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Transport of Radioactive Materials: A Strong and a Weak Link in the Nuclear Fuel Cycle

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The efficient and reliable transport of radioactive materials is essential for many vital functions in our society and daily life. The most stringent requirements apply to the transport of materials for use in the nuclear fuel cycle, but the largest number of shipments is of isotopes for medical purposes. In addition, transport is needed for materials used in agriculture, industry and research.

In relation to the worldwide transport streams of materials and products for society's many needs, the quantities of radioactive materials transported are very small. They are also small in comparison with, for instance, the volumes of dangerous goods transported or products for other types of energy production. This illustrates very well the fact that nuclear power is an extremely dense energy resource.

Movements within the nuclear fuel cycle, from the mining of uranium, through processing, the use of nuclear fuel in reactors, and the subsequent back end treatment, storage and disposal, are often optimised from a transport point of view. Transport has obvious relations with the locations of the mineral deposits, the power production units, and the specialised nuclear fuel facilities involved.

All movements of radioactive materials within the nuclear fuel cycle are carried out under well-defined and documented conditions. Few if any industries have such an extreme level of control from start to finish. This is the case whether it be for internal local movements, such as discharge of fuel from a reactor to an on-site storage pool, or for transport of spent fuel to a national storage facility, or for international shipments of mixed oxide (MOX) fuel.

The use of radioactive materials in agriculture, industry, research and medicine needs a smooth-running system of transportation between the relatively few producers of these radioactive substances to the large group of users. Materials for medical purposes often have strict time constraints. Sometimes, the transport of these substances may lack the support of the solid infrastructure that exists for the nuclear fuel cycle.

The transport of radioactive materials can give rise to politically charged issues. Transport can cause concerns and put pressure on political decision makers, not only in direct relation to the transports themselves but also in the form of political tensions between regions and nations. Experience demonstrates that general perceptions and attitudes may influence political groups and, to a certain degree, the regulations and their implementation. Regulators are often asked to defend or re-evaluate the adequacy of existing regulations and forced to implement extremely cautious controls.

To describe and quantify the transportation of radioactive materials on a worldwide basis is complicated and it has so far been a rather frustrating experience to try to put together a complete database of all transport on local, national and global scales within and outside the nuclear fuel cycle. Detailed statistics do exist regarding events and shipments within a number of countries and for particular types of shipments, and some important data are available from International Atomic Energy Agency (IAEA) databases. The IAEA, however, has ongoing work — with the collaboration of the World Nuclear Transport Institute (WNTI) — to compile a better and more relevant factual database of the world's movements of radioactive materials.

Rough estimates of the many thousands of transports by rail, road, sea and air can, however, be based on the streams of nuclear materials related to power production from the world's 432 power reactors. For nuclear electricity production, transport must be carried out for the mining of 36 000 tonnes of uranium per year, its enrichment and fuel manufacturing. The operation of reactors generates up to 10 000 tonnes of used fuel per year and 100 000 to 200 000 m^3 of operational waste, often transported for disposal. Of the used fuel, 3000 to 4000 tonnes are reprocessed and 5000 to 6000 tonnes are put into storage. In addition to this, there is transport of older wastes, materials in storage, inventories and, not least, materials from military and other programmes.

Since transport of radioactive materials is demanding both for society and industry, efforts will certainly be made in future to minimise transport movements. Despite this, it is realistic to plan for an increase, regardless of the future development of nuclear power. Power production over the coming decades by a more mature, integrated and specialised industry will contribute to this, and the decommissioning of old reactors and clean-up activities will increase the demands for transport resources.

A New and More Complicated Situation

The transport of radioactive materials has always been carried out under complex and strict regulation. Transport issues have always been a sensitive link in the nuclear fuel cycle, exposed to public opinion and related political pressures, and requiring very strict and cautious operations. The overall experience is, nevertheless, that transportation has not caused major problems from a practical point of view, and has often been carried out using regular transport systems which are available.

However, as for many other transport systems, disturbances will soon cause severe problems for society and, indeed, for the nuclear industry. For the nuclear industry it is to some extent possible to cope with delays, but in some cases it is absolutely crucial for the operation of plants and facilities to have access to smooth-running and reliable transport systems.

The depressed market for uranium production, the restructuring in the nuclear industry worldwide, and reduced economic margins following electricity market deregulation and liberalisation have placed additional strong pressures on the nuclear transport industry. It must become more cost-efficient, flexible and even more responsive to the needs of utilities and others.

From developments during recent years it has become obvious that in future transport movements may not be carried out in the same uninterrupted way as in the past. In particular, there is concern about international transports. To address this in the best possible way, effective and creative measures must be considered by both industry and regulators, with support from political decision-makers.

The most important issues to be considered are:

- The regulatory environment, its implementation and time frames.
- Routing requirements and possibilities.
- Cost efficiency and flexibility of transports.
- Public opinion and the political context.

Safety and Transport Operations

A basic aspect of transport safety — from a technical point of view — is the very robust packaging systems used. In addition, there are several other technical and administrative layers of safety measures designed to meet the tough and unpredictable situations which can be encountered during transport by sea, rail and road.

The fundamental measure which provides for the safety of transported materials is the package or transport cask. The package provides protection against the various hazards of the materials under all transport conditions, including accident conditions. Solid stable materials and purpose-built transport systems further add to the safety margins. Also important is the fact that most transport operations are carried out by qualified and specialised organisations applying high standards.

There is very positive experience from the large number of transport operations over a period of more than 40 years. This demonstrates that the systems are working very well and, indeed, is a good illustration that the technology used, the operating methods and the regulations support the desired high level of safety.

Routing Requirements and Possibilities

Although they are much discussed, and now and then temporarily stopped in some countries, the great majority of transport movements for nuclear purposes are carried out as planned and without too much trouble. This is true in particular for fresh and used fuel, and operational waste transports, to and from power plants or on a national scale to interim storage and reprocessing facilities. Purpose-built transport systems and well-defined transport routes and routines certainly contribute to this.

For some international transports, in particular those connected to the front-end of the nuclear fuel cycle, the previously rather good possibilities to find alternative carriers and harbours to carry out shipments are now becoming much more limited. Increased demands on carriers and perceived risks of disruptions have led to a situation where fewer carriers are available to the organisations in charge of nuclear transport. This has occurred as transport scenarios have become more complicated.

Many ship owners have taken the position that they are not prepared to carry out all the work required for transport of radioactive materials, such consignments being just a small fraction of their overall cargo. In addition, the organisation of the shipping industry has evolved into a complicated structure of ownership, rights and obligations. This is not at all supportive of the complex requirements of radioactive product transport.

For economic reasons — chartered ships would normally would be unrealistically expensive — it is necessary to use scheduled liner shipping. This in turn means that radioactive products must be allowed to be shipped with other cargo and to pass through transfer harbours in many countries. This situation can cause problems with, for instance, port authorities.

Regulation and Control of Transport

For the transport of radioactive materials, safety issues have always been the first priority both for the industry concerned and for society through its competent authorities. For the industry, these regulations and compliance with them form the central pillar in the implementation and operation of nuclear transport systems. As a result, the transport of radioactive materials is carried out under strict regulatory controls and in accordance with internationally agreed requirements. For nuclear transport, this has led to conservative approaches and robust systems where high safety standards, covering all modes of transport, are enforced.

Because of their central position, new regulations that have to be interpreted and implemented by many international organisations and individual countries, place strong demands on harmonisation and require efficient collaboration between the various authorities and organisations. For the industry, regulatory harmonisation and time-efficient licensing procedures are extremely important to enable transport to be carried out efficiently.

The international nature of the nuclear power industry requires trans-boundary movements of radioactive materials on a regular basis. This means that a single transport operation may fall under the jurisdiction of numerous regional, national and international regulatory schemes. Besides safety and security, such related issues as insurance, liability and compensation are becoming even more complicated to handle for politicians, authorities and the industry.

As regulations and other requirements are becoming very complicated and strict, it is crucial to maintain and defend a well-balanced regulatory regime where the needs and concerns of both society and industry are considered.

International Regulation

Since 1961, the IAEA has issued advisory regulations and standards for the safe transport of radioactive materials. These regulations have been recognised throughout the world as the basis not only for national safety requirements but also for international and regional regulation by such organisations as the International Maritime Organisation (IMO), the International Civil Aviation Organisation (ICAO), and the European ADR/RID for transport at sea, land and in the air.

In 1998, the IAEA General Conference recognised that, "Compliance with regulations which take account of the Agency's Transport Regulations is providing a high level of safety during the transport of radioactive materials" (Resolution GC(42)/RES/13). The IAEA regulations historically have been revised every ten years, but this now has moved to an accelerated two year revision cycle.

Implementation of ST-1

The most recent revision of the IAEA transport safety regulations — known as ST-1 — is scheduled for implementation in 2001. Effective implementation is one of the most pressing current issues for the competent authorities and industry. Although to a large extent based on the previous set of regulations, a number of significant new requirements are introduced, such as:

- a radiation protection programme for carriers,
- test criteria for UF_6 packages,
- a new Type C package for air shipments.

An important aspect of the introduction of ST-1 is harmonisation between IAEA regulations and their implementation at the national level and by international organisations like the IMO, ICAO and ADR/RID. Starting with IMO regulation on 1 January 2001, ST-1 will be operational in all the above mentioned organisations as of 1 July 2001, and will be mandatory by 1 January 2002.

The background to and comments on the regulations in ST-1 are being compiled as ST-2, which is in the process of being published. Since this is an important part of the documentation, not least for the communication and understanding of the new regulations and their intent, the late availability of ST-2 is regrettable. Sufficient lead time is important to allow for appropriate training for those involved in the implementation of the new regulations, and to permit timely changes in operations.

Regarding the technical issues, industry is working intensively to ensure that it meets its requirements under ST-1; for example, in ensuring that UF_6 continues to move unimpeded within the requirements and possibilities of ST-1.

As already mentioned, the IAEA has moved to a two year revision cycle for its regulations. While this conforms to other regulatory regimes for dangerous goods, it potentially could cause severe problems for industry if the very long — up to five years — approval periods for international package licences remain the case in future.

The latest IAEA revision process has begun in earnest, with approximately 175 proposed changes to ST-1 submitted by IAEA member states and some international organisations such as WNTI. An IAEA Revision Panel will begin sifting through all these proposals in September 2000, and a Technical Committee Meeting in November 2000 will address such issues as:

- radiation protection programmes,
- grandfathering arrangements,
- harmonisation and parallel regulations.

The nuclear transport industry through WNTI has compiled views and submitted its proposals. WNTI will participate in the IAEA process with the help of its members.

Regulation by the IMO, ICAO and Others
The IMO has incorporated the relevant parts of ST-1 into its International Maritime Dangerous Goods (IMDG) Code, and is expected to make this mandatory from 1 January 2001. The ICAO regulations are important for the increasing number of shipments by air. Regulations for transport in Europe by road and rail are set by the ADR/RID. Fortunately, understanding has been shown to ensure some degree of harmonisation in the implementation schedules of all these organisations.

Public Opinion and Perception

The perception of risks connected to transport is perhaps one of the key issues that influence the efficiency of and the availability of options for smooth transport operations. It is clear that the industry's long and excellent safety record, and careful regulation and control, have not built the understanding and trust among the public and other groups necessary to provide proportion and balance when events occur or transport operations are criticised. Instead, we still have many examples showing that the perception of laymen and of many political decision makers is that transports of radioactive materials are extremely dangerous, and that the risks and consequences if something should happen are enormous.

Understanding the Attitudes
Nuclear transport operations are particularly susceptible to public scrutiny and misunderstandings since shipments are carried on the highways, waterways and airways of the world and so are exposed to situations where extensive knowledge of nuclear matters is lacking. Often shipments pass by countries which themselves derive no direct benefit from them. Under these circumstances one can understand that there might be a lack of interest in helping or being involved.

The lack of knowledge and information, together with existing misunderstandings, creates worries and sometimes fears. Such a situation can be a platform for constructive dialogues with interested parties, but is often instead used as a tool by those groups interested in raising fears of the risks and consequences of nuclear transports out of all proportion, usually as part of anti-nuclear campaigns.

In this context, it also is important to note that the strict regulation, control and reporting of nuclear transport can be frightening to the general public. Very few industries, if any, test their transport equipment as rigorously in fire tests, drop-tests, impact tests, etc. as does the nuclear industry. All this sends out the message that these transports are different and very dangerous. At same time, the nuclear transport industry tries to explain that the consequences of conceivable severe accidents are generally very small. This is certainly not an easy situation in which to build trust, and much more understandable information and education is needed.

For this we need accurate and specific understanding of the concerns of the general public in relation to nuclear transport. To draw conclusions only on

the basis of media reports or the actions of protesters is too narrow a basis. There is limited relevant information available in this area. We need to obtain a scientifically thorough and in-depth understanding of people's real concerns and attitudes in relation to transport, based on investigations such as tailored polls and in-depth interviews.

Some general conclusions can, of course, be derived from other studies of attitudes towards nuclear power. The many studies made on nuclear waste issues may also be useful, since there are a number of similarities between, for instance, site-selection for a repository and transport operations, both being outside the "nuclear fence" and exposed to the NIMBY effect.

Need for Information and Efficient Communication
Whatever the results of further studies, it is obvious that we must expect and be prepared in future for strong reactions to events, incidents and accidents, and related criticism from groups opposed to nuclear power.

The need for more facts, background information and communication is — from an overall perspective — obvious, and comprehensive experience shows that providing relevant information is one very important way to improve the situation. For many individuals and groups concerned, it is very important to put transport and its risks into perspective in order to allow for a balanced response when events occur or when transport operations are criticised.

Information and better understanding will certainly not solve all problems. It is important to realise that many groups which might be both well informed and have trust in the industry may not be interested in accepting or supporting nuclear transport because they do not regard the transports as fair or necessary, or they simply do not like the nuclear industry.

The industry has had quite a lot of experience of both how to communicate and how not to communicate. Information activities on nuclear matters, radiation, waste and to some extent transport have been carried out for many years. Various "come and see" activities related to transport, fuel and waste disposal, and the systematic information programmes connected to the transport of MOX fuel, are good recent examples. Communication regarding the surface contamination of transport casks in recent years has, with some exceptions, been less successful.

Although the industry has made great progress in recent years it must continue to demystify all aspects of nuclear power and address misconceptions about transport. This is a task not only for the industry but also for the competent authorities, intergovernmental organisations and other expert groups. For the industry, this requires being proactive in disseminating information, being professional in its approach, and being open and trustworthy. It is not sufficient today, when there is so much information of all kinds about, to counter misperception with rehearsals of technical data. Messages must be direct and understandable in layman's terms, responding to people's attitudes. In this respect, there is a solid and excellent factual basis for information on transport of radioactive materials to be communicated.

Transport of radioactive materials has been carried out for more then 40 years and there has never been a transport accident resulting in the injury or death of an individual as result of the radioactive nature of the cargo. Nor has there

been any impact on public health or the environment. Further, the transport of radioactive materials is carried out under strict regulatory controls, and the excellent safety record has been maintained despite this being a highly specialised field.

Collaboration and WNTI

The need for balanced regulation and harmonised implementation on both national and international levels, and the crucial importance for the transport industry of balanced reactions to events or criticism, are issues where the industry derives particular advantage from working together. In order to develop its common positions, to get its voice heard and contribute to the important work of forming regulations in intergovernmental organisations like the IMO and IAEA, it is necessary for the industry to combine its efforts.

Over many years, there have been several methods of collaboration within the industry on transport matters, ranging from companies directly working together to the collaboration in working groups within, for instance, the Uranium Institute, FORATOM and other industry organisations. However, a few years ago the need for and the potential of more focused collaboration on radioactive and nuclear material transport issues formed the basis for the World Nuclear Transport Institute (WNTI), and the Institute was established in 1998.

Today, the Institute has grown to 30 members worldwide and it has established good collaborative arrangements and representation with key intergovernmental organisations such as the IAEA and IMO. In addition, the Institute has forged links with industry organisations like the Uranium Institute, FORATOM and the Nuclear Energy Institute.

The Institute has its headquarters in London and regional offices in Washington and Tokyo. In addition to the secretariat, the work is very much linked to and carried out by the Institute's members working together and exchanging views, with the Institute acting as a platform.

Concluding Remarks

The transport link of the nuclear fuel cycle is, from a technical point of view, a very safe and robust link and should not cause many problems. Experience shows, however, that the perception of transport of radioactive materials by the general public, and the response to this by political decision-makers, authorities and carriers, may cause concerns and has led to far reaching demands.

Despite excellent experience, robust technology and strict regulation and control, radioactive materials transport is seen as dangerous. There is a great need for understandable information and for education of almost all groups outside the organisations involved in nuclear transport.

The industry has over the years developed close collaboration, both directly and collectively, with intergovernmental organisations such as the IMO, IAEA and others. Through organisations like WNTI it is represented in key intergovernmental organisations and has improved its ability to work together to help develop and to comply with all the regulations and other demands.

The newly developing market situation for nuclear power production and the depressed market for the supply of uranium and nuclear fuel place new and strong demands on the companies involved in transporting radioactive materials. These organisations must be even more cost effective, flexible and responsive to complicated transport scenarios.

Forceful and creative efforts must be considered in order to meet new regulations, to address market requirements, and to achieve improved understanding of and balanced reactions to events and criticism involving nuclear transport.

