increasing all over the world because of the expansion of the usage of nuclear energy and the decommissioning of the old facilities. The BETWG continues to tackle various issues flexibly with members' expertise and experience. Through these activities, the WNTI provides a channel for the industry to facilitate the safe, efficient and reliable transport of radioactive waste materials.

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