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NOTE

The International Atomic Energy Agency (IAEA), in co-sponsorship with the International Civil Aviation Organization (ICAO), the International Maritime Organization (IMO) and the Universal Postal Union (UPU), and in co-operation with the International Air Transport Association (IATA) and the International Organization for Standardization (ISO), is organizing an International Conference on the "Safety of Transport of Radioactive Material", to be held at Vienna, Austria, from 7 to 11 July 2003. The Conference is hosted by the IAEA.

This book contains concise contributed papers submitted on issues falling within the thematic scope of the Conference which were accepted following the guidelines established by the Conference Technical Programme Committee for consideration at the Conference. The material compiled in this book has not been edited by the editorial staff of the IAEA. However, certain modifications were made: a unified format was adopted for all papers, abstracts were added when missing, and corrections were made in the text where required. It is intended that, after the Conference, the contents of this book will be published in form of a CD ROM as part of the proceedings of the Conference. Authors wishing to make slight modifications or corrections to their papers are encouraged to contact the Conference Secretariat.

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COMPARISON BETWEEN THE REVISED VIENNA AND PARIS CONVENTIONS ON NUCLEAR LIABILITY IN THE FIELD OF NUCLEAR ENERGY

Provisions applicable to transports of radioactive materials

E. Mignot[a], D. Degueuse[b], J. Javanni[c], C. Ciuciu[d]

[a]Minsitry of Foreign Affairs, Strategic Affairs Division
[b]Atomic Energy Commission, Division of Legal and Commercial Affairs
[c]Ministry of Industry, General Directorate for Energy and Raw Materials
[d]AREVA Group, Division of Legal Affairs
France

Abstract

The revised Paris Convention was conducted with reference to the revision of the Vienna convention which ended in 1997. It differs however on several aspects. The liability amounts for transports have been substantively increased to provide up to € 700 millions in case of nuclear damage. A definition of damage was introduced and the scope of application was widely broadened in order to upgrade the indemnification of potential victims. The revised Paris Convention will impose the most stringent rules of liability for nuclear transport of international instruments.

1. Scope of application

The revised Vienna Convention will apply to nuclear damage wherever suffered in the world. (Limited exclusions concerning non-contracting nuclear states, which do not afford equivalent reciprocal benefits, may be introduced by contracting parties through domestic legislation).

The revised Paris convention will apply mainly to nuclear damage occurring on the territory of member states, on the territory of revised Vienna member states which are also parties to the Joint Protocol providing the revised Paris state of the responsible nuclear operator is also party to the Joint Protocol. It will also apply to non nuclear states, including their territorial waters and any maritime zones established in accordance with international law (for example EEZ).

2. The definition of damage

(2.1) In order to ensure compensation for broadest range of damage possible, while at the same time ensuring compatibility with the provisions of the Vienna Amending Protocol, the Contracting Parties of the Paris Convention have agreed to revise the present Convention by adding a new definition for the term «nuclear damage», and defining the concepts of «measures of reinstatement», «preventive measures» and «reasonable measures» included within that definition.

(2.2) The text of the present Paris Convention provides only that the nuclear operator is liable for all damage to persons and to property, with the nature, form and extent of compensation therefor being determined by national law. The Contracting Parties believed that there should be greater harmonisation between them on the matter of compensable damage, and based upon the model of the Vienna Amending Protocol, agreed to add new heads of damage to those already set forth in Article 3 of the Convention, in the form of a new definition of «nuclear damage». These new heads concern economic losses, costs of preventive measures and of measures for reinstating an impaired environment, as well as certain other losses resulting from such an impaired environment that are likely to constitute major portions of the damage resulting from a nuclear incident. While it is true that such new heads of damage will

only be compensable «to the extent determined by the law of the competent court»[1], the Contracting Parties will now, at least, be obliged to include these heads of damage in their national law, even if only to a limited degree. The concepts of «preventive measures»[2] and «measures of reinstatement» of impaired environment, both of which are included in the definition of «nuclear damage», will be specifically defined in the revised Convention, such measures generally being required to be «reasonable» and to be approved by the competent national authorities for their costs to be compensable. On the other hand, the concepts of «economic loss» and «loss of income», also included in the definition of «nuclear damage», are referred to in more general terms, allowing for greater flexibility in their interpretation.

(2.3) The definition of «nuclear damage» and its component elements, and the definition of «nuclear incident», are identical to those found in the Vienna Amending Protocol and the Supplementary Compensation Convention, with two exceptions: first, unlike the definition contained in the Vienna Amending Protocol, the definition of «nuclear damage» in the Paris Amending Protocol does not include «any other economic loss, other than any caused by the impairment of the environment, if permitted by the general law on civil liability of the competent court». The Paris Convention States were simply not convinced that this head of damage was not already covered by other heads of damage included in the definition. In addition, there is a difference in the way in which «nuclear incident» and «preventive measures» are defined in the Paris Amending Protocol, a difference that is explained in the next paragraph.

(2.4) It seemed more logical that the reference to «…any occurrence…which…creates a grave and imminent threat of causing such (nuclear) damage» which is contained in the definition of «nuclear incident» in the Vienna Amending Protocol, be inserted into the definition of «preventive measures» in the Paris Amending Protocol. In essence, the Contracting Parties want to extend the scope of compensation under the Convention to the cost of «preventive measures» taken to prevent or minimise nuclear damage where there is a grave and imminent threat that such damage will be caused. In addition, the description of the origins of a nuclear incident[3] will, under the revised Convention, be included in the definition of «nuclear damage», following the model used in the Vienna Amending Protocol.

(2.5) Finally, the Contracting Parties have always interpreted the notion of strict liability and the definition of «nuclear incident» as including radioactive emissions released in the normal course of operations of a nuclear installation or in the normal course of transport of nuclear substances where such emissions cause nuclear damage, even though they are within prescribed limits. They have decided, however, that this interpretation should be noted in the Exposé des Motifs rather than in the Convention itself.

(2.6) The revised Paris-Brussels Conventions do not deal with «rumour damage» as such. This wording refers to a situation where an incident having happened without any release of radiation, the perceived risk of actual nuclear damage fuelled by unfair and inaccurate report of the event may adversely affect the economy of States in the vicinity of which the event occurred, causing for example downturn in tourism and fisheries.

Compensation of economic loss under the revised article 1 (a) vii) 3 is indeed conditioned by the fact that this damage actually results from a release of ionising radiation. Similar conclusions can be drawn when analysing the revised Vienna Convention and the 1997

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1 This is a reference to the national law of the court having jurisdiction over claims for compensation arising out of a nuclear incident.

2 Including the defined term «reasonable measures» which is incorporated into the definition of «preventive measures».

3 Reference is made to that part of the existing definition of «nuclear incident» which reads as follows: «..arises out of or results either from the radioactive properties….of nuclear fuel or radioactive products or waste…inside a nuclear installation».

Convention on Supplementary Compensation for Nuclear damage. However through the inclusion in the definition of nuclear damage of "the costs of preventive measures and any loss or damage caused by such measures"[4], the revised Paris-Brussels Conventions address the situation where an incident "creating a grave and imminent threat of nuclear damage" has occurred, even where there is finally no ionising radiation emission. The revised Vienna Convention and the CSC contain similar provisions[5].

The revised Paris Convention specifies that preventive measures and consequential loss will be taken into account to the extent determined by the law of the competent court and establishes a set of criteria that must be satisfied for their compensation. One criterion refers to the situation itself. The threat of nuclear damage must be grave and imminent. This should prevent intervention on the sole basis of vague speculation that radiation might be released. Other criteria relate to the type of preventive measures that can be compensated. These measures can be taken by anyone and can be subject to the approval of competent authorities if so requested by the law of the State where the measures are taken. The key criterion is the reasonableness standard: the costs of preventive measures will only be compensated if these measures appear to be reasonable i.e. appropriate and proportionate with respect to all circumstances. This assessment will rest in fine with the competent court according to its national law and the guidelines provided for by revised Article 1 a) x).

No additional guidelines are given as regard loss or damage resulting from preventive measures. The wording of the revised Paris Convention seems sufficiently broad to cover in particular both damage to property and economic loss. It will in fact largely depend on the law of each Contracting Party to determine the extent to which this will be compensated. It will be for example for this domestic legislation to determine to which extent loss of earnings such as cancellation of resorts bookings further to an evacuation order taken by the local competent authorities because of a grave and imminent threat of nuclear damage could be compensated.

3. Jurisdiction

(3.1) The Paris and Vienna conventions provide that, if there is a nuclear incident, liability for damage resulting from the incident is to be attributed to the operator of the installation involved, that the operator is liable to pay compensation without proof of fault up to a fixed amount, and that insurance against this liability is required.

(3.2) Regarding the competent courts, many factors motivate in favour of a single competent forum to deal with all actions against the operator arising from the same incident. Most important is the need for a single legal mechanism to ensure that the limitation on liability is not exceeded. Moreover, if for the same incident judgements could be rendered in the courts of several different countries, the problem of assuring equitable distribution of compensation might be insoluble.

(3.3) For these reasons, Article 13 of the Paris Convention provides for exclusive jurisdiction in respect of a nuclear incident involving nuclear material :

- where an incident occurs in the territory of a Contracting State, jurisdiction lies exclusively with the courts of that State ;
- where an incident occurs during transport outside the territory of a Contracting State, or where the place of the nuclear incident cannot be determined with certainty, jurisdiction

4 See revised article 1 (a) vii) 6, ix) and x) of the Paris Convention. As for the type of nuclear damage to be compensated under the revised Brussels Convention, article 2 of r.BC refers to the definition of nuclear damage embodied in the Paris Convention.

5 See revised article I, 1 k) vi) of the revised Vienna Convention and article I (f) (vi), (h), (i), and (l) of the CSC.

lies with the courts of the Contracting Party in whose territory the nuclear installation of the operator liable is situated ;

- where jurisdiction would lie with the courts of more than one Contracting Party, jurisdiction shall lie, if the nuclear incident occurred partly outside the territory of any Contracting State and partly in the territory of a single Contracting Party, with the courts of that Contracting Party and, in any other case, with the courts of the Contracting Party determined, at the request of a Contracting Party concerned, by the Tribunal referred to in article 17 of the Paris Convention, as being the most closely related to the case in question.

(3.4) Article XI of the Vienna Convention of 1963 provides for the same solutions in these different cases. The Protocol adopted in 1997 to amend the Vienna Convention and the draft Protocol amending Paris Convention do not modify the above provisions of articles XI and 13 of these two instruments. But they add a new provision that grants jurisdiction to the Contracting Party in whose exclusive economic zone (EEZ) a nuclear incident has occurred, as long as that Party has notified the depositary of the Convention of such zone prior to the nuclear incident. If such a zone has not been established by the contracting State, this rule is applicable in an area not exceeding the limits of an exclusive economic zone if one had been established. This provision concerning the jurisdiction in the EEZ is only intended to address jurisdiction over nuclear damage claims arising from a nuclear incident; it is clear that neither the notification of such an EEZ to the depositary nor the exercise of jurisdiction pursuant the new provision will create any right or obligation with respect to the delimitation of maritime areas between States.

(3.5) The Convention on Supplementary Compensation for Nuclear Damage of 1997 contains the same rules concerning the competent Courts and particularly, the provision concerning the case of an incident in the EEZ of a Contracting Party.

(3.6) A further new provision will be incorporated into Article 13 of Paris Convention, again modelled on the corresponding provision contained in the Vienna Amending Protocol, which requires a Contracting Party whose courts have jurisdiction to ensure that a State may bring an action on behalf of persons who are nationals of, or who are domiciled or resident in that State and that any person may bring an action to enforce rights under the Convention that are required by subrogation or assignment.

(3.7) Lastly, as in the Protocol amending the Vienna Convention, a provision of the Protocol amending the Paris Convention implements a Steering Committee Recommendation by which Contracting Parties are called upon to provide, in their national legislation, for a single court to be competent to rule on compensation claims under the Convention.

4. Liability amounts

Presently, in case of an accident occurring during a nuclear transport, the Paris convention requires a minimum amount of 5 millions SDR due to an amendment adopted in 1982. However, several contracting parties have introduced in their legislation an amount equivalent to 150 millions SDR.

The revised Paris convention will provide that, the operator is liable for a minimum of 80 millions €. To cover the liability, the operator shall be required to have and maintain insurance or other financial guarantee of this amount. The revised Vienna convention will require a minimum of 5 millions SDR in its Article V.

In the revised Paris convention, in case of a damage exceeding 80 millions €, the state of the liable operator shall compensate damage up to 700 millions €. In the revised Vienna Convention, this state shall compensate up to 300 millions SDR.

LIABILITY IN THE TRANSPORT OF RADIOACTIVE MATERIALS

F. Maughan, E. Carroll

Nuclear Safety Division,
Department of the Environment and Local Government,
25 Clare Street, Dublin 2, Ireland.

Abstract

This paper considers the application of the IAEA-sponsored 1963 Vienna Convention on Civil Liability for Nuclear Damage to the maritime transport of radioactive materials. The paper refers also to the regime for civil liability created by other Conventions, including the 1960 Paris Convention on Third Party Liability in the Field of Nuclear Energy, concluded under the auspices of the OECD and the Convention on Supplementary Compensation for Nuclear Damage, also an IAEA sponsored Convention. The paper will primarily focus on the Vienna Convention.

1. Introduction

Ireland is neither a nuclear state nor a signatory to any of the nuclear liability Conventions. Ireland is however a member of both the IAEA and the Nuclear Energy Agency of the OECD and, acutely conscious of the harm that might result to its citizens in the event of a major nuclear incident, regularly attends, and actively participates in, the meetings of these bodies and their various committees. Ireland therefore closely monitors developments in relation to both the Paris and Vienna Conventions.

2. International regime

There are currently two separate, but complementary, international regimes dealing with civil liability for nuclear damage.

1960 Paris Convention

The first, in time, is based on the OECD Paris Convention of 1960 [1], to which all the West European nuclear States are party. This Convention has been amended by protocols in 1964 and 1982. The contracting parties have agreed a further revision protocol and, at the time of writing, it is expected that this will be signed sometime later this year. The parties to the Paris Convention can also avail of the 1963 Brussels Supplementary Convention, which has also been amended by protocols in 1964 and 1982, and a further revision protocol has been agreed and will also be signed later this year. Ratification and entry into force of these revision protocols is, however, likely to take some considerable time.

1963 Vienna Convention

The IAEA Vienna Convention [2] of 1963 affords a scheme for global participation. This Convention has also been amended by a revision protocol in 1997 [3], which at the time of writing has not yet entered into force. The 1997 Protocol has the effect of broadening the geographical scope of the 1963 Convention, increasing the amount of liability for the operator to 300 million Special Drawing Rights (SDRs) (approx. US$400 million), extending the period for which claims may be brought and providing for jurisdiction of coastal States in respect of nuclear incidents occurring in their EEZ or equivalent maritime zones.

1988 Joint Protocol

In 1988 a Joint Protocol [4] was agreed to afford mutual recognition to the Vienna Paris Conventions. Thus victims in a contracting party to either of the foregoing Conventions could obtain compensation for an accident occurring in the territory of a contracting a party to the other Convention. It also prevents conflicts of jurisdiction by ensuring that only one Convention applies to any one nuclear accident.

1997 Convention on Supplementary Compensation

The Convention on Supplementary Compensation [5] was designed to superpose itself on the Vienna and Paris Conventions by defining additional amounts to be provided through contributions by States parties on the basis of installed nuclear capacity and the UN rate of assessment. States may become signatories to the Convention on Supplementary Compensation whether or not they are parties to any existing nuclear liability regime, provided that the national law of the State in question satisfies the provisions of the Annex to the Supplementary Compensation Convention.[1] In effect, a third regime of third party nuclear liability would arise. This Convention is not yet in force.

1971 Convention relating to civil liability in the field of maritime carriage of nuclear material

This Convention was intended to address concerns arising after adoption of the Paris and Vienna Conventions as to how liability provisions of those Conventions would interact with the considerable body of existing law on liability for maritime carriage of goods. It provides, inter alia, that a person otherwise liable for damage caused by a nuclear incident will be exonerated from liability if the operator of a nuclear installation is liable for such damage under either the Paris or Vienna Conventions or by virtue of a national law governing liability for such damage provided such law is in all respects as favourable as either the Paris or Vienna Conventions.

3. Scheme of the conventions

It is generally acknowledged that, that for contracting parties, both the Paris and Vienna Conventions provide a unified system of liability and recovery for compensation for damage caused by the operator of nuclear installations. Despite variations in the details, the overall scheme of the Paris, Vienna and Supplementary Compensation Conventions is based on the following elements:

1. Liability is strict or absolute. No proof of fault or negligence by the operator is required.
2. Liability is channeled exclusively to the operators of the nuclear installation where the incident occurs or which has responsibility for the transported material involved in an incident. All other persons, who may otherwise have been liable, are thereby relieved of liability for nuclear damage arising from that incident.
3. The amount of compensation available is strictly limited. However, additional funding has been made available by the 1963 Brussels Supplementary Convention and the 1997 Convention on Supplementary Compensation.
4. Jurisdiction is conferred on the courts of one State only, this generally being the State where the nuclear incident occurred.
5. Compensation will only be paid if a claim is brought against an operator within a defined amount of time. In the case of both Convention systems, an action needs to be brought within ten years; a period which may be increased or decreased if national legislation of the installation State provides financial security. However, the period within which a claim must be brought is increased to 30 years, for damage resulting in loss of life or personal injury.[2]
6. A system of compulsory insurance up to the prescribed limit of liability must be held by the operator and must be guaranteed by the installation State. Additional public funds are provided under supplementary Conventions under both the Vienna and Paris regimes.

4. Provisions applying to the maritime transports of radioactive materials

Geographical scope and application

The 1963 Vienna Convention was silent on its geographical scope and therefore, in accordance with the rules of international law and the Vienna Convention on the Law of Treaties, the Convention applies only to damage occurring on the territory of contracting parties or on aircraft or shipping registered with contracting parties. The 1997 Protocol extends the geographical application by providing that the Convention will apply “to nuclear damage wherever suffered.” It will therefore

[1] Article 18(1), Supplementary Compensation Convention
[2] Article 6(1)i. 1963 Vienna Convention, as amended by the 1997 Protocol.

apply to the territory and maritime zones of non-contracting parties, as well as to the high seas. By exception, an "installation State" (contracting party with a nuclear installation) can exclude damage suffered in the territory of a non-contracting party or its maritime zones but only if the non-contracting party has a nuclear installation on its territory or its maritime zones and does not afford equivalent reciprocal benefits in its laws. Damage suffered in a non-nuclear non-contracting party's territory or maritime zones cannot be excluded.

Application to transport

Article II of the Vienna Convention, as amended by the 1997 Protocol, provides that the operator of a nuclear installation shall be liable for nuclear damage on proof that such damage has been caused by a nuclear incident involving nuclear material coming from or originating in or sent to his nuclear installation unless another nuclear installation operator has assumed liability expressly in writing or has taken charge of the nuclear material. This is a departure from the usual rules, whereby a carrier is liable for damage to goods during the course of carriage. This was thought necessary due to the nature of the material being carried and the fact that the expertise in relation to such material lay with the nuclear operator. The operator is also responsible for, and has full control of, the packaging of the material, which, because of the nature of the material, has to remain intact and sealed throughout the duration of the carriage.

Jurisdiction

Having extended the geographical scope and application of the Convention to include, inter alia, maritime zones, the question arose as to jurisdiction in respect of damage incurred in the EEZ. The 1982 United Nations Convention on the Law of the Sea did not regulate precisely matters relating to the EEZ but did provide that coastal States had jurisdiction with regard to the marine environment within their EEZ. Maritime carriage of nuclear materials frequently occurs within the EEZ of States other than the shipping or installation State. Nevertheless, nuclear liability Conventions generally provide that it is the courts of the State where the incident occurs which have jurisdiction, regardless of where the damage occurs. As an exception to this rule, the 1997 Protocol provides that, if a nuclear incident occurs within the area of the EEZ of a contracting party, or within such area were one to be established, jurisdiction over actions concerning nuclear damage would, for the purposes of the Convention, lie with the courts of that contracting party, subject to notification requirements.

Liability amounts

The 1963 Vienna Convention provides that liability of the operator can be limited to not less than US$5million for any one nuclear incident (exclusive of interest and costs). The 1997 Protocol increases this amount to not less than 300 million Special Drawing Rights (SDRs) funded by the operator or by the operator (not less than 150 million SDRs) and the installation State. However contracting parties are also given the option of providing that the liability of the operator may be limited to a transitional amount of not less than 100 million SDRs in respect of a nuclear accident for not more than a maximum of 15 years after entry into force of the protocol. An amount lower than 100 million but not lower than 5 million SDRs may be established providing the installation State makes up the balance in public funds.

The Paris Convention, when combined with the Brussels Supplementary Convention, currently limits liability to 300 million SDRs. This is provided by a three tier system, the first tier being provided by the nuclear operator's insurance, the second being the balance up to a limit of 175 million SDRs coming from the public funds of the installation State and the third being the balance up to 300 millions SDRs coming from a fund contributed to by all the contracting parties in accordance with an agreed formula partly based on nuclear reactor capacity in each State. If the aggregate liability in any one accident exceeds 300 million SDRs, it is envisaged that the national law of the installation State will apply some form of apportionment.

The effect of the revision protocols, if they eventually enter into force, will be to raise these limits. The revised Paris Convention will provide for a minimum operator's liability of €700 million. The existing minimum liability amount of 5 million SDRs for incidents arising from low risk installations and transport of nuclear substances will be raised to €70 million and €80 million respectively. The

Brussels Convention tiers will be revised to €700 million (operator's insurers), €1,200 million (installation State funds) and €1,500 million (all contracting parties' contribution).

The Supplementary Compensation Convention provides for two additional tiers of funding over and above the basic rules in the Vienna and Paris Conventions. The first additional tier of 300 million SDRs is to be made available by the installation State. Until September 2007 a transitional amount of 150 million SDRs may be set. The installation State is permitted, however, to exclude damage suffered in a non-contracting State. A second tier is to be made available by all the contracting parties under a specific formula based on installed nuclear reactor capacity in the contracting parties. This second tier is confined to damages suffered in the territory of contracting parties or elsewhere but excluding the territory and territorial waters of non-contracting parties. 50% of this second fund is reserved for damage suffered outside the territory of the installation State (excluding, of course, the territory and territorial waters of non-contracting parties).

Nuclear damage

The 1963 Vienna Convention limits the definition of nuclear damage to loss of life, any personal injury or any loss of, or damage to, property which arises out of an incident with nuclear material, radioactive products or waste and any other loss or damage to the extent that the law of the competent court so provides. It was widely agreed that the definition needed broadening. The 1997 Protocol, therefore, extended the definition to include:

a. Economic loss arising from loss of life or personal injury or damage to property, in so far as not included already in those heads of loss or damage, if incurred by a person entitled to claim in respect of such loss or damage.
b. Reinstatement costs of significantly impaired environment.
c. Loss of income deriving from an economic interest in any use or enjoyment of the environment incurred as a result of significant impairment of the environment.
d. Preventative measures.
e. Any other economic loss other than that caused by impairment of the environment if permitted by the general law of the competent court.

The Paris Convention regime is similar to the Vienna Convention regime in this respect and the revision protocol adopts similar revised definitions with the exception of 'e' above, which is simply deleted on the basis that the parties to the Paris Convention believe it was already incorporated into the other types of damage.

5. Weaknesses of the convention regime

There are a number of weaknesses to the current regimes established by the Vienna and Paris Conventions that have hindered more widespread adoption of the Conventions by other States.

Current regimes

The 1997 Vienna Revision Protocol, the Revision Protocols to the Paris and Brussels Supplementary Conventions and the Convention on Supplementary Compensation are not yet in force and will not be so for quite some time. Accordingly the existing Conventions with all their deficiencies still stand. Moreover, not all of the shipping States or relevant nuclear States are parties. Even with the revisions as described above, weakness will continue to exist.

Jurisdiction

The general provision is that jurisdiction lies only with the court of the State where the nuclear incident occurs. However, if an incident occurs outside the territory of a contracting party, liability rests with the court of the contracting party in whose territory the nuclear installation of the nuclear operator is located. Thus, victims in other contracting States who suffer damage are, under the Convention, disadvantaged by not being able to pursue claims for compensation in the courts of their own State. Differences in, law, legal systems, administrative procedures, language, location, currency, economic and socio-political circumstances, may place additional obstacles in the way of victims. To some extent this would be alleviated by ratification of the various revision protocols that allow jurisdiction to reside with the contracting State in whose EEZ the incident occurs. However, this provision will not benefit victims of an incident occurring on the high seas or in non-contracting States.

Inadequate levels of compensation

The levels of compensation available in the Conventions that are currently in force remain inadequate and will remain so for large-scale incidents even when the revision protocols enter into force. The situation is not helped by the considerable widening of the definition of damage, which, while welcome, may mean a large increase in the number of claimants. Provisions exist for priority to be given in respect of loss of life and to personal injuries and, subject to national legislation, for States to provide for equitable distribution. However, and while there is a limit to which this can happen, it would appear that the amounts available for compensation to victims can in fact be reduced by virtue of the claims for compensation of the owner of the means of transport involved in a nuclear maritime incident.[3] While the Revision protocols to the Vienna Paris and Brussels Conventions extend compensation rights to victims in non-contracting States, it may be noted that access to further compensation funds under the Supplementary Compensation Convention is excluded in respect of the third tier[4] and in respect of the second tier may, subject to obligations of that State under other Conventions (e.g., Vienna Convention), be excluded[5].

Definition of nuclear damage

Although the revision protocols have considerably widened the definition of nuclear damage, the definitions as applied to the Conventions that are currently in force remain largely inadequate. While the revised definitions extend to environmental damage, there still remains a very narrow definition - not including, for example, damage to biodiversity - which does not take account of developments in environmental protection and in environmental liability in other instruments.

In addition, there remains a lack of recognition for economic loss arising as a result of rumour damage. Compensation provided by the Japanese Government for economic loss arising from perceived damage in respect of the 1999 Tokai-Mura incident received mixed reactions among commentators. This suggests that there is not a widespread acceptance that such losses ought to be compensated and a belief that they are not covered by Convention definitions.

Scope

It would also appear that compensation in respect of environmental damage and preventative and reinstatement measures may be confined to persons who can prove rights of ownership in respect of the property affected. Damage suffered on non-privately owned property, such as rivers, lakes, fish stocks, wild animals, or loss incurred by State or local authorities in taking general preventative or reinstatement measures, may not be covered due to an inability to prove proprietorial rights, which may be required under the law of the court of the installation State.

While it would appear that the Conventions as currently worded do not exonerate States or nuclear operators from liability in respect of terrorist incidents, it is not clear that nuclear insurers will continue to provide cover for such events. In the event that they will no longer provide cover for terrorist incidents upon renewal of policies, the measures to be taken by the installation and or shipping State merit further consideration. Such States may need to make additional arrangements to provide the necessary cover from public funds into the future. Confirmation in the form of a Convention provision that they will do so and that funds will be available for victims in non-contracting and coastal States will be necessary.

Disincentive for non-nuclear State participation in conventions

The foregoing weaknesses are very strong disincentives militating against non-nuclear States participating in the nuclear third party liability Conventions. These disincentives are now exacerbated due to an expectation that non-nuclear States should contribute to one or other of the tiers of compensation funding. This contribution is required even though such States do not derive any benefit

[3] Article IV paragraph 6 of the revised Vienna Convention
[4] Combined effect of Articles V and III 2 (b)
[5] Article III 2 (a)

from such activities but are nevertheless put at risk by the activities of nuclear operators and nuclear states. This runs contrary to precedents in other Conventions and international case law, which accept the proposition that States causing transboundary harm to victims in another State are bound to compensate those victims[6].

6. Conclusion

As the amendments to the original Vienna Convention regime are not yet in force, the 1963 Convention remains the applicable regime for civil liability in the Transport of Radioactive Materials. The amended regime, however, remains the product of a compromise between States in whose territories nuclear installations operate and the limited capacity of private insurance markets to fund claims for compensation. In this respect, a number of weaknesses remain which make participation in them unattractive for States with no nuclear installations. Such weaknesses may be ameliorated through, inter alia, introducing unlimited liability for the installation State and ensuring the necessary funding is in place; amendment of jurisdiction provisions to allow victims to sue through domestic courts rather than the courts of the State in which the incident occurs; confirmation that all victims, including those in non-nuclear and coastal States suffering loss or damage in a nuclear incident will be fully compensated and greater clarity and broadening in scope in the definitions of damage to human health, the environment and economic loss. As no significant claim has ever been brought under its provisions, the capacity of the regime to fully compensate victims of a serious incident remains completely untested.

References

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[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention, IAEA, Vienna, (1988).

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Convention on Supplementary Compensation for Nuclear Damage, IAEA, Vienna, (1997).

[6] Article 11 of the Convention on International Liability for Damage caused by Space Objects; Article 235 of the United Nations Convention on the Law of the Sea; Principles 21 and 22 of the Stockholm Declaration; trail Smelter Arbitration, 33 A31L (1939) 182; 35 A31L (1941) 684; Gut Dam Arbitration 8 ILM (1968) 118.

NUCLEAR LIABILITY CONVENTONS AND TRANSPORT: *An Overview*

N.L.J.T. Horbach[a], O.F. Brown[b],

[a]Director, Nuclear Law Programme, University of Dundee, Dundee, Scotland, United Kingdom

[b]Harmon, Wilmot and Brown, L.L.P., Washington, District of Columbia, United States of America

Abstract

This paper provides an overview of the international nuclear liability conventions and their applicability to transport, with particular emphasis on the coverage for international shipments already provided under the IAEA's Vienna Convention (including the 1997 Protocol) and the 1997 Convention on Supplementary Compensation for Nuclear Damage. The paper draws upon extensive knowledge of and experience with nuclear liability and transport matters. In particular, the paper outlines the advantages of expanding adherence by nuclear and non-nuclear States to the existing IAEA nuclear liability conventions. It also outlines the scope of available supplier's and transporter's nuclear liability insurance.

1. Introduction

Liability for nuclear damage during transport can implicate a number of complicated legal issues that would be simplified if more States were to join the existing nuclear liability conventions under the auspices of the International Atomic Energy Agency (IAEA)[1]. States with 57 percent of the world's 442 operating nuclear power reactors unfortunately are not yet parties to any nuclear liability convention[2]. Shipments between and among them thus are not covered by any treaty. Harmonising nuclear liability protection and applying it to additional international shipments would be facilitated by more countries being in treaty relations with each other as soon as possible. Adherence to an international convention by more countries would better protect the public and the environment, promote the open flow of nuclear services and advanced technology, and better facilitate international transport. The conventions protect the public, harmonize legislation in the participating countries, and

[1] Many elements can bear on liability for nuclear damage during transport. These include, for example, the origin and destination of the shipment, the type of nuclear material involved, the situs of the accident, the nature of the damages (personal injury, property damage, environmental damage, preventive measures, etc.), the nationality and domicile of the victims, court jurisdiction, and applicable law. For a more comprehensive discussion, see *O. Brown and N. Horbach, Liability for International Nuclear Transport: An Overview, Proceedings of OECD Nuclear Energy Agency 1999 International Symposium on Reform of Civil Nuclear Liability, Budapest, Hungary at 237-261.*

[2] There currently exist at least seven such agreements that are intertwined with each other: These are the 1960 Paris Convention on Third Party Liability in the Field of Nuclear Energy (PC), the 1963 Vienna Convention on Civil Liability for Nuclear Damage (VC), the 1963 Brussels Supplementary Convention (BSC), the 1971 Maritime Carriage of Nuclear Material Convention (MC), the 1988 Joint Protocol linking the Paris and Vienna Conventions (JP), the 1997 Protocol to Amend the Vienna Convention (VP), and the 1997 Convention on Supplementary Compensation for Nuclear Damage (CSC). Additionally, revisions of the Paris Convention and Brussels Supplementary Convention have been in progress for about five years. The MC, or so-called "1971 Brussels Convention," supplements both the VC and PC in relation to maritime transport, and will not apply if either the 1960 PC or the 1963 VC or applicable national law covers the nuclear damage (provided that it is not less favourable to the victim). The MC basically retains a very narrow application confined to certain Paris States from Western Europe (Belgium, Denmark, Finland, France, Germany, Italy, The Netherlands, Norway, Spain, and Sweden), joined by two non-Vienna/non-Paris flag States (Liberia and Yemen), and Argentina and Gabon.

promote the safer use of nuclear energy through their common principles: channelling of liability, absolute liability, liability limited in amount, liability limited in time, a single competent court to adjudicate claims, compulsory financial security, and non-discrimination based on nationality, domicile, or residence.

The *Amoco Cadiz* case, while it involved oil and not nuclear materials, is illustrative of what can occur in the case of a transport accident at sea. In 1978, *Amoco Cadiz*, a Liberian-registered supertanker operated by a U.S. oil company ran aground causing a large oil spill off France's Brittany coast. French Government authorities and private parties brought lawsuits in the United States to recover for oil pollution damages and cleanup costs (presumably because they viewed American courts as providing a more favourable forum). The U.S. court decided to apply U.S. law, despite the facts the injury occurred in French territory and both France and Liberia were parties to the 1969 International Convention on Civil Liability for Oil Pollution Damage (which should have made French law applicable). Fourteen years of litigation ended in 1992 with a total award to claimants of US$ 206 million, while the limit under the 1969 Oil Pollution Convention would have been US$ 14.6 million. If the United States had been a party to that Convention, its provisions would have been binding on U.S. courts under the U.S. constitutional provision that makes treaties the supreme law of the land. The reason for this decision was that, although this Convention provides for strict liability channelled to the ship owner, this liability is limited to an unrealistic level inappropriate to the *Amoco Cadiz* pollution case. Since in respect of such an oil spill, victims succeeded in forum shopping, the risk that they would attempt to do so and succeed seems even higher in respect of nuclear transport accidents.

Where countries currently are in treaty relations under the VC, there are a number of explicit provisions covering nuclear shipments between and among them. When and where it applies, the VC contains provisions (Article II) channelling to the installation operator liability for "nuclear damage" caused by a "nuclear incident" both at the installation itself and, in the absence of express terms of a written contract, when such involves nuclear material coming from, originating in or being sent to the installation. In short, under the VC, the installation operator usually is liable for nuclear damage resulting from materials being transported to or from its installation, unless a written contract explicitly provides otherwise. The VC further provides the operator is not liable for nuclear damage to the means of transport upon which the nuclear material involved was at the time of the nuclear incident[3].

1997 saw significant changes in the VC and the introduction of the new CSC. The 1997 VP and particularly the CSC were designed to increase world-wide treaty membership[4]. The basic

[3] The 1960 PC also contains explicit transport provisions, but they are slightly different from those in the VC. In short, again, liability in principle is imposed on the installation operator sending the nuclear substances, because it will have the responsibility for the packaging and containment, and passes to the receiving operator upon the assumption of liability by that operator pursuant to the express terms of a written contract or, failing such a contractual provision, when that operator takes charge of the shipment. In the case of transport to or from operators in States that are not Parties, special provisions apply to ensure that an operator to whom the PC regime applies will be liable. In principle, the territorial application of the PC is limited to nuclear incidents occurring and nuclear damage suffered in the territory of Contracting Parties, unless the legislation of the Installation State (*i.e.,* the Contracting Party in whose territory the nuclear installation of the operator liable is situated) determines otherwise.

4 The 1960 PC and the 1963 BSC established a nuclear liability regime for most of Western Europe (minus Austria, Ireland, Luxembourg, and Switzerland). The 1988 JP attempted to link the Paris and Vienna Conventions, but the goal of a global treaty has not been met. For example, France and the United Kingdom have not ratified the Joint Protocol, so are not in treaty relations with any VC. The United States is not eligible to join the VC or PC, because its domestic nuclear liability law (the Price-Anderson Act) provides for economic, rather than legal, channelling of liability to the installation operator. The United States is eligible to join the CSC, as provide in the CSC Annex.

transport provisions were not modified by the 1997 Protocol to Amend the Vienna Convention. The 1997 VP, however, does contain several significant changes that will have impacts on transport coverage when the amendments eventually enter into force. For example, the VC's definition of "nuclear damage" has been expanded to include certain environmental damages, economic losses, and costs of preventive measures. These provisions, which were incorporated into the CSC, are not in the 1960 PC. Additionally, there are discrepancies between the 1997 Conventions and the PC in the areas of geographical scope and court jurisdiction.

Particularly for transport activities, it is significant that the amended VC and the CSC will apply within the EEZs of Contracting Parties. Under the 1963 VC, jurisdiction in principle lies with the court of the Contracting Party within whose territory the nuclear incident occurred, and, in case such incident occurred outside the territory of any Contracting Party or the place cannot be determined, the courts of the Installation State of the operator liable will have jurisdiction. This rule was left unchanged by earlier drafts of the 1997 Vienna Protocol, but was supplemented with an additional rule in respect of incidents occurring in the EEZ of a Contracting Party (in which case their courts would have jurisdiction). Because of a controversy around the extent of jurisdiction of coastal States over types of nuclear damage occurring in their EEZs according to the 1982 Law of the Sea (LOS) Convention, this provision was the subject of final drafting at the IAEA Diplomatic Conference in September 1997. Since the LOS Convention provides coastal States jurisdiction with regard to the preservation of the maritime environment of the EEZ, a compromise was made, under which for nuclear incidents occurring in the EEZ of a Contracting Party (or, if such zone has not been established, in an area not exceeding the limits of an EEZ were one to be established in the future), jurisdiction will lie only with the courts of that Contracting Party. This is further conditioned to the extent that such EEZ was notified to the Depository prior to the nuclear incident and by a provision that the exercise of jurisdiction contrary to the 1982 LOS is not permitted. The rules under the CSC are similar. This means that, whereas normally a nuclear incident occurring during maritime carriage in the EEZ would render the law of the competent court of a Contracting Party where the nuclear operator (sender or receiver of the nuclear substances) is situated (i.e., Installation State) applicable, the VP would allow the rules of the competent court of a coastal State to be applied to the incident occurring in its EEZ, provided it is a Contracting Party to the VP and despite the fact that the liable operator is not situated in its territory. In other words, it allows the liable operator to be subjected to foreign law, potentially increasing the number of valid claims for compensation (particularly, of course, in respect of marine environmental damage).

Under the CSC, the supplementary funds apply to nuclear damage suffered (a) in the territory of Contracting Parties, (b) in or above their maritime areas beyond the territorial sea (i) by a national of a Contracting Party or (ii) on board or by a ship flying the flag of a Contracting Party, or on board or by an aircraft registered in the territory of a Contracting Party, or on or by an artificial island, installation, or structure under the jurisdiction of a Contracting Party; or (c) in or above EEZ or its continental shelf in connection with the exploitation or the exploration of the natural resources. These funds may be used only if an operator of a nuclear installation used for peaceful purposes situated in the territory of a Contracting Party to the CSC is liable, and the courts of a Contracting Party have jurisdiction pursuant to either of the two basic Conventions or national legislation in conformity with the Annex. Contrary to the 1997 VP, the CSC geographical scope is not extended to damage wherever suffered, since the supplementary funds would not apply to nuclear damage in the territory of non-Contracting State parties. This is not clearly stated though, since only nuclear damage suffered in or above the territorial sea of a State not Party to the CSC is explicitly excluded, whereas a similar phrase is not inserted with respect to damage suffered on the territory of a non-CSC Party.

However, in defining its purpose to supplement the system of compensation, the CSC explicitly states that it will apply to nuclear damage for which an operator is liable under the 1963 VC and 1960 PC, both of which do not impose operator's liability for damage suffered in non-Contracting States. This clause seems logical since non-nuclear power generating countries would have little incentive to become a CSC Party, if damage to their nationals would be covered regardless.

More than seventeen years already have passed since the Chernobyl accident, and more than five years have passed since the 1997 VP and CSC were opened for signature[5] [**5**]. Further delay in implementing a truly international nuclear liability regime is contrary to the interests of us all - governments, suppliers, environmentalists and potential victims alike. The CSC represents a good opportunity for more States to enter into treaty relations with each other in the near term. This is because a State is eligible to join the CSC if it is a member of the VC, the PC or meets the conditions prescribed by the CSC Annex. Although the ratification of the JP would have a similar effect (without, for example, including the United States and about one-fourth of the world's nuclear power plants), it does not ensure a comparable comprehensive coverage of damages as the CSC and the VP, which do ensure the protection of victims of environmental damage or maritime casualties occurring in the EEZ. The CSC has been sent to the U.S. Senate for ratification (on November 15, 2002), because the U.S. Government recognizes the benefits of treaty relations, without the necessity to change its national nuclear liability regime in order to be eligible to join either the Vienna or Paris Convention. Although this exception is in fact confined to the U.S. situation (and States that can meet the requirements of the CSC Annex) the CSC also has particular benefits for transport activities, because it covers accidents in a member's EEZ, thereby increasing protection for shipments by sea.

The revisions to the VC and the drafting of the CSC took eighteen sessions over five years. The results of these deliberations were not perfect. However, instead of spending the next several years negotiating yet another treaty specific to transportation, coastal and other States concerned about nuclear transport should join the 1997 VC and/or CSC. This action would much more rapidly bring about greater harmony in a larger geographical area, and thereby bring about greater protection for potential victims of a nuclear accident.

Without greater adherence to the new VC and the CSC, any transport route is likely to be a labyrinth of statutes and treaties not yet interpreted by the courts, and damage to the marine environment could be left uncompensated under the 1960 PC or 1963 VC regimes. If tested in court, this might result in a deviation from the existing rules of the Vienna and Paris Conventions. As we said in Budapest in 1999, it would be wiser to control this *a priori* by adhering to a modernised nuclear liability regime as the CSC and the VP with all the benefits of legal certainty, rather than allowing jurisprudence to supersede (at random) the legal facts.

[5] As of April 2003, the revised PC and BSC had not been opened for signature.

LIABILITY IN THE TRANSPORT OF NUCLEAR MATERIAL - EXISTING LIABILITY REGIMES AND GAPS IN THEIR COVERAGE

J. Ludbrook

Legal Division,
New Zealand Ministry of Foreign Affairs and Trade
New Zealand

Abstract.

There are two separate multilateral legal regimes covering liability for loss sustained as a result of harm incurred in incidents involving nuclear materials, including during their transportation by sea. Efforts have been made in recent years to clarify the relationship between them in order to develop a more coherent international regime but the situation remains complicated, unclear and inadequate. Complicated because there are two competing regimes with different memberships. Unclear because the scope of coverage under the two regimes is not identical. Inadequate because they do not assure coastal states suffering economic loss from an incident that they will not be left to bear the costs of such loss.

1. Introduction

The transportation of nuclear materials by its nature involves a risk of a release of radiation which may cause considerable harm. The magnitude of that risk may be small (albeit less so with the risk of terrorist action). And the relatively low risk needs to be kept in perspective so that appropriate attention is given to prevention and, in the event of an incident, response.

But even if the risk is small, if a release does occur, the harm sustained can be substantial. And the magnitude of this potential harm means that the perception of risk associated with an incident can itself result in economic loss being sustained. It is because of the magnitude of potential harm that liability regimes have been developed. For normal commercial insurance may not be willing to cover all that harm.

This paper examines the existing multilateral framework of liability regimes and the gaps which exist which need to be addressed and filled.

2. Existing liability regimes

There are currently five inter-related sets of Conventions and associated instruments:

- The *Paris Convention on Third Party Liability in the Field of Nuclear Energy 1960* ("the Paris Convention") and the *Brussels Supplementary Convention 1963*;
- The *Vienna Convention on Civil Liability for Nuclear Damage 1963* ("the Vienna Convention") and the *1997 Protocol* to amend the Vienna Convention ("the 1997 Protocol");
- The *Convention relating to Civil Liability in the Field of Maritime Carriage of Nuclear Material* ("the 1971 Brussels Convention");
- The *Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention 1992*; and
- The *Convention for Supplementary Compensation 1997* ("the Supplementary Convention").

The key elements of these various instruments are as follows:

- *Liability is absolute* (but with certain exceptions in the case of war and natural disaster).
- *Limitations are placed on liability*, in terms of total amount and the time for bringing claims. The more recent instruments have increased the level of these limits and also set a tiered structure for the way in which they are met, with the first tier being channelled to the operator of the nuclear installation, the second to the Party in whose territory the nuclear installation causing the damage is situated, and the third tier involving contributions by all Parties based on a formula varying according to the applicable instrument.
- *Operators must have compulsory insurance or security corresponding to the limit of their liability.*
- There are *limits placed on the territorial application of the Conventions*. The Paris Convention as amended by the Brussels Supplementary Convention applies when an incident involving an installation in a Party causes damage in the territory of a Party, on the high seas on a vessel or aircraft registered in a Party, or on the high seas to a national of a Party or a vessel or aircraft registered in a Party. The Vienna Convention as amended by the 1997 Protocol covers damage occurring anywhere, but subject to the ability to exclude it where occurring in the territory or maritime zone of a non-Party which has a nuclear installation and does not afford reciprocity. Also, an installation state can in its national law exclude liability for damage in a non-Party. The Supplementary Convention covers damage suffered in the territorial sea or EEZ of a Party, as well as aboard a ship or aircraft registered in a Party, or suffered by a national, but excluding damage suffered in or above the territorial sea of a non-Party. Revisions recently made to the Paris Convention would extend the scope to include a right of compensation for victims in countries with no nuclear installations.
- The *form of damage or loss covered varies*. In the Paris and Vienna Conventions, it is limited to personal injury and property damage, but the 1997 Protocol (to the Vienna Convention) extended this definition to include, to the extent determined by the law of the competent court, (i) economic loss arising from covered damage, (ii) loss of income from an economic interest as a result of impairment of the environment, (iii) the costs of preventive measures, (iv) the cost of measures of reinstatement of impaired environment, and (v) any other economic loss (other than caused by impairment of the environment) if permitted by the general law on civil liability by the competent courts of a Party. The Supplementary Convention employs the same language as the 1997 Protocol, and recently agreed changes to the Paris Convention are along similar lines.
- *Competence for actions for compensation is restricted* to the courts of the Party in whose territory (or EEZ where this is included) the accident occurred. If it occurred outside the territory of a Party, then jurisdiction is with the courts of the Party of the responsible Operator.

3. Key concerns of coastal states

Coastal states past whose territory or waters vessels carrying nuclear materials pass are concerned at the potential damage and associated economic harm that they might sustain in the event of an incident involving any such shipment. In the Pacific region, the maritime environment is a fragile one and also one on which many of the coastal communities depend for their survival and livelihood. This is especially true in terms of fisheries resources, but for many it is also true in terms of their tourism industries.

They are also often isolated with limited resources at their disposal, including to take steps to prevent or repair harm that might be caused by an incident involving a vessel carrying nuclear materials.

Against this background, it is very important that the transportation of nuclear materials, wherever it takes place, does so according to the strictest safety standards so as to reduce any real risk of an accident or other form of incident that might result in a release of radiation. It is important also that there be prevention mechanisms ready against the possibility of any such accident or incident.

But there needs also to be an acceptance that, in the event that an accident or other form of incident occurs with an actual release of radiation, or a perceived likelihood that such a release may following such incident have occurred or yet occur, resulting in actual physical damage to persons or property, harm to the environment of the coastal state (whether on land or in its territorial sea or EEZ), or economic loss as a result of the perceived risk to the environment or property, liability mechanisms to assure adequate compensation are available. For coastal states not benefiting from the activity causing them harm are innocent victims in such a scenario and should not be left to meet the costs.

4. Gaps in existing regime

There are several areas in the existing liability regimes where there are serious gaps and deficiencies from the perspective of potentially affected coastal states:

- *The limited forms of economic loss covered*. The early Conventions are very limited, in that they cover only personal injury and property damage. Later Conventions cover also economic loss as a result of such damage and loss of income from an economic interest as a result of impairment of the environment. But none of them cover economic loss sustained as a result of a perceived danger of harm resulting from an accident/incident, such as irradiation of fish resources or of tourism areas, thereby threatening human health. And they seem not to cover either more general forms of economic loss resulting from impairment of the environment, aside from the costs of measures to reinstate the environment.
- *The lack of a single coherent liability regime*. The present complicated network of liability instruments and amendments to them, all with slightly different regimes applying (e.g. to definition of "damage", territorial application, compensation limits, contribution levels by Parties, jurisdiction for pursuit of claims) and different memberships, makes it very unattractive to coastal states to become party to them. Membership of these Conventions by transport states is patchy, with some (e.g. Japan) not party to any of them. And the two more recent instruments are not even yet in force. Moreover, the focus of most of these instruments is much broader than the transportation of nuclear waste, suggesting that they have been built on participation by and the interests of states using this form of energy rather than the participation and interests of states who are merely the innocent victims when harm actually occurs.
- The *inadequacy of some of the compensation* provided for as a maximum in some of the earlier Conventions (e.g. 5 million SDRs in the Paris Convention, US$5 million in the Vienna Convention) or possibly in the case of a very serious incident. In the case of the 1997 Protocol to the Vienna Convention, the levels of compensation will be limited if an installation state excludes claims for damage in a non-Party.
- *The limited or non-availability in some of any compensation to non-Parties in respect of harm sustained in their territorial sea or Exclusive Economic Zone or on their territory*.

- The *expense for small states*, with little substantive interest in these Conventions save in relation to a possible incident, in meeting the costs associated with becoming Party and maintaining membership.
- The *requirement in several of the instruments (the Brussels Supplementary Convention and the Supplementary Convention) to contribute to funding of compensation* for damage or economic loss flowing from an activity which they do not benefit from or necessarily themselves support – and which furthermore may not be in relation to an activity occurring in their region. They are innocent victims. It is those that benefit from the activity putting others at risk who should meet the consequences of the activity.
- The *jurisdictional limits placed on pursuing remedies*. Actions are normally required to be brought in the Party in whose territory (in some cases including the Exclusive Economic Zone) where the incident occurred but, where the incident occurred outside its territory, it will be brought before the courts of the responsible Operator. This would be very expensive for coastal states.

5. Areas for improvement in relation to existing or new legal regimes

- *Development of a single comprehensive regime*, so that the present serious shortcomings of differentiated scope, coverage and membership are overcome.
- *A regime geared solely to the question of nuclear transportation* and developed to take account of the respective interests and concerns of transport and coastal states.
- *Broadening of the definition of harm and economic loss* covered so that it clearly encompasses all forms of economic loss, including that flowing from the perceived risks when an incident of some kind occurs.
- *Extending the benefits of the liability regime* to all who are affected by an incident, wherever it occurs, rather than excluding or limiting protection for non-Parties.
- *Where coastal states are Parties, not levying them for the costs of compensation*.
- *Establishment of a Fund built up from a levy on transportation of these materials* to be available to assist in the event of an incident occurring.
- *Develop mechanisms for prompt and co-ordinated response* where an incident does occur.

6. Other Initiatives

In advance of, and in anticipation of the possibility of, an incident, there should be:

- A *commitment to consult* closely concerning management of the required response to any such incident, including responding to any perceived risks associated with it.
- There should be *adequate and effective response mechanisms* in place to minimize the risks of any actual harm being sustained, these then forming the basis for all possible preventive measures needing to be taken. Coastal states have no expertise in the management of incidents of this kind, nor the financial resources or expertise likely to be required. The Government of the relevant transport state needs to assume early responsibility and leadership.
- *Compensation commitments*, e.g. through the establishment of a fund for compensation adequate to cover all forms of economic loss (including that sustained from perceived risks) that may be sustained.

THE MODERNISATION OF THE INTERNATIONAL NUCLEAR LIABILITY REGIME: *its Impact on Transport Operations*

P. Reyners

OECD Nuclear Energy Agency
Issy-les-Moulineaux, France

Abstract.

The international legal framework applicable to the liability and compensation of damage caused by a nuclear incident has been considerably modified by the adoption, in 1997, of a Protocol amending the 1963 Vienna Convention and, in parallel, the adoption of a Convention on the Supplementary Compensation of Nuclear Damage. In 2003, the 1960 Paris Convention and the 1963 Brussels Convention Supplementary to the Paris Convention [were revised] with a view to substantially upgrading the protection of potential victims of nuclear damage. Although the main objective of this exercise of modernisation was to better cope with the consequences of serious nuclear incidents in land-based installations, it also had the effect of making significant changes to the liability regime applicable to the carriage of nuclear material, both domestic and international. Such changes concern in particular the right to indemnification of victims located in non-Contracting States, the limits of liability of the nuclear operator, including that for transport operations, the insurance arrangements for such operations and the determination of the competent courts, notably those of coastal states affected by an incident during maritime transport.

1. Introduction

The Chernobyl catastrophe in 1986 had devastating consequences for the then USSR but also affected a significant number of countries across Europe. It also evidenced some serious shortcomings in the international nuclear liability regime and, accordingly, the international community acknowledged the need to strengthen the instruments governing the compensation of nuclear damage and, particularly, to ensure that victims of transfrontier damage would be entitled to such compensation. This explains why the first step was to adopt, in 1988, a Joint Protocol[1] whose primary purpose was to enlarge the geographic application of the special international nuclear liability regime through a mechanism of mutual recognition of the protection afforded by the two international Conventions in this field.

The second step was in 1997, with the adoption of a Protocol to Amend the 1963 Vienna Convention on Civil Liability for Nuclear Damage, as well as the opening for signature of a new Convention on Supplementary Compensation for Nuclear Damage (CSC). While the Vienna Convention has a world-wide character[2], a comparable legal regime pre-existed in Western Europe, based on the 1960 Paris Convention on Third Party Liability in the Field of Nuclear Energy and the 1963 Brussels Convention Supplementary to the Paris Convention (BSC)[3]. The third step of this modernisation exercise was therefore the revision of the Paris and Brussels Conventions which completion is expected in the course of the year.

The purpose of this paper is to briefly explain the nature of the modifications brought about by the revision of the Vienna Convention and the Paris Convention concerning the international transport of nuclear material. It will not address the particular regime established

1. Joint Protocol relating to the application of the Vienna Convention and the Paris Convention. The Joint Protocol entered into force on 27 April 1992. The list of Contracting Parties is set out in Annex 1 of this paper.
2 . The list of Contracting Parties to this Convention is set in Annex 2 of this paper.
3 . The list of Contracting Parties to these Conventions is set out in Annexes 3 and 4 of this paper.

by the CSC, since that Convention is dealt with in a separate paper[4]. Nor shall this paper deal with the BSC because the aim of this instrument is to provide additional public funds for the compensation of nuclear damage under the Paris Convention and it does not contain provisions specifically related to transport, although it applies to transport incidents as well.

The provisions of the Vienna and Paris Conventions[5] are intentionally very similar, although some limited differences do exist between those Conventions, including those rules governing transport operations. These differences which do not affect the general concordance of both Conventions do persist after their respective revision and, in a limited number of cases, may have actually increased, reflecting the particular intentions or concerns of the Paris Convention countries. Such differences will be noted, as appropriate, in the course of this presentation.

2. Liability and compensation for nuclear damage resulting from the transport of nuclear material - the current rules

Today, the threat of a significant nuclear accident (the Conventions use the term "incident") is mostly associated with the operation of large-scale nuclear installations such as nuclear power reactors and accordingly, the international nuclear liability conventions are often considered as addressing primarily this type of risk. This perception is in fact encouraged by the absence so far of serious transport incidents in this field, a record which is, in fact, a tribute to the very safe conditions of the transport of nuclear materials.

It should however be recalled that one of the prime motivations for originally adopting a special nuclear liability regime was the harmonisation of national legislation and that nowhere more than in the field of international transport operations was such harmonisation felt desirable. Accordingly, the Conventions as presently applicable cover the transport of nuclear material ("nuclear substances" for the Paris Convention), i.e. nuclear fuel other than natural or depleted uranium, and radioactive products or waste. In practice, this extends to most of the nuclear fuel cycle activities but leaves aside, however, some "front-end" operations such as the transport of uranium which is neither enriched nor irradiated (for example, UF6), because the hazards associated with radioactive contamination are considered relatively low in the case of such transport. It should also be noted that the transport of radioactive sealed sources (radioisotopes) that are designed to be used outside nuclear installations (for medical, industrial, agricultural purposes etc) is not covered by the special regime of the Conventions, for the same reason that the risks involved do not warrant the application of a special nuclear liability regime.

One of the prime objectives of the Conventions is to ensure that in all circumstances, there will be one person identified as liable for any incident. While the operator of a land-based nuclear installation is held strictly and exclusively liable under the Conventions for any nuclear damage originating from its installation, in the event of transport of nuclear material, there are normally two (or more) operators concerned and one must determine how the liability will be transferred between the sending and the receiving operators (to take a simple case). The Conventions contain therefore detailed provisions to this effect, whether the transfer takes place through the effective taking charge of the material or pursuant to the terms of a written contract between the operators concerned. The carrier itself may, subject to certain conditions, assume liability for the transport but this possibility is not widely used.

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4. [See paper by Mr. Ben Mc Rae]
5. For a detailed analysis of the international nuclear liability regime, see Liability and Compensation for Nuclear Damage - An International Overview, OECD/NEA, 1994.

As for the operation of land-based installations, the transport of nuclear material must be covered by insurance or other suitable forms of financial security, consistent with the applicable limit of liability. In the case of international transport operations, the liable operator must provide the carrier with a certificate issued by the insurer, providing all necessary details concerning the financial cover and the material transported, including a statement by the national competent authority that the transport is carried out under the regime of the Conventions. The OECD Nuclear Energy Agency has established a model of such a certificate. There are also some provisions dealing with the particular case of carriage to or from non-Contracting States or the case of transit through the territory of Contracting Parties.

The Paris Convention provides that the financial limits applicable to transport may be somewhat reduced by comparison with the general limit of the operator of a nuclear installation, taking into consideration the fact that the magnitude of the damage likely to be caused is much lower that that of a land-based installation. Another provision of the Paris Convention which has no equivalent in the Vienna Convention provides that a Contracting Party may subject the transit of nuclear substances through its territory to the condition that the limit of liability of the foreign operator concerned be increased if considered insufficient, but not above the limit applicable to national nuclear operators. In respect of carriage by sea, this rule does not affect however the right of entry in case of distress into the port of that Contracting Party or of innocent passage and, in the case of carriage by air, the right to fly over or to land on its territory.

Otherwise, the general rules of the Conventions apply to the transport of nuclear material in the same way as they apply to other activities.

3. Nuclear liability and transport conventions

When originally adopted, it was accepted that both the Paris and Vienna Conventions needed to preserve the application of previously concluded transport conventions dealing with liability. This meant that in the event of an incident involving the transportation of nuclear material, the Paris or Vienna Conventions and a transport convention, albeit not drafted with nuclear activities in mind, might be applicable simultaneously to the issue of third party liability. In particular, there were at the time a number of maritime liability conventions that would apply to the carriage of nuclear material by sea. Accordingly, if there were an incident involving nuclear material for which an operator were liable under one of the nuclear liability conventions, and if the flag State of the vessel were party to a convention on maritime liability, then both conventions might be applicable. Thus, the owner of the vessel might be liable under the transport convention just as the operator would be liable under either the Paris or Vienna Convention, each with a separate liability limit. Furthermore, courts in different States might have jurisdiction over the incident and different national legislation might be applicable.

Because of that legal uncertainty resulting in problems of insurance coverage of the maritime transport of nuclear material, a Convention relating to Civil Liability in the Field of Maritime Carriage of Nuclear Material was adopted in December 1971 under the auspices of the NEA, the IAEA and the IMO, and came into force 15 July 1975. In the preamble to the Convention, the purpose is declared as being to ensure that the operator of a nuclear installation will be exclusively liable for damage caused by a nuclear incident occurring in the course of maritime carriage of nuclear material. This effect is achieved by providing in the Convention that any person who might be held liable for the nuclear damage in the course of maritime carriage by virtue of an international convention or a national law is exonerated from such liability if the operator of a nuclear installation is liable for such damage under the Paris or the Vienna Convention, or under a national law governing nuclear liability, provided that the national law is in all respects as favourable to the victims as Paris or Vienna.

Exemption clauses in respect of nuclear damage, based on the principle established by the 1971 Convention, have since been included in many civil liability conventions covering activities where nuclear material may be involved[6]. This is for example the case for the IMO Convention on Liability and Compensation for Damage in Connection with the Carriage of Dangerous Goods by Sea and the Liability Protocol to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. An even more recent example is the Athens Convention relating to the carriage of passengers and their luggage by sea, as revised in November 2002.

4. The new regime

It is generally acknowledged that the most significant improvement resulting from the revision of the Vienna and Paris Conventions is the increase in the amount of indemnities payable after a nuclear incident. The Protocol amending the Vienna Convention established a minimum of 300 million SDRs[7] as the limit of liability of the nuclear operator, although it allows for some attenuation of this obligation. The revised Paris Convention will bring the minimum liability for nuclear damage to 700 million euros (EUR). The two additional layers of contributions which can be mobilised under the revised BSC increase this amount from EUR 700 million to EUR 1.5 billion. As will be explained *infra*, this increment of the mandatory financial cover also benefits transport of nuclear material for which special rules have been devised.

This paper will now address the modifications introduced into the Conventions which are of particular relevance to the transport of nuclear material.

Definition of nuclear damage: environment

Although this modification does not specifically concern transport operations, it is a major achievement of the revision exercise and is therefore worth mentioning.

It has become clear that apart from loss of life or personal injury and direct damage to property, other economic losses, the cost of measures to reinstate an impaired environment, the loss of income associated with an impairment of that environment, as well as the cost of preventive measures to avoid or minimise damage are likely to constitute major portions of the total damage caused by a nuclear incident. Considering also the need to harmonise national compensation systems in this respect, both Conventions now explicitly provide for the compensation of such damage.

Extension of the geographic scope of application of the conventions

The existing Paris Convention only applies where a nuclear incident occurs in the territory of a Contracting Party and the nuclear damage is suffered there, unless the relevant national legislation provides otherwise. The Vienna Convention does not contain such an explicitly restrictive clause but the implementing legislation generally reserves the benefit of the nuclear liability regime to damage suffered on national territory.

More generally, the Paris Convention is understood to apply to damage suffered in or above maritime areas beyond the territorial sea of a Contracting Party on board a ship or an aircraft of that Contracting Party.

The revised Vienna Convention now applies to nuclear damage wherever suffered, unless the "Installation State"[8] has excluded in its legislation damage suffered in a non-Contracting State

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6 . On the other hand, this is still not the case for the conventions relating to carriage by air (Montreal Convention and Protocols).

7. Special Drawing Rights of the International Monetary Fund. 1 SDR is roughly the equivalent of 1.4 USD.

8. Meaning, in relation to a Nuclear Installation, the Contracting State within whose territory that installation is located.

or in any maritime zones established by a non-Contracting State. This exception, however, is only allowed in respect of a non-Contracting State which is equipped with a nuclear programme and does not afford equivalent reciprocal treatment. In other words, victims in countries which do not have nuclear installations are entitled to compensation under the revised Convention without discrimination.

The equivalent provision of the Paris Convention is drafted in a different way but it explicitly states that it also covers nuclear damage suffered in the territory of, or in the maritime zones established by, non-Contacting States which have no nuclear installation at the time of the incident.

Liability amounts in respect of transport

The 1963 Vienna Convention does not provide for a particular amount of liability applicable to transport, the liability of the nuclear operator being set at no less than 5 million US "gold dollars"[9]. The 1960 Paris Convention, as revised in 1982, allows for the establishing of a lower amount for transport if justified by the limited hazard associated with such transport. The purpose of this provision is to avoid burdening the operators concerned with unjustified insurance costs. The Contracting Parties have nonetheless committed themselves to make available public funds, if necessary, to ensure compensation of the damage between the lower amount and the regular amount established for nuclear operators generally. Today, in most Paris Convention Countries, this amount is at least equivalent to 150 million SDRs and in several cases significantly higher.

An equivalent provision has now been introduced into the Vienna Convention with a minimum liability amount set at 5 million SDRs. When revising in turn the Paris Convention, the original clause allowing Contracting Parties to adopt a reduced limit for transport has been kept but there was much discussion before agreement upon the minimum level at which this limit should be established. It was finally decided that the new amount should be no less than EUR 80 million, which is significantly higher than the corresponding figure in the revised Vienna Convention.

Damage to the means of transport

Damage caused to the means of transport upon which the nuclear material was at the time of the incident can be substantial. This explains why it was originally not covered under the Conventions, unless otherwise provided by a Contracting Party and on the condition that compensation of such damage would not have the effect of reducing the funds available for other nuclear damage below a given amount. The revised Vienna Convention now sets this amount at either 150 million SDRs or any higher limit fixed by a Contracting Party in its legislation. The corresponding amount provided by the revised Paris Convention is EUR 80 million, an amount corresponding to the new minimum limit applicable to transport (see above).

Insurance forum shopping

As indicated earlier in this paper, in the case of transport, the Conventions allow the consignor and consignee operators to decide contractually between themselves who will assume liability for the transport (often the consignor because it has been in charge of organising the shipment). This arrangement was left untouched by the revision of the Vienna Convention.

On the other hand, during the work on the revision of the Paris Convention, it was noted that nuclear operators located in countries whose legislation provide for relatively low liability

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9. The US dollar referred to in this Convention is equivalent to its value in 1963, i.e. 35 USD per one troy ounce of gold.

limits for transport activities, happened to assume liability for such transport even though they had no genuine interest in the particular operation. This practice was obviously motivated by the advantage of paying less expensive insurance premiums and was tantamount to a type of forum shopping. A notable consequence of such a practice, in itself already questionable, was that the Contracting Party on whose territory the operator concerned was situated could, in the event that the operator's financial security be insufficient to compensate the damage, be required itself under the Convention to provide compensation as a consequence of a nuclear incident with which it had no real connection. With a view to discouraging this practice, an amendment has been made to the Paris Convention which will authorise the transfer of liability from one operator to the other only if that other operator has a direct economic interest in the nuclear material being transported.

Competent court and coastal states

The general principle in respect of the designation of the competent court in the event of a nuclear incident is that jurisdiction lies only with the courts of the Contracting Party in whose territory the nuclear incident occurred. However, the Paris and Vienna Conventions contain some specific provisions applicable in the case where the incident occurred outside the territory of Contracting Parties or when the exact place of the incident cannot be determined with certainty, as may happen in respect of transport.

A new provision has now been inserted into each Convention with the effect of granting jurisdiction to a Contracting Party in whose Exclusive Economic Zone (EEZ), or equivalent area, a nuclear incident has occurred, it being understood that this provision shall not be interpreted as permitting the exercise of jurisdiction in a manner which would be contrary to the international law of the sea. A further clarification of this new rule, introduced in the Paris Convention alone, is that it will not create any right or obligation, or set a precedent, with respect to the delimitation of maritime areas between States with opposite or adjacent coasts. In addition, when jurisdiction may belong to the courts of several Contracting Parties and the matter is referred to the special European Nuclear Energy Tribunal, it is provided that the competent court should be that of the Contracting Party most closely related to and affected by the consequences of the incident.

5. Conclusion

As noted earlier, the solution whereby nuclear conventions take precedence over transport conventions in respect of liability for damage cause by the carriage of nuclear materials is increasingly accepted internationally as the best assurance for potential victims to be entitled to adequate compensation.

This implies that the Paris and Vienna Conventions which already provide for a detailed system of liability and compensation for nuclear damage suffered during transport should be kept abreast with the evolving requirements in this field.

The modernisation of these Conventions which has just been achieved is an answer to this challenge. Combining in particular the widening of the geographical scope, an expanded definition of nuclear damage and increased liability limits, these Conventions will tomorrow guarantee that a greater financial compensation will be available to cover a larger number of victims in respect of a broader range of damage. It remains now to mobilise the efforts of the countries concerned to bring into effect these improvements in the nearest possible future.

ANNEX 1

1988 Joint Protocol relating to the application of the Vienna Convention and the Paris Convention

(Entry into force 27 April 1992)

Status of ratifications, accessions, acceptance

State	Date of deposit of instrument of ratification, accession, acceptance		
Bulgaria	24	August	1994
Cameroon	28	October	1991
Chile	23	November	1989
Croatia	10	May	1994
Czech Republic	24	March	1994
Denmark	26	May	1989
Egypt	10	August	1989
Estonia	9	May	1994
Finland	3	October	1994
Germany	13	June	2001
Greece	16	May	2001
Hungary	26	March	1990
Italy	31	July	1991
Latvia	15	March	1995
Lithuania	20	September	1993
Netherlands	1	August	1991
Norway	11	March	1991
Poland	23	January	1990
Romania	29	December	1992
St. Vincent & the Gernadines	18	September	2001
Slovakia	7	March	1995
Slovenia	27	January	1995
Sweden	27	January	1992
Ukraine	24	March	2000

ANNEX 2

1963 Vienna Convention on Civil Liability for Nuclear Damage

(Entry into force 12 November 1977)

Status of ratifications, accessions, successions

State	Date of deposit of instrument of ratification, accession, acceptance		
Argentina	25	April	1967
Armenia	24	August	1993
Belarus	9	February	1998
Bolivia	10	April	1968
Bosnia & Herzegovina	30	June	1998
Brazil	26	March	1993
Bulgaria	24	August	1994
Cameroon	6	March	1964
Chile	23	November	1989
Croatia	29	September	1992
Cuba	25	October	1965
Czech Republic	24	March	1994
Egypt	5	November	1965
Estonia	9	May	1994
Hungary	28	July	1989
Latvia	15	March	1995
Lebanon	17	April	1997
Lithuania	15	September	1992
Mexico	25	April	1989
Niger	24	July	1979
Peru	26	August	1980
Philippines	15	November	1965
Poland	23	January	1990
Republic of Moldova	7	May	1998
Romania	29	December	1992
St. Vincent & the Grenadines	18	September	2001
Serbia & Montenegro	5	February	2002
Slovakia	7	March	1995
Former Yug. Rep. of Macedonia	8	April	1994
Trinidad & Tobago	31	January	1966
Ukraine	20	September	1996
Uruguay	13	April	1999

ANNEX 3

1960 Paris Convention on Third Party Liability in the Field of Nuclear Energy

Status of ratifications or accessions

State	Convention *(entry into force 1 April 1968)*		1964 Additional Protocol *(entry into force 1 April 1968)*		1982 Protocol *(entry into force 7 October 1988)*	
Austria*	...		...		...	
Belgium	3 August	1966	3 August	1966	19 September	1985
Denmark	4 September	1974	4 September	1974	16 May	1989
Finland	16 June	1972	16 June	1972	22 December	1989
France	9 March	1966	9 March	1966	6 July	1990
Germany	30 September	1975	30 September	1975	25 September	1985
Greece	12 May	1970	12 May	1970	30 May	1988
Italy	17 September	1975	17 September	1975	28 June	1985
Luxembourg*	...		...		...	
Netherlands	28 December	1979	28 December	1979	1 August	1991
Norway	2 July	1973	2 July	1973	3 June	1986
Portugal	29 September	1977	29 September	1977	28 May	1984
Slovenia	16 October	2001	16 October	2001	16 October	2001
Spain	31 October	1961	30 April	1965	7 October	1988
Sweden	1 April	1968	1 April	1968	8 March	1983
Switzerland*	...		...		...	
Turkey	10 October	1961	5 April	1968	21 January	1986
United Kingdom	23 February	1966	23 February	1966	19 August	1985

* Austria, Luxembourg and Switzerland signed the Paris Convention upon its adoption, but have not ratified this instrument.

ANNEX 4

1963 Brussels Supplementary Convention

Status of ratifications or accessions

State	Convention and 1964 Additional Protocol *(entry into force 4 December 1974)*		1982 Protocol	
Austria*	...		...	
Belgium	20 August	1985	20 August	1985
Denmark	4 September	1974	10 May	1989
Finland	14 January	1977	15 January	1990
France	30 March	1966	11 July	1990
Germany	1 October	1975	25 September	1985
Italy	3 February	1976	14 June	1985
Luxembourg*	...		...	
Netherlands	28 September	1979	1 August	1991
Norway	7 July	1973	13 May	1986
Slovenia	5 March	2003	5 March	2003
Spain	27 July	1966	29 September	1988
Sweden	3 April	1968	22 March	1983
Switzerland*	...		...	
United Kingdom	24 March	1966	8 August	1985

* Austria, Luxembourg and Switzerland signed the Paris Convention upon its adoption, but have not ratified this instrument.

TOWARDS A GLOBAL AND COMPREHENSIVE IAEA'S NUCLEAR LIABILITY REGIME, IN PARTICULAR FOR NUCLEAR DAMAGE CAUSED DURING THE TRANSPORT OF RADIOACTIVE MATERIAL

C. Azurin-Araujo

Permanent Mission of Peru to the IAEA in Vienna
Peru

Abstract.

Seventeen years ago, the Chernobyl accident demonstrated the weakness of existing international arrangements on liability for nuclear damage. The IAEA's liability regime was reviewed and enhanced. However, the enhanced regime is not into force and does not have global membership. Countries that carry substantial nuclear and related activities across the globe are not yet parties to the international liability arrangements. The IAEA should assess the reasons that are preventing the entry into force of a clear, more comprehensive and global nuclear liability regime.

1. The evolution of the IAEA's nuclear liability regime

The use of nuclear energy can be beneficial, but it may also yield risks and could have harmful consequences over people, the environment, property and economic activities for a long time. National borders and artificially established maritime zones offer no protection against such effects. In order to protect the welfare of their citizens and, at the same time, facilitate the development of the nuclear industry, governments have envisaged three interlinked sets of regulations to minimise radiation risks and deal with their eventual harmful effects:

- Preventive safety and security regulations to minimise risks.
- Emergency preparedness and response measures to minimise the negative effects of radiation.
- Liability regulations to compensate for harmful effects and if possible reinstate things to their previous status.

These regulations reinforce each other, in particular liability and compensation measures, which encourage those who carry hazardous activities to comply with safety and security regulations and take the utmost possible care to prevent incidents an react promptly to emergency situations, so as to qualify for insurance coverage and to relieve themselves from the costs of emergency response and legal or administrative claims.

Western European countries were the first to establish national liability legislation in order to develop their nuclear industry, back in the 1950's. Later, they negotiated regional liability and compensation arrangements for nuclear damage, as embodied in the Paris Convention on Third Party Liability in the Field of Nuclear Energy (1960)[1] and its 1964 and 1982 amendment protocols, as well as in the Brussels Convention Supplementary to the Paris Convention (1963) [2].

Under the auspices of the Agency and entrusting it as depositary, Members States also undertook to set up a global nuclear liability regime, through the Vienna Convention on Civil Liability for Nuclear Damage (1963). Later, the Chernobyl accident and its ensuing transboundary effects revealed important gaps in this instrument and triggered its review.

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[1] The States Party are Belgium, Denmark, Finland, France, Germany, Greece, Italy, Netherlands, Norway, Portugal, Spain Slovenia, Sweden, Turkey and the United Kingdom.

[2] The States Party are Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Spain, Sweden and the United Kingdom

As a result, an enhanced regime was designed, which comprises the Joint Protocol that links the Vienna and the Paris conventions (1988) was adopted, as well as the Vienna Convention Amendment Protocol (1997), the Convention on Supplementary Compensation for Nuclear Damage (1997) and the Optional Protocol Concerning the Compulsory Settlement of Disputes to the Vienna Convention (1999).

2. The enhanced liability regime under the IAEA auspices is not global and is not into force.

The number of States adhering to the IAEA liability instrument greatly increased in the aftermath of the Chernobyl accident. Afterwards, the status of international instruments on liability adopted under the Agency's auspices has not improved at the same pace as the enlargement of its membership or the development and volume of activities carried out by the nuclear industry. Furthermore, countries that carry out substantial nuclear and related activities, such as reprocessing and international transportation of nuclear fuel and highly radioactive wastes are party to regional arrangements only or to none at all, as illustrated below.

- Forty years after being adopted and twenty-six years after coming into force, the *Vienna Convention on Civil Liability for Nuclear Damage* has 32 parties[3] and 14 signatories.
- Since there were particular arrangements concerning liability during maritime transport, the IAEA, IMO and OECD sponsored the adoption of the 1971 *Convention relating to Civil Liability in the Field of Maritime Carriage of Nuclear Material* (NUCLEAR). This convention prevents the simultaneous application to nuclear damage of certain maritime conventions dealing with ship owners' liability. It is into force since 1975 and has 16 parties. [4]
- The *Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention* came into force in 1992 as an attempt to combine both conventions into one expanded liability regime. To date it has 22 signatories and 24 parties[5], 9 of them linked to the Paris Convention[6] and the rest to the Vienna Convention.
- The *Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage* opened for signature in 1997. Currently, it has 4 contracting States[7] and 15 signatories. It needs one more instrument of ratification, acceptance or approval to enter into force.
- *The Convention on Supplementary Compensation for Nuclear Damage* seeks to involve States to provide compensation when insurance coverage does not suffice. It has only 3 contracting States[8] and 13 signatories. Pursuant to Article XX.1, the Convention shall come into force following the deposit of instruments of ratification, acceptance or approval by at least 5 States with a minimum of 400,000 units of installed nuclear capacity.
- *The Optional Protocol Concerning the Compulsory Settlement of Disputes to the Vienna Convention* came into force in 1999. It has 2 parties[9] and 4 contracting States.

[3] Argentina, Armenia, Belarus, Bolivia, Bosnia and Herzegovina, Brazil, Bulgaria, Cameroon, Chile, Cuba, Croatia, Czech Republic, Egypt, Estonia, Hungary, Israel, Latvia, Lebanon, Lithuania, Mexico, Niger, Peru, Philippines, Poland, Republic of Moldova, Romania, Saint Vincent & the Grenadines, Slovakia, the Former Yugoslav Republic of Macedonia, Trinidad und Tobago, Ukraine, Uruguay and Yugoslavia.

[4] Argentina, Belgium, Denmark, Dominica, Finland, France, Gabon, Germany, Italy, Latvia, Liberia, Netherlands, Norway, Spain, Sweden and Yemen.

[5] Bulgaria, Cameroon, Chile, Croatia, Czech Republic, Denmark, Egypt, Estonia, Finland, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Netherlands, Norway, Poland, Romania, Saint Vincent & the Grenadines, Slovakia, Slovenia, Sweden and Ukraine.

[6] Denmark, Finland, Germany, Greece, Italy, Netherlands, Norway, Slovenia and Sweden.

[7] Argentina, Latvia, Morocco and Romania.

[8] Argentina, Morocco and Romania.

[9] Philippines and Uruguay.

3. **The process of harmonization of national and regional nuclear liability regulations should take into account the basic principles laid out in IAEA's enhanced nuclear liability regime.**

With a view to secure effective legal protection for the victims of nuclear damage, national and regional nuclear liability regulations should be assessed against the backdrop of these principles:

- ***Channelling of liability***

The operator of the nuclear installation that sends or is meant to receive the radioactive material is held liable.

- ***Objective or strict liability***

The operator of the nuclear installation will be held liable even if he was not a fault. To obtain compensation the victim needs to proof damage and the link between the damage and the carriage of radioactive material for which the operator is liable.

- ***Absolute liability***

There are few circumstances to exonerate the operator of a nuclear installation, namely armed conflict, hostilities, civil war or insurrection. *Force majeure*, acts of terrorism, sabotage or theft during the transport of radioactive material are not considered exonerating circumstances.

- ***No discrimination of victims***
- ***Definition of nuclear damage***

For liability purposes, nuclear damage is defined in a restricted manner by the Vienna Convention in article I, paragraph 1(k), namely loss of life, personal injury, loss of or damage to property and any other loss that the law of the competent court accepts. A broaden definition is provided in Article II.2 of the amendment protocol, which includes economic loss arising from loss or damage to property, the costs of measures to reinstate the environment, loss of income deriving from an economic interest in any use or enjoyment of the impaired environment, the costs of preventive measures, further loss or damage caused by such measures and any other economic loss if permitted by the general law on civil liability of the competent court.

- ***Compulsory financial security***

This should be provided by the operator in the form of third party civil insurance and eventually by the Installation State.

- ***Limitation of liability***

In the Vienna Convention, liability is limited to not less than US$ 5 million. Considering that insurance coverage for nuclear installations and effects of a single international incident greatly exceed such limit, the amended Vienna Convention sets the liability amount at not less than 300 million Special Drawing Rights (SDRs). The Convention on Supplementary Compensation will require the availability of additional amounts to be provided collectively by States Party, on the basis of a formula that combines installed nuclear capacity and the UN rate of assessment.

- ***Limitation in time for the submission of claims***

The Vienna Convention establishes that compensation rights shall be extinguished if an action is not brought within 10 years from the date of the incident. Its amendment protocol establishes 30 years with respect to loss of life and personal injury, and 10 years with respect to other damage.

- ***Discovery rule***

Claims may prescribe if they are not filed within 3 years after the claimant knew or ought to have known of the damage and of the operator liable for it.

- ***Determination of jurisdiction and applicable law***

The applicable law is that of the court that has jurisdiction over the incident. Jurisdiction lies with the courts of the State Party in whose territory the nuclear incident took place. If the incident happened within the exclusive economic zone of State Party, jurisdiction lies with the courts of that Party, provided it has notified the Depositary of such area prior to the incident. If damage arises from an incident during carriage of radioactive material through the high seas, jurisdiction lies with the courts of the Installation State of the liable operator.

4. Liability issues that require clarification, discussion and further action

The Agency is the appropriate forum to consider and assess the following issues, with a view to take further action, as appropriate, in co-ordination with other specialised UN agencies:

- Promotional measures to make its enhanced nuclear liability regime global in scope.
- The reasons that prevent the entry into force of the enhanced IAEA's liability regime, in particular the Supplementary Compensation Convention.
- Ways for dealing with liability claims for nuclear damage that occurs during the carriage of radioactive material that originates in and/or is sent to a non-civilian nuclear installation.
- The applicability of IAEA's regime to nuclear damage caused by a nuclear ship, since the Convention on the Liability of Operators of Nuclear Ships (1962) is not into force.
- Ways of bringing national laws and financial arrangements made by Member States into conformity to enhanced arrangements on liability for nuclear damage.
- Ways of dealing with legal and practical complications that may arise when the nuclear damage during transport affects parties to the IAEA's liability regime and also non-parties.
- Harmonization of terms used in IAEA documents, for instance, in the framework of the Vienna Convention, the word "incident" appears to have been used to mean both "accidents" and "minor events", which is not the case in other IAEA's documents.
- The obligation of the carrier or the operator to inform third parties about the occurrence of an incident is not mentioned in nuclear liability instruments. Only if the carrier flies the flag of a State Party to the IAEA's Convention on Early Notification, he shall notify nuclear accidents but not "incidents" or "minor events".
- The time limitation and discovery rule should not apply if the carrier or operator did not duly notify or provide enough information about the incident.
- The time limitation should not apply either to harmful effects that became to be known only after subsequent scientific and technical developments determined their link to the incident.
- The broad definition of nuclear damage, as well as important elements of the enhanced liability regime, such as the nature, form and extent of the compensation and its equitable distribution, should not depend on the national law of the competent court.
- Pure economic loss should be considered nuclear damage, since it may occur simply because of public perception that an area or its produce may have been affected, even without release of radioactive material, ionising radiation or toxic reactions.
- The enhanced IAEA liability regime determines that the coastal state court is competent for liability arising from incidents in the Economic Exclusive Zone and that it should apply its national law. However, there is a contradiction to the effects of article 6 of the Supplementary Convention, which provides that this court will have to apply foreign laws concerning the maximum liability of the operator.
- Uniform criteria should be developed to determine when the impairment of the environment is "not significant". Further long-term research and evaluations should be carried in this respect, in particular concerning delicate ecosystems and taking into account migrating habits of species in the marine environment. Such long-term studies should take into account radiological and other toxic and hazardous effects of nuclear fuel, radioactive materials and low and high level wastes, as well as their cumulative effects on foodstuffs and people who consume them.
- Liability limits and the capacity of certain arrangements -such as national nuclear insurance pools- need to be appraised to determine if they could cover the damage caused by a large international incident during the maritime transport of radioactive material. To this end, levels of insurance coverage available in the market, the potential peril posed by different radioactive materials, the profits made by nuclear operators and the profits made by carriers of radioactive material, should be taken into account.

CONVENTION ON SUPPLEMENTARY COMPENSATION FOR NUCLEAR DAMAGE:
Path to a Global Liability Regime Covering Nuclear Incidents During Transportation

J.B. McRae

Civilian Nuclear Programs, Office of General Counsel
U.S. Department of Energy, Washington DC
United States of America

Abstract

The Convention on Supplementary Compensation for Nuclear Damage (CSC) was negotiated under the auspices of the International Atomic Energy Agency (IAEA) to provide the basis for a global liability regime for dealing with nuclear incidents, including those during transportation. It contains many features to attract broad adherence from countries that ship nuclear material (shipping states) and countries in the vicinity of shipping routes (coastal states). These features include: exclusive jurisdiction of member countries over incidents in their exclusive economic zones (EEZs); broad definition of nuclear damage; and increased amounts of compensation. In addition, the CSC contains a provision to permit adherence by the United States, which cannot adhere to either the Paris or Vienna Convention.

1. Introduction

There is a need for broad adherence to a global regime that deals with the legal liability resulting from a nuclear incident during the transportation of nuclear material. The lack of broad adherence to a global liability regime creates uncertainty as to the legal consequences of a transportation nuclear incident. For example, if a nuclear incident occurred during the transportation of nuclear material from the United States to a country that belonged to the Paris or Vienna Convention and outside the United States in the vicinity of a coastal state that did not belong to either the Paris or Vienna Convention, there could be lawsuits in the United States, the recipient country and the coastal state. While the lawsuit in the recipient country would apply the provisions of the Paris or Vienna Convention (including those that channel legal liability exclusively to the responsible operator and that limit the amount of liability), the lawsuits in the United States and the coastal state most likely would apply normal tort law with no channelling of legal liability exclusively to the responsible operator and no limit on the amount of liability.

2. The Convention on Supplementary Compensation for Nuclear Damage (CSC)

Following many years of negotiations under the auspices of the IAEA, the CSC was adopted at a Diplomatic Conference in 1997. The CSC provides the world community with the opportunity to deal with liability issues related to the transport of nuclear material through a global regime that includes all shipping and coastal states. This global regime can remove legal uncertainty as an impediment to transportation, while guaranteeing the availability of meaningful compensation in the event of a nuclear incident. The treatment of legal liability resulting from transportation nuclear incidents and the assurance of adequate compensation in the event of such an incident were recognized as major concerns during the negotiation of the CSC. Accordingly, the CSC contains many features to make it attractive to shipping and coastal states.

The CSC recognizes recent developments in the Law of the Sea and the concerns of coastal states over maritime shipments of nuclear material by providing the courts of a member country with exclusive jurisdiction over a nuclear incident that occurs within its EEZ. The CSC is clear that this jurisdictional rule is intended only for determining which member country's courts have jurisdiction for the purposes of the CSC and does not permit any exercise of jurisdiction that is inconsistent with the Law of the Sea. Although the CSC grants jurisdiction over a nuclear incident to the member country in whose

EEZ the incident occurs, the amount of the liability is determined by the national law of the country where the operator responsible for the shipment is located, subject to the CSC requirements on minimal liability limits. (The CSC does not affect the ability of a country to establish the amount of liability for a nuclear incident within its territory, including its territorial sea; a country's EEZ is not part of its territory.).

The CSC responds to longstanding concerns over the definition of nuclear damage by explicitly identifying the types of damage that are considered nuclear damage. In addition to personal injury and property damage, the enhanced definition includes five categories of damage relating to impairment of the environment, preventive measures, and economic loss.

Many countries, and especially coastal states without nuclear power plants, are unwilling to enter into treaty relations on the basis of the compensation amounts potentially available under the Paris and Vienna Conventions. The CSC addresses these concerns by providing for a substantial increase in the amount of guaranteed compensation for nuclear damage. First, it requires a member country to ensure the availability of at least 150 million SDR's to compensate nuclear damage during the period prior to September 29, 2007, and at least 300 million SDR's thereafter. Second, it supplements the compensation available under national law through an international fund that would be more than 300 SDR's if most countries with nuclear power plants adhered to it. And third, one-half of the international fund is reserved exclusively for transboundary damage (that is, damage outside the country where the responsible operator is located). Finally, the CSC is a free-standing instrument open to all countries. As a free-standing instrument, it offers a country the means to become part of the global regime without also having to become a member of the Paris or Vienna Convention. The free-standing nature of the CSC is important because many shipping countries and most coastal countries are not members of the Paris or Vienna Convention. Of the ten countries with the largest amount of nuclear power generating capacity (Canada, France, Germany, Japan, the Republic of Korea, the Russian Federation, Sweden, Ukraine, the United Kingdom, and the United States), only half (France, Germany, Sweden, Ukraine, and the United Kingdom) belong to either the Paris or Vienna Convention.

The CSC makes a global regime possible by providing the basis for treaty relations among countries that adhere to the Paris or Vienna Convention and those countries that do not adhere to either. To the maximum extent practicable, the CSC is compatible with the Paris and Vienna Conventions, including the basic principles of nuclear liability law set forth in these Conventions, such as (1) channelling all legal liability for nuclear damage exclusively to the operator, (2) imposing absolute liability on the operator, (3) granting exclusive jurisdiction to the courts of the country where a nuclear incident occurs, and (4) limiting liability in amount and in time. Thus, countries that adhere to the Paris or Vienna Convention can also adhere to the CSC, while other countries can adhere to the CSC if they are willing to accept the basic principles of nuclear liability law in the context of the CSC. In addition, the CSC takes into account the special situation of the United States whose nuclear liability national law predates both the Paris and Vienna Conventions. Although the national law of the United States is generally consistent with the basic principles of nuclear liability law set forth in the Paris and Vienna Conventions, it uses a different legal theory to achieve the same practical result of making the operator exclusively responsible for nuclear damage. This difference prevents the United States from adhering to the Paris or Vienna Convention. The Compensation Convention addresses this situation through a grandfather clause under which the national law of the United States is deemed to satisfy certain requirements of the CSC. By permitting the United States to join the CSC, the grandfather clause removes a major impediment to achieving a global regime. The United States has begun the ratification process by submitting the CSC to the United States Senate in December 2002.[i]

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[i] For a more detailed discussion, *See,* McRae, Ben, *The Compensation Convention: Path to a Global Regime for Dealing with Legal Liability and Compensation for Nuclear Damage*, 61 Nuclear Law Bulletin 25 (June 1998) (Nuclear Energy Agency) www.nea.fr/html/law/nlb/NLB-61/benfinal.pdf ; *See also,* Gioia, Andrea, *The New Provisions on Jurisdiction in the 1997 Vienna Protocol and in the 1997 Convention on Supplementary Compensation*, 63 Nuclear Law Bulletin 25 (1998) (Nuclear Energy Agency) www.nea.fr/html/law/nlb/NLB-63/gioia.pdf.

TRANSPORTING PLUTONIUM:
W*hat comes after the analysis?*

J.A. Read, R. Clark

Transport Dangerous Goods, Transport Canada
330 Sparks Street, Ottawa, Ontario, K1A 0N5
Canada

Abstract

Two shipments of test quantities of MOX fuel to Canada from Russia and the United States received high interest. In addition to analysis of MOX fuel, containers, accident rates in modes, accident forces, dispersion patterns, effects of released product, emergency response assistance plans, security considerations and reasons for the shipments, conclusions had to be communicated to the public. The focus of this paper is on the interaction with the public.

Introduction

By the early 1990's, disarmament had resulted in approximately100 metric tons of plutonium being removed, or identified for removal, from warheads in the United States and Russia. Studies were conducted on what to do in order to ensure it would be difficult to return the plutonium to use in nuclear weapons. Among the options considered was the proposal to convert the plutonium into plutonium oxide, and blend this with uranium oxide to produce fuel for use in nuclear reactors. This mixed oxide fuel is commonly referred to as MOX fuel. Setting aside the questions of who would process the plutonium and develop the MOX, there still remained the question of determining which reactors would use this weapons associated MOX as fuel. Among the possibilities are reactors of the CANDU® (Canada Deuterium Uranium) design. There are several of these in operation in Canada, including the National Research Universal Research Reactor operated by the Atomic Energy of Canada Limited at Chalk River in Ontario, Canada. Following negotiations involving several parties it was agreed that MOX fuel samples would be prepared in each of the United States and Russia for testing in a CANDU reactor in Chalk River. The focus of this paper is on the public's interest in the transport of the MOX fuel samples from these two countries to Chalk River.

There were to be three shipments from each country with pairs of shipments from the two countries arriving at approximately the same time. For consultation purposes, each shipment was assumed to consist of 28 fuel pins containing a total of 14.5 kg of ceramic MOX fuel pellets, of which 528 g would be plutonium oxide.

The two federal government entities with responsibility for regulating the transport of MOX fuel are the federal department of transport, Transport Canada, and the Canadian Nuclear Safety Commission (which at the time of the MOX shipments was named the Atomic Energy Control Board of Canada). The role of the Canadian Nuclear Safety Commission extends well beyond safety during transportation and the role of Transport Canada extends well beyond safety during the transport of Class 7 materials. However, where the two overlap there is only one Canadian program.

Transport Canada does have a mandatory emergency response assistance plan program with respect to dangerous goods that would affect a large area, or which would require specialized equipment and trained responders, if released. These materials include propane, chlorine and

MOX fuel. Under this requirement, no person in Canada may offer for transport or import into Canada such dangerous goods unless they have in place an emergency response assistance plan that has been approved by Transport Canada.

The importer into Canada of the MOX fuel shipments would be the Atomic Energy of Canada Limited who would in turn be regulated by the Canadian Nuclear Safety Commission and Transport Canada. The Canadian Nuclear Safety Commission approved the container and Transport Canada approved the emergency response assistance plan, commonly referred to as the ERAP. It is instructive to point out that the final ERAP approved was specific to mode and route due to the manner in which it was submitted.

This paper is not about an analysis of MOX fuel, containers, accident rates in modes, accident forces, dispersion patterns, effects of released product, emergency response assistance plans, or security considerations. The focus of this paper is communication with the public.

What generated the need for public involvement?

(a) Transforming weapons plutonium into spent nuclear fuel, several processes away from nuclear weapons, is a good story to share with the public. It was decided that information sessions would be provided to town councils by the importer, together with two other government departments (Natural Resources Canada and the Department of Foreign Affairs and International Trade) who would speak on the goals of the initiative. Most of these town council meetings were also attended by Transport Canada or the Canadian Nuclear Safety Commission, but clearly in the role of regulator, not promoter.

(b) Transport Canada advised the importer that an ERAP approval would not be granted unless every fire department through whose zone of operation the MOX fuel would move on the ground was offered a briefing on MOX fuel. Transport Canada offered to participate in any such briefings.

Of the two types of sessions, fire department briefings and town council meetings, which was the more important?

Both types of sessions were important. However, the order was important. Town council meetings that followed fire department briefings allowed for more informed discussion. Although there were still points of disagreements, the disagreements were more readily understood and respected by both sides. When the town council meetings occurred first, disagreements became frustrations as often the reasons behind them were not clear or could not be understood. Such sessions were not satisfactory for the attendees.

How many fire departments did you brief?

The routes to be followed from the two countries were changed several times during the evolution of the project. In the end Transport Canada, together with the importer, briefed over 75 fire departments or fire department chiefs. Transport Canada staff drove several hundred kilometers with a Type B container secured in the back of a van to various locations.

What did a briefing consist of?

The purpose of each briefing was to let the fire department know what was expected of them should there be an accident, and what the importer would provide through their response team. Brought to each briefing was the 4H drum container that would be used, empty fuel pins, mock-ups of fuel elements that fit inside the pins, a plutonium sample used for calibration purposes and a meter for reading alpha radiation. In brief, fire departments were asked to fight any fire resulting from a highway accident as they normally would. Specifically, they should decide to apply water or not by assuming the MOX container was not on board.

What made the most impact in the sessions?

At both the town hall meetings and the fire department briefings people appeared not to really believe that alpha radiation could be stopped by a piece of paper, until we showed them. Answers were provided to all questions. This avoided the potential conclusion by attendees that we did not know the answer, or, we did know the answer and were afraid to provide it. This policy resulted in the promoting departments and the regulating departments disagreeing in public occasionally. This was more beneficial than it sounds and was appreciated. There was an effort made by the regulating departments to be the last people to leave each session, to ensure all who wished, were able to ask questions. In one of the first the town hall meetings, one person spoke up at the end of the presentations and said that he was quite willing for the plutonium to arrive in Canada as a component of MOX rather than as a component of a warhead. This thought was raised often. It was tempered by the observation that such a solution would be acceptable but the other options for plutonium disposition should be fully explored.

Did anyone object to you carrying a plutonium sample?

Yes. We had not thought it necessary to describe the sample because of its minute quantity and because we almost immediately would illustrate the short range of alpha radiation. However, following the first concern raised we then made clear that there were only a few micrograms of plutonium, it was permanently fixed to the test strip, it was in the possession of an inspector at all times, and it was intended for use in calibrating instruments.

Did you compare this quantity of MOX to other dangerous goods normally transported in the same area?

We did not initiate this. However, in most fire department briefings the participants raised the topic by pointing out the quantities of some products, including Class 7, which were normally present in their areas. Comparisons made most often by participants were that the MOX shipments posed less of a concern.

Was there anything unexpected?

Part way through the consultation process a truck loaded with 18,000 kg of an explosive mixture of ammonium nitrate and fuel oil left the highway and caught fire. The resulting explosion was powerful enough to shift the roadbed. As the MOX fuel was to travel on the same highway, we calculated the shock wave effect on the container assuming the MOX fuel transport was located next to the detonation. The impact would not result in a release of MOX fuel. We did not calculate the effect of an impact of a projectile from such an explosion contacting the container. Also during the consultation period a criticality accident occurred at the Tokai nuclear fuel plant in Japan. This was raised but had no real impact.

Conclusions

The importer, the Atomic Energy of Canada Limited, developed a very sound response plan. They had in their possession all equipment required by the plan. They trained as per the plan, and they tested the activation and conduct of their plan. The analysis of the safety of the container and the mode of transport in Canada was sound. It was important to not stop at this point and simply announce that all would be done safely. The briefing of fire departments on their role in the event of an accident was beneficial to the fire departments and thereafter facilitated discussions with town councils. In the end there were two larger shipments received in place of six smaller ones. One of these was from Russia and one was from the United States. Both shipments arrived in 2000 without incident. Security was a significant component of this project but was not the object of this paper.

INES SCALE: FRENCH APPLICATION TO RADIOACTIVE MATERIAL TRANSPORT

J. Aguilar

Direction générale de la sûreté nucléaire et de la radioprotection
Fontenay-aux-Roses, France

Abstract.

After getting the control of radioactive material transport in 1997, the French safety Authority (ASN) decided to apply the INES scale to transport events, following a wide debate involving experts, industry and the high council for nuclear safety and information (CSSIN). The French experience was used by IAEA to develop a draft guide and IAEA asked countries to use this draft for a trial period since the 7th TRANSSC meeting in February 2002. An EU directive or regulation for notification and rating of transport events in EU countries is underway.

1. Historical background

In October 1999, the emergency services were called out to an accident on the A31 motorway, near Langres, in which a vehicle carrying hazardous goods had caught fire. It was only a few days later that the authorities were informed that the vehicle had been carrying 900 smoke detectors equipped with americium sources, which had been completely destroyed during the fire. This incident, which had no radiological consequences for those involved, was rated at level 1 on the International Nuclear Event Scale (INES). This was one of the first applications in France of this communication tool designed to give an idea of the seriousness of a radioactive material transport incident.

In the same way as for natural phenomena such as earthquakes, wind or avalanches, France in 1987 set up a scale measuring the degree of seriousness of nuclear-related events. The Organisation for Economic Cooperation and Development (OECD) first of all, and then the International Atomic Energy Agency (IAEA) made extensive use of it when putting together the INES scale.

The INES scale was internationally implemented in 1991. Following a recommendation made in France by the high council for nuclear safety and information (CSSIN), the INES scale was adopted by the Nuclear Safety Authority (ASN) in April 1994. This scale is now applied to all the installations controlled by the ASN (EDF reactors, COGEMA plants, laboratories of the Atomic Energy Commission, etc.).

However in the early 90s, the INES scale was in reality applied only to nuclear facilities and not to transport events. This situation can perhaps be explained by the small number of transport incidents which were actually notified to the authorities and by the absence of precise rules for use of the INES scale in this type of incident.

The late 90s saw several significant transport-related events: contamination from spent fuel convoys made a deep impression internationally on public opinion and the media, forcing the authorities to react. At the same time, the authorities themselves were significantly restructured in France. The Nuclear Safety Authority, which was already in charge of the Basic Nuclear Installations, was getting responsibility for controlling the safe transport of radioactive materials, which was previously the role of the ministry for transport.

Expanding the scope of its activities to include controlling the safe transport of radioactive materials, the ASN then decided to apply the INES scale to transport events, following a wide debate bringing together experts, industry and the high council for nuclear safety and information (CSSIN).

International interest in French experience has gradually raised the question of harmonised application of the INES scale to transport events by the competent international authorities.

2. New role of ASN in transport

2.1. The new assignments of the ASN

The ASN has since 12 June 1997 been responsible for controlling the safe transport of radioactive and fissile materials for civil use under the joint authority of the ministry for industry and the ministry for environment. This reorganisation of the authorities is part of a move to rationalise the organisation of the State in terms of controlling nuclear safety. Initially relying on the existing jurisprudence and organisation and with the technical support of the nuclear protection and safety institute (IPSN), the Nuclear Safety Authority defined the new assignments and modified the organisation accordingly, to bring it closer into line with that existing for the safety of basic nuclear installations. This change in particular concerned informing the public about the radioactive materials transport activity.

2.2. The ASN's public information role

Under decree 93-1272 of December 1st, 1993 and confirmed by the decree 2002-255 of February 22, 2002, the Nuclear Safety Authority is responsible for proposing and organising public information concerning nuclear safety. In the transport field, the ASN thus relied on the practices and tools which it had used to set up regular, high-quality exchanges with the public through the media concerning installations safety, with the watchwords being clarity and thoroughness. Prime examples are the "transport" heading of the control review which details the authorisations issued and the incidents which have occurred, the publication of information on the ASN's server and web site (www.asn.gouv.fr), exchanges with the media (conferences, press releases and public reports), and the inclusion of transport in the debates of the local information committees. Finally, the ASN decided to apply the INES scale to transport events.

2.3. The decision to apply the INES scale to transport events

In line with the wishes of the CSSIN, the aim of the Nuclear Safety Authority was to extend application of the INES scale to transport incidents and accidents. The criteria for application of the INES scale to transport had to be drawn up on the basis of three objectives: ease of use, consistency with the general principles of the INES scale and inclusion of the data and examples concerning transport contained in its application manual, plus production of a balance of past incidents/accidents with a view to subsequent rating.

3. Application of INES scale to transport events

3.1. Initial studies and debate under the aegis of the CSSIN

In order to study the scope of the events to be included, the ASN asked all those involved in the transport chain to declare events, incidents or accidents of any kind which occurred during their transport in France. On the basis of this information, technical discussions were held with the consignors and forwarding agents, in order to define the criteria for declaring incidents to be rated on the INES scale. At the same time, at the instigation of the IPSN, the ASN drew up a project to apply the INES scale to radioactive material transport events. On 15 December 1998, the president of the CSSIN decided to create a working group in charge of examining the project produced by the ASN. This working group consisted of CSSIN members, information and communication specialists, environmental protection associations, operator representatives, administrations, and radioactive material transport experts. The working group examined the INES scale project on the basis of a number of incidents and accidents that had occurred in recent years.

Following this wide consultation, an amended version was presented at the CSSIN meeting of 24 June 1999. The Council then issued a favourable opinion regarding its application for an experimental period of one year.

3.2. The test phase and adaptations

The experimental phase began on 1 October 1999. During the course of the following year 55 radioactive material transport incidents were rated on the INES scale. 24 of these incidents were rated at level 1 and none was rated at a higher level. The nuclear safety authority felt that the system adopted for the trial period led to no major problems for rating of these incidents. Nonetheless, certain minor adaptations were proposed in order to reinforce the clarity and consistency of the system. These adaptations in particular concern incidents involving industrial or fissile packages, loss of radiation sources and nonconformity with the regulations concerning documentation or reporting, along with clarification of the level of impairment of the safety functions in the event of defence in depth being degraded.

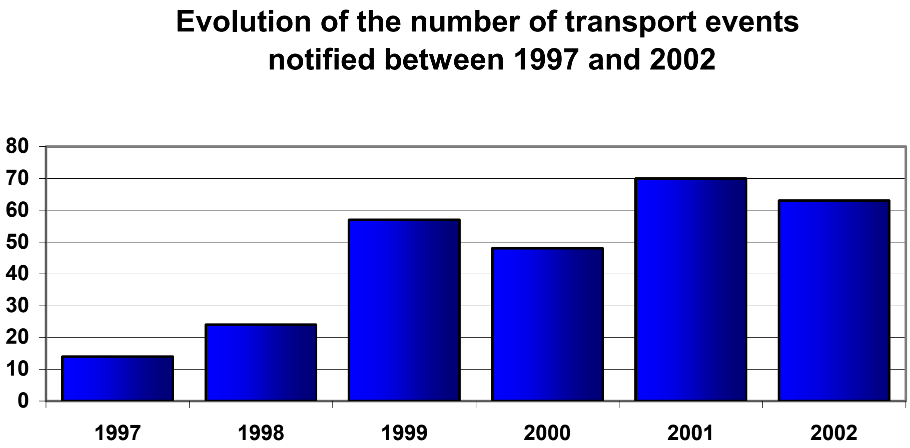


Figure 1: Notified events since 1997

3.3. Application and results since 1999

During its 24 October 2000 meeting, the CSSIN examined the feedback from the experimental phase and the amendment proposals presented by the ASN. The decision was taken to set up a working group to deal with these two issues. This group met on 21 November 2000 and its work was presented during the CSSIN meeting of 14 February 2001. After this meeting, the CSSIN urged the ASN to implement the INES transport scale. On 11 April 2001, this implementation was confirmed by a decision of the ASN. In 2001, 70 events were rated, including 18 at level 1. No incident was rated at a higher level. In 2002, 63 events were rated, including 50 at level 0, 12 at level 1 and one was rated at level 3 by the Swedish Authority. At the beginning of 2002, the competent Swedish authority rated a level 3 to an air transport incident concerning an abnormally high level of irradiation for iridium-192 package sent from Sweden to the United States via France. This incident, which simultaneously involved three countries, showed all the potential benefits of generalised international application of the INES scale to transport.

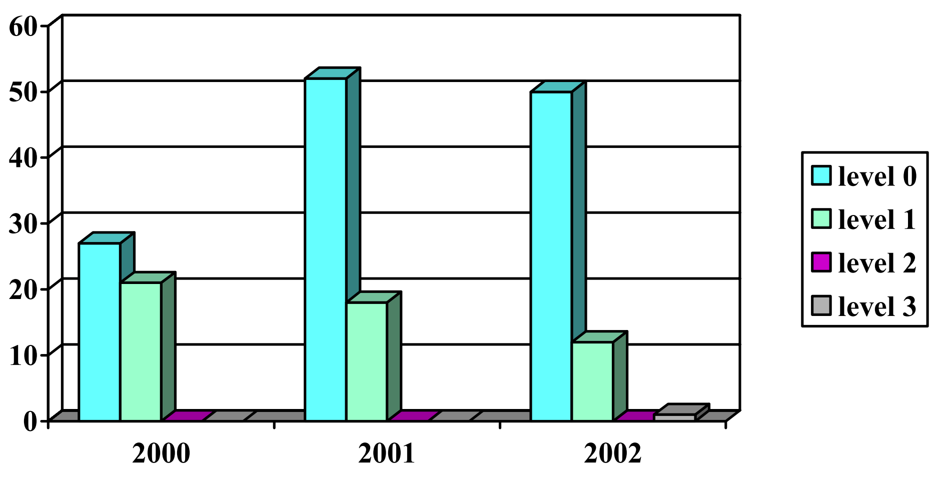


Figure 2: Number of transport events rated on INES in France

The Figure 2 shows the rated incidents trend since 2000. The change in number of events rated at level 1 between 2000 and the following years is explained by a change in the criteria used to rate the events. These new criteria are more close to the draft guide proposed by IAEA at the TRANSSC meeting on February 2002.

The arrangement to inform the public and media is the following : all events rated at the level 1 are systematically mentioned on the web site with a short explanation notice of what happened and which were the consequences, and some of events rated at level 0 are also mentioned on the web site depending of the possible interest of the public and media. With respect to IAEA, the events rated at level 2 and higher are systematically filed to IAEA, but some events rated at a level lower are also filed to IAEA, in particular concerning loss of source near borders.

4. International sharing of France's experience

4.1. The ASN is sharing its experience abroad

Application of the INES scale to transport in France was transmitted for information to the foreign safety authorities competent in the transport area and to the International Atomic Energy Agency. It was presented in turn to the participants at the IAEA's Radioactive transport safety group (RTSG) during the 29 September 1999 meeting in Antwerp (Belgium), on 30 March 2000 to the 32nd meeting of the European Commission's standing working group (STWG-DG-TREN), as well as to the IAEA's TRANSSAC Committee meeting of February 2001. These presentations led to large numbers of comments, demonstrating the need to continue to work on this subject.

4.2 Changes to the IAEA's INES User Manual

Although the scale was not specifically designed for application to the transport of radioactive materials in general, information about rating events occurring during transport is given as of the 1993 edition of the INES User Manual. In 2001, the IAEA and the Nuclear Energy Agency of the OECD (NEA) published a revision of the INES User Manual, with more information about the rating of transport incidents. The system put in place in France, for which the operating procedure is nonetheless more detailed than the manual, takes account of these changes.

4.3. The initiative of the European Commission

In June 2001, the European Union organised a meeting for an exchange of views by the European authorities concerning application of the INES scale to radioactive material transport events. The European Commission consulted the Member States over the application protocol draft prepared during this meeting. International agreement on application of the INES scale to transport is thus probable in the medium term. During the last meeting of the Standing working group on transport in October 2002, EU proposed a draft of a directive or a regulation for notification and rating of transport events.

4.4. The initiative of the International Atomic Energy Agency

The document discussed at European level was forwarded to the IAEA, which recognised the need for further development if the INES scale was to be applied to transport. The Agency therefore in December 2001 organised a consultants meeting (CSM) to propose additions to the scale. Experts from Belgium, France, the United Kingdom and the United States all contributed to this CSM. After approval by the Agency, the draft guide was proposed during the TRANSSC meeting in February 2002 for a trial period. Subsequently, this information could then be included in a future revision of the INES User Manual.

5. Conclusion

Notification and rating transport events in the INES scale are a good way to inform public and media on what happens in transport of radioactive materials. This is also a good tool to share experience with other countries. The French approach is now going to be proposed to other countries involved in radioactive material transport, so that transborder harmonisation result in a better and clearer information of the population.

A NOTIFICATION OF RADIOACTIVE MATERIALS SHIPMENT AND THE UNITED NATIONS CONVENTION ON THE LAW OF THE SEA

H. Tani

The Federation of Electric Power Companies, Tokyo,
Japan

Abstract

It is important to provide appropriate information on safety to relevant coastal States in advance of shipments of radioactive materials. This will improve mutual understanding and confidence regarding shipments of radioactive materials, as recommended by the IAEA general conference resolution, however it is not obligatory, and is on a voluntary basis. In addition, the information provided should not contradict measures of physical protection and safety. Furthermore, a ship has a right to free navigation based on the United Nations Convention on the Law of the Sea and is not obliged to give pre-notification. However, such notification is assumed when there are special regulations such as traffic separation schemes in internal waters or territorial sea.

1. Introduction

The notification to relevant coastal States is described in the IAEA general conference resolution (GC (46) /RES/9) adopted in September 2002 as follows.

(1) National regulations

"10. Urges Member States shipping radioactive materials, consistent with resolution GC (45)/RES/10, to provide, as appropriate, assurances to potentially affected States that their national regulations accord with the Agency's Transport Regulations".

(2) Information of shipments

"11. Welcomes the practice of some shipping States and operators of providing in a timely manner information and responses to relevant coastal States in advance of shipments for the purposes of addressing concerns regarding safety and security, including emergency preparedness, and invites others to do so in order to improve mutual understanding and confidence regarding shipments of radioactive materials. The information and responses provided should in no case be contradictory to the measures of physical protection and safety".

It is clear that it is important to provide appropriate information regarding safety to relevant coastal States in order to improve mutual understanding and confidence regarding shipments of radioactive materials as recommended in this resolution. However it is not obligatory, but is on a voluntary basis. In addition, sensitive information on physical protection, such as detailed transportation date and time or transportation route, should remain confidential, based upon international and national law. Furthermore, a ship has the right of the free navigation based on the United Nations Convention on the Law of the Sea (UNCLOS) and is not obliged to give pre-notification. However, such notification is assumed when there are special regulations such as designated or prescribed sea lanes and traffic separation schemes in internal waters or territorial sea.

2. Notification of the transportation

Notification covers a wide meaning, and different people will have different interests in the notification. However, as described in the IAEA resolution mentioned above, there are three points regarding the introduction of the IAEA Transport Regulations into national regulations, safety information about the real transportation, and information regarding the consequences of an accident or an incident are the main subjects of concern in the transportation of radioactive material. The current situations on the three points are as follows.

2.1. The status of the introduction of the IAEA regulations into national regulations and the IAEA web page

The IAEA Transport Regulations provide consistency of regulating the safe transport of various dangerous goods through the United Nations Economic and Social Council (ECOSOC). When the IAEA Transport Regulations are completed, these are transferred to the ECOSOC, and are unified with other dangerous goods as United Nations Model Regulations (the orange book). Furthermore, the Model Regulations are transferred to the International Maritime Organization (IMO) and the International Civil Aviation Organization (ICAO), and becomes respectively IMO regulations (IMDG-code) and ICAO regulations after the addition of special requirements to each transport mode. After that, these regulations are each executed as obligatory regulations based on the International Convention for the Safety of Life at Sea (SOLAS) and the ICAO Convention in member states. The obligatory IAEA regulations will also be substantially executed at this point. This is described in the 2002 general conference resolution as follows:

"3. Welcomes the fact that implementation of the 1996 edition of the Agency's Transport Regulations became mandatory on 1 January 2002 (*) under the International Maritime Organization’s International Maritime Dangerous Goods Code, having already become mandatory on 1 July 2001 in respect of air shipments of radioactive materials under the International Civil Aviation Organization’s Technical Instructions for the Safe Transport of Dangerous Goods by Air”.

(*Note: The amendments to SOLAS for making the IMDG Code mandatory were adopted in May 2002 and will take effect on 1 January 2004).

The current status of the IAEA regulations into national regulations is published on the IAEA transport safety web page, and all member states are requested to report necessary information on the situation in order to complete and up-to-date the information on the web page. This situation is also described in the 2002 general conference resolution as follows:

"9. Requests the Secretariat to continue to seek regularly from each Member State data needed in order to ensure that the information on how it regulates the transport of radioactive materials which is published on the Agency's transport safety web page is complete and up-to-date and urges those Member States which have not provided such data to do so expeditiously".

If each member state collaborates in providing information to the IAEA for this web page, it will result in each person in the world easily being able to find out the status of introducing international regulations into national regulations.

2.2. The information related to real transportation

There are many countries that are concerned not only on whether a transportation country has introduced the IAEA regulations into national regulations, but also how the real transportation is done.

As described in the 2002 IAEA general conference resolution, Japan, UK and France provided safety information regarding shipments of radioactive materials between Europe and Japan to the relevant coastal States by briefing sessions. It is not the obligatory notification system, and is being carried out on a voluntary basis. However, it is a very useful system to improve mutual understanding and confidence regarding shipments of radioactive materials. Safety information, such as the safe transport regulations in three countries, INF-code requires ship to be constructed as double hull structure based upon the INF-code of the IMO and Third Party Liability System in the field of nuclear energy were explained at the sessions. However, the IAEA resolution states that: "The information and responses provided should in no case be contradictory to the measures of physical protection and safety". Therefore, the detailed information regarding the date and time and the transportation route where publication is prohibited in the international or national regulations on physical protection was not included.

In addition to providing safety transportation information on a country-to-country base, a place of broad information exchange such as this 2003 transportation conference is very useful.

(NOTE: INF-code means the Code for the Safe Carriage of Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes in Flasks on Board)

2.3. Establishment of the INES for transportation

To facilitate communication and understanding between the nuclear community, the media and the public on the safety significance of events at nuclear installations, the International Nuclear Event Scale (INES) was introduced jointly by the IAEA and the OECD/NEA in 1990. However, the primary purpose of the INES was for events at nuclear installations, and the existing structure was not always suitable for events in the transportation of radioactive material.

Therefore, the TCM of INES National Officers provided additional guidance for rating transport events and approved it for use on a trial basis from March 2002. After experience and feedback of its use, full-scale implementation is planned from spring of 2004. However, many experts point out that these additional guidelines still includes the matters that we should be improved. It is necessary for these problems to be improved during the test trial.

Attention should be paid to the trend so that INES can be improved, and the best choice for improving communication and understanding between the nuclear community and the public is made.

3. UNCLOS and the navigation right of a ship

3.1. UNCLOS

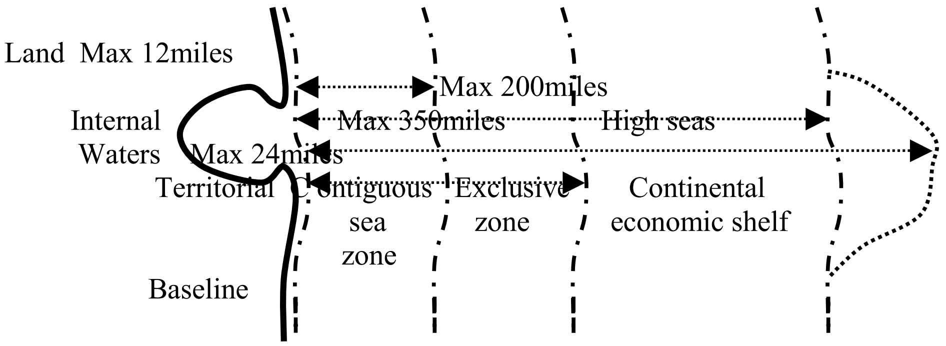
Many people have an interest in the safe transportation of radioactive material. It is the basis of a notification issue to want to know transport safety. However, it is necessary to understand basic structure of transport safety taken internationally in order to know whether transportation is really safe. Therefore, it is very important to make clear who has authority and responsibility in the transportation and whether contents of the notification are obligatory or voluntary.

Control rights for a ship navigating the sea are divided into the rights that belong to the state where the ship is registered (flag state) and the control rights of coastal states. In addition, ship control rights of the coastal states are limited to the items defined in UNCLOS. UNCLOS established basic principles on international maritime law such as "how to control or not control a ship” about "which kind of item" at "which place".

The basic principles of UNCLOS are taken into many international conventions. For example, the International Convention for the Safety of Life at Sea (SOLAS) established control rights about the INF ship which was built based upon the INF-code for a ship transporting spent fuel, high level waste and plutonium (INF material) as follows. "The inspection and survey of ships, so far as regards the enforcement of the provision of present Regulations and the granting of exemptions therefrom, shall be carried out by officers of the Administration (flag state). "Every ship when in a port of another Party is subject to control by officers duly authorized by such Government in so far as this control is directed towards verifying that the certificates issued under Regulation 12 or Regulation 13 of Chapter 1 of the Convention are valid."

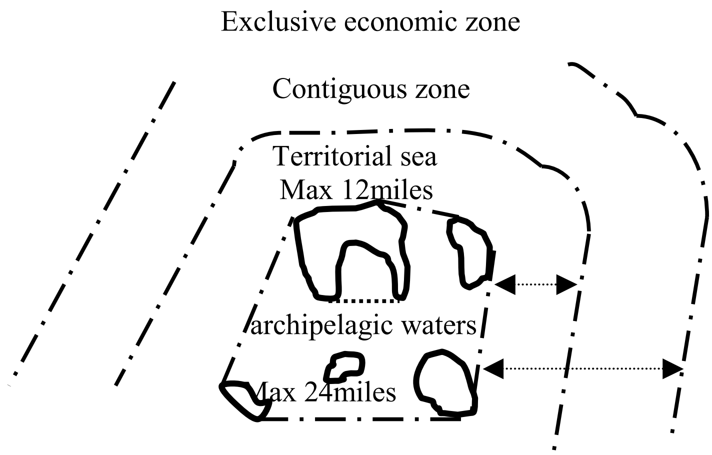
In UNCLOS, the sea is divided into internal waters, archipelagic waters, territorial sea, contiguous zone, exclusive economic zone, continental shelf and high seas. Each sea area has different legal status. These sea areas are fixed in accordance the baselines determined by UNCLOS, but there are many detailed rules for determination of each sea area. Following Figures show only generic concept of each sea area in the cases not including and including the archipelagic waters.

3.1.1. The case not including the archipelagic waters



3.1.2. The case including the archipelagic waters

"Archipelago" means a group of islands, including parts of islands, interconnecting waters and other natural features which are so closely interrelated that such islands, waters and other natural features form an intrinsic geographical, economic and political entity, or which historically have been regarded as such.



3.2. The navigation right in every sea area

Ships of all States have historically enjoyed freedom of navigation on the sea. In UNCLOS, this historic freedom was adjusted in such a way to extend the ability of coast states to apply regulation. The sea has been divided into many sea areas with different legal status. In each sea area, the different navigation rights of ships and the different control rights of coast country are carefully detailed. The convention is very important in ensuring that people know who has responsibility and authority for the safety of the transportation.

3.2.1. Internal waters: The sovereignty of a coastal State extends to its internal waters. However, UNCLOS provides a right of innocent passage in the newly established internal waters. (A2)

3.2.2. Territorial sea: The sovereignty of a coastal State extends to its territorial sea. However, subject to the UNCLOS, ships of all States enjoy the right of innocent passage through the territorial sea. (A2

& A8). The coastal State may, where necessary for safe navigation, require foreign ships exercising the right of innocent passage through its territorial sea to use designated or prescribed sea lanes and traffic separation schemes. (A22)

This "passage" means navigation through the territorial sea for the purpose of:
(a) traversing that sea without entering internal waters or calling at a roadstead or port facility outside internal waters; or
(b) proceeding to or from internal waters or a call at such roadstead or port facility. (A18)

Foreign nuclear-powered ships and ships carrying nuclear or other inherently dangerous or noxious substances have the right of innocent passage through the territorial sea, but they shall, when exercising the right of innocent passage, carry documents and observe special precautionary measures established for such ships by international agreements. (A23)

3.2.3. Contiguous zone: The coastal State may exercise the control necessary to prevent infringement of its customs, fiscal, immigration or sanitary laws and regulations within its territory or territorial sea. (A33)

3.2.4. International straits: All ships and aircraft enjoy the right of transit passage in the straits that were newly established as territorial sea by UNCLOS and used for international navigation. (A38)

3.2.5. Archipelagic waters: The sovereignty of an archipelagic State extends to its archipelagic waters. But, ships of all States enjoy the right of innocent passage through archipelagic waters, in accordance with UNCLOS. At the same time an archipelagic State may designate sea lanes and air routes there above conformed to accepted international regulations. .

3.2.6. Exclusive economic zone: In the exclusive economic zone, the coastal State has sovereign rights and jurisdiction only for economical items as provided in the Article 56 of UNCLOS. On the other hand all States enjoy, subject to UNCLOS, the freedoms referred to in article 87 of navigation and over flight (the freedoms of the high seas). In exercising their rights, " the coastal State shall have due regard to the rights and duties of other States and shall act in a manner compatible with the provisions of UNCLOS" and other "States shall have due regard to the rights and duties of the coastal State and shall comply with the laws and regulations adopted by the coastal State in accordance with the provisions of UNCLOS."

3.2.7. Continental shelf and high seas: All States enjoy, subject to UNCLOS, the freedoms referred to in article 87 of navigation and over flight (the freedoms of the high seas).

4. Conclusion

It is important to provide appropriate information regarding safety to relevant coastal States in order to improve mutual understanding and confidence regarding shipments of radioactive materials. However, attention should be paid to the issues that sensitive information on physical protection should remain confidential, and a ship has a right of the free navigation based on the United Nations Convention on the Law of the Sea and is not obliged to give pre-notification although such notification is assumed when there are special regulations such as traffic separation schemes in internal waters or territorial sea. In addition to providing safety transport information on a country-to-country base, publication on the IAEA web page about the status of the introduction of the IAEA Transport Regulations into national regulations and INES information on accidents or technical troubles of transportation should be compiled and completed in future. Furthermore, a place of broad information exchange such as the 2003 transportation conference of this time is very useful. Documents and contents of argument submitted to the transportation conference should be distributed to all IAEA member states including non-participating states and the public broadly through the publications or the web page of IAEA.

THE RATIONALE OF COMMUNICATION BETWEEN STATES ABOUT ENVIRONMENTAL IMPACT ASSESSMENTS AND NOTIFICATION PRIOR TO SHIPMENTS OF NUCLEAR FUEL, RESIDUES AND RADIOACTIVE WASTES.

C. Azurin-Araujo
Permanent Mission of Peru to the IAEA in Vienna
Peru

Abstract

Stringent regulations, including the obligation of prior notification, already apply to the transboundary transportation of nuclear fuel cycle material, residues and radioactive waste. However, sea carriers of such materials are not compelled to give prior notification of shipments. An increasing number of States, in all regions of the World, are continually voicing concerns about these shipments and have requested to be informed, notified and consulted before they take place, as reflected in governmental declarations, joint communiqués and various documents and decisions approved by various international fora, including the IAEA. The widely accepted practice of notifying transboundary movements, the right and the obligation to protect the marine ecosystem and the need to be prepared to respond to an emergency, provide legitimacy to these requests. International rights and obligations that respond to the "precautionary principle", freedom of navigation and physical security can and should be adequately balanced.

1. National, regional and international regulations governing the transboundary movement of radioactive material contain provisions concerning previous notification of shipments to transit and on-route States, which apply to transport through territorial waters

The transport of hazardous nuclear and radioactive materials by land, by air and by sea became a matter regulated by the IAEA since 1961. From 1973 onwards, the transportation of nuclear fuel increased. In the 1990's, the use of mixed uranium/plutonium oxide (MOX) fuel grew, as well as the shipping of high-level radioactive waste. This met greater public attention as some countries started to reprocess their nuclear wastes and stockpile nuclear fuel.

The ever increasing frequency and volume of dangerous cargoes by sea, especially that of nuclear fuel and highly radioactive waste induced some countries, mainly those involved in transport and reprocessing activities and their close inland neighbours, to swiftly adopt national and regional regulations on the movement of such cargoes through their territories, territorial seas, exclusive economic zones and aerospace. These regulations have consistently included provisions about the duty of concerned States to give prior notification to and the right of transit or on-route States to receive such prior notification.

In the framework of the IAEA, paragraphs 558 of the Regulations for the Safe Transport of Radioactive Material establish that for each shipment of a certain type:

> "… the consignor shall notify the competent authority of each country through or into which the consignment is to be transported. This notification shall be in the hands of each competent authority prior to the commencement of the shipment, and preferably at least 7 days in advance."

Also, paragraph 559 of the Regulations requires, amongst other things, that the notification shall include sufficient information to enable the identification of the package, information on the date of shipment, the expected date of arrival and proposed routing and the names of the radioactive materials or nuclides.

Therefore, in the case of marine transport of radioactive material through territorial seas, it is clear that the consignor has the duty to notify the competent authorities of transit and on route States.

2. International arrangements and practice governing the transboundary movement of hazardous and radioactive waste contain provisions concerning environmental impact assessments and previous notification of shipments to transit and on-route States which also apply to transport through territorial waters.

Article 3 of the IAEA's Code of Practice on the International Transboundary Movement of Radioactive Waste, adopted by the General Conference in 1990, stipulates that:

> "Every State should take the appropriate steps necessary to ensure that, subject to the relevant norms of international law, the international transboundary movement of radioactive waste takes place only with the prior notification and consent of the sending, receiving and transit States in accordance with their respective laws and regulations."

Article 4.2 (f) of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, into force since 1992, requires that each Party shall:

> " Require that information about a proposed transboundary movement of hazardous wastes and other wastes be provided to the States concerned, according to Annex V A, to state clearly the effects of the proposed movement on human health and the environment;"

Article 27 of the IAEA's Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, into force since 2002, provides that:

> " i. a Contracting Party which is a State of origin shall take the appropriate steps to ensure that transboundary movement is authorized and takes place only with the prior notification and consent of the State of destination;
>
> ii. transboundary movement through States of transit shall be subject to those international obligations which are relevant to the particular modes of transport utilized; "

Therefore, according to international arrangements and accepted practices, consignors of radioactive materials must carry environmental impact assessments and inform, notify and get the consent of on route and transit States prior to any shipment through territorial waters.

3. The "precautionary principle" informs international rights and duties of States concerning the protection of the environment during all modes of transport of radioactive materials

As the frequency and volume of hazardous cargoes increased, countries concerned with the preservation of the environment, developed national and regional legislation to carefully plan and avoid activities that could be harmful for the environment, based on a customary law, later known as the "precautionary principle". This principle was conceptualised during the 1992 United Nations Conference on Environment and Development, also known as Agenda 21, which adopted the Rio Declaration on Environment and Development. Principle 15 of this Declaration states that:

> "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

The precautionary principle informs environmental and sustainable development arrangements within the UN and other regional fora, including the European Commission, and has gained rapid and universal acceptation as a most relevant norm of International Law. Nowadays, it is not contended that States have both, the duty to protect the environment, as well as the right to request that other States do not disregard this obligation by acting within their borders or outside them in such a way as to cause damage to other States' environment and the world's environment as a whole.

4. Environmental impact assessments for transport through the exclusive economic zone and the high seas are in tune with the UN Convention on the Law of the Sea (UNCLOS) since the exercise of the freedom of navigation should take into account rights and duties of coastal States, as well as the interests of mankind in the Area

Article 58, paragraph 3, of UNCLOS, which has become customary law, provides that:

> In exercising their rights and performing their duties under this Convention in the exclusive economic zone, States shall have due regard to the rights and duties of the coastal State and shall comply with the laws and regulations adopted by the coastal State in accordance with the provisions of this Convention and other rules of international law in so far as they are not incompatible with this Part.

In respect to freedom of the high seas, article 87, paragraph 2, UNCLOS establishes that:

> These freedoms shall be exercised by all States with due regard for the interests of other States in their exercise of the freedom of the high seas, and also with due regard for the rights under this Convention with respect to activities in the Area".

Also, article 300 of UNCLOS determines that:

> States Parties shall fulfil in good faith the obligations assumed under this Convention and shall exercise the rights, jurisdiction and freedoms recognized in this Convention in a manner which would not constitute an abuse of right.

Furthermore, article 204, paragraph 2, and article 206 of UNCLOS state that:

> In particular, States shall keep under surveillance the effects of any activities which they permit or in which they engage in order to determine whether these activities are likely to pollute the marine environment.
>
> When States have reasonable grounds for believing that planned activities under their jurisdiction or control may cause substantial pollution of or significant and harmful changes to the marine environment, they shall, as far as practicable, assess the potential effects of such activities on the marine environment and shall communicate reports of the results of such assessments in the manner provided in article 205.

UNCLOS establishes that Coastal States have the duty to protect living resources in the exclusive economic zone the marine environment and the right enjoy resources in their exclusive economic zone. At the same time, article 192 mentions that "all States have the obligation to protect and preserve the marine environment", whilst article 94 stipulates that "the flag State have the duty to prevent, reduce and control marine pollution".

Therefore, considering that a nuclear incident during transport of radioactive material could cause radiological and toxic damage in the exclusive economic zone or the Area located below the high seas and based on the "precautionary principle", environmental treaties, the Basel Convention and UNCLOS, the national laws of Coastal and Flag States could require consignors engaged in the maritime transport of radioactive material to prepare environmental impact assessments about long term effects of an accidental release of radioactive material along maritime routes.

These assessments should take into account climatic conditions, existing ecosystems, marine tides and other relevant circumstances that prevail along the transportation route that carriers use. Also, for transparency and credibility reasons, these measures should be carried our by independent experts, with the concourse of the Agency, the Authority of the Area and specialised Un Agencies, keeping close communication with the competent authorities of transit and on route States, who should have the opportunity to contest matters that are not substantiated in the light of the existing technical and scientific knowledge.

5. Prior notification of shipments is a legitimate request of coastal states to protect their rights and perform adequately their duties according to UNCLOS and environmental arrangements and does not imply per se a threat to security

Article 98, paragraph 2, of the UN Convention on the Law of the Sea requires that

> Every coastal State shall promote the establishment, operation and maintenance of an adequate and effective search and rescue service regarding safety on and over the sea and, where circumstances so require, by way of mutual regional arrangements cooperate with neighbouring States for this purpose.

Also, article 199 of the Convention, requires that in cases of imminent or actual damage to the marine environment:

> States in the area affected, in accordance with their capabilities, and the competent international organizations shall cooperate, to the extent possible, in eliminating the effects of pollution and preventing or minimizing the damage. To this end, States shall jointly develop and promote contingency plans for responding to pollution incidents in the marine environment.

In order to be adequately prepared to comply those obligations, Flag States and Coastal States should co-ordinate emergency and contingency plans. To this effect, Coastal States should be opportunely notified of consignments of radioactive materials that will be transported through their territorial waters, contiguous zone, exclusive economic zone, straits, archipielagic waters and above their continental shell. They should also be informed of shipments through the high seas along their exclusive economic zone, since the delicate marine ecosystem and migrating habits of marine species could be affected by radiological and toxic damage arising during the transport of radioactive material.

The information that Coastal States require to be prepared and respond to an emergency involving radioactive material include, inter alia, the designation and physical description of the material, including its composition and hazardous characteristics, information on any special handling requirements, estimated weight and volume, type of packing, contingency and emergency provisions envisaged by the carrier in case of an accident, the weight and volume of the cargo, the projected dates when the expected shipment will pass through, along or above such areas, the proposed itinerary, as well as details concerning insurance to cover the costs of preventive and clearance measures.

In respect to the high seas, considering that they are above the Area, which has the status of common heritage of mankind and have been placed under the care of the Authority, the latter should also receive prior notification of shipments of radioactive material, to be able to monitor any possible damage to the Area and its resources, which may arise during the transport of such material.

The competent authorities of Coastal States as well as the Authority of the Area under UNCLOS, should be notified, through official channels and –if necessary- following agreed procedures to secure the confidentiality of the information. Prior notification is already an accepted practice concerning transboundary movement of nuclear and hazardous materials and waste, which has so far not endangered the safety or security of consignments, even though most transboundary carriage is made mainly through land and train, where risks could be greater than through any other modes of transport.

Finally, as stated in IAEA's Code of Practice on the International Transboundary Movement of Radioactive Waste, "policies and criteria for radiation protection of populations outside national borders from releases of radioactive substances should not be less stringent than those for the population within the country of release". In the case of internal and transboundary carriage, protective measures consider prior notification. Therefore, prior notification should also be given for international transport of radioactive material.

INTERGOVERNMENTAL COORDINATION AND COMMUNICATION ON UNITED STATES DEPARTMENT OF ENERGY SPENT FUEL SHIPMENTS: *Building Trust and Partnerships*

J.A. Holm

U. S. Department of Energy, P. O. Box 5400,
Albuquerque, New Mexico 87185-5400
United States of America

Abstract

In response to the intense public concern and wide-spread interest in transportation of radioactive materials, the United States Department of Energy (DOE) developed programs that focused on important opinion leader groups and standardized processes that engaged representatives of governmental bodies (state, tribal and local governments and other federal agencies) in shipment planning. The state and federal participants represented agencies with responsibilities for transportation regulation, law enforcement, or public health and safety. Because of the involvement of these partners, DOE has been successful in meeting its program commitments. The processes included development of transportation, security and communications plans which outlined the responsibilities of the DOE, its carriers, the state and tribal government agencies and other federal agencies, such as the Nuclear Regulatory Commission and the Department of Transportation.

1. Introduction

The U.S. DOE has safely shipped radioactive materials for over 50 years. In the early years, shipments were conducted without public knowledge or interest. However, beginning in the 1960's and 1970's, as the U.S. embarked on programs to identify permanent sites for disposal of waste from defence processes and from commercial nuclear reactors, public attention began to focus on transportation of radioactive materials, particularly wastes. This was parallel to the interest in other kinds of waste disposal issues, including municipal and hazardous wastes. The advent of the National Environmental Policy Act[1] and its provisions for public disclosure and comment on governmental actions also highlighted interest of the public in these issues. Several key policy decisions, including the reinstatement of the U. S. non-proliferation policy, ending spent fuel reprocessing, and national searches for permanent deep geological repositories for defence and commercial radioactive waste along with the associated public involvement activities for actions related to clean-up of contaminated sites, created an environment for public debate about transportation of radioactive materials.

2. Program description

DOE based its program to co-ordinate with state, tribal and local governments on risk communication and public policy theories developed by Peter Sandman, who initiated a series of policy papers for the Environmental Protection Agency in the 1980's. His work, along with Vince Covello, Hank Jenkins-Smith and other academic risk communication experts, proposed that the public, in a democracy, has a right to know what actions its government is taking and how those actions could impact their health and safety. When the government does not inform its citizens about its actions so they can be engaged in understanding those actions, they then will oppose the action until the government addresses their concerns and issues. Another premise is that not everyone wants to be involved, but there is a range of

[1] National Environmental Policy Act, 1970.

interest in an issue from general information to active involvement. Sandman suggests that the responsible agency needs to understand what level of interest exists, who has the interest, and build programs to address those interests and concerns.

The DOE conducted public surveys from 1994 to 1996 to gain understanding on how the public received information about radioactive materials transportation, what kind of information was needed and who was trusted to successfully manage transportation. At the same time, DOE established relationships with states through four regional state associations and with other key participant associations through a national working group, the Transportation External Co-ordination Working Group. The findings from those national and regional surveys confirmed the approach of working with state and local fire, police and state policy agencies on planning for DOE shipments. The findings also indicated the need for development of partnerships to provide information to the media and the public, because DOE was not the most credible agency with the general public at that time. Another finding of the research is that certain individuals are influencers of opinion and understanding and that they are critical to successfully informing others about an issue. The notion of "informed consent" has been useful to understand that government agencies are responsible for their programs and actions and cannot give those responsibilities away. Citizens will allow government officials to make decisions if they feel their issues have been considered and if they are provided good information about why an action such as a shipment of spent fuel is needed, what the impacts are from the shipment, and who at the state or local level is prepared to assist in the event of an accident or incident.

In response to public concern and in order to continue to ship radioactive materials to meet its treaty and clean-up commitments, DOE developed a three-tier program which includes:

(a) identification of which groups and stakeholders need to be involved in direct discussions about transportation activities and planning,

(b) development of information materials and activities to assist in informing the public, and

(c) maintenance of two forums for resolution of specific kinds of issues: the Transportation External Co-ordination Working Group and four State Regional Associations.

2.1. Transportation External Co-ordination Working Group

The Transportation External Co-ordination Working Group (TEC) was formed in 1992 by the DOE Civilian Radioactive Waste and Environmental Management programs. The goal was to develop a Department-wide approach to transportation emergency preparedness and to identify and resolve key transportation operational and policy issues. TEC is a forum with "membership" from associations of state, tribal and local governments, industry, professional and technical groups, and all the major DOE program offices. Other federal agencies, including the Department of Transportation, the Federal Emergency Management Agency, Nuclear Regulatory Commission and Environmental Protection Agencies also participate. The group meets twice a year. The first few years of the working group involved an exchange of ideas and clarification of issues, which allowed the group to learn about the concerns of the various participants. After a formal evaluation, the TEC developed Topic Groups, which focused on specific issues of importance to the group or to the DOE. The Topic Groups identify issue-focused work products, such as training materials for transportation emergency preparedness or comparisons of regulatory structures for transportation modes, develop or research the issue and present the result to the whole TEC Working Group. The product is then provided to a DOE Executive group to review and either adopt the findings and develop new policy or change a program approach. Topic Groups sunset (adjourn) after the product is developed. The TEC evaluation identified seven TEC Key Achievements, prioritized by DOE and TEC. The most highly valued outcomes of the TEC process were:

(a) Dialogue and communication;
(b) Product development and program impact;
(c) Relationships, interactions, and networking;
(d) Better understanding and increased trust of DOE;
(e) Increased understanding and awareness of other organizations' viewpoints; and
(f) Provision of information.

Key outcomes or products from the TEC include:

General Glossary of Transportation Terms, Paper on Routing of Radioactive Material used as the basis for the DOE Transportation Protocols, Investigation of Rail Regulation and Roles and Responsibilities of States and Tribes, Comparison of CVSA Inspection Procedures to Rail Regulations and WIPP Program Procedures, Summary of Q & A's on Transportation from selected DOE EIS's, Risk Communication Bibliography, Key Safety Messages for Use in DOE Information Materials, Training Modules on Radioactive Materials Response for First Responders, Merged Training Program with WIPP/STEP courses, Development of a Consolidated Transportation Grant for DOE shipments, Review of the NTP Web page, resulting in a significant revision currently underway, and a Lessons Learned Document on Tribal Interaction with State and Federal Organizations.

2.2. Shipment planning with state and tribal government officials

DOE also maintains a program activity that focuses on co-ordination and planning with state and tribal governments which have responsibilities for public health and safety and for enforcement of transportation rules and regulations for commercial carriers on the highway. DOE engages with states by funding and support to various regional state groups (the Western Governors' Association, the Southern States Energy Board, and the Midwestern Office and the North-Eastern Regional Office of the Council of State Governments) and a with professional association of state highway safety enforcement officers, the Commercial Vehicle Safety Alliance. These groups participate in operational planning for radioactive materials shipping campaigns, particularly high-visibility shipments like spent fuel, across the various states and regions. The participants in four regional state organizations include state agency staff, appointed by the governor of the state, and state legislators. The agencies represented include state law enforcement, emergency management, environmental and regulatory, transportation, radiological health and direct policy staff to the governors.

The groups meet at least twice a year with DOE Headquarters policy staff and senior managers and with program staff from sites planning to ship through the various states. The meetings are used for information exchange, co-ordination and review of specific transportation plans that are prepared for spent fuel or other high-visibility shipments. Other federal agencies with a role in transportation, including the Department of Transportation, the Nuclear Regulatory Commission and Federal Emergency Management Agency also participate. The major outcome of the meetings is familiarity among all parties at the federal, state and tribal government levels about who is responsible for shipments, agreements about the operational component of the transportation plan, including routes, security provisions, emergency preparedness, communications and points of contact at the state an federal agencies. Tribal government officials also participate, when appropriate; however, direct interaction with tribes affected by DOE shipments also occurs. The transportation plans provide the basis for shipping and identifies all the appropriate contacts at state, tribal, and federal agencies should an emergency or unplanned event occur.

Various protocols for information and planning are agreed upon through the development of transportation plans, based on a standardized DOE policy that was developed through the TEC forum process. These protocols include guidance on transportation planning, pre-notification, emergency preparedness, safe harbour/safe parking, routing, satellite tracking, emergency notifications and public information for all DOE program shipments, including the national security shipments.

Recent Examples of Shipment Planning: Two recent examples of the benefits of this kind of close working relationship include the West Valley shipment of spent fuel from New York to Idaho and ongoing foreign fuel shipments to the U. S. In the case of the West Valley rail shipment, extensive planning for the shipment was conducted with States and Indian Tribes along the routes. The States provided alternative route suggestions, co-ordinated training and prepared their own agency and policy staff for the shipment. At the same time, a co-ordinated effort to challenge spent fuel shipments was underway by an environmental group. The group went along the corridor expressing great concern and challenging the safety of the shipment. The state officials along the corridor were able to answer the questions from the media and from local elected officials about the shipment's safety, to describe how the federal government had involved the states and explain how well prepared the states were through their training and co-ordination with local fire and police responders along the routes. This support from the state officials helped dispel the misinformation being presented by the anti-nuclear organization.

The second example is the ongoing planning and shipments conducted under the DOE Foreign Fuel program. The Foreign Research Reactor (FRR) Spent Fuel Program supports the non-proliferation policy of the United States by returning highly enriched uranium fuels to the United States from its treaty partners around the world. In the United States, state involvement is routine and shipments have become a non-event because of extensive work up front to involve them in the planning, training and co-ordination of information about the shipments. In addition, the DOE shipper prepared detailed plans that identified proposed routes, outlined the approach to the shipments and engaged the rail and highway carriers before discussions with the states began. The systematic and detailed approach to FRR shipments illustrated to the states and tribes that DOE was capable of handling those shipments and clearly outlined DOE, carrier, and state and tribal government responsibilities in advance. The principle of no surprises was well in place for these shipments and continues.

As a result of a comprehensive approach to developing partnerships with state and federal officials outside the DOE, preparing transportation, communications, emergency and security plans in conjunction with state and tribal officials and having clearly defined goals and objectives regarding why and how spent fuel shipments would occur, DOE has been successful in shipping on average about 30 spent fuel casks per year since 1994.

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TRANSPORTATION RISK MANAGEMENT PROGRAM:
A Strategy for Development and Communication

C. Macaluso[a], D. Zabransky[a], P. Van Nelson[b]

[a]U.S. Department of Energy, Office of Civilian Radioactive Waste Management
1000 Independence Avenue, S. W., Washington, DC 20585
[b]Booz Allen Hamilton, Inc., 1309-R Continental Drive, Abingdon, MD 21009,
United States of America

Abstract

The U.S. Department of Energy's Office of Civilian Radioactive Waste Management (OCRWM) has been engaged in designing a comprehensive system for the shipment of civilian spent nuclear fuel and high-level radioactive waste for many years. Now that Yucca Mountain, Nevada, has been approved for development as the site for the Nation's first geologic repository, a comprehensive approach to risk management for the transportation program is timely and appropriate. This paper briefly describes the approach OCRWM will take to ensure that it develops a transportation risk management program that is effective in addressing the potential risks to the program and is also inclusive of and transparent to its stakeholders. ***Presented by*** *Error! Unknown document property name.*

1. Introduction

In the years since passage of the Nuclear Waste Policy Act in 1982, the Department of Energy's Office of Civilian Radioactive Waste Management (OCRWM) has studied environmental, health and safety risks that may be involved in transporting spent nuclear fuel and high-level radioactive waste. Now that one site, Yucca Mountain, Nevada, has been approved for development as the Nation's first geologic repository, OCRWM will develop a comprehensive approach to risk management for the transportation program.

To address the full range of creating, managing and operating a transportation program of the size and complexity of OCRWM's mission, consideration must be given to multiple sources of risk. Definitions of risk abound. Often these definitions are dependent upon the discipline of the definer. For example, scientists frequently define risk quantitatively as the probability of an event occurring times the consequence if it does occur; others, such as risk communicators, have defined risk as the hazard plus the outrage felt by the public.[1] This difference in approaches to discussions of risk has led some observers to make a distinction between "actual" and "perceived" risks. This generalization often has the effect of polarizing the scientific experts and the lay public.

For purposes of its strategy, OCRWM will consider risk as "any uncertainty about a future event that can threaten OCRWM's ability to perform its mission." Thus, this definition not only includes health, safety, and environmental risks, but also encompasses what are sometimes called programmatic risks. For example, work stoppages, vendor inability to deliver goods or services on time, public controversy, or litigation would all be considered possible future events that could threaten mission accomplishment.

OCRWM's risk management approach will include the essential elements of a comprehensive risk management program. These include: anticipating future events (*risk identification*); determining the likelihood of their occurrence (*risk assessment*); developing the measures (methods and resources) to prevent, avoid, or mitigate them (*risk reduction*); interacting with stakeholders (*risk communication*); and implementing and managing the measures as appropriate (*risk monitoring*).

2. Developing a risk management program

The OCRWM transportation program is both technically and socially complex. The planning, equipment acquisition, and mobilization processes associated with loading and shipping from 77 temporary storage sites located in 35 states over a period of 24 years, introduce a variety of business, schedule and operational risks. The large number of institutions and individuals that could be involved points to the need for a sound and robust risk communication strategy. In addition, the potential for sabotage or terrorism must now be even more vigorously considered.

Developing a risk management program involves a sequence of actions that are relatively logical and straightforward. However, it should be noted that each step could involve multi-party interactions and discussions regarding trade-offs among competing priorities. OCRWM will develop its transportation risk management program through a systematic series of steps that begins with a management policy statement; includes empowerment of a risk management team to identify and evaluate potential risks; and development of a risk management plan that includes risk avoidance or mitigation strategies. Engaging the program's stakeholders in OCRWM's plans to manage potential risks will be a significant factor in determining the program's success.

3. The stakeholders' roles

The idea that the public has a right to know and to have a voice in the actions of its government is not a new concept. In the United States, the phrase "taxation without representation" initiated a grassroots sequence of events that led to creation of a nation over two hundred years ago. Nonetheless, the environmental movement in the 1970s is often credited with bringing government and the public to a more collaborative working style. The National Environmental Policy Act of 1969, with its mandate for public input into environmental decision making, is an example of institutionalizing this relationship between the government and the governed.

3.1. *Risk communication and public participation*

Risk communication is described as "any purposeful exchange of information and interaction between interested parties regarding health, safety, or environmental risks."[2] While risk communication has become a separate field of study, at its core is the concept that the public has a right to participate in decisions that may impact their lives. The Department of Energy's public participation policy states "[P]ublic participation is a fundamental component in program operations, planning activities, and decision-making within the Department. The public is entitled to play a role in Departmental decision-making."[3] Thus, a fundamental aspect of the OCRWM risk management plan will be engaging those organizations and individuals who have an interest in OCRWM's transportation plans and actions.

3.2. *OCRWM's experience*

Shortly after passage of the Nuclear Waste Policy Act, OCRWM began to develop plans for interacting with stakeholders on the transportation of spent nuclear fuel and high-level radioactive waste. Although transportation of such material had occurred through the country previously, OCRWM realized that a national transportation program would engender more public interest than had prior, less visible shipments.

In 1992, the Department of Energy created the Transportation External Co-ordination Working Group. This group includes representatives from national, state, tribal and local government organizations, labor, industry and professional groups. Members meet semi-annually to participate in plenary and more specialized working sessions.

Another action was to execute co-operative agreements with national, regional, State and Tribal organizations whose interests include spent nuclear fuel and high-level radioactive waste transportation. Co-operative agreements have facilitated two-way communications and collaboration between OCRWM and transportation stakeholders.

One significant mechanism for public participation is the process involved in the application of the National Environmental Policy Act to OCRWM's activities. The Act has minimum requirements for public notice, public meetings, public comment and public hearings. However, OCRWM has been known to go beyond the minimum requirements to conduct extra briefings and hearings or to expand the public comment period to accommodate its stakeholders needs. The Yucca Mountain environmental impact statement (EIS) was an example of this extra effort. OCRWM received more than 11,000 comments on the Draft EIS. These comments came in the form of letters, emails, faxes, and from transcripts of the public hearings conducted at 21 locations across the country. The final EIS contains all of those comments individually or in summary form, and OCRWM's responses to them.

3.3. *OCRWM's plans*

The Yucca Mountain EIS provides the information that OCRWM needs to make broad transportation-related decisions, such as the choice of a national and Nevada-specific mode of transportation and the choice among alternative transportation corridors. OCRWM, in the EIS, " identified mostly rail as its preferred mode of transportation, both nationally and in the State of Nevada."[4] At this time, OCRWM is still considering the best mode of transportation for shipping spent nuclear fuel and high-level radioactive waste.

OCRWM's risk management approach recognizes that the public has a right to know and that the Federal Government has an obligation to explain the who, what, where, when and why of what it is doing. OCRWM's risk communication efforts must both support the transportation project and accommodate the stakeholders' need for information. Risk communication therefore has to be multi-directional. OCRWM will need to both provide *and* receive information.

Providing information

Providing information will take the form of crafting the project's messages, identifying the universe of potential audiences, and selecting the methodologies best suited to conveying the messages. A process for evaluating the appropriateness and cost-effectiveness of these efforts will ensure that, where necessary, modifications can be made. In this regard, OCRWM's communication professionals have a myriad of tools and tactics that they have used and refined based on experience, extensive analysis of lessons learned and evaluation of empirical data.

Receiving information

The risk communication literature is consistent in acknowledging that when projects can impact the public, risk management is incomplete without the feedback from those potentially impacted. In a government setting, this feedback should be a structured, transparent process. Participants need to know how to provide their input and what will be and has been done with it once provided. Much has been written about public fear and concern when the materials to be transported are radioactive.[5] Although the safety record of radioactive shipments in the United States is excellent, the public perception is that radioactive shipments are more dangerous than other hazardous cargoes. Consequently, OCRWM will address these risk perceptions in its communication efforts by facilitating opportunities to involve its stakeholders in meaningful, interactive settings. It will continue to work with its institutional stakeholders through the Transportation External Coordination Working Group and co-operative agreements. It will also explore means to gather feedback from the public, such as responding to public comments in structured ways that further the understanding of citizens and agency personnel alike.

Closing the Circle

It is clear that risk communication is more than telling people that the risks have been identified and everything is "under control." In developing the transportation risk management plan, risk communication will be a continuous process. OCRWM will solicit input from stakeholders to identify potential risks; provide feedback to them on the results of the risk assessments; describe, where appropriate, the measures that have been put into place to avoid or reduce the risks; and demonstrate that a process is in place to monitor the identified risks and to implement the risk management plan.

4. Conclusion

Taking a step-wise approach that systematically considers the universe of risk types and fully utilizes all available sources of information is fundamental to developing a sound risk management program. A development process that is transparent to interested stakeholders and is the product of full and open discussion of potential risks will not only withstand public scrutiny, but will best serve OCRWM's interest in protecting public health and safety, safeguarding the integrity of the environment, and achieving its transportation mission.

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USER FRIENDLY INSTRUMENTS FOR ENHANCING COMMUNICATIONS

E.M. Supko

World Nuclear Transport Institute (WNTI)
6th Floor, 7 Old Park Lane,London,
United Kingdom

Abstract

Radioactive materials are widely used in everyday life, but the transport of such materials receives more public attention than the transport of other classes of hazardous materials. To improve this situation, the nuclear transport industry and other stakeholders in the safe, efficient and reliable transport of radioactive materials need to develop and maintain the way they effectively communicate messages to the public. Industry and regulators can communicate a clear picture of the issues involved in transporting radioactive materials using the wide range of resources that are available including: technical and communications staff, audio-visual aids, Internet sites, print material, facility tours, and publications geared specifically to communicating with the public. It is necessary for industry and competent authorities to train technical staff in effective communications with the public, train communications professionals about the technical issues involved so that they can better present the issues, make effective use of all means of communicating messages (videos, web sites, written material and facility tours); ensure that all published documents are written in straight-forward language easy for the public to understand, and ensure that the explanation of risks includes comparisons with other activities to help the public visualise the situation.

1. Introduction

The use of radioactive materials (RAM), and their transport, are vital components to many aspects of our everyday lives. Radioactive materials are used in medical diagnostic equipment and radiopharmaceuticals, as the key component in many smoke detectors, in the exploration for oil and natural gas, to date historical artifacts, in research applications in metallurgy, genetics, biotechnology and engineering, and in nuclear power plants to produce electricity.

The transport of RAM attracts an inordinate amount of attention some compared to other classes of hazardous materials; due partly to a perception by some decision makers, some in the media, and general public that the risks associated with RAM transport of are somehow greater than those for other classes of hazardous materials. Groups opposed to the use of nuclear power to produce electricity further exaggerate this skewed perception of relative risk. Radioactive materials have been transported safely for decades, but industry cannot rely solely on this exemplary safety record to provide assurance to the public. It is also necessary for industry, national competent authorities, experts and governmental organisations to make a concerted effort to enhance communications with the public so that limited regulatory resources can be applied to those activities that carry the greatest safety significance.

2. Communicating the benefits of radioactive materials

The perception that the risks of transporting RAM are greater than those for other classes of hazardous materials is a complex issue for the industry, RAM users and national competent authorities to address. It is important to explain the benefits of RAM and the reason why this transport is necessary, so that the public will better appreciate the importance of these materials being transported.

The use of RAM is a vital aspect of our daily lives. Important applications of radioactive material range from medical diagnostics to the production of clean, efficient electricity.

In order to realize the benefits of these applications, transportation becomes the vital link between the producers of RAM and the ultimate benefactors – the consumer.

For example, the various transport steps involving nuclear fuel cycle materials – from uranium mining to processing facilities, to transport of fuel to nuclear power plants, and to transport of used nuclear fuel for storage or disposal – are all necessary in the production of electricity from nuclear energy. Nuclear energy supplies approximately 16% of the world's electricity without emitting green house gases or controllable pollutants such as sulfur dioxide and nitrous oxide. While much of the opposition to transporting RAM is aimed at these nuclear fuel cycle materials, these are just a minor fraction of total radioactive material packages shipped on an annual basis. Transport of RAM associated with nuclear power plant operation represent a fraction of the 10 million packages of RAM shipped each year internationally. The bulk of the shipments are radiopharmaceuticals and RAM for industrial uses.

3. Communications training

Public opinion research in the USA indicates that the majority of Americans view nuclear scientists and engineers as an "excellent or good" source of information on nuclear energy issues [1]. Similar conclusions were made in public opinion research by Environment Canada which found that scientists were the most trusted spokespeople. Environment Canada has embarked on a training programme to "foster communications skills for scientists and also develop better links between communicating scientists and departmental communications staff." [2].

Technical staff can serve as very credible sources of information, particularly when communicating complex issues. It is important to give technical staff training in effective communications to enhance their ability to reach the widest audiences. Training could include basic communications skills to assist technical staff in describing technical matters in terms easily understood by the public instead of using technical jargon. More intensive training can include training in preparation for interviews with electronic and print media, debate training where individuals may need to counter opposing views, and so on.

Communications professionals usually are the first to field questions from the media and a broad knowledge of these issues is important. Thus, it is equally important to train communications professionals to help them better understand complex technical issues, such as package testing requirements, risk assessment, regulatory framework, and so on.

4. Communications resources

In addition to using human resources to best advantage, there is a wide range of other resources including audio-visual aids such as videos, internet web sites, print material, facility tours, and publications geared specifically to communicating with the public.

5. Using video to convey a key message

Audio-visual media such as videos can be valuable in describing complex topics. An excellent example is a video developed by the Nuclear Energy Institute (NEI) entitled, *"An American Success Story: The Safe Shipment of Used Nuclear Fuel*." This video uses computer generated graphics to demonstrate the multiple layers of transport package construction; film footage of actual container tests performed at the U.S. Department of Energy's (DOE) Sandia National Laboratories (SNL); and interviews with experts on transport safety. It provides a highly effective means of communicating a complex subject – used nuclear fuel transportation safety – in a manner easily understood by any audience.

BNFL, COGEMA and the Overseas Reprocessing Committee have developed several videos (Safe Passage, More for less, Safety in Depth) to explain all the details on the transport concept for mixed oxide fuel (MOX) and vitrified high-level radioactive waste (HLW), including descriptions of the material transported and the energy context associated with the transports.

6. The wide reach of the world wide web

The internet has put a great deal of information at the public's fingertips and should be employed by industry and regulators to communicate on RAM transport issues. Regulatory agency web sites can be used to post regulations governing RAM transport, provide regulations for public comment, distribute technical documents and fact sheets, and communicate the results of risk studies. Industry can use web sites to post fact sheets provide information on transport package design and safety features safety records and emergency response planning, and provide links to other web sites. Several Internet sites that are useful references on this subject are discussed below.

SNL runs a web site developed for the US DOE National Transportation Program (www.sandia.gov/tp/SAFERAM/RAM_HOME1.HTM). This site provides public information on radioactive material packages including examples of some of the "severe testing" performed on Type B packages, photos taken during and after tests, and video clips of various thermal and impact tests.

WNTI was established to promote sound and objective principles for ensuring that radioactive material is transported safely, efficiently and reliably within a secure international framework. Its website (www.wnti.co.uk) covers all aspects of RAM transport and is intended to help those with no industry knowledge of the industry gain a better understanding of terminology and regulatory aspects.

The UK National Radiological Protection Board's Internet site has a section on "Understanding Radiation." including a module on RAM transport which provides background information on the uses of RAM, transport package types, transport regulation, and links to other Internet sites. It is easy to navigate and written in simple language providing a useful source of information. (www.nrpb.org/understand/index.htm).

The French National Competent Authority (ASN) operates a website providing comprehensive information on nuclear safety in France. In the field of transport of radioactive material, reports of transport inspections as well as reports of incident and accident (using the INES scale as a media tool to communicate on the severity of the incident) are available. The Website also presents press releases, information files on selected items and annual reports (www.asn.gouv.fr/actualite/evenements/index.asp "transport de matières nucléaires").

7. Facility tours – seeing is believing

Another powerful resource available to industry is to providing tours of key facilities to decision makers, the media and the public so they can have a firsthand view of how facilities operate and the regulatory and safety culture of the industry. This includes tours of nuclear power plants, fuel cycle facilities, manufacturing facilities that use or produce RAM, transportation vehicles and shipping vessels, and transportation package fabrication facilities. Many of these facilities have visitors' centers and trained communications professionals to provide another source of credible information. Tours of nuclear facilities showing the various types of operations have been used effectively around the world.

COGEMA has employed an interesting supplement to facility tours by installing cameras at its La Hague facility for real-time broadcast over the internet including placement of cameras in various locations at the La Hague facility, in the Valognes rail terminal and in the Port of Cherbourg. While the live broadcasts have been suspended for security purposes, the use of cameras and video tape on Internet sites to show transport related operations can provide another tool for communicating with the public and is one that other companies could consider as a supplement to facility tours. (www.cogemalahague.com).

8. Use of simple language in written material

In order to communicate successfully, it is important for industry and competent authorities to communicate in simple language avoiding industry jargon and acronyms, and summarize technical information so it is easily understood. Technical analyses on transportation risk assessment generally are written in very technical language. Summarizing the results of these studies in simple language is an important step in communicating the results.

Information brochures developed by BNFL, COGEMA, and the Japanese Overseas Reprocessing Committee (ORC) for the return shipment of MOX and vitrified residues from Europe to Japan provide a good example of information material covering all aspects of RAM transport. The materials are written in simple language, have been prepared in several languages and cover a range of topics including package design and safety requirements, design of the purpose-built Pacific Nuclear Transport Limited (PNTL) ships, security and physical protection, emergency response arrangements and exercises, and so on and includes colour photographs and diagrams of transport packages, transport operations and shipping vessels.

Since many in the public do not have a good understanding of radiation or radiation dose measurement, it is important to provide comparisons of radiation dose from RAM transport with natural background radiation doses, natural and man-made sources of radiation, and so on. The American Nuclear Society (ANS) has developed a worksheet allowing the public to "estimate" personal annual radiation dose, including values for common sources of natural and manmade radiation.

It can be downloaded from the ANS internet site (www.ans.org/pi/raddosechart).

9. Summary

While anti-nuclear groups will continue to advance inaccurate information regarding RAM transport and try to raise the fears regarding transport risk, these efforts can be counter-balanced by the nuclear industry if it makes a concerted effort to listen to the concerns of the public and decision makers, provides factual, easily understood information, and corrects inaccurate information.

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COGEMA LOGISTICS' GLOBAL INFORMATION POLICY FOR TRANSPORTS

H.-J. Neau

COGEMA LOGISTICS,
Montigny-le-Bretonneux,
France

Abstract.

In addition to strictly enforcing internationally accepted and regularly reviewed safety rules as well as ensuring the smooth operation of their international nuclear transportation, COGEMA LOGISTICS and industrial partners involved in the international transportation of nuclear materials wish to increase the general understanding of these operations. COGEMA LOGISTICS, as well as its partners and customers, has been listening around the world to understand local concerns and has discussed and explained aspects of nuclear transportation with governments' Officials, Representatives of regional organisations, associations members and media representatives. COGEMA LOGISTICS will keep making every effort to inform whoever must be on our transport operations. We consider that we have a responsibility to make the relevant information accessible and are continually assessing the most appropriate way to achieve this. Transparency remains the mainstay of our information policy.

1. Background

COGEMA LOGISTICS (formerly TRANSNUCLEAIRE) has been transporting nuclear fuel cycle materials for 40 years, at national and international levels. These transports are implemented daily in France with exceptional concerns from the Public Opinion. Things can be relatively different for some international transports. There is no denying that these transport operations meet the international regulation of United Nations bodies like the International Atomic Energy Agency (IAEA) or the International Maritime Organisation (IMO). Neither is there denying that they comply with the requirements of national regulations of the countries involved in the transports. In spite of that, some opposition to our international transports has developed in the nineties. Public and media scrutiny has fallen on these transports from 1995, when vitrified residues started to be returned from France to Japan and to some European customers in Germany – which was fairly new. From this time, some opponents and hostile media have undertaken to misinform general public on our international activities and it has been necessary to implement a communication policy aimed at dealing information on our activity and tackling misinformation. This Global Information policy is applied to international transports (e.g. between Europe and Japan) as well as put into practice to inform on transports within Europe or domestic transports. Thanks to the sustained implementation of this Global Information policy in these three fronts, governments' Officials as well as diplomats, association members and media representatives are now convinced of the high safety level of our transports.

2. The implementation of a Global Information policy

Generally speaking, the information on our transports is issued on classical information mediums as websites, booklets and CD-ROMs. Each kind of information tool squares with a specific transport operation and is adapted to the targeted audience: officials, experts, media, etc. In parallel, we arrange meetings for making presentations of our activities to various audiences, as often as required. Our Global Information policy is definitely based on our availability to those who need or wish to be informed. As an illustration, the doors of the COGEMA-La Hague reprocessing facility (France) used to be opened to the general public until the enforcement of the post-11.09.01 exceptional security measures. The information policy we carry out in France is also addressing scholars and students, trade union members and transport companies committees (e.g."Hygiene Security and Labour Conditions Committee" members). In foreign countries (e.g. South and Central American countries, Pacific Island countries), COGEMA LOGISTICS and its partners for shipments between Europe and Japan (BNFL in UK and ORC in Japan) issue, in agreement with their respective Authorities, a complete information on the details of their transports. In the specific case of European transport activities, each stakeholder implements a nationally dedicated information policy in his own country. Consultation and availability between COGEMA LOGISTICS and its partners and customers remain the basis of our collaboration.

3. Information missions

Information missions are frequently arranged and implemented by a team of experts fully dedicated to this Global Information policy, notably for issuing information on international shipments.

In the specific case of maritime transports between Europe and Japan, the particular dimension raised by those we call "Coastal States" appears. Indeed, these countries, which feel they have no direct benefit in these shipments which are passing far away off, unduly think they are the victims of external interests, hiding risks they are exposed to. This perception is resulting from inaccurate information coming from alarmist speeches propagated by some opponent to nuclear energy as a whole. Nuclear transportation takes place every day in many countries around the world in the highest safety conditions and it is our role (industry and regulator) to provide accurate and objective information using the wide range of resources that are available.

As an example and for these shipments, shipping States and industries are carrying out information missions in order to inform Coastal States. These missions take place all year long and at the time of transports. Two dominant characteristics can be given to these missions. "Diplomatic missions" are implemented to inform government Officials, political Authorities and high ranking civil servants on our activities. Such missions also permit to initiate dialogue and fruitful relationships with foremost Officials, in the case no contact was yet established. On the other hand, "media missions" aim at informing the general public, throughout media. It gives us the opportunity to bring answers to journalists' questionings and permits us – as occasion arises – to speak to associations and groups of interest. Officials from shipping states as well as Global Information industry experts have paid calls to Officials from various countries as part of this information visit program: South Africa, Australia, New Zealand, Fiji, Caribbean States, Panama, Brazil, Uruguay, Chile, Argentina, countries of the Pacific Island Forum.

Many other information actions are developed: we frequently organise visits of our industrial sites (e.g. COGEMA La Hague's and BNFL Sellafield's reprocessing plants); regional information seminars (e.g. in Trinidad & Tobago) are implemented. In the same way, we arrange what we call "Inward Visit Projects", consisting in visits of prominent Officials, academics or journalists from concerned countries to our European sites (Sellafield and Barrow in Great Britain, COGEMA-La Hague in France). This "come and see" approach characterises most of our information operations by allowing a first hand information recovery.

4. The content of information

The information we issue about our transports tends to be, so to speak, exhaustive. The nature and main features of the material to be transported are clearly addressed, as well as the recycling process it results from. It is the same for the transport organisation, the type of conditioning we use and the main points of the implementation phase: dates, route, and information disclosure policy. Added to the safety aspects of these transports, the legal area (e.g. liability matters) is also addressed. Regarding safety measures, it is relevant to consider the attention these transports are subject of, compared to the measures applied to other dangerous goods transportation: nuclear materials are by far more regarded. We also insist on the draconian regulations our transports meet (e.g. standards enacted by the IAEA, the IMO and national legislative assemblies) to show how intransigent we are when safety and security are at stake. In a nutshell, there is no more regulated transport activity than the nuclear materials one.

5. The results of the Global Information policy

This Global Information policy enables our interlocutors to develop a better perception of the reality of our activities – some of them, formerly prejudiced, had even been considering us as sorcerers' apprentices for a long. Visits of our sites by officials, Authorities and media allow them to get a first-hand information which erases, in many cases, the misinformation they were previously facing. Considering media, we noticed a real improvement in the attitude of serious newspapers. As a summary, most of the people we have been in touch with now recognise the high quality and the very stringent safety standards of our transport operations and appreciate our efforts for transparency and dialogue.

6. Still room for improvement

In the years to come, we will follow up, intensify and diversify our efforts. We will notably improve our information and communication process by maintaining a close monitoring of the international political, economic and social concerns. We want to manage more room for the "rational" – needless to say, less room for the "emotional" – in the information move over transports.

COMMUNICATION BETWEEN GOVERNMENTS

F. Maughan, P. Brazel

Nuclear Safety Division,
Department of the Environment and Local Government,
25 Clare Street, Dublin 2, Ireland.

Abstract.

This paper addresses the requirements for communication, consultation and information exchange between governments. It focuses on these requirements in relation to shipments of INF category cargoes. The paper reviews the consideration of these issues at the IAEA General Conference and in selected legal instruments and evaluates the effectiveness of the current regulations.

1. Introduction

The effectiveness of the regime concerning the safety and security of the transport of radioactive materials depends crucially upon (i) the communication of information and (ii) the active co-operation of all States concerned in exchanging information and consulting as promptly and fully as possible without compromising the measures for physical security and safety. The communication of information plays several critical roles, all of which help reduce uncertainty and enhance States' preparedness. Communication and consultations amongst States can help to build confidence; enable those States to assess the prevailing situation; to identify gaps in knowledge and planning; to take adequate emergency planning measures; contribute to risk assessment and measures to counter possible threats and help to evaluate performance and standards.

Standards and regulations need to be continually developed and subject to a regular and systematic process of review. Their application and enforcement must, in addition, be universal and transparent. It is the responsibility of national governments and competent authorities to ensure the safety and security of the transport of radioactive material accords with these standards. Member States must collectively ensure, through the IAEA and other relevant international organisations, as well as regional and bilateral fora and contacts, that only the highest safety standards are employed and adhered to and all risks are critically assessed and addressed. This is a necessary and clear obligation on nuclear States arising from the inherent risks associated with nuclear activities and their implications for neighbouring States.

As States not engaged in the transport of radioactive materials may be exposed to similar risks to those engaged in such activities, transporting States have a responsibility to ensure that potentially affected States are kept fully informed so that they can also adopt the requisite measures of safety and preparation. Member States of the IAEA fully understand the potential trans-boundary implications of radiological release. However, the opportunity for potentially affected States to establish and refine effective, rapid and efficient emergency response procedures is absent. There is a clear need for transparency in transport activities to develop international confidence in those activities. International confidence is built on a foundation of transparency, which includes, inter alia, effective consultation and communication about events, feedback on operational experience, self-assessments and wide-ranging peer reviews. Suitably developed IAEA safety services, such as the Transport Safety Appraisal Service, can play an important role in this regard.

2. International regime for the transport of radioactive materials

The transport of radioactive materials between countries has been a regular feature of trade in hazardous materials for several decades. The transport of radioactive materials involves many types of materials, including radionuclides and radiation sources for applications in agriculture, energy production, industry, and medicine. Materials are transported by road, rail, sea and waterways, and air. The transport of radioactive materials is governed by the *Regulations for the Safe Transport of Radioactive Material* (the *IAEA Transport Regulations*). These regulations were first established in 1961, with revised editions of the regulations being issued in 1964, 1967, 1973, 1985 and 1996 [1].

The IAEA Transport Regulations serve as the model regulations for regulatory documents issued by organizations concerned with transport via specific modes, including the International Civil Aviation Organization (ICAO), the International Maritime Organization (IMO), the UN Economic Commission for Europe (UNECE) and the Universal Postal Union (UPU). The IMO has adopted a uniform regulatory document for the transport of dangerous goods by sea, the International Maritime Dangerous Goods (IMDG) Code. First introduced in 1965, the IMDG code has been the subject of periodic revisions; based on proposals from Member States of the IMO and updates to the UN Recommendations on the Transport of Dangerous Goods (which, in turn, are based, in part, on the IAEA's Transport Regulations).

The IMDG Code is divided into nine specific clauses, which give detailed advice on the handling and transport of specific classes of dangerous goods. Class 7 of the Code concerns the handling and transport of radioactive materials. As part of the IMO Safety of Life at Sea (SOLAS) Convention [2], the IMDG Code will become mandatory from 1 July 2004 by amendments to the SOLAS Convention, adopted in May 2002.

In addition to the IMDG Code, the transport of materials which form a part of the nuclear fuel cycle are subject to the Code for the Safe Carriage of Irradiated Nuclear Fuel, Plutonium and High Level Radioactive Wastes in Flasks on board Ships (INF Code) [3]. The INF Code sets out specific requirements for ships used to carry nuclear fuel cycle material (INF Code material) and was incorporated into the SOLAS Convention, eventually becoming mandatory on 1 January 2001.

3. Notification and consultation in international instruments

Instruments of General Application

The principle of notification and consultation has been set out in a number of international instruments regarding cooperation between States where there may be transboundary implications of hazardous activities. A general duty to co-operate, which is especially relevant to shipping States involved with the transport of INF Code material, is set out in the United Nations Convention on Law Of the Sea (UNCLOS) in relation to the protection and preservation of the marine environment. Article 197, UNCLOS, states that:

> *"States shall co-operate [...] in formulating and elaborating international rules, standards and recommended practices and procedures [...] for the protection and preservation of the marine environment, taking into account characteristic regional features"* [4].

The need for co-operation was earlier recognised in the 1972 Stockholm Declaration, which stated:

> *"Co-operation through multilateral and bilateral arrangements or other appropriate means is essential to effectively control, prevent, reduce and eliminate adverse environmental effects resulting from activities conducted in all spheres, in such a way that due account is taken of the sovereignty and interests of all States"* [5].

This was reinforced in Principle 19 of the 1992 Rio Declaration, which stated that:

> *"States shall provide prior and timely notification and relevant information to potentially affected States on activities that may have a significant adverse transboundary environmental effect and shall consult with those States at an early stage and in good faith"* [6]. *(Emphasis added).*

One of the more recent indications of the necessity for cooperation and notification has come from the International Law Commission (ILC), which has stated that:

> *"The principle of co-operation between States is essential in designing and implementing effective policies to prevent or minimise the risk of causing significant transboundary harm. The requirement of co-operation of States extends to all phases of planning and of implementation"* [7].

The International Law Commission's Draft Articles on the Prevention of Transboundary Harm from Hazardous Activities, adopted in 2001, includes provisions relating to "activities not prohibited by international law which involve a risk of causing significant transboundary harm through their physical consequences" that provide for cooperation, assessment of risk including any environmental impact assessment, notification and information, consultation on preventive measures, emergency preparedness and exchange of all available information in a timely manner [8].

IAEA Instruments

A duty to co-operate is central to several international agreements, such as the Convention on Early Notification of a Nuclear Accident [9], the Nuclear Safety Convention [10] and the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management [11]. Such instruments require the exchange of information on proposed installations designed to ensure adequate reporting of activities of risk of transboundary harm or plans for such activities. Although the provisions for reporting mechanisms designed to make available information on installations are not applied for the transport of radioactive materials, the Convention on Early Notification of a Nuclear Accident, which imposes a duty on States to notify other States which are likely to be affected by an accident, does include within its scope 'the transport and storage of nuclear fuels or radioactive wastes' [9].

IMO Instruments

The IMDG Code contains requirements for shipboard emergency planning arrangements. As applied to radioactive materials, these requirements draw upon the IAEA's Guidelines for Planning and Preparing for Emergency Response to Transport Accidents involving Radioactive Material. [12]. Paragraph 3.6 of the Guidelines states that the notification and communication concerning transport accidents involving radioactive material should be handled in a manner similar to that used for other transport incidents involving dangerous goods. [13]. Paragraph 3.7 of the Guidelines suggests the establishment of marine emergency centres, which should have effective liaison capability and the provision to notify, either directly or through the IAEA, those States that may be affected by a transboundary emergency[1]. The Guidelines also require that provisions be in place to notify the IAEA promptly of a transboundary emergency and to respond to requests for information relating to the emergency in accordance with IAEA requirements.

Chapter 10 of the INF Code sets out the requirements for a Shipboard Emergency Plan (SEP). According to the IMO Guidelines for developing shipboard emergency plans, [14] one of the essential provisions of an SEP includes a report to the nearest coastal State of an actual or probable release, and a report in the event of damage, failure or breakdown of a ship carrying INF Code material. Furthermore, Chapter 11 of the INF Code sets out provisions for notification in the event of an incident [3]. These requirements however, go no further than the existing notification obligations already contained in the MARPOL Convention, [15] which contains obligations (Article 8 and Protocol 1) for vessels to report any incident which has caused or could cause pollution to the nearest coastal State.

The principles of marine emergency management can be broadly categorised as Prevention, Preparedness, On-board emergency planning, Response and Co-operation. These principles relate, inter alia, to ship design, construction, lifesaving equipment, shipboard operations, crew numbers and qualifications, carriage of cargos, safety of navigation, radio-communications and regulations for the prevention of pollution. Each of these principles has, over time, been codified in various conventions of the IMO, including MARPOL, SOLAS, SAR, MARPOL 73/78, and OPRC and its Protocol on Preparedness, Response and Cooperation. These and other conventions have established a framework for the safe and secure navigation of the world's oceans. Member States of the IMO, in negotiating and adopting these Conventions have sought to ensure a universal and uniform application of their

[1] Transboundary emergencies are events that are of actual, potential or perceived radiological significance for other States. This includes events that have resulted in significant exposures or contamination in other States, lost or stolen dangerous sources that could have passed over a national border, events influencing international trade or travel, and events perceived to be of radiological significance by the news media or public in another State. Source: IAEA Planning and Emergency Response Guidelines, p. 9.

provisions to international shipping. These provisions, however, have been based primarily on the need to ensure that the highest standards are adopted to ensure the integrity and safety of ships and their dangerous cargoes.

Finally, the Marine Environmental Protection Committee (MEPC) of the IMO has discussed the question of prior notification for INF category cargoes. As there has been no consensus in this forum, the MEPC could not agree on any amendments to the INF Code but resolved to keep the question on the agenda for further discussion [16].

4. Resolutions of the IAEA General Conference

The safety of the transport of radioactive materials has been addressed in a number of resolutions of the IAEA General Conference. These resolutions have sought to address the basic concerns of some States that insufficient information has been communicated relating to the transboundary shipments of radioactive material. The 1998 General Conference invited States shipping radioactive materials "to provide [potentially affected States] with relevant information relating to shipments of radioactive materials" [17]. This was echoed by the 1999 General Conference [18].

In 2000, the General Conference noted the concerns of coastal States and invited shipping States to provide assurances to "potentially affected States upon their request […] with relevant information relating to shipments of such material." In addition, the General Conference called for "efforts at the international, regional and bilateral level to improve measures and regulations for international maritime transport of radioactive materials and stressed the importance of having effective liability mechanisms in place"[19].

Prior to the 2001 General Conference, several Member States made declarations expressing concerns about the inherent risks associated with INF category transports, for the health of coastal populations, the environment of coastal regions and potential economic damage and the lack of information made available to them. [20] They sought constructive dialogue and certain assurances from a number of shipping States. Areas of concern included:

1. Prior informed exchanges regarding
   a. Routes and timing of shipments
   b. Emergency/contingency plans in the case of accidents
   c. Security arrangements consistent with the need to ensure safety and security of the shipments and
   d. Assurances of non-contamination of the marine environment.
2. Ongoing exchanges to build mutual understanding and confidence, and to
   a. Carry out risk assessments
   b. Establish effective mechanisms to govern recovery, clean up and compensation in case of an accident or incident and damage
   c. Establish a comprehensive and effective mechanism to address liability
   d. Strengthen existing security and safety measures and
   e. Conduct joint exercises in areas of emergency response and preparedness.

The 2001 General Conference [21] noted the Declarations by Member States and Regional Groups Regarding Safety in the Maritime Transport of Radioactive Material [20] and the concerns expressed therein. It also noted the recommendation in an April 2001 decision of the UN Commission on Sustainable Development urging Governments to take into account the very serious potential for environment and human health impacts of radioactive wastes, to make efforts to examine and improve measures and internationally agreed regulations regarding safety, while stressing the importance of having effective liability mechanisms in place, including, *inter alia*, arrangements for prior notification and consultations in accordance with relevant international instruments. Prior notification and consultation were singled out as the key to securing the safe movement of radioactive materials.

There has been a discretionary practice of States shipping INF Code material to provide certain basic information on routes and timing to certain States. While the communication of all information is welcome, this practice does not vindicate the rights and obligations of all concerned States to take appropriate measures to protect their populations and their environment. The receipt of information on shipments would enable concerned States to affirm such rights and obligations. Indeed the discretionary nature of this practice does not seem to fit with the purposes of providing such information.

While the 2002 General Conference "[welcomed] the practice of some shipping States and operators of providing in a timely manner information and responses to relevant coastal States in advance of shipments for the purposes of addressing concerns regarding safety and security, including emergency preparedness", it also emphasised the "importance of maintaining regular dialogue and consultation aimed at improving mutual understanding, confidence building and enhanced communication." The Director General was requested to "examine how the Agency could assist to further this objective and to report to the next General Conference" [22]. This underlined the importance of the right of consultation for potentially affected States and to make their concerns known to shipping States. Such rights of consultation are distinct and independent of the rights of notification of activities as they occur.

As described in Section 2, there are binding international regulations for the transport of dangerous goods in general and radioactive materials in particular. However many States, as reflected in a number of declarations made prior to the 2001 General Conference, have concerns that the regulations in place for the transport of INF Code material do not adequately provide for notification of shipments and related information and that the regulatory framework in place differs or does not sufficiently take account of the regulations concerning the transport of other categories of dangerous goods.

5. Conclusion

Recognising the potentially devastating transboundary effects of an accident involving radioactive material and recognising the rights of States to take adequate precautions to protect their populations, environment and economies, it follows that the maritime transport of radioactive materials must be subject to a systematic procedure of notification and consultation, regardless of the risk of transboundary harm.

While recognising the right of freedom of navigation through States' exclusive economic zones and territorial seas enshrined in UNCLOS, States shipping INF Code material have certain responsibilities to potentially affected States. While providing timely information and engaging in constructive dialogue they must not discriminate between States as all potentially affected States have a duty to protect their environment, their populations and indeed, under the various IMO conventions, the safety of a ship and its crew. Given the extremely hazardous nature of INF Code cargoes, the right of freedom of navigation must be tempered by a duty on the shipping State to take all necessary precautions to ensure the safety of the shipment and the protection of the environment, including prior notification to potentially affected States to allow them to take their own precautions, including ensuring emergency preparedness.

The process and range of engagement, communication, confidence-building and co-operation between States should be guided by the respective needs and requirements of all concerned States on the basis of mutual interest and respect. While existing regulations and standards can and usefully do provide a benchmark for such communication, these do not, as yet, meet the needs of all concerned States. Particularly where the fulfilment of such regulations is dependent on a unilateral assessment of the possible risk of particular activities, this is considered insufficient to address the dangers to potentially affected States. These States must be afforded a right of consultation and notification to consider the risk and the assessment on which it is based. The existing instruments are not comprehensive and leave open several areas of concern including the establishment of effective mechanisms to govern recovery, clean up and compensation in case of an accident and the establishment of a comprehensive and effective mechanism to address liability. States must therefore make efforts to examine and improve existing standards and regulations regarding safety, while stressing the importance of ongoing communication between governments.

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COMMUNICATION BY THE COMPETENT AUTHORITY
Why and How

J. Stewart

Radioactive Material Transport Division, Department for Transport,
76 Marsham Street, London SW1P 4DR,
United Kingdom

Abstract.

Transparency is an issue of increasing importance. Calls for improvements in transparency are made at all levels; international, regional, national and local bodies call for improvements. One of the key tools in assuring transparency is communication. Communication has also long been a tool that has aided safety. This paper describes communication by the UK Competent in broad terms, and notes the importance given to bi-directional communication. The complexity of relationships and breadth of communication is set out and examples of communication are cited to demonstrate the means by which the UK Competent Authority uses communication to advance safety and transparency.

1. Communication routes

Communication is on the surface a simple process. However, considering communication from the point of view of a Competent Authority there are many groups and individuals with whom communication is required. Many of these groups and individuals then communicate with each other about the issues involved. Fig. 1 illustrates some of the groups involved and some of the many communication paths. Within each of the groups there can be many people and organisations communicating with each other. The Competent Authority can become a communication hub, gathering and disseminating information.

Because communication is bi-directional the communication from the Competent Authority is often different to each group. However, it is possible to establish common threads over several groups. Where this is possible the opportunity is taken to produce reports that serve multiple groups. For example, most groups are interested in reports on incidents involving the transport of radioactive material, albeit for slightly different reasons. Pressure groups look for information to support their views, either for or against the transport of radioactive material, regional bodies look for information to respond to the public they answer to, and other governments look for information on any problems that can affect them. The many ways in which a single communication from a competent authority can be used makes the production of such a single document difficult. However, with the multiple communication routes that exist, the benefits of having a single message to several points has obvious advantages.

Further complications come from legal issues. Again considering communication related to incidents there are occasionally privacy/confidentiality considerations. Where commercial organisations make information available to competent authorities on a voluntary basis beyond that required by legislation this can often bring with it confidentiality agreements. Where there are questions of legal proceedings against individuals or organisations there can be restrictions on the release of information in order to prevent the prejudicing of court cases. Since transparency is something much communication is intended to both demonstrate and achieve this restriction often needs to be carefully explained. The guiding rule is that the requirement to ensure safety is more important than the desire for transparency.

However, perhaps the real challenge for the Competent Authority is to arrange communication in such a manner that reduces the possibility of misunderstanding as the information is used by others.

2. Messages being communicated

While there are many individual messages and many strands to Competent Authority communication there are key themes that underlie many communications. One key theme in many messages is to convey background information on how radioactive material is transported and how safety in transport is ensured.

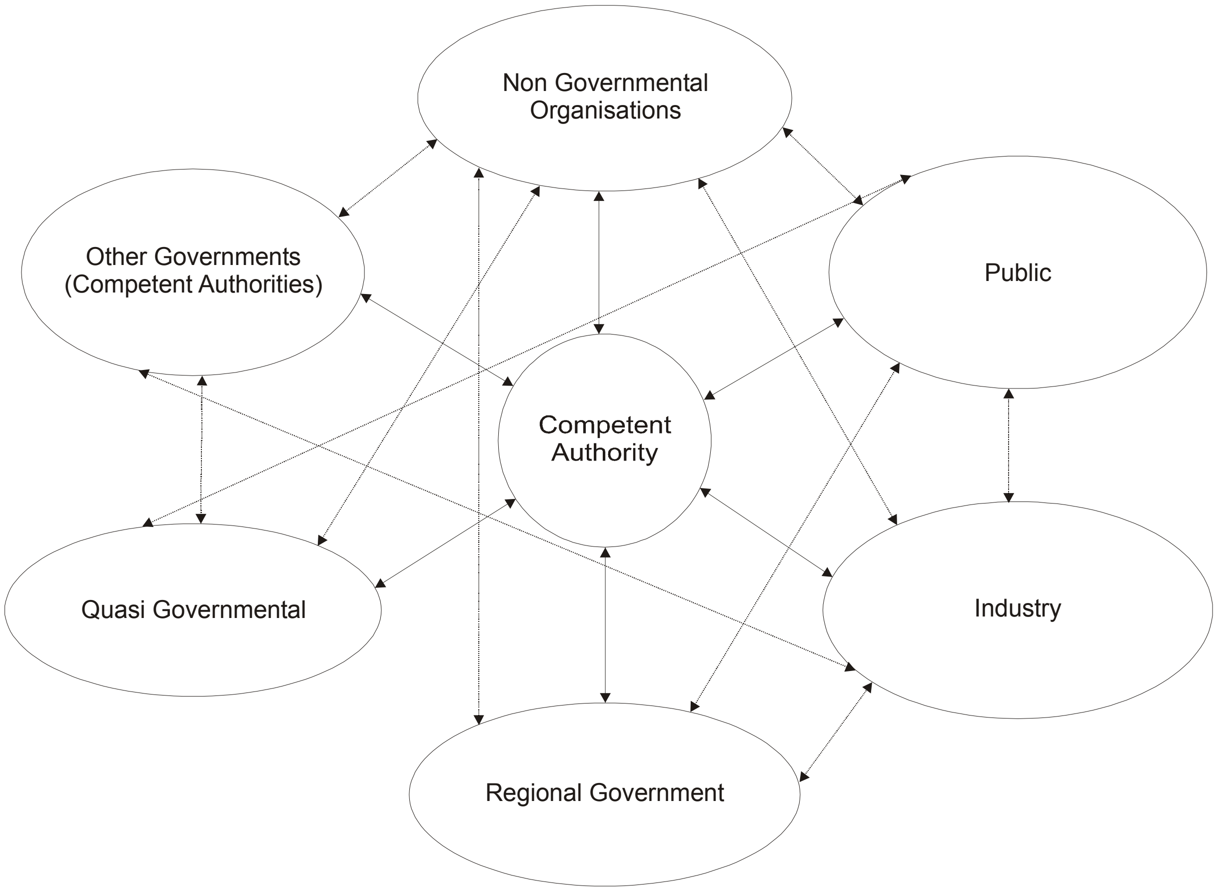

FIG. 1. Some Communication paths

A very large proportion of radioactive material packages transported contain medical products; another large proportion of packages contain industrial products. A small proportion of radioactive material packages contain material associated with the nuclear industry, however these packages tend to have a comparatively high profile. A large part of the communication related to the transport of radioactive material involves emphasising these facts as a foundation for other communication and redressing the attention paid to nuclear shipments in many ways. Decisions and opinions, which are made on the wrong basis, often result in the wrong output.

Messages that convey information on how the radioactive material transport industry is monitored by regulators convey a sense of how safety is ensured. Another important approach is to ensure open dialogue on the acceptability of rules governing the transport of radioactive material. The ownership of the rules and regulations by all those with an interest in the transport of radioactive material is an effective means of demonstrating their suitability and encouraging full compliance. The degree to which this ownership is achieved can depend on the effectiveness of communication between those interested and the Competent Authority.

Specific examples of how and why the Competent Authority in the UK communicates with different groups follow. For the purpose of this paper the term Competent Authority is given a broad meaning, including several different bodies who all perform duties as Competent Authority.

3. Communication with the public

The first issue with public communication is that there are obviously too large a number to engage Radioactive Material Transport Division, Department for Transport, 76 Marsham Street, London SW1P 4DR, United Kingdom each person individually. One of the main methods of communicating with the public in the UK is indirectly through another body. The National Radiological Protection Board (NRPB) is a government body which is recognised as being independent from political direction. Because of their standing as a government organisation they can provide effective assurance of confidentiality. NRPB are given free access to Competent Authority records in order to enable them to collate information to communicate to the public (amongst others). Some of the communication work they undertake is on their own behalf, other work is funded by the Competent Authority. An example of their effective communication with the public is their "Understanding Radiation" (At a Glance) series on their web site, which includes a very good presentation on "Transport of Radioactive Material"**[1]**. This reference is used extensively by the Competent Authority in establishing a clear understanding of the transport of radioactive material. The NRPB produces reports on a regular basis, funded by the Competent Authority, detailing recent incidents involving the transport of Radioactive Material of interest in the UK **[2]**. These reports are produced on an annual basis. Other reports produced by NRPB and funded by the Competent Authority look at specific modes of transport to examine their effect, taking into account current patterns of transport **[3]** revising each about once every ten years. The use of an independent body such as NRPB to be the focus for public information helps to demonstrate transparency and has proved to be an effective means of making information available.

Other means of communication with the public include communication through their elected representative at national level (MP). In some cases these representatives will communicate their concerns through questions in parliament **[4][5]**. These are normally answered by the government minister responsible for the Competent Authority. This communication is public in nature and records are openly available. On other occasions the MP will write to government ministers directly regarding issues raised by people they represent. This communication tends to be more detailed and less public than the questions in parliament. Finally there are occasions when the public will write directly to the Competent Authority to raise an issue that they have a personal interest in. In many cases these communications seek again to establish the basic facts regarding the transport of radioactive material, demonstrate transparency and effectiveness of rules.

4. Communication with non-governmental organizations

Examples of non-governmental organizations (NGOs) with an interest in the transport of radioactive material are organisations with concern for the environment and industry pressure groups. While the environmental organizations and industry pressure groups may seem very different on the surface the reasons for communication with them are essentially the same. In both cases there is a role of listening to concerns and explaining decisions. One key area of communication with these groups is in the development of rules governing the transport of radioactive material. In the UK there is an extended consultation process at different levels of developing rules. The technical aspects of the rules are consulted on during the IAEA review and revision process. During this period the Competent Authority provides interested groups including NGOs details of proposals, solicits comments and collects proposals from any of them that wish to amend the rules. This written communication is backed up by meetings at which all interested groups can discuss the issues with the Competent Authority. The purpose of this communication is to ensure that the rules have the widest possible acceptance, that they are seen to be justified and suitable.

Again the reports prepared by NRPB**[2][3]** for the Competent Authority are helpful in communicating with these groups, since the information contained in them is often seen as important. The reports also provide a good basis for the discussion of necessary changes in rules in that they help to identify whether there are particular problems and how they might be remedied.

5. Communication with industry

One of the primary reasons for communicating with individual companies involved in the transport of radioactive material is to guide them through the rules that control their operations. Several guides are produced by the Competent Authority for this purpose. For example, a guide has been produced to explain the way in which industry can demonstrate to the Competent Authority that packages for radioactive material are adequate to meet the technical standards set by IAEA **[6]**. Another guide has been developed to explain how particular aspects of the internationally sourced rules should be applied within the UK **[7]**. Further guides are developed to deal with specific technical issues that arise due to changes in knowledge **[8]**. All of these guides are designed to make it easier for industry to meet rules governing the transport of radioactive material. As a result it helps to ensure a higher level of safety –the underlying aim.

Backing up this communication regarding best practice for applying the rules are the periodic reports by NRPB **[2] [3]** which are used to communicate to industry the effectiveness of their application of the regulations. This understanding of the value of applying rules helps to reinforce the ownership by industry and demonstrates to them the benefit of the application of the rules. The knowledge of the benefit of having a particular rule is an important motivator for individuals who are required to comply with it.

Industry also communicates with the Competent Authority throughout the process of developing and amending rules (mentioned in the previous section).

6. Communication with regional bodies

While Competent Authorities are normally related to national government there are other levels of representation of people. For example, the UK has elected representatives to local authorities and elected representatives to the European Parliament. Because these bodies represent the same public as the national government but in different geographic (regional) groupings they can provide valuable insight into the views of the public for the Competent Authority. While there are reasons for communication at official level on a working basis there is normally also a listening role for the Competent Authority when dealing with the elected representatives of regional bodies. One example of a regional body having interest in the transport of radioactive material is the recent investigation by the Greater London Authority **[9]**. While there was limited input to the investigation by the Competent Authority there was a significant listening role (communication to the Competent Authority), which has led to a better understanding of public concerns at a local level. This then feeds into the operation of the Competent Authority, again helping to create a greater sense of ownership and transparency. Another similar investigation took place in the European Parliament some years ago with similar Competent Authority involvement and response**[10]**.

7. Communication with quasi-governmental bodies

Typical quasi-governmental bodies include the international rule making bodies governing the transport of radioactive material. The Competent Authority communication role in this case is typically one of informing and representing. While there is an element of collecting information from the bodies and disseminating it, the main emphasis is on passing the views of the UK to these bodies. For example the UK Competent Authority takes an active role in representing UK views throughout the IAEA review and revision process which leads to updated rules. Previous sections have described how the Competent Authority has the views of interested bodies and industry communicated to them. This transfer of the views of individual organizations and industry members again reinforces the ownership of rules, and leads to greater transparency. Reports such as those developed by the NRPB for the Competent Authority **[2][3]** also serve to inform these organizations as to the efficacy of their international rules.

8. Communication with other governments

Because of the international nature of transport communication between governments and in particular Competent Authorities can be important. One clear example of the need for communication is in the event of an incident involving international transport of radioactive material. Although significant incidents are very rare it can be important to report insignificant incidents. A useful tool for describing the significance of incidents is the International Nuclear Event Scale (INES). This scale rates events from below scale to 7. Events rated at around two are where international communication for fixed facilities becomes reasonable. However, in transport events rated as below scale have been communicated by the UK Competent Authority to indicate to other Competent Authorities that a problem does not exist. The importance of this communication is to distribute clear facts to those who need the information on a relatively rapid timescale. Because of the nature of incidents this can be in a wide variety of forms and with a unique content on each occasion. Effective communication between Competent Authorities in this way reduces public and worker concern and helps to assure them of effective rules. Some of the communication between these authorities takes place within an overall assurance of an application of some confidentiality.

9. Conclusion

Effective communication can aid transparency. However, the main aim of the Competent Authority is to ensure safety, and so all communication is guided by the question "Does this improve or reduce safety?". The need for communication to take place both from the Competent Authority and to the Competent Authority is demonstrated in the sections above, where the Competent Authority is working as a hub to redistribute messages. The UK Competent Authority employs a wide variety of communication methods to communicate with a wide variety of groups. There is little doubt that the existence of the independent NRPB and their reports on the transport of radioactive material is a major benefit in demonstrating transparency. There is also significant benefit in their reports being used for a wide variety of groups – which helps to establish a sound basis and avoid confusion in messages.

The UK Competent Authority is committed to encouraging communication in order to improve safety and transparency by a wide variety of means. A good example of this commitment is the recent TRANSAS**[11]** – an audit of the UK by an IAEA led team. The purpose of being audited was not simply to identify necessary improvements in rules, but also to communicate widely in a way that demonstrated safety and encouraged a continued excellent safety record in the transport of radioactive material. Communication encourages ownership of the safety rules. This in turn leads to improved safety. Communication aids compliance with safety rules. This also leads to improved safety. Communication can play a significant safety role.

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DOSE ASSESSMENT AND SHIELDING OPTIMISATION FOR THE TRANSPORT OF RADIOPHARMACEUTICALS PRODUCED BY THE ISOTOPE CENTRE IN CUBA

S. Pérez Pijuán, F.E. Ayra Pardo

Centro de Isótopos
Cuba

Abstract

The paper presents a summary of a research conducted by the Isotope Centre in Cuba to evaluate effective doses and collective doses to occupationally exposed workers and public due to the transport of radiopharmaceuticals. The transport is divided from generic operations to the particular tasks performed by the persons exposed, according to the multiple exposures conditions usually existing. The effective doses are calculated from the measuring of $H_p(10)$ and the air kerma for each task during transport. The results are used in an optimisation study to select the optimum lead thickness for the Type A packages designed by the centre. The annual collective dose is 45 man-mSv. The 81 % are received by occupationally exposed persons and the 19 % by public. The principal exposure way is the air transport for the public; a critical passenger receives 327 μSv as maximum annual effective doses and the most exposed person of the airport staff receives less than 500 μSv in a year. The transport by road has the major impact on doses for occupationally exposed persons. The effective doses to drivers and distributors are evaluated around 2 mSv per year.

1. Introduction

The Isotope Centre (CENTIS) is the main supplier of diagnostic and therapeutic radiopharmaceuticals for the nuclear medicine in Cuba. CENTIS is managing around 4 000 radioactive packages annually, principally Type A packages of radiopharmaceuticals with Iodine 131 and Thallium 201. The 67 % of the radioactive materials are transported exclusively by road and the 33 % by air and road. The CENTIS´s transport responsibilities include the design, packaging, dispatch, handling, carriage and delivery of these packages.

The purposes of this research are to assess the radiological impact of the transport operations related to the radiopharmaceuticals produced by CENTIS and to apply the results in the evaluation of the optimum shielding thickness for the CENTIS´s Type A packages. Another important result expected from this research is to obtain, for the first time in the country, the real exposure levels for members of the public, usually worried about radiation risks, like the crew in domestic flights and the airport staff, who are key persons making decisions which could affect the efficiency of the radiopharmaceuticals logistic chain.

2. Methods and instruments

The evaluation method is selected, based on the analysis of the exposure conditions and the exposed individuals, according to:

1. The identification of the transport generic operations, as the ones which involve similar source terms in a repeatedly way during the year, e.g., packaging, transport by road in the capital, transport in the west and central provinces by road and transport to the east provinces by air and road.

2. The identification of the specific operations contained in each generic operation, as the ones which have similar exposure conditions and similar exposed persons during the year, e.g., dispatch of radioactive packages, vehicle transport, handling and storage in airports, air transport and delivery to hospitals.
3. The descriptive analysis of tasks, exposed individuals and exposure conditions in each specific operation, for example, the weighting of packages, in transit storage, carriage by the runway and loading (or unloading) of the aircraft during handling in airports.

The measurement method is applied in all cases, but in the 50 % of the specific transport operations doses are obtained from measurement of $H_p(10)$ by direct reading personal electronic dosimeters Dosicard, from Eurysis Mesures, calibrated for $H_p(10)$ with deviation of 13 % in a ^{137}Cs field for 95 % confidence level. Where direct measurement is not practicable, doses are evaluated from the measuring of air kerma rate (K_a) by an area portable dosimeter ALNOR (deviation of 4 % in a ^{137}Cs field for 95% confidence level) using distances and exposures times measured or referred in interviews.

The cost benefit analysis is chosen for the optimisation process, considering the protection and detriment costs, as continuous functions depending of the shielding thickness. It can be demonstrated that the expression, which describes the optimum condition, is [1]:

$$Wo_i = -\frac{1}{\mu} \ln \left[\frac{(C+T)n(i)}{\alpha\,\mu\,Sa_i} \right]$$

Where:

Wo_i, is the optimum shielding thickness for packages of the product "i", in mm.

μ, is the linear attenuation coefficient of the radionuclide involved in the product "i".

C, is the cost of the design, construction and test of the shielding unit, evaluated between 0.43 and 0.66 USD/mm.

T, is the cost of the shielding unit transported, evaluated between 0.23 and 0.46 USD/mm.

n (i), is the number of packages of the product "i".

α, is the monetary value assigned to the unit of collective dose, taken in Cuba as 8 000 USD/Man-Sv [2].

Sa_i, is the annual collective doses due to the transport of the product "i", taken as:

$$Sa_i = \Sigma_i E_i N_i$$

Where:

N_i, is the number of exposed individuals to the dose E_i.

E_i, is the average effective dose of the group "i", related to the $H_p(10)$ and K_a through conversion factors referred by [3] and considering anterior-posterior irradiation for all the exposed persons except for individuals exposed during carriage by road, which is a posterior-anterior irradiation.

3. Results and discussion

- *Collective doses*

The annual collective dose due to the transport of the radiopharmaceuticals produced by CENTIS is 45 man-mSv. Of this, 81 % are received by occupationally exposed persons (36.7 man-mSv) and 19 % by the public (8.3 man-mSv).

Table I shows the collective doses for each specific operation.

Table I: Annual collective doses due to specific transport operations.

Operation	Collective dose [μSv-hombre]	Contribution [%]
Packaging and storage	5.7	13
Dispatch	0.6	1
Transport by road	28	64
Transport by air	4.5	10
Handling in airports	4	8
Delivery in hospitals	2.3	5

Note how the packaging, considered in this research as part of the transport process, has the second important contribution in total doses. The maximum annual effective doses measured are 898 μSv for workers who perform the packaging of ^{131}I Na and 224 μSv for the radiation safety supervisor.

The principal exposure way is the air transport for the public, particularly for passengers. The maximum annual effective doses estimated are 327 μSv considering a critical passenger travelling in the critical seat. The most exposed member of the crews receives 98 μSv in a year. Airport staff receives a maximum of 358 μSv in a year due to the storage in transit. Other operations like weighting of packages, aircraft loading and carriage through the runway involve effective doses less than 200 μSv per year.

The transport by road has the major impact on doses for occupationally exposed persons. The main contribution to doses is due to ^{131}I Na (80 %) followed by ^{131}I radiopharmaceuticals (11 %) and ^{201}TlCl solution (9 %). The effective doses to drivers and distributors are around 2 mSv per year.

- *Sensitivity analysis*

The stability of the results can be affected by changes in the variables used. The following variations are considered:

- ✓ 22 % in the evaluation of the collective dose due to equipment deviations.
- ✓ 35 % costs reduction taking into account the use of recycled lead.
- ✓ An α value between 3 000 and 10 000 USD/Man-Sv as reported by international literature.
- ✓ A 40 % increase in the number of packages demanded.
- ✓ A 100 % increase in the activity demanded per ^{131}I Na package.

- *Constraints analysis*

Two constraints are taken into account: the dose constraint of 2 mSv/h at the packages' surface, technological constraints for the manufacturing of the lead shields and a transport index (TI) constraint of 10 in order to make possible the transport in any domestic aircraft, according to the restriction imposed by their Operations Handbook. Observing the dose constraint, the optimum thickness for ^{131}I Na packages must not be taken, because the condition is not fulfilled for thickness less than 11 mm. Technological constraints (and economical reasons) indicate as possible the manufacturing in CENTIS facilities of lead thickness more than 5 mm. The TI does not affect our calculations because the limited quantity of packages transported permit enough margins to consider the ^{99m}Tc generators.

The optimum shielding thickness is 15 mm for ^{131}INa packages and 5 mm for other radiopharmaceuticals.

4. Conclusions

The radiological impact during the transport of radiopharmaceuticals produced by CENTIS is evaluated and the results are used for optimisation purposes in the design of Type A packages.

The annual collective dose is 45 man-mSv, a low value, as expected for transport operations which do not include generators. The 81 % are received by occupationally exposed persons and the 19 % by public. The principal exposure is the air transport for the public and the transport by road has the major impact on doses for occupationally exposed persons. The main contribution to doses is due to ^{131} I Na (80 %) followed by other ^{131} I radiopharmaceuticals (11 %) and ^{201}TlCl solution (9 %).

The evaluation methodology shows consistency to expand it to other radiopharmaceuticals and generators produced by CENTIS.

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DOSE OF IONIZING RADIATION RECEIVED BY TRANSPORT WORKERS
A Study conducted in Canada in 2002

S. Faille

Canadian Nuclear Safety Commission Ottawa,
Canada

Abstract

The Canadian Nuclear Safety Commission conducted a multi-phase study on the doses received by transport workers. The first phase was completed in 2000 and provided general information on the transport of radioactive material in Canada and identified the areas of concerns for all modes of transport. The second phase was completed in November 2002. This phase included measurements of doses received by transport workers over a six-month period and the gathering of documentation on work procedures in place within the selected companies. The areas covered by the study included shipment by road and rail, air cargo terminals and ports. The dose results indicated that most transport workers included in the study are receiving doses below the limit for members of the public. The limit for members of the public was mainly exceeded by road transport workers. Within that group, workers of courier companies are receiving the highest doses due to the volume and size of the packages transported. The maximum dose received by a worker was approximately 3.7 mSv for the six-month period.

1. Introduction

The Canadian Nuclear Safety Commission conducted a multi-phase study to gather information on occupational dose received by transport workers. The first phase of the study was initiated in 1999 to gather information on doses received by transport workers, areas of concerns and information on the implementation of radiation protection programs for carriers. Only limited information was available and it was felt that more recent information on doses received by transport workers would be needed. The second phase of the project was initiated in January 2002 and consisted in measuring doses received by transport workers and collection of documentation on work procedures currently in place within the selected transport companies. This was completed in November 2002. Please note that this paper is not intended to discuss all aspects covered in the study. A similar study, completed in 1988 showed that doses received by the majority of transport workers were below 5 mSv/year, the old limit for members of the public. New data in that area was deemed necessary as the limit for members of the public had been lowered and the transportation industry may have changed significantly over that period.

2. Background

The study 1988 involved a total of 31 workers in 9 trucking companies. The study covered shipment of medical and industrial isotopes as well as uranium fuel cycle material and its associated radioactive waste. The data collection lasted 6 months. Extrapolation of the results indicated that most transport workers would receive less than 5 mSv/year which was the annual limit for members of the public. It was determined that the workers involved with the shipment of radiopharmaceuticals could be expected to receive an annual dose greater than 5 mSv/year. The study recommended that a more detailed assessment be conducted. The recent study, completed in November 2002, included measurements of dose of ionizing radiation received by transport workers over a 6-months period and the gathering of documentation on work procedures currently in place within the selected companies. A total of 17 companies at 25 different locations were included for a total of approximately 200 transport workers. The area covered by the study included shipment by road and rail, air cargo terminals and ports.

3. Results of the monitoring period

A series of three two-month dosimetry period was used for the study. The rational for selecting these short periods was that it gives more chances to revise the information and make adjustments if it is necessary. The down side is that since the doses are expected to be low for the majority of the workers, having short monitoring period does not permit the measurement of very low doses.

Some of the transport companies had historical data on the doses received by their workers. These data were provided for up to the last five years. The results indicated that the doses were constant over the years and that the doses collected in the study were similar to the results of the previous years in these companies.

3.1. Port, Railway and Air Cargo Terminals

The study indicates that most workers who participated in the study were receiving less than 1 mSv in a year. This was the case for all workers at a port and the railway station, where only one of the workers received a measurable of 0.1 mSv. This is due to the nature of the cargo, there is very limited handling of individual packages, if any, most operations are done remotely. For the air cargo terminals, only one location was handling a significant amount of packages and showed that doses were below 1 mSv except for one worker where the annual dose could be close to 2 mSv. Most of the cargo is handled remotely except for smaller packages that are often handled manually.

3.2. Trucking companies

Trucking companies are usually handling large heavy packages and therefore most of the handling is done remotely with the exception of securing the package on the trailer or into inter-modal containers. Figures 1 to 6 shows that most drivers and handlers would not receive a doses exceeding 1 mSv/year. When the dose is exceeded, it remains between 1 and 3 mSv in a year. Please note that 2 trucking companies have been left out since none of the workers monitored received a measurable dose.

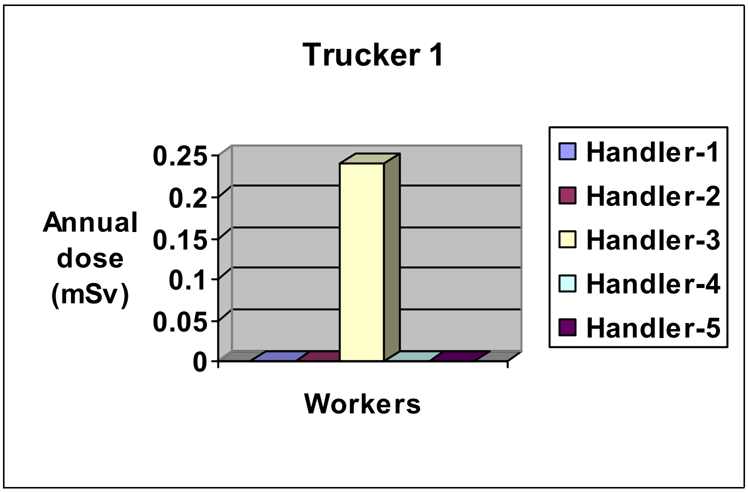

Figure 1

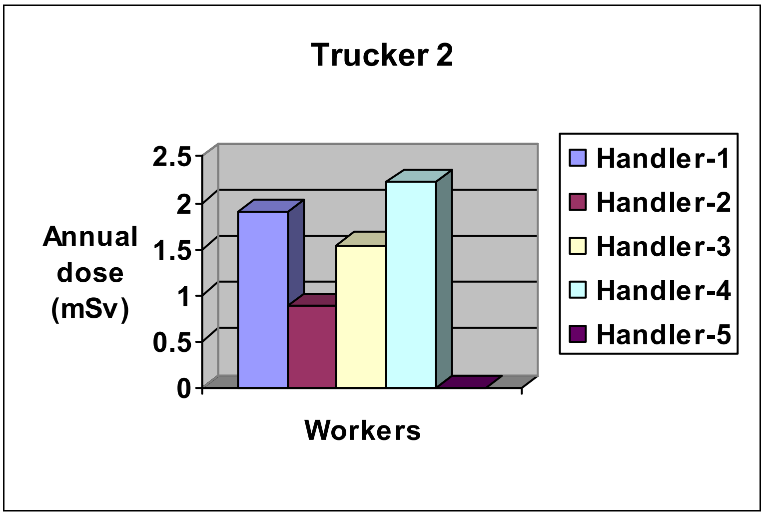

Figure 2

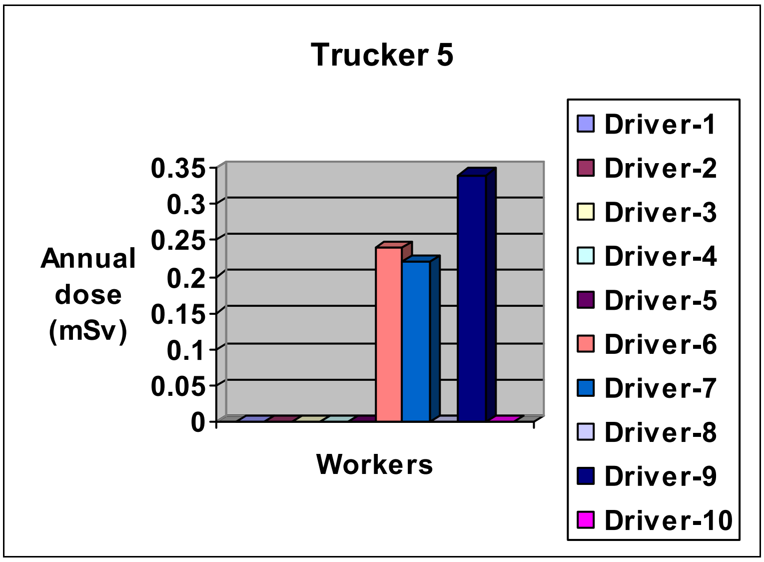

Figure 3

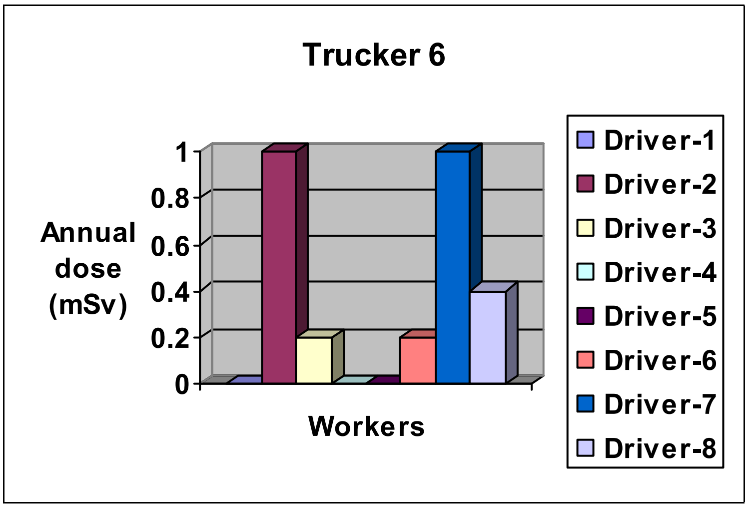

Figure 4

3.3. Courier company

Workers of courier companies are receiving the highest doses of all transport workers included in the study. Courier companies are usually transporting small light weight packages, consisting mainly of radiopharmaceuticals, which are handled manually. The volume of packages transported varies significantly from one location to another giving a wide range of doses received by the workers. Most of the workers who are in frequent contact with packages transporting radioactive material are likely to exceed the 1 mSv in a year and some of them may even exceed 5 mSv in a year, the trigger for using personal dose monitoring and a licensed dosimetry service in Canada. Figures 7 to 10 show the dose received for each workers of 4 out of 5 locations of a courier company since none of the workers of the other location received a measurable doses.

3.4. Manufacturer

Drivers of a manufacturer were also included in the study. These workers are classified as nuclear energy workers and are issued with a personal dosimeter. These drivers are delivering the packages near the manufacturer's location. These workers are also working in other areas within the company where they may receive some exposure not related to the transport of the material. Nevertheless, the doses received by these workers vary between 1 and 2 mSv per year as seen in Figure 11.

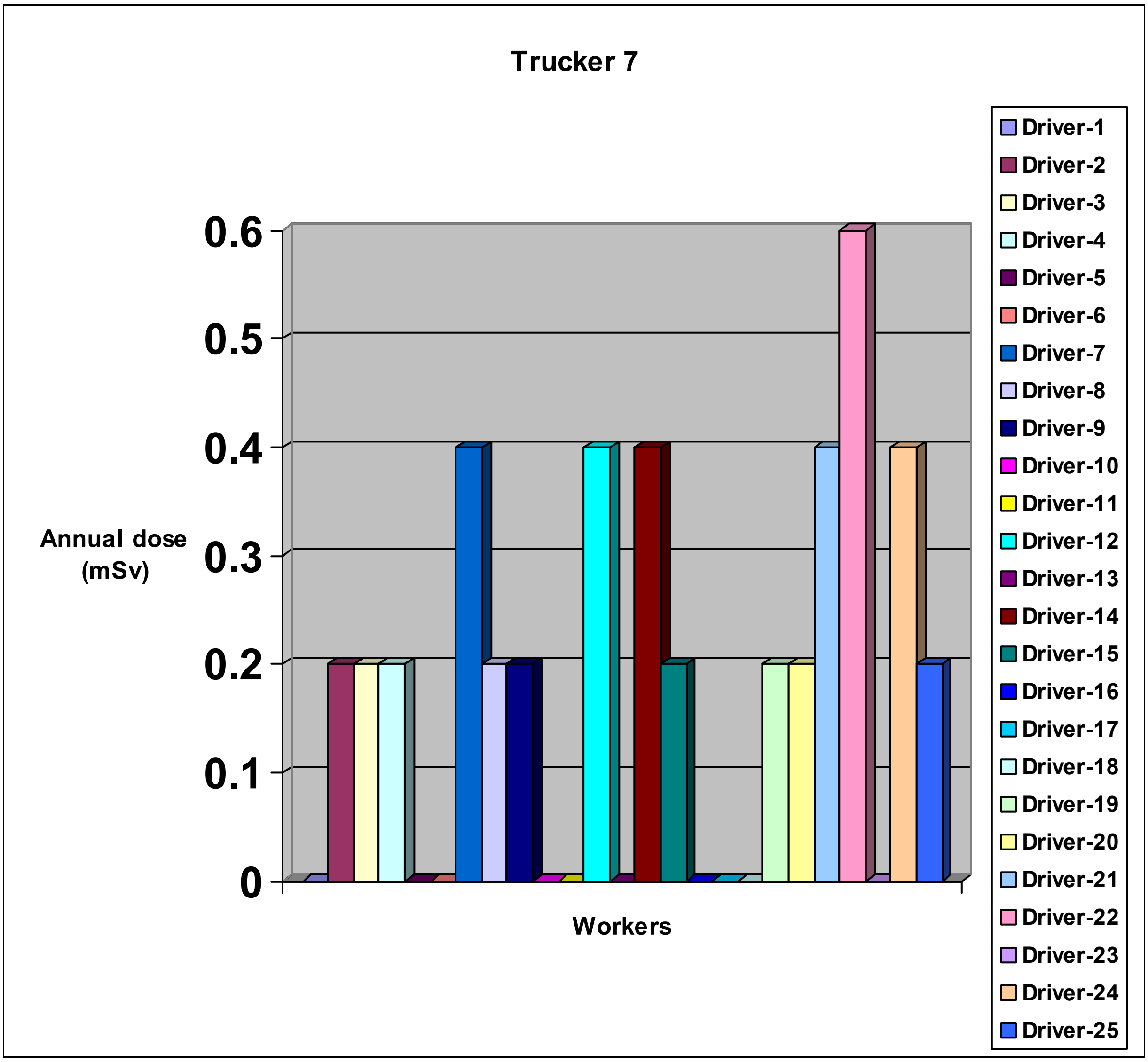

Figure 5

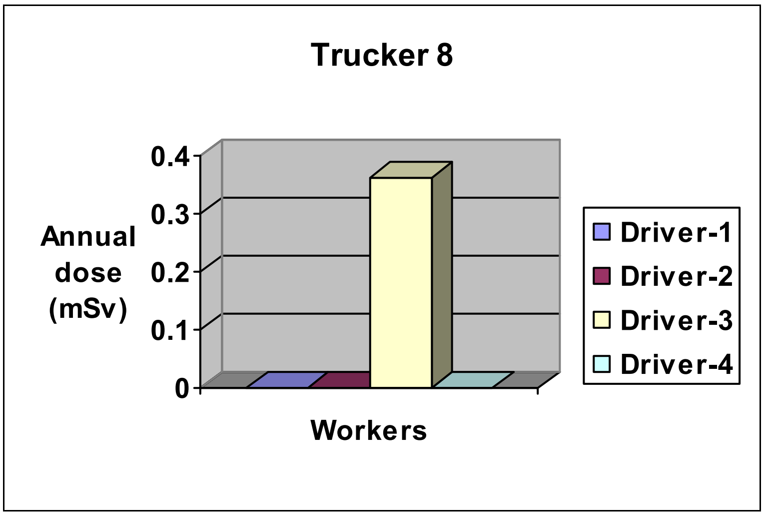

Figure 6

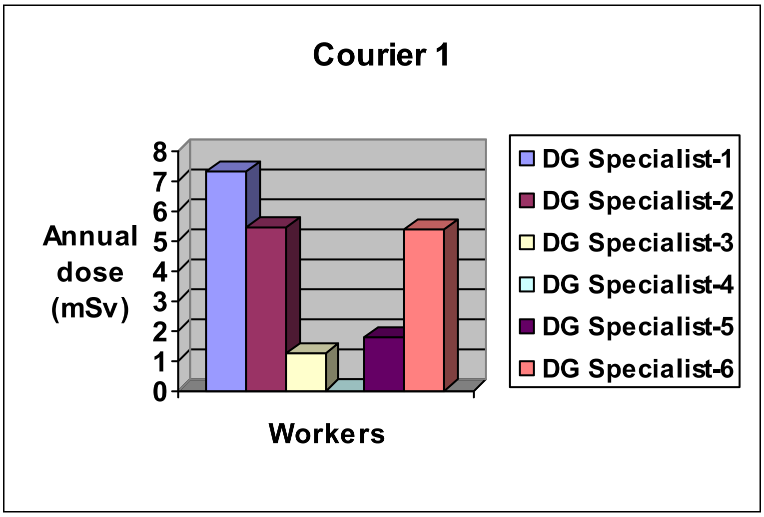

Figure 7

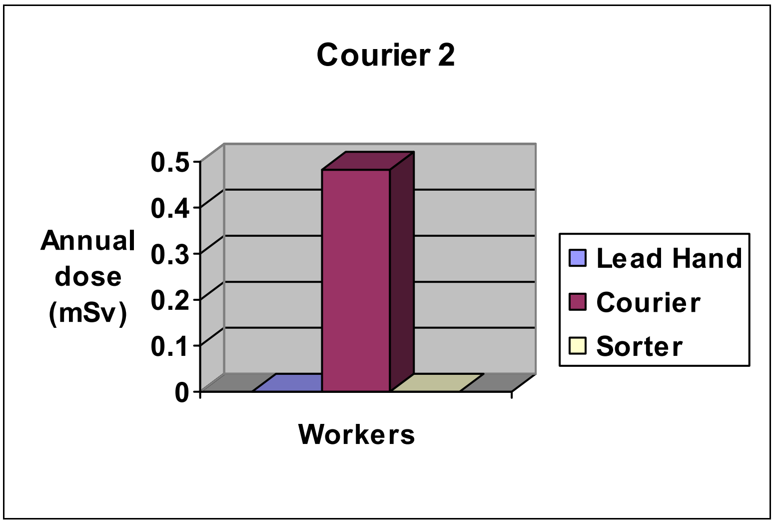

Figure 8

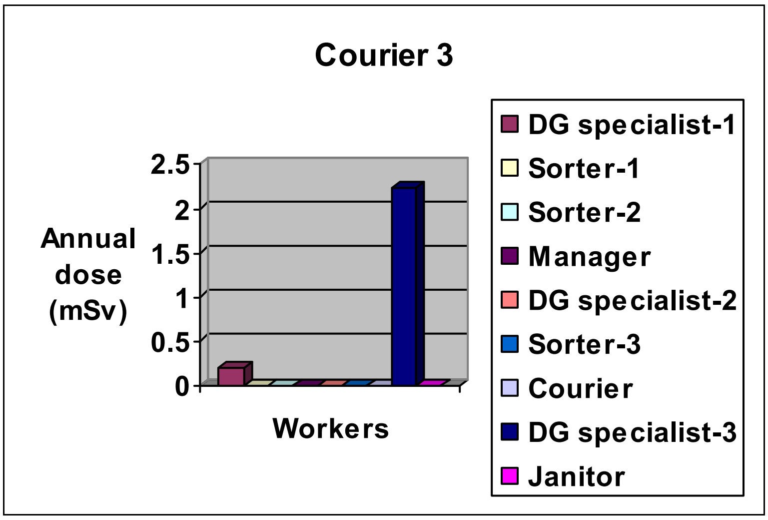

Figure 9

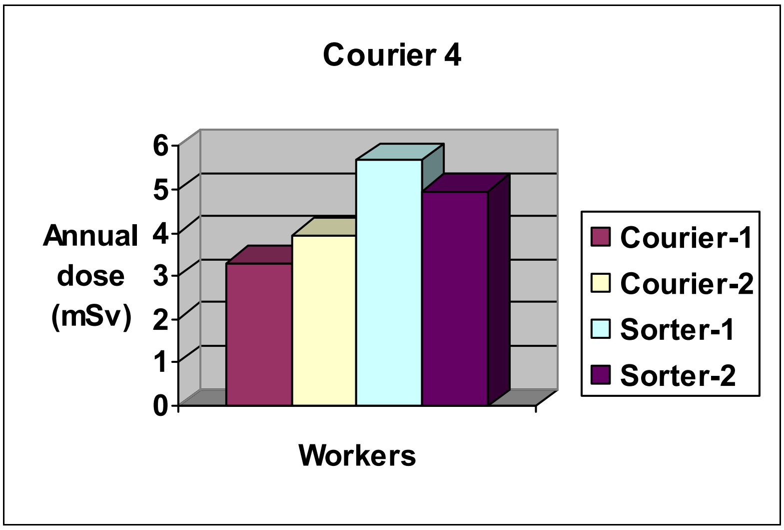

Figure 10

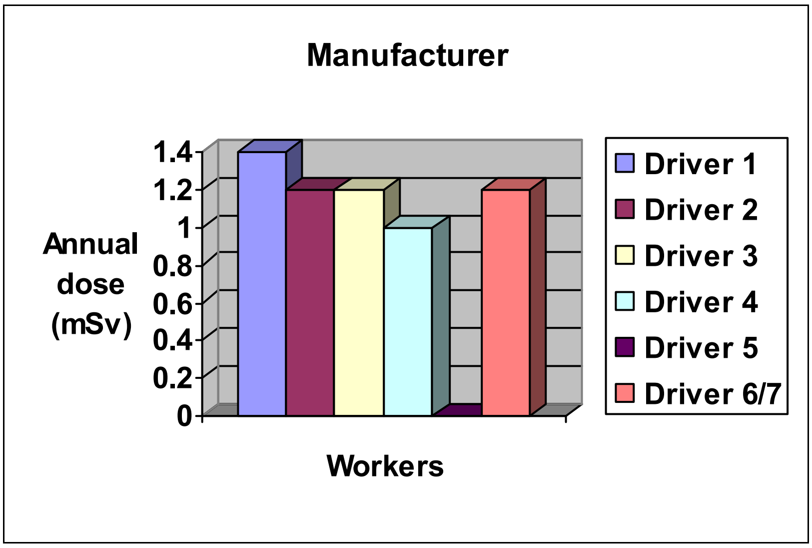

Figure 11

3.5. Other workers included in the study

The other workers involved in the study are not considered here due to the fact that they are either not transport workers or that no dose was recorded during the monitoring period. The study also included portable gauge users, which are licensed by the CNSC, from which the doses are above 1 mSv but since the dose related to the transport of the gauge and the use of the gauge could not be made, therefore these are not considered.

3.6. Area and control dosimeters

Control dosimeters were provided to each transport companies and exchanged every two months, along with the other badges. A total of three control dosimeters showed none zero doses. These dosimeters indicated doses between 0.12 and 0.26 mSv for a two-month dosimetry period. These numbers were subtracted from the dose received by the workers during that period. Some area dosimeters showed doses up to approximately 4 mSv over a two-month period and in some cases these numbers were consistent throughout the whole period. These sites were contacted but were unable to explain these results and were seeking assistance in order to determine the reason for these high readings.

4. Review of work procedures and radiation protection program collected

Limited information related to work procedures and current radiation protection program have been collected as part of the study even thus approximately 60 % of the companies indicated that they have such procedure and agreed to provide them. We have received information for only 4 companies, 2 companies indicated that they were working under the umbrella of the consignor radiation protection program two are licensees.

A review of the information provided showed that three of the documents received are work procedures and one is an actual radiation protection program. One procedure provide some information about radiation and on what and where the information on the package and shipping document is coming from with the definition of the terminology used but it does not provide any information about how a worker can limit its exposure or what to do in case of an incident or accident. The other three procedures deal with emergency procedure but only one deal with the ALARA principle or give some guidance as of how the worker can limit its exposure to radiation.

5. Results of the mathematical correlations

Table 1 provide the number of TI and the type of material transported for each company having provided such information. It can be seen that the number of TI varies significantly from one company to another and within the same company, from one location to another.

Table 1

Location	*Total TI Transported*	*Isotope Transported*
Port	470	Fuel Cycle Material
Air Cargo Terminal 1	0.5	N/A
Air Cargo Terminal 3	2060	Various
Trucker 1	8.4	Industrial Isotopes
Trucker 5	237	N/A
Trucker 6	439	Industrial Isotopes
Trucker 7	121	N/A
Trucker 8	804	Fuel Cycle Material
Courier location1	3442	Radiopharmaceuticals
Courier location 2	70	Radiopharmaceuticals
Courier location 3	422	Radiopharmaceuticals
Courier location 4	19	N/A
Courier location 6	26	Radiopharmaceuticals

Correlation of dose and transport index

for the study, the information collected on the packages transported was not specific for each worker but for the all workers included in the study, therefore, it was not possible to do any correlation or regression analyses for doses to individuals. From the information provided by the transport companies, an estimation of the sum of TI handled was made. Due to fact that omissions may have been made in the number of packages transported by each company, these may not be reliable but they are useful to evaluate if a general correlation can be developed between the number of TI transported and the dose received. Only workers having a non zero dose have been included to derive the correlation since it was not possible to determine which individuals were in contact with the packages. This introduces another uncertainty but provide some conservatism in the results. The results of the different correlation can be found in Table 2.

Based on the information gathered in the study, a general relation between the sums of the Transport Index transported and the dose received by the workers could be developed. This is due to variations between the material transported, the mode of transport and the operations of the different transport companies included in the study. Based on the above it was decided to develop a simple correlation for each company or location and then, group them based on the type of material transported. These correlation shows that, for the same type of material transported, the number of TI giving rise to a dose of 1 mSv can be significantly different. This can be explained by the difference in the operation of each company.

Table 2

Type of Carrier	Total Dose (mSv)	Total TI	TI/mSv
Courier 1	10.58	3442	325.3
Courier 2	0.24	70	291.7
Courier 3	1.22	422	345.9
Courier 4 (DG)	2.42	19	7.9
Courier 4 (handler)	3.56	19	5.3
Courier 6 (marker)	1.65	25.8	15.6
Courier 6 (DG)	0.82	25.8	31.5
Courier 6 (sorter)	0.4	25.8	64.5
Air Cargo 3	0.84	2060.1	2452.5
Trucker 1	0.12	8.4	70.0
Trucker 2	4.95	0	0.0
Trucker 5	0.4	237	592.5
Trucker 6	1.4	439	313.6
Trucker 7	2.2	121	55.0
Trucker 8	0.12	804	6700.0
Manufacturer	2.7	6367	2358.1

6. Conclusion

The study showed that most transport workers handling radioactive material are receiving a dose below 1 mSv in a year. Only some drivers of trucking companies that are transporting radioactive material on are likely to exceed the 1 mSv limit but that in all cases their annual dose would remained below 5 mSv in a year. Courier companies are the workers receiving the highest dose of all transport workers included in the study. This can be explained by the fact that these companies are usually handling a high volume of small light weight packages which is very different from all other carriers included in the study. Workers at ports and railways station are less likely to exceed the 1 mSv per year limit as all operation are done remotely and that the workers do not stay in close proximity of the packages for a very long period of time. Some air cargo workers may exceed the 1 mSv per year limit depending of the volume of packages transported. Because of the limited information gathered on the radiation protection policies and work procedures, it is not possible to verify the effectiveness of these programs. A general correlation between the number of TI transported and the dose received was found to be impractical due to the wide range of results given by the analysis. This kind of correlation could be developed for a group of carriers performing similar work and transporting similar material.

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EXPERIENCE WITHIN INTERNATIONAL TRANSPORT AND DIRECT RAIL SERVICES IN MEETING THE IAEA REQUIREMENT FOR A RADIATION PROTECTION PROGRAMME(S)

D. Billing
Spent Fuel Services, British Nuclear Fuels plc
Warrington, Cheshire
United Kingdom

Abstract

BNFL International Transport and Direct Rail Services have successfully developed appropriate Radiation Protection Programmes for their business. The business supports BNFL's worldwide Nuclear Fuel Services with key customer bases in Europe, Japan and the UK, utilising marine, rail and road modal transports. Experience in this business spans over 4 decades. The preparation of RPP's for each aspect of its operations has been made relatively straight forward in that the key elements within the internationally recognised model RPP (by WNTI) were already in place in BNFL's procedures to satisfy current National UK and International Regulations and supported by Management systems which comply with International Standards for Quality Assurance.

1. Introduction

BNFL International Transport Group have over 30 years experience in the movement of packages designed to carry nuclear material. The design, construction and operation of these packages satisfy all the requirements of the IAEA and associated National and International transport of Dangerous Goods (Category 7). Marine operations are managed through BNFL and Pacific Nuclear Transport Limited utilising a fleet of seven specially designed ships. Within the UK the majority of domestic Spent Nuclear Fuel movements from Power Stations to the BNFL Sellafield Reprocessing Plants is undertaken by Direct Rail Services (a wholly owned subsidiary company of BNFL). D.R.S. currently operates a fleet of 45 locomotives between Sellafield and 10 UK Reactor Sites.

Publication TS.R-1 (ST-1-Revised) of the IAEA Safety Standard Services requires the preparation of a Radiation Protection Programme. This paper provides a description of the particular arrangements in place within BNFL International Transport including PNTL and DRS that satisfy the IAEA requirement for an RPP.

2. Model structure for the radiation protection programme

Guidance on the content of an individual Radiation Protection Programme has been provided by the Work Nuclear Transport Institute (ref. 1) and more recently within the UK the National Radiological Protection Board (ref. 2). These Guidance documents build on the key requirements specified within TS-R-1. i.e.

- Optimisation of protection and safety (para 302)
- Training of Workers (para 303)
- Exposure Control (para 305)
- Segregation from workers, members of the public and undeveloped films (para 306 and 307)
- Emergency Response (para 308 and 309)

The model structure for RPP's within BNFL International Transport and DRS has in addition to the above aspects recognised WNTI and NRPB guidance and included arrangements covering: 'Scope of the programme'; 'Roles and Responsibilities', 'Dose Assessment', 'Surface Contamination Control', 'Optimisation' and 'Quality Assurance'. The paragraphs below describe the implementation of these elements of the programme within BNFL International Transport and DRS.

3. Implementation of RPP's within BNFL International Transport and DRS

Scope:

Under this section is simply a Company address, a description of the total number of employees, the materials being transported, package types, transport range and Applicable Law.

Within BNFL International Transport the worker groups who are subject to radiological assessment/monitoring comprise of dockworkers, Health Physics personnel, ships crew, and flask engineers. For DRS the key worker group is train crew.

The materials being transported are by the nature of the business nuclear material including Spent Oxide and Magnox fuels, new fuel, vitrified High Level Waste, and Low Level Radioactive wastes.

The package types although principally 'Type B' also comprise IP1,IP2, IP3 and type A excepted.

Key intermodel points on the transport routes include marine port(s) and UK rail heads, associated with the power stations.

Roles and Responsibilities:

This section presents named post holders with key responsibilities e.g. the Radiation Protection Advisor and Radiation Protection Supervisor (appointments under the UK Ionising Radiations Regulations (1999). The Operations Manager and the QA Manager for each business function.

Dose Assessment:

Prior dose assessment has been undertaken for BNFL IT and DRS principally based on the results from personal dosimetry monitoring over many years of operation. The results from compliance radiological surveys on packages has also supported the prior dose assessment methodologies.

As new packages are brought into use, perhaps requiring different 'handling' techniques detailed assessment is undertaken accounting for worker occupancy. For the worker groups identified above historically all group average and individual exposures have been controlled to less than 1 mSv/year (category 1). Under TS-R-1 the level of individual monitoring vs workplace monitoring indicates that sufficient control can be implemented through workplace monitoring only. However, partly for historical reasons and partly for worker reassurance arrangements. BNFL IT have issued their dock workers, sea staff and Flask engineers with routine, or voyage specific personal issue film badges. The Health Physics Monitor team are a 'bought in' service from elsewhere in BNFL and are already issued with film badges for other work.

For the train crew in DRS routine film badges are not issued. Workplace monitoring is undertaken on a campaign basis (total rail journey).

It should be noted that the above arrangements have not been developed out of the TS-R-1 regulations but were already in place to ensure compliance with European Basic Safety Standard/UK legislative/BNFL Corporate Requirements.

Optimisation:

It is recognised by WNTI (ref 1) that for Category 1 exposures '…the possibilities of optimisation to further reduce this low dose may be very limited'. Never the less within BNFL IT we as part of Risk Assessment reviews undertake analysis of exposure and associated occupancy times in the vicinity of packages in order to demonstrate ALARA (ALARP).

Surface Contamination Control:

The requirements of a Carrier are to take into account potential contamination of conveyances. In due recognition of loose surface contamination being occasionally found on certain European and UK Spent Fuel transports BNFL IT has established, in conjunction with its customers (and their regulators), a comprehensive regime for surface contamination monitoring at intermodal points.

Segregation:

As recognised in the WNTI paper (ref 1) 'segregation requirements have been part of model regulations and no additional requirements needs to be imposed in a Category 1 RPP'.

Emergency Response:

A separate conference paper 'Emergency Response Arrangements for the Pacific Nuclear Transport Fleet' (ref 3) provides a detailed discussion of the arrangements covering BNFL IT's marine emergency response.

For rail operations DRS operates under the UK RADSAFE scheme working with National Agencies, Local authorities and designated Emergency Services.

The scheme provides:

- A single 24 hour national notification number
- Early generic information to the emergency services
- Technical Support
- Clear responsibilities for 'clean up'
- A communication route for expert advice and technical support
- A framework for media support
- Consignment owner support.

Training:

The level of training given to the worker groups (and key individual roles) identified above is commensurate with their function. For personnel designated as Classified (Radiation) Persons under the UK Ionising Radiation Regulations training comprises a BNFL Corporately prepared course covering:

- Arrangements for Entering Controlled/Supervised areas
- Emergency Alarms and appropriate response
- Radiation types; Hazards, Units of measurement, Limits Contamination, Fixed, Loose, Airborne, Internal Dosimetry Contamination Control
- Signs and Warning Notices
- Radiation, Detection, Personal Dosimetry

Understanding is tested at the end of the course and all Classified Persons are required to attend refresher training every 5 years (minimum).

For those groups not appointed as Classified Persons i.e. Dockworkers, Sea Staff, Train Crew, training is delivered by the Radiation Protection Supervisor or Designated Training professional. The contents of this local area training manual is customised version of that for Classified Persons training. Specifically covers is:

- Delineation of the restricted area;
- Arrangements for entry/exit from restricted area:
- Radiological monitoring arrangements:
- When advice must be sought;
- The role of Nominated Persons.

Refresher training provided to the crew (sea) by a ships Nominated Person on every voyage.

Quality Assurance:

Both BNFL IT and DRS are certificated to ISO 9000 (2000) and the RPP and associated records are maintained to satisfy the requirements of the Standard.

4. Conclusions

BNFL International Transport and Direct Rail Services have established Radiation Protection Programmes which satisfy the requirements of IAEA recommendations TS-R-1.

In establishing their RPP's BNFL IT and DRS were able to call on robust Radiological Management Systems that were already in place to satisfy National and International regulations.

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THE IMPLEMENTATION OF RADIATION PROTECTION PROGRAMME REQUIREMENTS IN THE TRANSPORT OF NUCLEAR FUEL CYCLE MATERIALS

W.L. Wilkinson

World Nuclear Transport Institute (WNTI)
6th Floor, 7 Old Park Lane, London,
United Kingdom

Abstract.

The IAEA requires organisations involved in transport of radioactive material to implement a Radiation Protection Programme (RPP) to control radiation dose exposure to both workers and the public from transport operations. For nuclear fuel cycle materials, radiation protection is dealt with prior to shipment by using a package design to control exposures to workers and the public. Dose assessment and evaluation is a key issue for RPPs. The extent of control measures in the RPP should relate to the magnitude and likelihood of radiation exposure. The World Nuclear Transport Institute (WNTI) therefore made an assessment of the likely doses to workers in the transport chain, for the various modes of transport and for the main nuclear materials. Analysis of the data on dose up-take during the various modes of transport of nuclear fuel cycle materials indicates that it is very unlikely that any group of workers, or any member of the public, will receive annual doses in excess of 1mSv and the transport of nuclear fuel cycle materials should therefore fall into the lowest category, for which no workplace or individual dose monitoring is required.

1. Introduction

Nuclear power generates electricity in 32 countries, and supplies over 16% of the world's electricity demand. It will continue to play a major role in meeting the world's increasing need for electricity and reducing carbon dioxide emissions without putting undue stress on the environment. The nuclear power industry is becoming increasingly global in terms both of products and services. The national and international transport of nuclear fuel cycle materials by all modes of transport is essential to support this activity.

The IAEA requires the organisations involved in the transport of radioactive material to implement a Radiation Protection Programme (RPP) in order to control radiation dose exposure to both workers and the public from transport operations. The major nuclear fuel cycle companies and their customers normally operate on nuclear licensed sites and have extensive experience in the preparation and implementation of comprehensive radiation protection provisions. In some cases, nuclear fuel cycle materials are transported by dedicated carriers and these companies also have well established radiation protection provisions.

However, there are many transport organisations for which the transport of nuclear fuel cycle materials is only a small part of their business; typical of these are trucking companies, sea carriers, port handling organisations and airline services. Previously, such companies may not normally have had fully developed radiation protection programmes in operation which would meet the requirements of the IAEA Transport Safety Regulations (TS-R-1). Accordingly, without a good understanding of what is required in a radiation protection programme, there is the possibility that they would perceive the development and implementation of a formal RPP as difficult to justify in terms of the value to them of the nuclear fuel cycle business. This need not be the case.

It clearly is necessary to ensure that radiation protection programmes are implemented properly to protect workers and the public. However, it is important to allay the concerns of operators in the transport chain that such programmes would be too onerous to justify in business terms as well as to allay perceived risks among the public.

2. Implementation of RPPs

RPPs are intended to provide for and document the framework of controls applied by a transport organisation to limit the normal and potential exposure of workers and the public. They have to include details on the procedures to be adopted to optimise protection and safety, including such issues as dose assessment, segregation of packages, emergency response, training and quality assurance.

Dose assessment and evaluation is a key issue for RPPs, and this includes both a dose assessment at the pre-operational stage to ensure that account has been taken of all reasonably practicable radiation protection measures, and radiation monitoring and dose assessment where appropriate during transport to demonstrate compliance and to establish good practice.

The nature and extent of control measures in the RPP should relate to the magnitude and likelihood of radiation exposure. Therefore, it is possible to apply a graded approach to the RPP requirements as provided for in the IAEA Transport Safety Regulations (TS-R-1). TS-R-1 applies the following actions:

- Where it is most unlikely that the dose will exceed 1mSv/year, very little action needs to be taken for evaluating and controlling worker doses.
- Where it is likely that the dose will be 1-6mSv/year, a dose assessment programme is necessary, and can involve workplace or individual dose monitoring.
- Where it is likely that the dose will exceed 6mSv/year, individual monitoring of transport personnel is mandatory.

The 1mSv/year effective dose limit is the dose limit for members of the public and for operations below this level no workplace or individual dose monitoring is required.

TS-R-1 accepts that the categories will be based generally on a prior radiological assessment using existing dose data for similar transport activities. This is why it is important to collect reliable dose data relating to nuclear fuel transport operations to assess the implications of the new requirements for nuclear fuel cycle transports.

2.1. Dose assessment

A study carried out by the World Nuclear Transport Institute (WNTI) with the co-operation of its members made an assessment of the likely doses to various types of worker in the transport chain, and also to members of the public for the transport of various fuel cycle materials, for various modes of transport, mainly based on experience of actual operations, as follows:

- Workers - loading and unloading workers, crew/drivers, inspectors, supervisors;
- Mode - rail, road, sea;
- Materials - uranium ore concentrate (UOC), uranium hexafluoride, oxide powder, new fuel, spent fuel, plutonium, mixed oxide fuels (MOX) and wastes.

There are several published studies covering the major nuclear fuel cycle materials but the studies are fragmented, and in some cases specific to particular situations; they require careful analysis to establish confidence in their accuracy and validity. Data from direct measurements, or estimates based on assumed transport scenarios and dose rates from packages are the most reliable. Computer codes can also give a useful guide.

For accurate assessments, the dose rates should be those in occupied areas combined with appropriate exposure times. The aim of the WNTI study was to collect the best data, which represent current practice from both existing published sources and records of WNTI member companies.

Road, rail and sea transport are all commonly used for nuclear fuel cycle materials. Air transport is carried out, but only to a limited extent.

For road transport, non-irradiated nuclear fuel cycle materials - uranium ore concentrates, uranium oxide powder, uranium hexafluoride, and new fuel - are normally carried in containers on trailers. Loading is by crane or lift-truck with limited access by workers. Similar conditions apply to rail transport. The quantities of uranium ore concentrates and uranium hexafluoride are quite large - typically thousands of tonnes per year in countries involved in the nuclear fuel cycle industry. Low- and intermediate-level wastes are transported by road under conditions similar to those for uranium ore concentrates; that is, packed in drums and loaded into standard ISO containers. Rail transport is similar.

Spent nuclear fuel is transported within Europe mainly by rail, with road transport confined to the short journeys from the reactor site to the railhead. Spent fuel is transported by sea from Japan to Europe for reprocessing in dedicated vessels to sea terminals close to the reprocessing plants followed by short road/rail journeys. For spent fuel, crane handling of flasks is used at the sea terminals with limited access by workers. Some spent fuel is likewise transported by sea from continental Europe to the UK. The limited transports of high-level waste, for example from la Hague in France to storage facilities in Europe and Japan, are closely similar to spent fuel transport.

The individual dose up-takes to workers and the public resulting from the transport of the various nuclear fuel cycle materials by different modes of transport are summarised in the following table:

Table 1: Maximum annual dose up-takes for various materials and modes of transport

Material	**Persons**	**Road**	**Rail**	**Sea**
	(all measurements in microSievert)			
Non-irradiated material	Handlers	300	300	<300
	Crew	100-700	<4	<300
	Public	<4	<1	<20
Spent fuel	Handlers	<1000	200	<1000
	Crew	200-500	2	<700
	Public	<4	<6	<1
Waste (LLW/ILW)	Handlers			
	Crew	20-400	<600	
	Public	<4	<4	
High-level waste	Handlers		1700	<1000
	Crew		200	<600
	Public		20	<1
MOX/plutonium	Handlers			<1000
	Crew			<200
	Public			<1

Analysis of the data on dose up-take during the various modes of transport of nuclear fuel cycle materials indicates that it is very unlikely that any group of workers, or any member of the public, will receive annual doses in excess of 1mSv. The transport of nuclear fuel cycle materials should therefore fall into the lowest category, for which no workplace or individual dose monitoring is required.

The International Basic Safety Standards also require operators all along the transpor chain to adopt the safety principle that in operations that give rise to exposure, radiation protection should be optimised to reduce doses to As Low As Reasonably Achievable (ALARA), which is normal practice in the nuclear industry. For nuclear fuel cycle transport, the ALARA principle can be met by demonstrating that attention has been paid to minimising dose up-take and that best practice has been adopted; for example, in the segregation and storage of containers, the shielding of drivers, the supervision of working practices, operator training, and so on. The optimisation principle can be achieved with the application of common sense and good practice.

2.2. Actions to facilitate implementation

The requirement for radiation programmes is included in the IAEA Transport Safety Regulations as part of the General Provisions, and as such, sets down the basic principles. Detailed guidance is essential to achieve successful implementation of these principles by the industrial organisations concerned. WNTI and its members have co-operated closely with the IAEA and national competent authorities by providing an input of industrial experience to ensure that the guidance document, the IAEA Provisional Safety Guide (TS-G-1.5) clearly interprets the intentions of the regulations and gives detailed guidance and information sources to the various organisations in the transport chains which have to implement them. It is important to set down clearly the various responsibilities of the transport organisation, its management and workers.

In addition, WNTI within its working groups has prepared advice for onward transmission to the supply chains involved in nuclear fuel cycle transport. On that basis seminars have been organised by leading nuclear fuel cycle companies for their transport service providers which covered all aspects of RPPs and discussed typical examples which could be used as pro-formas for consignors, carriers, port handling organisations, and similar organisations. WNTI also gives lectures at the IMO World Maritime University to students involved in various aspects of sea transport from many countries on the transport of radioactive materials and the requirement to establish RPPs.

3. Conclusions

Preparation of RPPs ensure that an adequate framework of controls will be applied by the various organisations in the transport chain to meet the radiation protection principles protecting workers and the public.

This is a new requirement for many organisations which have traditionally played an important role in the transport of nuclear fuel cycle materials. The detailed guidance provided by the IAEA coupled with the help and advice provided by WNTI and the nuclear fuel cycle industry will help them to develop RPPs, and this is important to facilitate the provision of international transport services.

OCCUPATIONAL AND PUBLIC EXPOSURES ARISING FROM THE NORMAL TRANSPORT OF RADIOACTIVE MATERIAL: EXPERIENCE IN GERMANY

G. Schwarz, H.-J. Fett, F. Lange

Gesellschaft fuer Anlagen- und Reaktorsicherheit (GRS) mbH,
Schwertnergasse 1, 50667 Cologne,
Federal Republic of Germany

Abstract.

This paper summarizes the principal findings and conclusions of work undertaken on behalf of the national competent authorities. The work was performed with the objective to provide guidance material on occupational and public radiation exposures arising from the normal transport of radioactive material in Germany. The survey and assessment results provided cover all major categories of materials (fuel cycle and non-fuel cycle material) and all relevant shipping modes. The findings confirm the general understanding that the radiation doses to workers and members and the public received during the normal transport of radioactive material represent - with very few exceptions - only a small fraction of the relevant regulatory dose limits.

1. Introduction

Over half a million of packages containing radioactive material are transported each year in Germany by road, rail, air and sea. The great majority of radioactive material shipments contains small quantities of solid, liquid and gaseous radioactive substances for use in medicine, research and development, hydrology, geology, power production and various industrial applications and commodities, that assist our daily lives, e.g. smoke detectors. Large quantity shipments of radioactive material such as spent nuclear fuel, industrial radiation sources etc. packaged in heavy rigid transport flasks account only for a small proportion of the total traffic of radioactive material shipments.

Most radioactive material packages transported emit penetrating ionizing radiation and radiation exposures of transport workers and the public may occur during their transport. To ensure an adequate level of safety and protection of persons, property and the environment the potential radiological hazards arising from exposure to ionizing radiation must be constrained below prescribed levels, i.e. the regulatory dose limit. The packagings and containers being used for the transportation of radioactive material shipments are therefore designed to comply with and the transport takes place according to the safety standards and requirements agreed upon internationally and developed and published by the International Atomic Energy Agency (IAEA), i.e. the "Regulations for the Safe Transport of Radioactive Material" (No. TS-R-1). The general provisions on radiation protection of the Regulations also require, (a) that periodic assessments of transport-related radiation doses to persons are carried out (para 304 TS-R-1) and (b) that safety and protection in transport "shall be optimized in order that the magnitude of the individual doses, the number of persons exposed .... shall be kept as low as reasonably achievable (ALARA), economic and social factors being taken into account, and doses to persons shall be below the relevant dose limit" (para 302 TS-R-1). The IAEA Regulations are fully reflected in the Modal Regulations, i.e. ADR, RID, ICAO-DGR, and IMDG-Code, and these international regulations form the essential basis of the nationally applicable legislation concerning the transport of hazardous material including radioactive substances.

The nature and extent of measures and procedures being employed at the operational level to satisfy the basic radiation protection requirements and the effort and resources committed to determining optimized levels of protection and safety in the transport of radioactive material are left to be decided by the operator (e.g. by the establishment and application of a Radiation Protection Programme for transport). In the everyday control of ensuring compliance with the radiation protection requirements of the Regulations, the use of professional experience and knowledge by suitably qualified and experienced staff is being considered as an acceptable approach (para 92 ICRP Publ. 75) for judging if all reasonable practical measures relevant to transport safety have been accounted for at the operational level on the basis of a comparison of radiologically relevant performance indicators (e.g. transport worker doses) with what has been achieved in similar or related transport activities. Therefore a broad understanding of the nature and magnitude of the exposures to radiation of transport workers and the public in various transport disciplines is of prime importance to the parties with responsibilities for safety in the transport of radioactive material, i.e. transport operators and the competent authorities.

2. Scope and objectives

In order to assist in the assessment and evaluation of the adequacy and effectiveness of the measures and procedures being employed to control occupational and public exposures during the normal transport to levels as low as reasonably achievable and to ensure compliance with the basic safety requirements of the Regulations, work has been undertaken on behalf of governmental agencies with responsibilities for the safety in transport of radioactive material (i.e. The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Federal Office for Radiation Protection (BfS)) with the principal objective to provide guidance material on the nature and magnitude of radiation exposures received by transport workers and members of the public from the normal transport of radioactive material by all modes in Germany, i.e. road, rail, air and sea [1]. The guidance material being provided is limited to transport operations closely attributable to the moving phase of a radioactive material shipment in the public domain and includes in particular the preparation of radioactive material shipments for despatch (e.g. labelling, placarding), loading and unloading of vehicles, carriage including in-transit storage, inter-and intra-modal transfer operations, package handling at distribution centres and depots and delivery to the consignee at the final destination. Normal transport is used to describe transport operations which occur without unusual delay, loss of, or serious damage to the package, or an accident involving the conveyance.

3. Assessment approach

The nationally applicable legislation and regulatory requirements concerning the transport of radioactive material do not require reporting, compilation and publication of occupational and public radiation exposure data in a consistent and harmonized manner on a routine basis. Therefore, the occupational exposure data have primarily been gathered and compiled with emphasis on personal monitoring data from a number of commercial transport operators in Germany known as major shipper or handler of fuel cycle and non-fuel cycle material (in terms of the number of packages and the amount of radioactivity transported). To some extent advantage was taken of compilations of statistical transport and exposure data collated within other transport safety assessment studies including Research Projects funded by the European Commission (DG TREN).

Radiation dose monitoring of members of the public, however, is generally been considered to be impracticable and relies on employing dose assessment models and transport and exposure model parameters relevant for hypothetical individuals, e.g. persons living or working permanently near, or travelling on, roads or railways or depots used for shipping consignments of radioactive material, and being imposed to static and transient exposures to ionizing radiation during transport. Several nationally relevant population dose assessment studies were identified and have been examined for this study purpose.

4. Survey and assessment results

The survey and assessment results in terms of the maximum observed occupational and public radiation exposures arising from the normal (incident-fee) transport of radioactive material in Germany are summarized in Table 1. The transport-related radiation exposures were made available or assessed for various transport practices and have been broken down accordingly in a range of broad categories of radioactive materials and their predominant transport mode: a) Non-irradiated nuclear fuel cycle material, b) Irradiated nuclear fuel cycle material including spent nuclear fuel, vitrified high-level radioactive waste and large quantity radiation sources, c) Non-nuclear radioactive waste, e.g.

medical and research waste, d) Supply and distribution of radioisotopes for medicine, research and industry, and e) Radiographic radiation sources and monitoring and gauging devices.

The maximum observed transport worker doses from external exposure to ionising radiation given in Table 1 are expressed as annual effective dose (mSv/yr). The worker doses related to road, rail and air transport activities are most representative for road vehicle drivers, package handlers and marshalling yard and airport personnel being physically involved in the carriage, handling, inter-/intra-modal transfer and in-transit storage of packaged radioactive material shipments and are believed to reflect well-managed transport practices. The public radiation doses given in Table 1 represent upper (or conservative) dose estimates for hypothetical individuals being exposed to static and transient external exposure from radioactive material shipments by road and rail. Hypothetical individuals and exposure scenarios being considered in the dose assessment include, for example, residents living or working permanently in close proximity to an approach road to a storage facility, re-distribution centre or inter-modal transfer point with a significant traffic density of radioactive material shipments.

The survey and dose assessment results indicate that the radiation exposures arising from the normal (incident-free) transport are in the range or below of 1 mSv/yr for transport workers in all major fields of radioactive material applications (e.g. drivers, escort personal, package handlers, railway and airport personnel) and well below of 0,1 mSv/yr for member of the public. Radiation doses at these levels represent only a small fraction of the relevant regulatory dose limit for radiation workers and the general public of 20 mSv/yr and 1 mSv/yr, respectively. A small fraction of the workforce being involved in the supply and distribution of medical, scientific and industrial radioisotopes represents a notable exception under circumstances where routinely large volumes of packaged (generally predominantly excepted and Type A packages) radioisotopes are handled in distribution centres and depots and subsequently shipped by road resulting in maximum driver and handler radiation doses of approximately 10 - 14 mSv annually. The number of drivers/handlers being exposed to this enhanced levels of dose is, however, very limited.

Similarly, some site radiographers have been found to be occupationally exposed to levels which represent a significant fraction of or close to the regulatory dose limit of 20 mSv/yr from external radiation during both the field use and road transport of site radiography sources. However, analyses of typical exposure conditions of site radiographers during the transport and field use of radiographic radiation sources have led to the conclusion that the transport-related worker doses are generally below 1 mSv/yr.

5. Discussion and conclusions

This paper summarises the results of work undertaken on behalf of the national competent authority with the ultimate objective to develop guidance material on the nature and magnitude of occupational and public exposures from the normal (incident-free) transport of radioactive material in Germany. The information provided covers all major categories of radioactive material shipments (i.e. fuel cycle and non-fuel cycle material) and shipping modes (road rail air and sea) and represents the most extensive and comprehensive data base on transport-related radiation doses currently available in Germany.

The survey and assessment results confirm the understanding that the transport-related radiation exposures received by transport workers and members of the public under normal (incident-free) transport conditions in Germany are generally low for all major categories of materials and transport activities and well below the applicable regulatory dose limits (20 mSv/yr for workers and 1 mSv/yr for members of the public). A notable exception are transport worker doses arising from the supply and distribution (road) of radioisotopes for medical, scientific and industrial applications where a few workers (driver/handler) were identified to receive maximum effective doses in the range of approximately 10 - 14 mSv/yr. The number of persons concerned is based on the current knowledge, however, very limited.

The nature and magnitude of the observed occupational and public radiation exposures described above are believed to reflect well-managed transport practices and procedures and sound management principles and are therefore considered to be a useful basis for the establishment of an optimized level of safety and protection in the normal transport of radioactive material taking due account of the transport volumes under consideration. The nationally available radiation exposure data also indicate that application of the safety standards of the Regulations provide a suitable level of radiological protection of both transport workers and the general public for normal conditions of transport of radioactive material by all shipping modes and satisfy the radiation protection principles underlying the Transport Regulations (TS-R-1).

Table 1. Maximum observed radiation doses received by workers and members of the public from the normal (incident-free) transport of various categories of radioactive material in Germany.

Material Category/Transport Operations	**Transport Mode**	**Maximum Effective Dose** (mSv/yr)	
		Workers	Public [a)]
Non-irradiated nuclear fuel cycle material, e.g. U_3O_8, UF_6, UO_2-powder/pellets, non-irradiated fuel assemblies, radiation sources	Road/Rail	< 1	--- [b)]
	Sea	< 1 [c)]	---
Irradiated nuclear fuel cycle material , e.g. activated/contaminated equipment and components, radioactive waste, irradiated nuclear fuel, vitrified waste, radiation sources	Road	1 - 2	< 0,05
	Rail	< 1	< 0,1
Non-nuclear radioactive waste, e.g. medical and research waste	Road	< 1	---
Transport and distribution of radioisotopes for research, medicine and industry, other radioactive materials	Road	10 - 14	< 0,04
	Air	< 1	---
Radiographic and other radiation sources	Road	< 1 [d)]	---
Regulatory Dose Limits	All	**20**	**1**

a) Relevant to hypothetical individuals, e.g. permanent residents/by-standers or users of the transport route.
b) „---„ = Data currently unavailable.
c) Preliminary value derived from the general literature.
d) Transport-related worker dose without the extra dose received from the field use of site radiographic radiation sources.

Reference

[1] SCHWARZ, G. et al., Development, Application and Evaluation of Radiation Protection Programmes for the Transport of Radioactive Material, Final Contract Report GRS-A-3050 (in German), Gesellschaft fuer Anlagen- und Reaktorsicherheit (GRS) mbH, Cologne (Germany), September 2002.

ANNUAL COLLECTIVE DOSES DUE TO TRANSPORT OF DISUSED SOURCES

K.C. Upadhyay, M. Inamdar, R.K. Singh, S.P. Agarwal

Radiological Safety Division, Atomic Energy Regulatory Board
Niyamak Bhavan, Anushaktinagar, Mumbai-400 094,
India.

Abstract.

Sealed radioactive sources are used very widely in industry, medicine and research. These sources are required to be disposed off in a safe manner after they out-live their useful life. These sources are known as spent sources or disused sources. Some of the spent sources contain substantial amount of residual radioactivity. These sources are transported to the supplier or the national disposal agency for their safe disposal. Transport of radioactive material in India is governed by a code issued by the Atomic Energy Regulatory Board, the competent authority of India. This code is based on the IAEA regulations for safe transport of radioactive material. As part of the radiation protection program for transport of radioactive material in India, dose estimation studies for the transport workers and general public due to transport of spent sources are carried out. The paper estimates, annual collective dose for incident free and accident conditions, accruing due to transport of spent sources generated by nuclear application institutions in India. The estimation is carried out using the computer code INTERTRAN2. The results indicate that the maximum individual dose, due to transport of spent sources for disposal purpose, to transport workers and general public is at least two orders below the dose limits.

1. Introduction

Sealed radioactive sources are used very widely in industry, medicine and research. These sources are required to be disposed off in a safe manner after they out-live their useful life. These sources are known as spent sources or disused sources. Some of the spent sources contain substantial amount of radioactivity. For disposal, the sources are transported to the supplier or the national disposal agency. Transport of radioactive material in India is governed by the competent authority (Atomic Energy Regulatory Board) code viz. AERB/SCTR-1 [1], which, is based on the IAEA regulations for safe transport of radioactive material [2]. The paper estimates, annual collective dose for incident free and accident conditions, accruing due to transport of spent sources generated by nuclear application institutions in India.

Every year more than one thousand consignments of various decayed radioactive sources (belonging to nuclear application institutions) are transported in India. These consignments are transported from across the country to the designated radioactive waste disposal facilities located in different parts of country, for their safe disposal.

Dose assessment for transport workers and general public is computed using the INTERTRAN2* code. This code is a revised version of the INTERTRAN code [3]. The INTERTRAN code is based on the RADTRAN4 code [4], developed by the Sandia National Laboratories U.S.A. to estimate the population exposure and other health related consequences resulting from a given shipment of radioactive material. The code also generates a series of input and output data and tables, which can be used to compare the sensitive transport parameters for different cases. Since most of the transport of radioactive waste is undertaken by road, the paper analyzes transport by road mode only.

*INTERTRAN2 was developed as a co-operative effort between the IAEA and the Member States. It was tested during the summer of 2000 and is now available on a web site.

This work is part of a larger exercise, undertaken to estimate the total collective dose due to transport of radioactive material in India comprising of all the aspects of nuclear fuel cycle and radioactive material application industries. The exercise is divided into smaller parts, which include transport of uranium ore and fresh sources, heavy water, radioactive products and by-products, spent fuel, contaminated reactor components, radioactive waste etc.

2. Profile of the radioactive waste

Radioactive waste originates from different practices involving application of radioactive material in the areas of industry, agriculture, medicine, and research work. The strengths of these decayed sources vary from kilo becquerel to tera becquerel of different radioisotopes. The list of radioactive waste generated by these institutions in India during the period 1st January-31st December, 2001 is given in Table 1. It can be seen from the list that, a large number of consignments of radioactive waste transported are generated by the industries disposing decayed radiography and nucleonic gauge sources, hospitals disposing decayed teletherapy and brachytherapy sources and a few other institutions disposing decayed sources from Gamma Chambers.

Table 1:

Sr.No.	Radioactive waste (radioisotope)	No. Of Packages transported/y	Origin of waste
1@	Co-60	5	TT
2@	Co-60	4	GC
3	Co-60	125	BT, NG
4	Ir-192	861	BT, IR
5	Cs-137	7	BT, NG
6	Pm-147	7	NG
7	Sr-90	2	NG
8	Fe-55	3	NG
9	Cf-252	1	NG
10	Cd-109	1	NG
11	Kr-85	2	NG
12	Ra-226	1	NG
13	Am-241	8	NG
14	Cm-244	1	NG

@ Considered separately, **TT** Teletherapy, **GC** Gamma chamber,
BT Brachytherapy, **NG** Nucleonic Gauge, **IR** Industrial Radiography

About eight hundred and fifty consignments of Ir-192 radioisotope as decayed industrial radiography sources and brachytherapy sources are transported every year, for waste disposal purposes. Institutions using gamma chamber irradiators, hospitals using teletherapy machines for treatment of cancer and industries deploying nucleonic gauges for process monitoring purposes generate radioactive waste comprising of decayed Cobalt-60 sources. Annually there are about four cases of replacement/ return of gamma chamber sources, four to five cases of source replacement for teletherapy machines and a large number of decayed / disused nucleonic gauge sources, which are transported for waste disposal. Radioactive waste, containing decayed / disused Am-241, Cd-109, Cf-252, Cm-244, Cs-137, Fe-55, Kr-85, Pm-147, Ra-226 and Sr-90 radioisotopes is generated from the nucleonic gauges, which is transported to the Waste Management Facilities for it's safe disposal.

3. Calculations

Normalization of "radioactivity and the transport distance" for calculation purpose: Since the number of cases of radioactive waste transport is large, it will be a difficult proposition to estimate the population exposure for each case individually. To make the calculations part simpler, *an average activity of a given source transported over an average distance for a single transport per year* is considered for estimation of population exposure.

Considering the proportionality of the collective dose to the activity of the radioisotope and to the distance through which it is transported, it can be argued that, if, the product "activity x distance transported" is maintained unchanged in the calculations, estimation of collective dose will be fairly close to the actual value. Here it is also assumed that the demographic patterns, the traffic patterns, the accident rates and the values of other parameters used in the calculations are fairly similar for the respective zones, throughout the country.

The quantity C_i x D_i (where C_i is the activity of the radioisotope transported in the i^{th} case through distance $D_{i)}$ for each case of transport and the product sum Σ C_i x D_i for each radioisotope transported is estimated. Next, it is assumed that for all the cases of transport, the radioisotope is transported through an average distance of 500 km, i.e. the parameter D_i is assigned a uniform value of 500 km for all the cases. Using the value of D_i as 500 km, an average activity of the radioisotope transported is arrived at, which will not alter the product sum Σ C_i x $D_{i\ in}$ case of each isotope transported. These values are given in Table 2. The value of parameter Di is chosen uniformly as 500 km because, for a large number of cases of transport of radioactive waste in India, actual distances happen to be close to 500 km each.

Table 2:

Sr No	Radioactive Waste (Isotope)	No of packages	Σ $C_I D_I$ km x GBq	Assumed transport distance Km	Activity transported as single consignment for 500km (GBq)
1	Co-60 TT	5	1.97E+08	500	3.94E+05
2	Co-60 GC	4	0.74E+08	500	1.48E+05
3	Co-60 NG	126	6.92E+08	500	13.84E+05
4	Ir-192	861	0.70E+08	500	1.4E+05
5	Cs-137	7	0.022E+08	500	4.4E+03
6	Pm-147	7	0.0035E+08	500	700
7	Sr-90	2	421.0	500	0.842
8	Fe-55	3	325.12	500	0.650
9	Cf-252	1	1.2	500	2.4E-03
10	Cd-109	1	110.6	500	0.2212
11	Kr-85	2	2246.4	500	4.5
12	Ra-226	1	37.0	500	0.074
13	Am241	8	65.48E+03	500	131
14	Cm244	1	2.45E+03	500	4.9

TT Decayed Co-60 sources from Teletherapy machine,
GC Decayed Co-60 sources from Gamma Chamber
NG Decayed Co-60 sources from Nucleonic Gauge

These average values of C_i and D_i are then used as input data for the INTERTRAN2 program for estimating the population dose in case of each of the radioisotope transported individually. Details of some of the input parameters, used in the calculations are given in Table-3, wherever required, the built-in default values of the parameters are used for running the program.

Since the decayed radioisotopes from the teletherapy units and gamma chamber irradiators are of much higher activity than, those from the nucleonic gauges or other smaller sources, separate estimation of the population exposure is made for these decayed sources. This step will prevent undue biasing of the average activity.

Table 3:

INDEX	NAME	DESCRIPTION OF PARAMETER	PARAMETER VALUE
1	FTZNR	FRACT OF TRAVEL IN RURAL POP ZONE	0.80
2	FTZNS	FRACT OF TRAVEL IN SUBUR. POP ZONE	0.15
3	FTZNU	FRACT OF TRAVEL IN URBAN POP ZONE	0.05
4	VELR	VELOCITY IN RURAL POP ZONE(Km/h)	60
5	VELS	VELOCITY IN SUB POP ZONE(Km/h)	40
6	VELU	VELOCITY IN URBAN POP ZONE(Km/h)	25
7	CREWNO	NUMBER OF CREW MEN	2
8	ADSTCW	DISTANCE FROM SOURCE TO CREW m	3.0
9	HANDNO	NUMBER OF HANDLING	4.00
10	STOPTIM	STOP TIME PER KM (h/Km)	0.011
11	MINST	MINIMUM STOP TIME PER TRIP h	1.0
12	TIMZR	ZERO STOP TIME PER TRIP h	0.00
13	FMINCL	MINIMUM NO OF RAIL CLASSIFIC.	0.00
14	PDST	PERSONS EXPOSED WHILE STOPPED	50
15	RST	AVERAGE EXPOSURE DISTANCE m	3.00
16	DTSTOR	STORAGE TIME PER SHIPMENT h	24.0
17	PDSTOR	NO OF EXPOS PERSONS DURING STORAGE	100.00
18	RSTOR	AVERAGE EXPOSURE DISTANCE m	10.00
19	PPY	NO OF PEOPLE PER VEHIC. ON LINK	10.0
20	FRSHR	FR. OF URB TRAVEL DU RUSH HR TRAF.	0.01
21	FCTST	FR. OF URB TRAVEL ON CITY STREET	0.01
22	FTLFWY	FR. OF RUR-SUB TRAV ON FREE WAYS	0.8
23	TNCTPR	TRAFFIC COUNT RURAL ZONE	100
24	TNCTPS	TRAFFIC COUNT SUBURBAN ZONE	1800
25	TNCTPU	TRAFFIC COUNT URBAN ZONE	3000
26	------	ACCIDENT RATE IN RURAL ZONE	1E-06
27	------	ACCIDENT RATE IN SUBURBAN ZONE	2E-06
28	------	ACCIDENT RATE IN URBAN ZONE	5E-06

4. Results and discussions

From Table 3 it can be seen that, for Cobalt-60 radioisotope, though the average activity values for teletherapy and gamma chamber are larger as compared to that for nucleonic gauges, contributions to the collective dose by the teletherapy and gamma chamber sources are smaller. This can be attributed to the fact that large number of consignments are transported for gauges resulting in larger collective dose value.

From Table 4 it can be seen that, maximum contribution to the collective dose due to transport of radioactive waste i.e. 46.5 person Sv., comes from the Iridium-192 radioisotope which is mainly due to transport of decayed industrial radiography, brachytherapy and nucleonic gauge sources with the maximum individual dose of 7.4 micro sievert on the considered link segment. The transport of radioactive waste containing Co-60 radioisotope contributes next highest i.e. approximately 8.0 person Sv. Contribution to the collective dose due to transport of radioisotopes Cs-137, Pm-147, Sr-90, Fe-55, Kr-85 and Am-241 is relatively low.

5. Conclusion

From Table 5 it can be seen that the individual doses are quite low and that most of the contribution to the population exposure due to transport of spent sources in nuclear application comes from industrial sector. It is about 115 times, in incident free conditions of transport, 8 times, in accident conditions of transport and 124 times, the maximum individual in-transit dose, as compared to that in research sector.

Table 4:

SrNo	Isotope	Expected value of population risk in Person-Sv		Maximum individual In-transit Dose for the link
		Under incident Free conditions	Under accident conditions	E-06 Sv
1	Co-60TT	0.742	1.61E-03	0.115
2	Co-60GC	0.459	6.52E-04	0.07
3	Co-60NG	6.761	4.96E-03	1.07
4	Ir-192	46.5	2.88E-04	7.40
5	Cs-137	0.391	1.74E-05	0.06
6	Pm-147	0.391	1.43E-10	0.06
7	Sr-90	0.121	8.56E-12	0.0172
8	Fe-55	0.175	7.36E-15	0.0258
9	Cf-252	0.0668	1.94E-12	0.00860
10	Cd-109	0.0668	1.94E-08	0.00860
11	Kr-85	0.121	6.96E-18	0.01720
12	Ra-226	0.0668	3.39E-11	0.00860
13	Am241	0.445	3.34E-07	0.06880
14	Cm244	0.0668	6.34E-09	0.00860

TT Decayed Co-60 sources from Teletherapy machine
GC Decayed Co-60 sources from Gamma Chamber
NG Decayed Co-60 sources from Nucleonic Gauge

Table 5:

Sector:	Expected value of population risk				Maximum individual in-transit dose for the link E-05 Sv	
	Under incident free conditions		Under accident conditions			
	Dose@	Dose ratio*	Dose@	Dose ratio*	Dose@	Dose ratio*
Industry	52.438	114.24	1.118	7.60	0.868	124.00
Medical	3.477	7.57	0.435	2.96	0.011	1.57
Research	0.459	1.00	0.147	1.00	0.007	1.00

@ Person Sv
* Compared with the estimated dose values for research sector.

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STATISTICS ON THE ROAD TRANSPORT OF RADIOACTIVE MATERIALS IN ITALY

P. Caporali, L. Matteocci, G. Palmieri, S. Trivelloni

Agency for Environmental Protection and Technical Services (APAT)
Via V. Brancati, 48 - 00144 Rome
Italy

Abstract.

The data on transport of radioactive materials can be an useful tool for a competent authority to evaluate the performances of the regulatory framework established to guarantee the safety in the transport activities and to evaluate the radiation doses to people and transport workers arising from this activity. A domestic regulatory provision obliges the carriers to provide, to the competent authority, detailed data on the shipments of radioactive material performed.. The availability of these data has allowed to organize a database since 1987 about the shipments performed in Italy.. This paper summarize the historical statistical elaborations of the shipments data of radioactive material performed during the last decade. The results of a survey on the doses received by the transport workers and an evaluation of doses to the population associated to the transport of radioactive material are also presented.

1. Introduction

Data on transport of radioactive material are of great importance to evaluate the performances of the system protection and safety established by the Transport Regulations. Moreover the knowledge of data on the shipments of radioactive materials can help the competent authority in the periodic assessment of the radiation doses to person arising from transport activities as required by the IAEA Regulations (par. 304 TS-R-1) and to verify that the limits prescribed are respected. The data on transport of radioactive materials and their analyses are also useful for other reasons: to support compliance assurance by competent authority; to assist competent authority for inspection activities; to identify trends in transport of radioactive materials; to provide factual data to help meet public concerns. Italian domestic regulations allow to have available very detailed data on shipments of radioactive material. In particular the radiation protection regulations establish that the authorized carriers to the transport of radioactive materials have to provide to the competent authority, on quarterly basis, a detailed data regarding each shipment carried out. Since 1987 a database called TRARAD was established with the data on the shipments of radioactive material for all modes of transport.

2. Analyses of data (1987 – 2000)

2.1 Shipping volume

The analyses of data are referred to shipments carried out during the period 1987-2000 by authorized carriers. The results of the analysis of data are based both on direct elaboration and derived by statistical analyses sampling. Trend analyses have been carried out with the scope to evaluate changes in transport of radioactive materials and to evaluate transport flows inside the national territory and relating to the import and export activity. The data regarding the number of shipments and number of packages transported during the period analysed are summarized in Table 1. The maximum number of shipments (155000) was in 1996 with a number of packages transported of 458000. After 1996 the number of shipments and packages transported had a decrease for different reasons. This phenomena can be explained taking into account the changes in the production and use of radionuclides particularly in medical field. In medical field has been observed a decrease in the use of radioactive sources, in particular Co-60, for cancer treatment; the increase of the average activity transported for each package with the decrease in the number of packages shipped; the extensive use of Tc99 for medical diagnostic instead of other radionuclides previously used.

Table 1: Transport data (1987-2000)

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
No packages	227000	336000	341000	345000	334000	465000	469000	449000	406000	458000	356000	287000	203000	193000
No shipments	61000	81000	78000	92000	83000	90000	148000	144000	134000	155000	134000	118000	99000	86000

2.2. Type and number of operators

Shipments of radioactive material are carried out, for all modes of transport, by authorized carriers. The authorization is issued on the basis of the technical advice expressed by APAT. The number of road carriers has grown in the period 1990 – 1994 after the decision of Italian railways to stop the carriage of small packages of radioactive material. From 1994 to 2000 the number of carriers has decreased in virtue of a merging process among transport undertakings and because some gamma-graphics operators ceased their activity.

2.3. Type of packages shipped

The data regarding the type of packages transported are reported in Table 2 as percentage of total packages shipped. Type A and excepted packages represent the majority of the packages transported. Data of Table 2 should be analyzed taking into account that much more realistic figures in terms of percentage of Type A packages and excepted packages transported are those referred to 1999 and 2000. The packages shipped in these two years were about 55% for Type A packages and 43% for excepted packages. In the previous period it was observed that in many cases the carriers, providing the data, did not distinguish between Type A and excepted packages. Type B packages are only a small percentage of the total packages transported in the range from a maximum of 1% to a minimum of 0,1%. The percentage of Type B packages transported includes shipments of gamma-graphic devices and in many cases they contribute to the total number of shipments as round trip. Industrial packages are a small fraction of the total packages transported varying from a maximum of 5,7% in 1989 to a minimum of 0,4% in 1995.

Table 2: Package type as % of total packages shipped (1987-2000)

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Industrial	5,5	3,1	5,7	3,5	3,1	1,9	1,1	1,1	0,4	1,5	1,9	1,6	0,9	0,6
Excepted	2,6	1,9	1,6	0,5	1,0	1,0	5,2	7,6	1,1	1,2	8,0	11,5	43,7	42,8
Type A	90,9	94,3	92,2	95,4	95,3	96,7	93,4	91,0	98,5	97,2	89,9	86,6	55,2	56,4
Type B	1,0	0,6	0,5	0,5	0,5	0,5	0,3	0,3	0,1	0,1	0,2	0,3	0,1	0,2

2.4. Package characteristics

Information on the characteristics of radioactive materials transported in terms of physical state, total activity, kind of radionuclide and other package characteristics that are relevant for the evaluation of doses to the workers and population have been extracted from the database. Radioactive materials, used in particular for radiopharmaceutical delivered to hospitals, to industrial and research establishments, are shipped in large part in Type A and excepted packages. These radioactive materials are generally shipped in liquid form or solid non special form. The activity of the radioactive material transported in a single package is in the range from a few KBq to a few tens of GBq. The packages used for transport of those radioactive materials are suitable for manual handling by a person and therefore the knowledge of the category and transport index (TI) of the packages allows to evaluate the doses to transport workers received during transport operations. The trend analysis put in evidence an increase in the percentage of packages of category II and III yellow shipped in 1997 – 2000. That increase in transportation of packages of category II and III yellow is also confirmed in Table 3 that reports the total TI annually transported.

Table 3: Total annual TI (**ΣTI** sum of TI of each road links)

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
ΣTI	53040	23829	22299	26842	18507	28001	33418	30214	25141	49830	41075	41213	65995	83011

The increase in the number of packages with categories II and III yellow and the increase of the total TI shipped can be explained with the increase of average activity contained in a single package and the increase in the use of radionuclide with more penetrating radiations, i.e. Tc-99 for medical diagnostic (Figure 1). However in spite of the increase of the average activity in a single package recorded in the period 1997–2000 the package activity inventory for excepted packages and Type A packages expresses in units of A_2, is very low as reported in Table 4 for the year 2000. Data of Table 5 confirm that a single excepted package and Type A package generally contain a small fraction of the activity limits, in unit of A_2, allowed by the Transport Regulations. This element should be taken into account in case of an accident involving excepted packages or Type A packages in virtue of the fact that the radiological consequences of an accident could be more lighter considering that the activity contained into these packages is generally below the limits established in the Regulations.

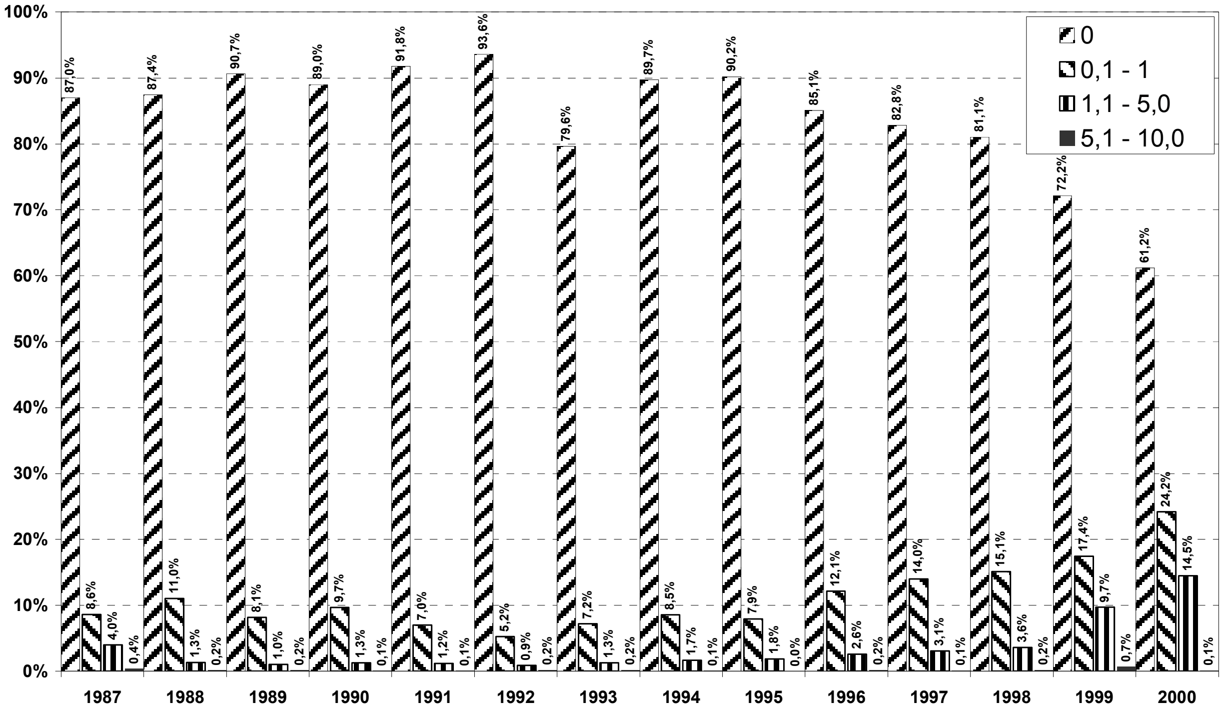

Figure 1 – Transport Index distribution as % of total road links (Years 1987-2000)

Table 4: Statistics on the radiological characteristics of excepted and Type A packages (Year 2000)

Package characteristic	Package Type	
	Excepted	Type A
Average package activity inventory (GBq)	0,13	14
Average Transport Index (TI)	n.a.	0,5

Table 5: Activity of the contents in Type A and Excepted packages in terms of A_2 (Year 2000)

Activity	% of Type A Packages	% of Excepted Packages
from 1 to 1/10 of A_2	11	-
from 1/10 to 1/1000 of A_2	24	-
from 1/1000 to 1/100000 of A_2	41	19
from 1/100000 to 1/1000000 of A_2	4	16
< 1000000 of A_2	20	65

Radiation exposure

The information on transport workers radiation doses have been collected from the carriers and undertakings operating in the main national airports involved in transport and handling of radioactive materials. The survey was carried out by a questionnaire that was sent to 75 operators including carriers and undertakings responsible for transport and handling of packages. Data regarding the gamma-graphics operators were not included in the doses evaluation due to the difficulty for such workers to distinguish between the doses arising from transport of radioactive sources and doses deriving from the gamma-graphic operations. Radiation exposure data of the workers collected for the period 1996 – 2000 are based on a radiation monitoring service adopted for drivers and handlers by the operators. All transports and handling operations are carried out under a radiation protection programme established by the operators. Table 6 and Table 7 report the doses arising principally from transport operations associated with radioisotope supply and distribution and with transport of non nuclear waste. The doses arising from transport operations associated with nuclear fuel cycle are negligible due to the very small number of shipments of nuclear materials. The results of the survey indicate that the occupational average exposure to workers, arising from routine transport of radioactive material is generally below of 1 mSv/y. The data are quite homogeneous during all the period examined. For routinely shipments of large number of Type A and excepted packages for transport of radioisotopes, and in particular for the operations at the redistribution centre the occupational exposure can be higher than 1 mSv/y. As reported in Table 6 only in few cases the maximum occupational exposures for single workers have been grater than 6 mSv/y with a maximum of recorded dose of 7,7 mSv/y (1999). Those data confirmed that occupational exposure associated to transport of radioactive materials is below the limit of 20 mSv/y, established by the radiation protection regulations, for a large part of workers (drivers, handlers).

Table 6: Annual effective dose for transport workers (1996 – 2000)

Year	No.Workers	Annual collective dose [man – mSv/y]	Average dose [mSv/y]	Dose [mSv/y]	
				min	max
1996	399	203	0,508	0.024	5.3
1997	445	252	0,567	0.024	4.5
1998	489	341	0,698	0.019	7.2
1999	503	347	0,690	0.024	7.7
2000	456	461	1,011	0.010	5.4

Table 7: Annual collective dose and total TI (1996 – 2000)

Year	Total annual TI	Annual collective dose [man – mSv/y]	Collective radiation doses per unit TI [man – mSv/y]
1996	49830	203	0,004
1997	41075	252	0,006
1998	41213	341	0,008
1999	65995	347	0,005
2000	83011	461	0,005

4. Discussion

The extensive analysis of the data regarding the shipments of radioactive material performed for the period 1987 – 2000 put in evidence the increase from 1987 to 1996 of the number of shipments performed and of the number of packages transported and a decrease in the period 1997 – 2000. A general increase in the number of packages of category II – yellow and III – yellow, associated to the increase of total annual Transport Index, has been recorded for the period 1996 – 2000. Those increases can be ascribed to an higher value of the average activity transported in a single package and to the increase in transport of technetium generators. Data on radiation exposures to workers show that the annually average dose is in most cases less than 1 mSv/y and in few cases in the range of 1 – 8 mSv/y. Exposures to people, estimated by INTERTRAN2 computer code for shipments of radioactive material for industrial and medical use show that most part of these exposures arising from transport of radioactive material for medical use with a value estimated of annual maximum effective dose of 1.2 μSv/y.

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RADIATION SAFETY OF INBOARD ENVIRONMENT AND HANDLING OF TRANSPORT CASKS IN SEA TRANSPORT OF RADIOACTIVE MATERIAL IN JAPAN

K. Ueki[a], N. Odano[a], H. Akiyama[b], H. Yanagi[b]

[a]Department of Maritime Safety, National Maritime Research Institute
Shinkawa, Mitaka, Tokyo,
[b]Nuclear Fuel Transport Co., Ltd., Shiba-Daimon,
Minato-ku, Tokyo,
Japan

Abstract

Radiation safety for sea transport of radioactive material in Japan has been discussed based on records of the exposure dose of sea transport workers and measured data of dose rate equivalents distribution inboard exclusive radioactive material shipping vessels. Recent surveyed records of the exposure doses of workers who engaged in sea transport operation indicate that exposure doses of transport workers are significantly low. Measured distribution of the exposure dose equivalents inboard those vessels indicates that dose rate equivalents inside those vessels are lower than levels regulated by the transport regulations of Japan. These facts clarify that radiation safety of inboard environment and handling of transport casks in sea transport of radioactive material in Japan are assured.

1. Introduction

Most of nuclear fuel materials used at nuclear power plants are transported by general cargo ships from abroad while spent fuels are transported to nuclear fuel reprocessing plants in Japan and abroad by shipping vessels in exclusive use. Although the spent fuel (SF) have been transported to a reprocessing plant at Tokai-mura and reprocessing plants in UK and France from each nuclear power station by exclusive shipping vessels, sea transport of spent fuels to domestic reprocessing plants from each nuclear power station would take lead from now on because receipt of spent fuel at a storage facility in the reprocessing plant of Japan Nuclear Fuel Ltd. (JNFL) located at Rokkasyo-mura has been started since 1998. The low level radioactive wastes (LLW) has been transported to the LLW burial site of JNFL located at Rokkasyo-mura. As described above sea transport of radioactive material has played an important role in the nuclear fuel cycle in Japan. Due to recent increase of transported radioactive material and diversification of transport form with enlargement of nuclear research, development, and utilization, safety securement for sea transport of radioactive material is one of important subjects in the nuclear fuel cycle.

To discuss the radiation protection for sea transport of radioactive material, the target consignment was set to the SF and LLW package transported to the facilities at Rokkasyo-mura from each nuclear power station by exclusive shipping vessels considering amount of radioactivity and transport track record of radioactive material to be conveyed. This paper verifies safety of sea transport of radioactive material in recent years from a viewpoint of radiation protection based on the surveyed records of the exposure dose of workers engaged in sea transport operation and measured data of distribution of dose rate equivalents inboard environment of the exclusive shipping vessels.

2. Radiation protection regulations for sea transport of radioactive material in Japan

In Japan legislative system between regulations in nuclear facilities that the radiation protection is managed by preparation of radiation control area and transport regulations applied outside an establishment differ. Sea transport of radioactive material is treated as shipment outside an establishment and is regulated by safety standards concerning nuclear fuel packages and methods of transportation including methods of loading onto the ship in the order of Ministry of Land, Infrastructure and Transport, "Rules concerning Maritime Transportation and Storage of Hazardous Materials" under Ship Safety Law. Nuclear entrepreneurs, however, may participate in shipment outside an establishment. Observance duty of regulations for package, packaging, marking, labelling, and placarding is applied to consignor, namely, nuclear entrepreneurs, while observance duty for requirements such as methods of loading onto a ship is applied to a captain or ship's owner. In case that consignor is nuclear entrepreneur, because general radiation control for workers, engaged in transport operation, as employees of nuclear facilities inside an establishment is managed by Reactor Regulation Law, no special prescription is carried out under the transport regulations and the transport regulations prescribed to inboard residence such as crew of a shipping vessel. Thus, the exposure dose limit prescribed in the transport regulation is 1 mSv/year that is same level as the dose limit for general public and the level of the dose limit is regulated as sufficiently safe level. In case that Minister of Land, Infrastructure and Transport especially approved under specific circumstances that it is impossible to obey the regulations and required radiation control measures are taken, the regulation allows to exceed the dose limit. It, however, is not allowed to exceed 50 mSv/year in any cases.

3. Records of exposure dose of sea transport workers

Survey of records of exposure dose of sea transport workers engaged in handling of packages at Mutsu Ogawara port and crew of the exclusive radioactive material shipping vessel was conducted. The packages concerned are the LLW and SF and the exclusive shipping vessels concerned are Seiei Maru and Rokuei Maru. Records from 1997 to 2001 were surveyed for the LLW transport while records from 1998 to 2001 were surveyed for the SF transport. The recent records of the exposure dose of workers were statistically processed and used for discussions hereafter.

Workers engaged in handling of packages include cargo operation workers, personnel for the radiation control and transportation firm personnel. For control of the exposure dose of workers engaged in handling of packages, both the glass batch and the pocket personal dosimeter are used. Measurement of the exposure dose for radiation control for crew of the exclusive shipping vessels is carried out by either the film batch or the glass batch. In case that personnel of electric power companies and cargo operation firms, and inspectors are temporarily required to enter inboard restricted area, measurement of the individual exposure dose is carried out by using the photo-diode type pocket dosimeter.

Results of survey of exposure dose records of the workers are shown in Table I and Table II. From a viewpoint of the individual exposure dose, the exposure dose of the workers, engaged in handling of the packages, such as personnel of transport firms, cargo operation workers, and radiation control workers at the Mutsu Ogawara port are shown in Table I. Packages considered for preparation of the Table I are the SF, LLW, vitrified wastes and UF_6. Results arranging the exposure dose records by type of package are shown in Table II. In the Table II, attention was paid to shipment of the SF and LLW, and records of the exposure dose during handling of each package are shown. Crew and personnel temporarily entered the vessels are also included in the workers in the Table II addition to workers engaged in handling of packages.

Table I. Exposure dose of sea transport workers

Year	Number of workers	Total dose (man·μSv)	Average dose (μSv)	Annual individual dose distribution				
				< 1μSv	1-9μSv	10-19μSv	20-29μSv	> 30μSv
1996	65	136	2.1	30	34	1	0	0
1997	60	200	3.3	19	35	6	0	0
1998	62	76	1.2	41	21	0	0	0
1999	69	285	4.1	19	38	12	0	0
2000	69	534	7.7	19	28	9	13	0
2001	76	460	6.1	27	30	12	7	0

Table II. Exposure dose and collective dose of sea transport workers engaged in transport of SF and LLW

Type of transport		Total number of workers	Total dose (man·μSv)	Average dose (μSv)	Maximum dose [a] (μSv)	Total IT handled	Collective dose per IT (μSv/IT)
LLW	1997	301	119	4.0×10^{-1}	20	16320.61	7.3×10^{-3}
	1998	333	42	1.3×10^{-1}	5	9275.85	4.5×10^{-3}
	1999	252	6	2.4×10^{-2}	1	3167.1	1.9×10^{-3}
	2000	152	10	6.6×10^{-2}	2	910.44	1.1×10^{-2}
	2001	229	25	1.1×10^{-1}	8	599.59	4.2×10^{-2}
SF	1998	165	4	2.4×10^{-2}	1	2.0	2.0×10^{0}
	1999	271	4	1.5×10^{-2}	1	1.0	4.0×10^{0}
	2000	480	39	8.1×10^{-2}	2	5.42	7.2×10^{0}
	2001	870	116	1.3×10^{-1}	9	19.81	5.9×10^{0}

[a] Maximum dose received in one time transport operation.

For workers, engaged in handling of the packages, such as transport firm personnel, cargo operation workers, radiation control workers, measured result of the glass batch was less than the detection limit of the dosimeter, 100 μSv. Because the workers also have put on pocket dosimeter whose detection limit is 1 μSv, small amount of the exposure dose was possible to measure. Average individual exposure dose for each year was 1.2 to 7.7 μSv and maximum exposure dose equivalent for one time transport operation for the workers is approximately 10 μSv. There was no worker whose annual exposure dose exceeded 30 μSv. The survey results indicate that recent records of the exposure dose for the workers are significantly small level compared with the exposure dose limit of the transport regulation.

The exposure doses for crew of the exclusive shipping vessels, Seiei Maru and Rokuei Maru, were less than detection limit of the dosimeter, 100 μSv, and the exposure doses for personnel temporarily entered the vessels were also less than the detection limit of the pocket dosimeter, 10 μSv, except for the LLW transport in 1997. These facts indicate that the exposure dose records inboard the vessel are significantly low level.

To compare the present survey result regarding sea transport workers with data of other mode of transport in abroad, the collective dose per the transport index (TI) was derived from the annual total dose and total transport index of packages transported in each year. The results are also shown in the Table II. Crew, personnel temporarily entered the vessel, transport firm personnel, cargo operation workers, and radiation control workers are included in the sea transport workers. The transport indexes used in the present study were determined from the measured doses of packages before dispatch. The collective doses per TI for transport of the SF are the order of 1 μSv/TI. The collective doses per TI for transport of the LLW are lower than those of the SF transport 2 to 3 orders of magnitude. The values for the SF transport are consistent with surveyed data in Ref. [1], the collective dose per TI during transport by road and air in UK and USA. It can be considered that a reason that the collective doses per TI for the LLW are lower than those for the SF is that complete remote handling of the LLW packages made possible by adoption of remote and automatic crane operation as much as possible and adoption of the gate monitor [2] to measure the dose equivalent rate of a track loading with packages automatically.

4. Dose distribution inboard exclusive shipping vessels

The National Maritime Research Institute has been conducting measurement of dose distribution inboard the exclusive shipping vessels during transport of the SF and LLW to verify radiation safety of sea transport of radioactive material.

Measurement of distribution of dose rate equivalents inboard the exclusive LLW shipping vessel, Seiei Maru, was carried out in October 1993 [3]. The Seiei Maru has 7 cargo holds and 336 containers were loaded in No.2 to No.7 cargo hold for shipment. Eight LLW drums are contained in one container. Principle radiation sources from the LLW container are ^{137}Cs and ^{60}Co. For measurement of distribution of dose rate equivalents, the NaI scintillation survey meter was used. Measured maximum dose rate equivalent in an accommodation area was 0.05 μSv/h and was sufficiently low level compared with a criterion for the accommodation area, 1.8 μSv/h. Measured maximum dose rate equivalent above the hatch cover was 1.2 μSv/h and was sufficiently low level compared with a criterion for above the hatch cover, 2000 μSv/h.

Measurement of distribution of dose rate equivalents inboard the exclusive SF shipping vessel, Rokuei Maru, was carried out in November 2001 [4]. The Rokuei Maru has 5 cargo holds and three NFT-14P casks were loaded in No.2 and No.3 cargo hold, respectively. Average burn-up of the SF enclosed in six NFT-14P casks was 40,000 MWD/MTU and cooling time varies between 694 and 2188 days. In the experiment, dose rate measurements at surface of the casks and at 1 m from surface of the casks were also carried out. Maximum dose rate equivalent, summation of neutron and gamma ray dose rate equivalent, at surface of the casks was 29 μSv/h and maximum dose rate equivalent at 1 m from surface of the cask was 6.8 μSv/h. These values were sufficiently lower than criteria prescribed in the transport regulations; dose rate equivalent at surface of the package is less than 2000 μSv/h and dose rate equivalent at 1m from surface of the package is less than 100 μSv/h. Maximum dose rate equivalent at surface of the shipping vessel was observed above the hatch cover of the No.3 cargo hold and was 0.15 μSv/h. The measured dose rate equivalent is sufficiently lower than criteria of the transport regulations; criteria at surface of the shipping vessel is less than 2000 μSv/h and criteria at 2m from surface of the vessel is less than 100 μSv/h. Although dose rate equivalents were also measured in the accommodation area, those were back ground level.

As described above, radiation level inboard the shipping vessels was significantly lower than the criteria prescribed in the transport regulations. This fact proves that the exposure dose record of crew of the shipping vessels is significantly low.

5. Summary

Result of survey of recent records of the exposure dose for workers engaged in sea transport operation of radioactive material indicates that the annual exposure dose of the workers is lower than the dose limit prescribed in the transport regulation. Measurement of distribution of dose rate equivalents inboard the exclusive shipping vessels for transport of the spent fuel and the low level radioactive wastes indicates that dose rate equivalents in the accommodation area and above the hatch cover are significantly lower than the criteria of the transport regulations. Thus, it is clear that radiation safety in handling of the transport casks and inboard the shipping vessel during sea transport of radioactive material is sufficiently secured in Japan.

Acknowledgement

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EFFECTIVENESS OF RADIATION PROTECTION IN TRANSPORT OF RADIOACTIVE MATERIALS

S. A. Masinza
Radiation Protection Board, Nairobi,
Kenya

Abstract

The increase in the use of radioactive materials worldwide requires that these materials be moved from production sites to the end user or in the case of radioactive waste, from the waste generator to the repository. Radioactive sources are useful in nuclear power (electricity production), medicine (diagnosis and treatment), research (increase of yields and disease resistance), Industry (monitoring of processes and non-destructive evaluations) among others. Transport is the main way in which the radioactive materials being moved get in the public domain. The Public is generally unaware of the lurking danger when transporting these hazardous goods. Thus Radiation Protection Programmes are important to assure the public of certainty of their safety during conveyance of these materials. The international community has thus formulated controls to reduce the number of accidents and mitigate their consequences should they happen. When accidents involving the transport of radioactive material occur, it could result in injury, loss of life and pollution of the environment.

1. Introduction

The use of radioactive material is an important part of modern life and technology. Tens of millions of packages containing radioactive material are consigned for transport each year throughout the world. The quantity of radioactive material in these packages varies from negligible quantities in shipments of consumer products to very large quantities of shipments of irradiated nuclear fuel.

Radioactive material is transported by land (road and rail), inland waterways, sea and air. These modes of transport are regulated by international ‘modal’ regulations. For instance, the International Maritime Dangerous Goods Code, issued by the International Maritime Organization, covers the sea mode.

In order to ensure the safety of people, property and the environment, national and international transport regulations have been developed. The appropriate authorities in each state utilize them to control the transport of radioactive material. Stringent measures are required in these regulations to ensure adequate containment, shielding and the prevention of criticality both in al spheres of transport i.e. routine, minor incidents and accident conditions.

Despite the extensive application of these stringent safety controls, transport accidents involving packages containing radioactive material have occurred and will continue to occur. When a transport accident occurs, it results in a significant release of radioactive material, loss of shielding or loss of criticality control. Thus a radiation protection programme must take note of these realities.

2. Radiation protection programme requirements of the IAEA Transport Regulations

The International Atomic Energy Agency regulations for the safe transport of Radioactive Materials require that there shall be established a *Radiation Protection Programme*. The nature and extend of the measures to be employed in the programme shall be related to the magnitude and likelihood of radiation exposures. The programme documents shall be available, on request, for inspection by the relevant *competent authority*.

In transport, protection and safety shall be optimised such that the magnitude of individual doses, the number of persons exposed, and the likelihood of incurring exposure shall be kept as low as reasonably achievable, economic and social factors being taken into account, and doses to persons shall be below relevant dose limits. A structured and systematic approach shall be adopted and shall include consideration of the interfaces between transport and other activities.

Workers shall receive appropriate training concerning the radiation hazards involved and the precautions to be observed in order to ensure restriction of their exposure and that of other persons who might be affected by their actions.

The relevant competent authority shall arrange for periodic assessments of the radiation doses to persons due to the transport of radioactive material, to ensure that the system of protection and safety complies with the Basic Safety Standards. For occupational exposures arising from transport activities, where it is assessed that the effective dose:

(a) is most unlikely to exceed 1 mSv in a year, neither special work patterns nor detailed monitoring nor dose assessment programmes nor individual record keeping shall be required;

(b) is likely to be between 1 and 6 mSv in a year, a dose assessment programme via work place monitoring or individual monitoring shall be conducted;

(c) is likely to exceed 6 mSv in a year, individual monitoring shall be conducted.

When individual monitoring or workplace monitoring is conducted, appropriate records shall be kept.

Radioactive material shall be segregated sufficiently from workers and from members of the public. For purposes of calculating segregation distances, a dose of 5 mSv per year is applied for workers in regularly occupied working areas; while a dose of 1 mSv per year to the critical group in areas where the public has regular access.

In the event of accidents or incidents during the transport of radioactive material, emergency provisions, as established by the relevant national or international organizations, shall be observed to protect persons, property and the environment. These emergency procedures shall take into account the formation of other dangerous substances that may result from the reaction between the contents of a consignment and the environment in the event of an accident.

3. Application of the Radiation Protection Programme requirements in Transport

To be able to practically realise the aim of protecting radiation workers involved in the transport of radioactive materials and members of the public, it is prudent to quantify the actual risk posed by the materials being conveyed, allocate responsibilities to persons and organizations involved in the transactions and put in place an effective quality assurance programme to ensure that the required conditions or levels of safety are consistently achieved.

A disciplined approach to all activities affecting quality, specifications and verification of satisfactory performance and or implementation of appropriate corrective actions, will contribute to transport safety and provide evidence that the required quality is achieved.

The quality assurance programmes will vary due to the diversity of operational needs and somewhat differing requirements of the competent authorities of each member state. The degree of detail in any quality assurance programme will depend on the phase and type of transport operation, adopting a graded approach to contents limits for packages and conveyances and to performance standards applied to package designs depending on the hazard of the radioactive contents. Secondly, imposing requirements on the design and operation of packages satisfies safety requirements. Finally, safety is achieved by requiring administrative controls including approval by competent authorities.

In the transport of radioactive material the safety of persons, who are either members of the public or workers, is assured when regulations are complied with. Confidence in this regard is achieved through quality assurance and compliance assurance programmes. The role of the competent authority is to ensure that radiation protection programmes are developed and applied by all those organizations involved in the transport of radioactive materials. It should also develop and maintain suitable arrangements for the assessment and approval of radiation protection programmes.

4. Guidance on application of radiation protection programmes

A key element in meeting IAEA transport regulations is the establishment of a radiation protection programme. These programmes provide a framework of controls to limit normal and potential exposures and the extent of the measures to be taken as related to the magnitude of exposure i.e. a graded approach.

The radiation protection programme should take cognisance of the nature of radioactive material being transported i.e. chemical/physical form, radioactive properties, fissile characteristics and heat generation. Thus it should contain details on measures for effective control of radiation from transported material, effective containment, adequate heat dissipation and maintenance of sub-criticality.

The prime responsibility of ensuring safety during transport should be vested in the consignor. Regulatory thresholds must not be exceeded, package requirements must be satisfied and competent authority approvals must be obtained. The programme should be clear on how each of these requirements is to be met.

5. Adequacy of or need for strengthening the regulatory radiation protection requirement

The Sept. 11 attacks in the U.S. heightened concern that terrorists may make dirty bombs, conventional explosives that scatter radioactive materials to contaminate a wide area. The International Atomic Energy Agency said in June 2002 that more than 100 nations don't have adequate controls over such materials. The UN's nuclear agency set up a commission with the U.S. Department of Energy and the Russian Ministry for Atomic Energy to locate and secure radioactive material in the former Soviet Union.

The above statement serves to reinforce the fact that radiation protection and physical security of radioactive materials are closely linked. Radioactive material that might be used to make a so-called dirty bomb has been confiscated at border posts in central Asia during the past year, Reuters cited a U.S. Defence Department official as saying.

The smuggling of radioactive material and the continued movement across borders is causing a lot of concern. Radiation protection programmes and national regulations should therefore address the issues of the security of materials during transport to prevent unlawful access and use.

6. Risk assessments, environmental impact assessments

Historically, there have been no reported transport accidents involving radioactive material that have resulted in serious radiological consequences. Despite this excellent safety record, plans should be developed, responsibilities defined and preparedness actions should be taken to ensure that an adequate emergency response capability is available when transport accidents involving radioactive material do occur.

In the same strength, the risk associated with the transport as well as the attendant environmental impact resulting from such accidents need to be quantified and mitigated. The Safety Fundamentals publication of the International Atomic Energy Agency (IAEA) says "*the objective of protection is to prevent the occurrence of deterministic effects in individuals by keeping doses below the relevant threshold and to ensure that all reasonable steps are taken to reduce the occurrence of stochastic effects in the population at present and in the future"*. It goes on to states "*the objective of safety is to protect individuals, society and the environment from harm by establishing and maintaining effective defences against radiological hazards from sources."*

Risk and environmental impact assessments therefore will have to be modelled along the worst-case scenario in normal or routine cases of transport as well as in severe accident conditions. When accidents involving transport of radioactive material occurs, and although it may not pose a radiation safety problem, emergency response actions are needed to ensure that radiation safety is maintained.

The radiation protection programme designed should contain a system of measures primarily to ensure that the health and safety of workers from radiation and radioactive material. Measures also need to be taken with the aim of minimising environmental impact.

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THE SAFETY TRANSPORT OF THE RADIOACTIVE MATERIALS IN ROMANIA

G. Vieru

Institute for Nuclear Research,
0300 Pitesti, P. O. Box 78,
Romania

Abstract

The transport of radioactive materials (RAM) is a very important problem considering the potential risks and radiological consequences in carrying-out this activity. Romania as a Member State of the International Atomic Energy Agency has implemented national regulations for a safe transport of RAM in accordance with the Agency's recommendations as well as other international specialized organizations. Based on the IAEA's Safety Standard-TS-R-1 (ST-1), Romanian National Nuclear Regulatory Body – CNCAN adopted and implemented, by Act no. 374/October 2001, the safety regulations for the transport of radioactive materials in Romania under the title: "*Fundamental Regulations for a Safe Transport of Radioactive Materials, in Romania"*.

The paper presents the main sources of radioactive materials in Romania their transportation routes with a particular interest paid to the radioactive wastes (low level radioactive materials), isotopes and radioactive sources, uranium ore. Starting from the fact that the safety in the transport of radioactive materials is dependent on appropriate packaging for the contents being shipped, rather than operational and/or administrative actions required for the package, the paper presents, briefly the main packages used for transport and storage of such RAM in Romania. There are presented hypothetical scenarios for specific problems related to the identification and evaluation of the risks and potential radiological consequences associated with the transport of radioactive materials in Romania, for all these three situations: routine transport (without incidents), normal transport (with minor incidents) and during possible accidents. As a conclusion, it is ascertained that the evaluated annual collective dose for the population due to RAM transport is less than that received by natural radiation sources. At the same time it is concluded that Romanian made packages are safe and prevent loss of their radioactive contents into the environment.

1. Introduction

The main categories of radioactive materials transported in Romania are: a). radioactive wastes, treated and packaged, to the National Repository, Baita; b). uranium ore to the uranium concentrate plant, Feldioara; c). uranium concentrate from Feldioara plant to the CANDU Nuclear Fuel Plant, Pitesti; d) f fresh nuclear CANDU fuel from Pitesti to the NPP CANDU Cernavoda; e). nuclear fresh/spent from NPP Kozloduy (Bulgaria) to Ukraine (Russian Federation) and vice versa, by Danube; f) radioactive sources to be used for industry purposes; g) others radioactive materials, such as: radioactive sources used in hospitals, research institutes, education, etc. In this paper, the main focus will be on the safe transport of the radioactive wastes. The radwastes resulting from Romanian nuclear facilities are transported to the disposal site both by road and by rail, as shown in Figure 1. In order to approach the risk and the safety of radwaste transport and because accidents were not reported, it was necessary to develop accident scenarios. During these hypothetical events radioactive materials (RAM) might be released from its packaging and could potentially affect the population and the environment.

To assess possible radiological consequences and risks over the environment it was necessary to analyze the characteristics of the transport procedures in terms of packages (geometry, radiological contents, dose rates, etc.), annual traffic (number of conveyances, packages, distance, etc.) and characteristics of exposures (handling and transport process, current individual and collective doses (exposures). Type A packages are used for transport of Low Level Waste (LLW) and have less than 0.1mSv at 2m distance from package surface. The qualification requirements for type A packages (testing program), environmental impacts and risk assessment activities are presented both for normal (accident-free) transport, and for those resulting from transport accidents involving radioactive shipments, either by road or by rail.

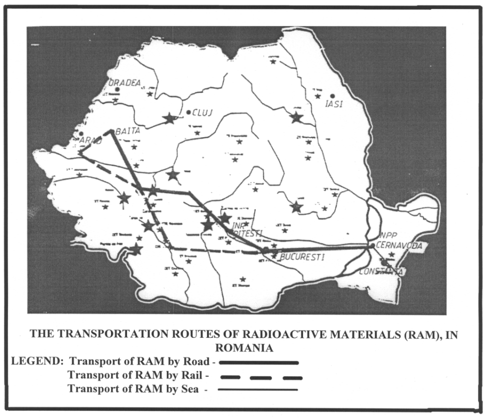

Figure 1: The radwaste routes transport in Romania

2. Test requirements for type A packages

The type A package is an industrial drum, made of 1mm thick mild steel having a volume of 220 liters. This package must be able to retain its contents without allowing more than a specified increase in external surface radiation level and shielding integrity if subject to: *free drop test, compression test and penetration test.* These tests constitute the compulsory minimum specifications for the manufacturer.

The free drop test: was performed for 2 hours after the end of the water spray test and the drum was then dropped so as to suffer maximum damage; the drop height was *1.2 m;* *Test pass criteria:* no rupture of the outer shield, no release of the sealing lid and the limits of the release fraction of the package contents, if any, to be within the range of *0.1%* to *1 %;* *results:* after the test the container was subjected to visual inspection and no damage or defects were observed.

The compression test: is intended to ensure that effectiveness of containment, shielding and any spacers are maintained while package is stacked in such a way normally likely to occur during loading, unloading, transport and intermediate storage. Before testing, the drum was subjected to 1-hour water spray test. *Test pass criteria:* package to withstand for a period of 24 h at 5 times its weight; *results:* no damage was observed at the end of the test.

The penetration test: is intended to demonstrate the capability of the package to withstand the kind of puncture damage that may arise in routine transport, such as: *sharp objects falling on the package, damage from loading hooks, and the like;* *Test pass criteria:* no rupture of the outer shield, and the limits of the release fraction of the package contents, if any, to be within the range of 0.1% to 1%; *results:* the drum shield was indented about 0.1 mm and the sealing lid was not affected. No release fraction of the content and no other damages were observed.

The qualification program is conclusive enough to qualify this container as a reliable one, suitable for conditioning, temporary or final storage of LLW wastes.

3. The assessment of the radiological risks due to road wastes transport, in Romania

The transport of radwaste is carried out under the authority of the Romanian National Commission for Nuclear Activities Control (CNCAN). The road route covers 608 Km to the national repository, Baita. To evaluate the probabilities and collective dose for normal transportation and those resulting from accidents involving radioactive shipments, the IAEA computer code INTERTRAN II has been used. The population along the route was considered to be distributed among three population density zones: *urban 5%, intermediate (45%), and rural (50%).* The collective doses assessed are: *dose to public alongside route:* 0.75×10^{-3} *personSv/y; dose to public during stops:* 1.12×10^{-5} *personSv/y; dose to* *package truck crew: 1x10^{-3} personSv/y; dose to public sharing route: 0.3x10^{-4} personSv/y.* The annual collective dose to members of the public of 2.17x10^{-3} *person-Sv* and can be compared with what is received due to naturally occurring cosmic sources: *1.8x10^{-3} Sv/y***.** The annual collective dose to a member of the public corresponds to *0.34x10^{-4}* expected fatalities/y due to routine transport. The calculated individual dose is ***0.****25 μS/y* and the associated latent cancer fatality risk is 1.2x10^{-8}/y. Using the following model given in Figure 2 the accident risk analysis for transportation of radioactive wastes has been done:

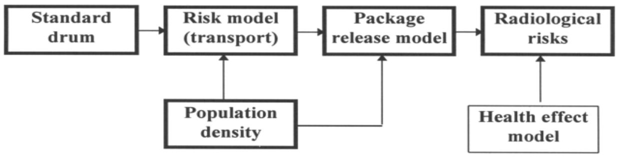

Figure 2: The accident risk analysis model

The defined accident scenarios were: *impact with a bridge; collision with a second road vehicle; collision with a train at level crossing; collision with train on railway adjacent to route***.** The accident probabilities are: *probability of impact only: 0.537x10^{-5}/(package journey); probability of impact and fire: 1.43x10^{-11}/(package journey).* For 10 shipments per year, the accident frequencies of accident are: *probability of impact only: 5.37x10^{-5}/year; probability of impact and fire: 1.43x10^{-10}/year.* It is also assumed that, following packaging failure, the content may become available for dispersion in the air. Therefore, two impact release possibilities were taken into consideration: *low wind speed condition and high wind speed condition.* For an impact in low speed conditions, the package release fraction was taken to be *4x10^{-6}* and for impact in high speed conditions, the fraction is *10^{-4}*.

4. The assessment of risks and radiological consequences for wastes transport by rail

The rail route covers 764 Km from Bucharest to Stei**.** There is a single wagon with a capacity of 72 standard packages of 220 liters each in volume. Between 1995 to 2001, 6045 packages were transported to Baita.The average population density along the route is 93 population/Km^2**.** Transport and handling accidents may occur posing a risk for human beings and the environment. The magnitude of such a release and the related frequency of occurrence depend on a number of factors such as: type and volume of waste being transported, severity and frequency of accidental events (collision, rail derailment, striking an object, vehicle derailment, etc)**.**

The risk assessment method adopted includes steps such as: characterization of the type and quantity of waste shipments; determination, selection and description of the type, severity and probability of occurrence of transport and handling accidents; assessment of transport packaging and waste to specific mechanical impact and release fraction; estimation of radioactive release and frequency of occurrence taking into account the shipping patterns and the accident severities; assessment of potential radiological consequences for the spectrum of wealth condition encountered along the rail transport route. For this assessment, an accident rate of about 1x10^{-6} train. km, was assumed as the most representative. 9 severity categories were taken into consideration: 3 mechanical and 6 combined-mechanical and thermal. The accidents involve: impact between train and road vehicles, derailment, collision between trains and fire. Three severity levels were defined: < 40Km/h, 40 ÷ 80Km/h, > 80Km/h**.** The relative frequencies determined were: for mechanical-only accident: 93%; for combined mechanical: 5%; and for fire engulfing: 2%**.**

Several kinds of operations contribute to the overall risk: rail transport, road transport, marshalling yard operations and railroad transfer activities. It has been concluded that the transportation by rail represents the most dominant risk contributor. The risk assessment results referred to the total volume of wastes transported in the period of 1985-1998. The container dose rate has conservatively been assumed to be 0.2mSv/h at 1m from the container surface. The computer code INTERTRAN 2 has been used to determine the collective dose to population and transport personnel. The results are: *crew:* 1.57x10^{-2} person Sv/y**;** *members of public***:** 2.39x10^{-2} person Sv/y; *total:* 3.96x10^{-2} personSv/y**.**

It is to be noted that for members of the public, the radiological impacts were calculated along the shipping route (performing the dose calculation over a distance of 800 m on each side), and during stop time. A total collective dose of 0.01 person Sv/y for professional exposures concerning crew of train and the loading personnel has been estimated. At each loading terminal radioactivity releases are not expected to occur in close proximity of accident site at a probability level as low as $10^{-7,}$ i. e, a chance of 1 in 10 million for the total volume of bituminous waste. If expressed as probability per year, the corresponding value would be well below 10^{-8} per year.

5. Conclusions

The type A package will survive most potential road and rail accidents intact but will fail to forces greater than those specified in the IAEA's Regulations. The determined radiological risks from routine and accident exposure associated with the transport process, represent insignificant increase over natural background dose. It is concluded, on the basis of the best estimation of these accident probabilities, that the proposed radioactive materials transport in Romania are safe and would have acceptably low societal, individual and expected risk values.

Acknowledgement

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RADIATION PROTECTION PROGRAMMES FOR THE TRANSPORT OF RADIOACTIVE MATERIAL - UK GUIDANCE

J. S. Hughes, K. B. Shaw

National Radiological Protection Board,
Chilton, Didcot, Oxfordshire OX11 0RQ
United Kingdom

Abstract.

The latest IAEA Regulations for the Safe Transport of Radioactive Materials require the establishment of Radiation Protection Programmes (RPPs). In the UK this requirement has been included in the latest edition of the regulations on the transport of radioactive materials by road. Guidance has recently been issued on this topic to assist UK operators in the formulation of RPPs.

1. New regulatory requirement

The latest Regulations for the Safe Transport of Radioactive Material were published by the International Atomic Energy Agency (IAEA) in 1996, and revised in 2000 [1]. One of the major new requirements in these model regulations was that those involved in the transport of radioactive material must establish a Radiation Protection Programme (RPP). An RPP contains systematic arrangements that are aimed at providing adequate consideration of radiation protection measures, and such programmes shall be available, on request, for inspection by the relevant competent authority.

A draft IAEA TECDOC has been produced that gives guidance on the content and application of RPPs. In the UK, this draft TECDOC has been used as the basis for a guidance document which aims to provide UK operators with advice on the establishment of an RPP within the framework of the UK regulatory environment.

2. UK legislation

In the UK there are separate but consistent regulations for the transport of radioactive materials by road, rail, sea and air. There are additional controls provided by general legislation such as the Ionising Radiations Regulations 1999 (IRRs) [2] and the Radioactive Substances Act 1993 [3].

For the transport of radioactive materials the executive role of the competent authority is carried out by the Radioactive Materials Transport Division (RMTD) of the Department for Transport. Enforcement of modal regulations is by the Department for Transport, HM Railway Inspectorate, the Maritime and Coastguard Agency and the Civil Aviation Authority.

The Ionising Radiations Regulations 1999 give effect to the basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation. The general provisions of these regulations apply to transport operations: they include requirements for control of exposure, Radiation Protection Advisers, training, assessments and notifications. The Health and Safety Executive is the enforcing authority.

The Radioactive Substances Act requires registration for the use of radioactive materials and authorisation for the disposal of radioactive materials. The Environment Agency administers and enforces the Act in England and Wales and in Scotland the relevant body is the Scottish Environment Protection Agency.

The Radioactive Material (Road Transport) Regulations 2002 [4] includes the requirement for an RPP. The UK RPP guidance document is intended to provide UK users of the transport regulations on how a Radiation Protection Programme can be established and implemented.

3. UK Road regulations

The Radioactive Material (Road Transport) Regulations 2002 state the following:

"Radiation Protection Programme - Regulation 24.

(1) This regulation applies to every carrier, consignor and consignee involved in the transport of a consignment and in this regulation an "employee" of a carrier, consignor or consignee includes any person who is an agent and any other person of whose services that carrier, consignor or consignee makes use in the transport of a consignment.

(2) Every carrier, consignor and consignee must, as respect his employees, establish a radiation protection programme which -

  (a) takes into account the nature and extent of the measures to be taken in respect of the magnitude and likelihood of radiation exposure, and

  (b) adopts a structured and systematic approach (including consideration of the interfaces between road transport and other activities).

(3) A carrier, consignor and consignee will be regarded as meeting his obligations under paragraph (2)(a) if he carries out and adheres to the relevant provisions of Part II (general principles and procedures) of the Ionising Radiations Regulations (1999).

(4) Every carrier, consignor and consignee must -

  (a) at suitable intervals (not exceeding 3 years) review and, where necessary, revise the radiation protection programme as respects his employees, such review taking into account any changes that have occurred in the transport of radioactive material to which the programme relates as well as any advances in technical knowledge and any material change to the assessment on which the programme was based;

  (b) upon a written request made to him by the secretary of state, make his radiation protection programme, or any revision of it, available to the Secretary of State."

4. Summary of Guidance

The UK guidance document follows the main features of the draft IAEA TECDOC and is summarised below.

Fundamentals of radiation protection.

There are three basic radiation protection principles for practices, which may give rise to exposure to radiation, they are:

- justification of a practice, i.e. no practice shall be adopted unless it produces a net benefit;
- limitation of dose and risk to individuals, i.e. exposure of individuals should be subject to dose and risk limits;
- optimisation of radiation protection and safety, i.e. all exposures shall be kept as low as reasonably achievable, economic and social factors being taken into account (ALARA principle).

The ALARA principle is the driving force behind the establishment of a Radiation Protection Programme (RPP) for the transport of radioactive material.

The International Commission for Radiological Protection (ICRP) [5] stresses that:

> "Much can be achieved in optimisation of protection, particularly in everyday operational control, through the use of professional judgement by suitably qualified, experienced and competent persons. The following are suggested to help judge if an action is reasonable:
>
> (a) Common Sense: this reflects experience, knowledge and the exercise of professional judgement. For example, a very low cost yet practical change that reduces dose probably should be done even if doses are already low.

(b) Good Practice; this compares what has been or is expected to be achieved with what has been achieved for similar or related facilities or practices. Care must be taken to ensure that reasonableness is maintained and that unwarranted expenditures do not become the norm."

In a paper on transport radiation controls and assessment [6] it is concluded that:

"The control measures required for transport purposes cannot in themselves ensure that the exposures of workers or members of the public are as low as reasonably achievable. Periodic assessments and, where appropriate, individual monitoring must occur."

5. Objectives

RPPs are intended to provide and document in a systematic and structured way the framework of controls applied by a transport organisation to satisfy the radiation protection principles and provisions: in particular to limit both the normal and potential exposures of workers and members of the public.

The objectives of an RPP for the transport of radioactive material are to:

- provide for adequate consideration of radiation protection measures,
- ensure that the system of radiological protection is adequately applied,
- enhance the safety culture, and
- provide practical measures to meet these objectives.

An RPP may consist of one or several documents and may be a part of the operator's general QA programme.

The operational radiation protection objectives incorporated in a programme may be diverse in nature and may reflect, for example, regulatory, managerial or operational requirements and criteria concerning radiation protection in transport. The nature and extent of control measures to be employed in an RPP should be related to the magnitude and likelihood of radiation exposures, i.e. the control measures employed are expected to be commensurate with the level of hazards arising from radioactive material transport ('graded approach'). Radiation Protection Programmes cover all aspects of transport and associated conditions including routine transport conditions and transport and handling incidents and accidents.

6. Need for and scope of RPPs in transport

A Radiation Protection Programme should cover all aspects of transport, but the main emphasis should be on the stages of transport operations giving rise to exposure to radiation. For example packing, preparation, loading, handling, storage-in-transit and movement of radioactive material packages and maintenance of packages.

The first step in establishing an RPP is to make a prior radiological evaluation of the situation. This involves a description of the type, nature and volume of radioactive material being shipped, the magnitude and likelihood of radiation exposures arising from these transport operations, the number of workers potentially involved and the duration of the operations involved and the distances from the radioactive materials. This information will allow the operator to define the scope of the RPP.

Radiation Protection Programmes define and document a systematic and structured way for the framework of controls to be applied by a transport organisation with the prime aim to optimise protection and safety in the transport of radioactive material. It is generally recognised that optimisation of protection and safety of workers and the public is most effectively addressed at the early stage of transport related activities such as the design, manufacture, scheduling and preparation of the radioactive material packages. The implementation of this approach may not be satisfactory for a variety of transport conditions. In particular, for more complex shipping conditions which may involve many organisation and transport related activities, there are transport related operations and related radiation protection considerations that are outside the scope of the radiation protection controls provided for by the designer of a package or manufacturer of packages. An example would be the lack of safety culture of the carrier or consignor. Even if radiation protection and safety have been optimised at the pre-operational stage of a radioactive material shipment and priority is given to the package design and technical measures for controlling exposure to radiation, there is generally still a need for optimisation of radiation protection arrangements at the various stages of transport operations.

An RPP is required for the operational stages of loading, carriage, in-transit storage, intermodal transfer, unloading and delivery of radioactive material packages at the final destination and maintenance of unloaded packages (if contaminated or containing residual radioactivity). An RPP is therefore mainly concerned with the loading, carriage, handling, delivery and unloading procedures involved with the operations on packaged or unpackaged radioactive material by the consignor, carrier, in-transit storage and transfer point operator and consignee.

The radiation protection controls employed in an RPP for these operations may encompass a broad set of regulatory or technical safety requirements but should be commensurate to the magnitude and likelihood of radiation exposures being incurred. The controls should be reasonably related to the hazards arising from radioactive material transport and consequently a graded approach is applied as shown in Table 1. Small operations involving only a limited number of package shipments may require a short RPP while more significant operations with very diverse materials and packages being shipped and handled in the public domain need to have a more significant programme in place. An RPP should cover all aspects of transport and associated conditions of transport including normal, routine and accident conditions of transport.

There are cases of a dedicated carrier or shipper organisation contracted solely for transport operations of a specific consignor or consignee. The consignor/ consignee has a properly developed RPP in place and this may cover the carrier or shippers operations. In such circumstances the competent authority may not require the carrier or shipper to have a separate RPP solely for transport if all relevant radiation protection obligations are accounted for by the relevant consignor or consignee organisation.

The principal radiation protection consideration to be accounted for in an RPP should, consistent with the programme structure outlined in Table 1, cover the following basic elements contributing to protection and safety. Each element should be documented with the appropriate level of detail:

- roles and responsibilities for the implementation of the programme,
- dose assessment and optimisation,
- surface contamination assessment,
- segregation and other protective measure,
- emergency response arrangements,
- training and information and quality assurance (QA).

7. Occupational dose and elements of an RPP

The basic elements of an RPP are shown in the first column of Table 1, RPP elements versus occupational dose.

Different factors determine the importance of each of these basic elements of an RPP such as dose rate, A_1/A_2 content, number of packages transported annually or public access to packages.

Low occupational dose or occasional transport does not mean an RPP is not required; for instance transport of high activities in heavily shielded packages generally gives low doses but still requires thorough consideration of other basic elements such as emergency response and training.

Depending on the assessed effective dose for occupational exposures arising from transport activities, it is possible to apply a graded approach to the RPP element requirements, for example where it is assessed that the effective dose:

- is most unlikely to exceed 1 mSv in a year, very little action, apart from optimisation, needs to be taken in this dose range for evaluating and controlling worker doses,

- is likely to be between 1 and 6 mSv in a year, a dose assessment programme is necessary and can utilise work place monitoring or individual monitoring,
- is likely to exceed 6 mSv in a year, individual monitoring of the transport personnel is mandatory.

High external dose rates do not necessarily result in high doses. Operational procedures and other protective measures including segregation are important in such circumstances.

8. Example of an RPP

In order to give practical assistance to operators in formulating their own RPP, examples of RPPs for each mode of transport are given in the UK guidance document. The RPP for road transport, developed at an international meeting, is given in Table 1 as an example.

TABLE 1. RPP ELEMENTS VERSUS OCCUPATIONAL DOSE

RPP Element	Occupational dose *		
	Not more than 1 mSv in a year.	More than 1 mSv in a year but not more than 6 mSv in a year	More than 6 mSv in a year
a) Scope	Yes		
b) Roles/Responsibilities	Yes		
c) Dose Assessment	No monitoring required	Workplace or individual monitoring	Individual monitoring mandatory
d) Dose Limits/Constraints/ Optimisation	Yes, but basic optimisation	Yes	
e) Surface Contamination	Must be considered		
f) Segregation** and other protective measures	Only applicable to II-YELLOW, III-YELLOW, III-YELLOW under exclusive use (and packages containing fissile material)		
g) Emergency Response **	Yes		
h) Training **	Yes		
i) Quality Assurance **	Yes		

* Note: A graded approach should be used as appropriate for each RPP element.

** Not only an RPP element, broader considerations may be involved. An RPP can, however, refer to elements existing elsewhere.

8.1. Scope

This RPP covers the shipment of encapsulated and non-encapsulated sources, nuclear fuel samples, contaminated and activated material, conditioned and unconditioned waste.

The radioactive material may be packaged in Excepted, Industrial, Type A, Type B(U), Type B(M), H(U), H(M) or Type C packages. The radioactive material may also be fissile material.

The shipments can be carried out if necessary under special arrangement. Normally the shipments are carried out under exclusive use, using transport equipment that is exclusively used for this type of transport. All the operators and drivers are occupational radiation workers with individual dose control on a monthly basis.

8.2. Roles and responsibilities

The overall responsibility for all items regarding radiological protection is taken by the person responsible for radiological protection, who is, if applicable, qualified according to regulatory and legal requirements. The administrative verification of the information concerning the shipment is the role of the administrative personnel of the carrier, using a checklist that indicates the different items for example:

- information on the radioactive material,
- description of the material,
- type of packages to be shipped,
- activity, isotopes, amount of fissile material,
- labels on packages /expected dose levels (contact and 1 m from the surface),
- certificate of absence of contamination, and
- information on actions to be taken in the event of an emergency.

The loading of the packages, securing of the packages on the vehicle, following the applicable instructions or procedures, the verification that markings and labels on the packages and placards on the vehicle correspond with the transport documents, etc. is the role of the driver. The driver uses a checklist.

8.3. Dose assessment and optimisation

The dosimetry for the workers is performed using individual dosemeters on a monthly basis. If dosemeter readings above background (or above the "normal" value) are encountered, an explanation should be given to the person responsible for radiation protection. In some cases investigation of abnormal (high) values should be undertaken in order to avoid the same problem occurring in the future (corrective/ preventive actions).

If new types of transport are envisaged and if is likely that this practice could result in doses to workers or public, a preliminary study should be carried out. This study can result in the production of appropriate specific instructions or procedures. These should be issued under the responsibility of the person responsible for radiation protection.

Before transport, dose rate measurements have to be carried out following an existing set of instructions. These measurements (contact vehicle, 2 m from the vehicle, driver's seat and – if appropriate – in contact with and at 1 m from the package(s) surfaces) have to be reported on the checklist. These readings should be compared with regulatory limits and if applicable with expected or estimated values. If unexpected or non-conforming values are found, appropriate countermeasures should be undertaken.

If the radiation is not only due to gamma radiation but if there is a substantial contribution from other radiations, for example due to neutron radiation, this should be taken into account.

8.4. Surface contamination

If third party transport equipment (vehicles, wagons, or freight containers) has been used, and this equipment is not exclusively used for radioactive material transport, this equipment should be verified to be free of any contamination before further use.

Other vehicles or equipment, which are used exclusively for radioactive material transport by the same carrier or company, should be controlled for surface contamination on a regular basis. Such control is also required if incidents happened with potential contamination consequences. Contamination should be removed according to existing procedures or instructions, approved by the Radiological Protection Officer. These instructions should also take into account the safe removal of potentially contaminated waste produced during this action.

8.5. Segregation and other protective measures

If II-Yellow or III-Yellow packages are loaded on a vehicle or the consignment is under exclusive use, specific or special procedures for loading, unloading, tie down etc. could be used. These instructions or procedures should be issued under the responsibility of a qualified person.

For packages transported under special arrangement, the use of special equipment, remote handling controlled by Closed Circuit Television (CCTV) may be the compensatory measures specified in the special arrangement certificate.

Although not part of a general RPP, if criticality is an issue then segregation will need to be considered for the purpose of criticality control.

8.6. Emergency response

A procedure or instruction for emergency response is required, and should take into account any instructions given by the consignor.

- actions to be undertaken by the driver.
- actions to be undertaken by the carrier (office).

The instructions for the driver should be very clear and limited:

1. Take care of people in danger (first aid, emergency medical help).
2. Risk of, or existence of, fire.
3. Information on carriers office.
4. Keep communication lines (telephone, radio) open.

Account should be taken of the fact that the driver could be injured or not in a capacity to act. A card with pictograms to facilitate communication with people having different language skills may be helpful.

8.7. Training

External training and on the job training in relation to the function and responsibilities of the different people (drivers, radiation protection agents, administrative personal, secretariat) should be provided under the supervision of the person responsible for radiological protection. The training should be in compliance with regulatory and legal requirements and should concern the radiation hazards involved and the precautions to be observed in order to ensure restriction of their exposure and that of other persons whom might be affected by their actions.

8.8. Quality Assurance

Application of quality criteria, such as document control, document review, issuing and review of instructions and procedures, follow-up of non-conformities, etc. should be done in accordance with the existing QA programme.

References

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Regulations for the Safe Transport of Radioactive Material, IAEA, Vienna, Safety Series TS-R-1 (ST-1 Revised), 1996 Edition (Revised), 2000.

[2] The Ionising Radiations Regulations 1999. SI 1999 No.3232. The Stationery Office Limited.

[3] Radioactive Substances Act 1993. HMSO 1993.

[4] The Radioactive Material (Road Transport) Regulations 2002. SI 2002 No.1093. The Stationery Office Limited.

[5] ICRP, Annals of the International Commission on Radiological Protection, Vol.27, No.1. General Principles for the Radiation Protection of Workers, ICRP Publication 75 (1997).

[6] SHAW, K.B., HUGHES, J.S. AND GELDER R. Transport Radiation Control and Assessments. RAMTRANS. Vol.10, No.3, pp 155-159 (1999).

PRESENT STATUS ON RADIATION PROTECTION FOR TRANSPORT OF RADIOACTIVE MATERIAL IN JAPAN

Y. Ikezawa[a], H. Yonehara[b], S. Ishimaru[c]

[a]Institute of Radiation Measurements, Tokai-mura, Ibaraki,
[b]Ministry of Education, Culture, Sports, Science and Technology, Tokyo,
[c]Ministry of Land, Infrastructure and Transport, Tokyo,
Japan

Abstract

This report outlines the requirements of radiation protection in the transport regulations for safe transport of radioactive material which has been implemented for long period in Japan, including the provisions such as dose standards, definition of transport and carriers, dose limitation and dose rates, evaluation of contamination, segregation of packages, training, emergency response and quality assurance. Also, the reviewing situation for incorporating the exemption levels of radioactive material in 1nternational Basic Safety Standards (BSS) into our domestic regulations is presented.

1. Introduction

The relevant regulations concerning the transport of radioactive material were revised in 2001, with incorporation of the IAEA transport regulation [1] in taking account of the special situation of our country. One of the major changes in the1996 IAEA transport regulation is the requirement for the establishment of radiation protection programme to emphasize the optimization for the procedure of radiation protection. The relevant regulations concerning the transport of radioactive material in our country are divided into three groups; the regulations for transports by land, by sea and by air, and the transports by land are subdivided into transport of nuclear fuel material and that of radioactive material except nuclear fuel material. The basic concept and criteria on radiation protection for carriers and the public are prescribed in these regulations. The outline is described below.

2. Requirements of radiation protection

2.1. Definition of transport and carriers

The transports of radioactive material are classified into the transport outside facilities (public road, sea and air) and that within facilities. In most cases the former includes the carriage including in-transit storage of packages, and the latter includes the preparation, consigning and receipt at the final destination of packages. The carriers during transport outside facilities are controlled with the standards of dose limitation in the transport regulations. On the other hand the carriers within facilities are designated as radiation workers within the facilities by the employers and subjected to radiation control according to ICRP 1990 recommendation [2]. In case of transport of type B(M) packages it is required by the regulatory authorities that the carriers should be accompanied by an expert (a national licensee for safe handling of nuclear fuel material or radiation protection etc.) in order to supervise the safety of radioactive material, and carry with the radiation measuring instruments and the protective devices.

2.2. Dose limitation and dose rate in working area

For the transport outside facilities it is a basic concept of dose limitation in our transport regulations that the exposure of carriers should not exceed the dose standard of 1mSv/y. Therefore, it is needed that the dose rate at any normally occupied position of road vehicles should not exceed 0.02mSv/h. In the approval of transport by sea the dose limitation beyond 1mSv/y would be approved by the regulatory authorities under the condition of implementing adequate dose management for carriers. The dose rate from the outer lateral surfaces of vehicles is provided not to exceed 0.1mSv/h at 2 meters in the IAEA transport regulation, while our transport regulations provides the same dose rate at 1 meter mainly to prevent exposure of the public.

2.3. Evaluation of dose

For any type packages other than excepted packages it is requested by the regulatory authorities that the carriers should confirm the calculated doses with the time engaged in transport and the dose rate in the working area, or the doses measured with individual monitoring. Especially, for the transport by air the carriers should submit each dose a year to pilots, cabin crews and ground workers calculated using the respective prescribed equation to the regulatory authority.

2.4. Criteria and inspection of contamination

Inspection of contamination on surfaces of packages and conveyances is carried out according to the same procedures as that provided in the IAEA transport regulation. Generally, non-fixed contamination on surfaces of the packages for nuclear fuel material is examined at one order of magnitude stricter contamination levels (beta and gamma emitters; 0.4 Bq/cm^2, alpha emitters; 0.04Bq/cm^2) by carriers or consignors.

2.5. Segregation of packages

In the transport by land, the different dose rates from those of the IAEA transport regulation as shown in Section 2.2. are applied to the segregation of packages with the categories of II-YELLOW and III-YELLOW. In the transport by sea the dose rate at any normally living place of vessel should not exceed 1.8 μSv/h. In the transport by air the carriers have made use of the table for segregation distance which presents the relation between total of TIs in the group and minimum permissible distance to prevent the exposure of them and passengers.

2.6. Training

The basic training course (basic knowledge of nuclear power and radiation, the relevant regulations, manual of safe transport of radioactive material) and the special training course (technical criteria and standards for safe transport) are periodically held for the applicants of carriers by the regulatory authorities.

2.7. Emergency response

In responding the transport accident involving nuclear fuel material, the emergency measure will be taken by co-operating with the parties such as carriers, consignors, fire fighting, police, experts for radiation protection or safe handling of nuclear material under directions of the authorities concerned. Should the packages containing nuclear fuel material lose their integrity and exceed 10mSv/h at 1 meter from the packaging, the emergency response organizations for nuclear disaster prevention will be set up with national and local authorities.

2.8. Quality assurance

The quality assurance programme is established to ensure that the type B packages, fissile packages and UF_6 packages are manufactured with the methods and materials used in accordance with the approved design specifications by the regulatory authorities.

The summary described above is shown as Table I.

Table I: Comparison between transport modes and provisions for radiation protection in the regulations

Transport mode	Land		Sea	Air
	Outside facilities	Within facilities		
Dose standard	≤1mSv/y	≤100mSv/5y (max 50mSv/y)	≤1 mSv/y(Ap-proval: >1mSv/y)	≤ 1mSv/y
Carrier	driver, assistant	radiation worker	person on board	crew
Dose rate in working area	· any normally occupied position of vehicle : 0.02mSv/h · from outer surface of vehicle : 0.1mSv/h at 1 m · others : the same as IAEA regulation		the same as IAEA regulation	the same as IAEA regulation
Dose evaluation	individual monitoring or estimation	individual monitoring	individual monitoring or estimation	
Contamination	the same as IAEA regulation			
Segregation of packages	the same as above dose rate		any normally living place : ≤ 1.8μSv/h	use of table of segregation distance
Training	for applicants	regulated	for applicants	
Emergency response	setup of organizations of nuclear disaster prevention and emergency measure regulated			
Quality assurance	apply to type B packages, fissile packages and UF_6 packages			

3. Reviewing situation for incorporating exemption levels of radioactive material

The exemption levels of radioactive material were reviewed by the Radiation Council to incorporate those of International Basic Safety Standards (BSS) [3] into the regulations involving radioactive material. As the result, it was judged that the exempt radioactive material do not give the significant exposure to the public even if these levels are adopted by the regulations. In the near future the exemption levels of radioactive material provided in the 1996 IAEA transport regulation will be incorporated into the relevant transport regulations in Japan.

4. Conclusion

In the transport of radioactive material in Japan there is no accident which resulted in abnormal exposure to the public and led to significant contamination on the environment in the past. And no transport worker has exceeded the exposure standard of 1 mSv/y until now. For the future it would be necessary that more consideration should be paid on applying the transport regulations concerned in taking account of types and categories of packages in order to implement more reasonable radiation protection in the regulations according to the magnitude and likelihood of radiation exposure.

References

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Regulations for the Safe Transport of Radioactive Material, Safety Standard Series No.TS-R-1(ST-1, Revised), IAEA Vienna (2000).

[2] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, ICRP Publication No. 60(1996).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, IAEA No.115, IAEA Vienna (1996).

TRANSPORT SAFETY APPRAISAL SERVICE (TRANSAS) MISSION TO THE UNITED KINGDOM

C. N. Young

Department for Transport, Great Minster House,
76 Marsham Street, London SW1P 4DR,
United Kingdom

Presented by ***Error! Unknown document property name.*****Abstract.**

A Transport Safety Appraisal Service (TranSAS) mission to the United Kingdom was carried out between 9 and 21 June 2002. This paper reports on the conduct of the TranSAS mission, which is more fully described in Ref. [1]. TranSAS identified 3 “Recommendations”, 21 “Suggestions” and 15 examples of “Good Practices” in the UK’s application of the IAEA’s Regulations for the Safe Transport of Radioactive Materials [2].

1. Introduction

In September 1998 the IAEA General Conference adopted Resolution GC(42)/RES/13 which, inter alia, recognized “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” and further requested “the Secretariat to provide for application of the Transport Regulations by - inter alia - providing a service, within existing resources, for carrying out, at the request of any State, an appraisal of the implementation of the Transport Regulations by that State.” The availability of this service, which became known as Transport Safety Appraisal Service (TranSAS), was made known to Member States by the Director General in letter J1.01.Circ. of 10 December 1998. The objective of a TranSAS mission is to assist the requesting Member State in evaluating and, as necessary, improving its Class 7 transport safety regulatory programme by providing:

- an appraisal of the State’s transport safety regulatory practices with respect to requirements of the Agency’s Transport Regulations and related international standards and guidelines; and
- recommendations, as appropriate, in areas where the State’s transport safety regulatory programme might be improved.

GC42/RES/13 also invited states shipping radioactive materials to provide, as appropriate, assurances to potentially affected States upon their request that their national regulations take into account the Agency's Transport Regulations and to provide them with relevant information relating to shipments of radioactive materials. This request has been repeated in subsequent resolutions in succeeding years (see GC(43)/RES/11, GC(44)/RES/17 and GC(45)/RES/10) reflecting the concerns of some States as to whether the Agency’s Transport Regulations were being universally adopted. The UK has regularly provided this information to the Agency as its national legislation has been updated. However, concerns over the safety of transport of radioactive materials persist.

2. Why TranSAS ?

The continuing safety concerns with radioactive material transport of some states were clearly not being satisfied by reassurances from the shipping states that their national regulations took account of the Agency’s Transport Regulations. Nor were they satisfied with other information made available to them. The perceived lack of transparency of operations (though to an extent inevitable for good security and commercial reasons) was hindering understanding of the measures which are in place to ensure safety.

Since requirements for Quality Assurance first appeared (in respect of manufacture of transport packagings for transporting radioactive material) in the 1973 Edition of the IAEA's Transport Regulations [3], the United Kingdom has been concerned to ensure that appropriate quality assurance measures are in place. The 1985 Edition of the IAEA's Transport Regulations [4] extended the requirements for quality assurance to embrace all aspects of transport of radioactive material, including the design, manufacture, testing, documentation, use, maintenance and inspection of packages. The1985 Edition also introduced requirements for Compliance Assurance which apply explicitly to the Competent Authority, which in the current IAEA Regulations [2] reads:

"The competent authority is responsible for assuring compliance with these Regulations. Means to discharge this responsibility include the establishment and execution of a programme for monitoring the design, manufacture, testing, inspection and maintenance of packaging, special form radioactive material and low dispersible radioactive material, and the preparation, documentation, handling and stowage of packages by consignors and carriers, to provide evidence that the provisions of these Regulations are being met in practice."

The Radioactive Materials Transport Division of the Department for Transport set up an in-house Branch in 1985 to ensure that the compliance assurance duties which fall to the Competent Authority are being fulfilled in all areas of its jurisdiction.

TranSAS offered a unique opportunity, not only to demonstrate that the UK Competent Authority's responsibilities under the Agency's Regulations to put in place appropriate national legislation are being fulfilled, but also to demonstrate that these are being followed and enforced "in the field" and Compliance Assurance is being achieved, thus "….. providing evidence that the provisions of these Regulations are being met in practice".

3. Planning and logistics

On 6 July 2001, in a letter from the Ambassador and Permanent Representative of the United Kingdom (UK) Mission to the Director General of the IAEA, the UK requested the IAEA to organize and conduct a TranSAS mission. An initial planning meeting took place 18 – 20 December 2001 in London between the IAEA and UK government representatives, following which a draft agreement was drawn up defining the scope of the mission as follows:-

The UK TranSAS Mission shall address all modes of transport (road, rail, maritime and air) with an emphasis on marine transport, and shall consider all relevant aspects of the regulation of the transport of radioactive material in the UK with regard to the requirements specified in the IAEA Regulations for the Safe Transport of Radioactive Material and other relevant international regulatory documents (e.g. the model regulations of the UN Committee of Experts' and the regulatory documents of the international modal organizations). Neither physical protection nor legal liability, which are not component parts of transport safety, will be addressed in this TranSAS Mission.

The draft agreement also defined how the mission team would be selected by the Agency to ensure that a balance would be achieved, not only from a geographical representation perspective, but also regarding the technical expertise of the team members and, as all modes of transport were to be addressed during the Mission (with a special focus on marine transport), expertise within the team in each of the modal areas was needed. The final team makeup consisted of 14 individuals from the IAEA Secretariat, Member States and International Organizations, including three observers[1].

[1] Argentina, Brazil, Japan, New Zealand, Peru, Spain, Turkey, USA (2), IAEA (2), ICAO, IMO (2).

Detailed planning for the mission reflected the need to appraise a wide spectrum of transport regulatory activities and operations over the full range of modes during a period of two weeks 9 to 21 June 2002. To achieve this required the team to attend at many locations within the UK. It was therefore necessary to divide the full team into up to three subteams to enable the ground to be covered. The logistics to achieve this were achieved with two minibuses to transport the team according to the schedule shown in Table 1.

Table 1. Schedule of the UK TranSAS Appraisal

Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
					Day 1. Team travels to London	Day 2. Training Meeting in London
Day 3. Plenary meeting with Team and UK Counterparts; introduction of team and UK counterparts, overview briefings by UK authorities Subteam A review of MCA (briefings by MCA, review of documents, individual interviews, emergency procedures) Subteam B reviews compliance assessments of operations at DfT Subteam C reviews regulatory design assessment at DfT	Day 4. Subteam A review of MCA (briefings by MCA, review of documents, individual interviews, emergency procedures) Subteam B reviews compliance assessments for emergency response at DfT Subteam C reviews regulatory design assessment at DfT *Subteams to depart to Barrow 1.30pm.*	Day 5. Team. Morning, inspection tour of ship/ review ships certificates and documents. Subteam A Assessment of INF Ships against INF Code Subteam B Review Carrier's Emergency Response facilities, for maritime operations and operational aspects of maritime transport in Barrow, Subteam C Reviews Road/rail operations	Day 6. Subteams A and B review maritime/rail intermodal activities, review of rail activities at Barrow Subteam C reviews maritime radiation protection programmes used in ship operations Afternoon: - All, team review, questions and answers with UK points of contact.	Day 7. *Team travels to Sellafield.* Subteams A, B and C at Sellafield (briefings on flask activities and experience with contamination; tour of flask receiving, handling, storage and maintenance facilities; review of flask maintenance QA documentation) Team meeting with key counterparts	Day 8. Day off	Day 9. *Team travel to London* Team housed in London Informal Team meeting in London in evening
Day 10. Team initiates partial drafting of report, co-ordinates with key counterpart at DfT	Day 11. Subteam D CAA appraisal at Amersham, tours/visits at Amersham, freight-forwarder /air-operator, Heathrow [Air, Road, intermodal] Subteam E tours nuclear power station [Road, Rail, intermodal] Subteam L meeting with legal personnel	Day 12. Team prepares initial full draft report, co-ordinating with key counterparts from DfT, MCA, HSE, CAA and DTI	Day 13. Team completes full draft report, co-ordinates with key counterparts as needed	Day 14. Exit meeting and report by individual Team members on their findings in their fields of expertise, response by key counterparts from UK Team travels home	Day 15. Team travels home as needed	

4. Findings

The TranSAS mission findings were structured into "Recommendations", "Suggestions" and "Good Practices", defined as:-

Recommendation: a recommendation is advice on improvements that can be made in the national regulatory arrangements in the areas that have been reviewed and discussed. Such advice is based on proven international practices and should deal with the root causes rather than the symptoms of the concerns raised;

Suggestion: a suggestion either is an additional proposal in conjunction with a recommendation or may stand on its own following a discussion of the associated background. It may indirectly contribute to improvements in national regulatory arrangements but it is primarily intended to make the regulatory body's performance more effective, to indicate useful expansions of existing programmes and to point out possibly superior alternatives to current work;

***Good practice*:** a good practice is an indication of an outstanding organization, arrangement, programme or performance, superior to those observed elsewhere, and more than just the fulfilment of current requirements or expectations. It has to be superior enough to be worth bringing to the attention of other nuclear regulatory bodies as a model in the general drive for excellence.

TranSAS identified 3 "Recommendations", 21 "Suggestions" and 15 "Good Practices" as follows:

4.1 Recommendations

- It is recommended that a written formal report be issued for each package design certificate and special arrangement certificate, including modifications to the certificates that clearly documents the basis of the approval.
- It is recommended that compliance assurance activities for transport include a systematic review of the non-competent authority approved package designs on some sort of sampling basis.
- It is recommended that the Department for Transport should evaluate the adequacy of its audit and inspection programme and necessary resources should be provided for audits and inspections. Specifically, minor consignors and consignors of mobile sources should be more fully integrated into this programme. Priorities should continue to be risk based to maximize the effectiveness of the limited resources.

4.2 Suggestions

- It is suggested that the Department for Transport consider encouraging the Carriage of Dangerous Goods Committee, consistent with its authority to liaise and co-ordinate with other governmental bodies, to re-establish and implement plans for joint agency enforcement liaison exercises, with a view to convening at least one exercise yearly.
- It is suggested that the UK evaluate the adequacy of its staffing and financial resources for the various regulatory bodies to ensure they are able to fulfil their responsibilities including those in the areas of "authorization" (e.g. the approval of packages designs), regulatory review and assessment, inspection and enforcement, and for establishing safety principles, criteria, regulations and guides.
- It is suggested that the Department for Transport should continue and enhance its efforts to communicate its concerns regarding the format of the ADR Agreement to UNECE, and work closely with them to ensure that future editions of the ADR Agreements are more user-friendly.
- It is suggested that the UK authorities should continue efforts to harmonize domestic adoption of the international regulatory requirements for radioactive material using a simpler and common approach for all modes.
- It is suggested that a common approach for domestic adoption of regulatory requirements on a modal basis could be facilitated by having all modes (a) adopt by reference rather than having some of the modal authorities rewriting regulatory requirements into UK-domestic documents and (b) adopt on the same schedule (subject to any constraints imposed by the international modal bodies).
- Although the records of approvals, i.e., certificates of approval, kept by Radioactive Materials Transport Division appeared organized and complete, it is suggested the following record keeping improvements be implemented:
- development of a programme to electronically archive approval certificates and files correspondence and package design data;
- inclusion of foreign certificates in validation and multilateral approval files;
- inclusion of all modification sheets in corresponding certificate files.
- It is suggested that the Radioactive Materials Transport Division review and amend as necessary its approval procedures and develop an implementation strategy and schedule ensuring that the applicability of each certificate is clearly specified so other competent authorities and users of the

certificate will be able to determine whether or not the certificate needs further multilateral approval action.

- It is suggested that, although not specifically authorized or prohibited by the Transport Regulations, the Radioactive Materials Transport Division assess its approval procedures to ensure it refrains from expanding the applicability of foreign certificates in the execution of its multilateral approval programme (e.g. authorization of additional contents for a foreign package design) and should consider expanding applicability only through an independent UK approval certificate.
- It is suggested Radioactive Materials Transport Division undertake an internal review to develop policies and practices that would minimize the number of certificates issued.
- It is suggested that the Radioactive Materials Transport Division consider issuing validation and multilateral approval of foreign package design certificates with a single approval valid for all applicants; include multiple models of a package design on a single certificate; and expand their use of multiple contents on a single approval.
- It is suggested that modification sheets be amended so that certificate holders are made aware that if the associated approval needs validation or multilateral approval, the modification sheet also need validation or multilateral approval.
- It is suggested that the Radioactive Materials Transport Division should prepare and implement a technical instruction document, i.e., an "assessment manual", which provides guidance for the review and approval of applications for package design, special form and low dispersible radioactive materials, special arrangements, shipments and radiation protection programmes.
- It is suggested a more structured approach to assuring consistency, possibly considering, inter alia, the following two elements:
- filling the leadership position for the mechanical engineering section that has been vacant for an extended time period, and
- additional formal technical oversight by the section leaders.
- It is suggested that Radioactive Materials Transport Division should continue ensuring that its interaction with applicants does not result in a conflict of interest or the perception of a conflict of interest and that the regulator remains clearly independent.
- It is suggested that restricted access to approval documents (both the application and the certificate) should be reconsidered by the Radioactive Materials Transport Division and its legal staff to assure that adequate information is available to the public regarding the activities of the division, consistent with the need to protect commercial information that is customary in the UK.
- It is suggested that the existing Department for Transport memoranda of understanding with the Health and Safety Executive and the Civil Aviation Authority should be reviewed to ensure they reflect how the respective responsibilities are currently being fulfilled.
- It is suggested that organizations involved in the transport of mobile sources should be requested to fill out the checklist for inspecting transport operations and documentation for mobile sources; an action which could facilitate the definition of and establishment of priorities for required inspections.
- It is suggested that, to prevent the use of outdated and inappropriate documentation and ensure user-friendly controlled documents, James Fisher and Sons and PNTL/BNFL work together to standardize the formats of and process for changing controlled documents used onboard ships, including the manner in which change controls are communicated in the documents.
- It is suggested that the Maritime and Coastguard Agency should consider assessing the need to stage additional exercises for evaluating UK response capabilities in the event of maritime Class 7 emergencies not involving PNTL or other INF Code ships.
- It is suggested that the UK government should consider continuing bilateral liaison with the Irish Government on counter pollution and response issues, including the provision of an Irish Sea ETV as identified by the risk-based approach in 'A Review of ETV provision around the coast of the UK'.
- It is suggested that the UK government should consider continuing multi-lateral liaison with neighbouring states. Such liaison agreement could prove beneficial in the event of an emergency in waters surrounding the UK involving ships carrying radioactive material.

4.3 *Good practices*

- It was determined that an excellent Memorandum of Understanding exists between the Civil Aviation Authority and the Health and Safety Executive, which is clear, concise, and does an excellent job of assigning responsibilities. This MoU is held up as a good model for others to follow.
- It was determined that the use of a national regulatory co-ordinating committees and groups with charters to co-ordinate the development and implementation of domestic regulatory documents reflecting the requirements of the international modal authorities, that meet regularly to co-ordinate inputs to new international regulations and to co-ordinate planning and scheduling of periodic enforcement liaison exercises, is viewed as a good practice that States should consider emulating.
- It was determined that the Maritime and Coastguard Agency implements maritime dangerous goods regulations through direct reference to the International Maritime Organization IMDG Code. This practice reduces the workload of the Maritime and Coastguard Agency, speeds up the process of adopting new regulations for that mode, allows the implementation date for this mode to coincide with the implementation date established by International Maritime Organization, and reduces the likelihood of errors or differences occurring in regulatory requirements.
- It was determined that the modification process used by Radioactive Materials Transport Division provides adequate regulatory control of modifications but allows a streamlined and efficient process for changes that have limited safety significance. It is understood that the UK has made a proposal to include this scheme within the IAEA transport regulations during the current biennial revision cycle.
- It was determined that the Radioactive Materials Transport Division has for many years provided prospective applicants with a document that provides guidance with respect to the information that is necessary for an application for approval.
- It was determined that the Radioactive Materials Transport Division has an established practice of early and active interaction with applicants during the design review process. The Radioactive Materials Transport Division has an established practice of regularly observing physical testing of package designs, consistent with para. 477 of IAEA Safety Series 112.
- It was determined with regard to the administrative aspects of the Radioactive Materials Transport Division functions that the project files appeared neat, complete, and properly maintained.
- It was determined that Radioactive Materials Transport Division's practice of receiving reports on the assessment by national radiological protection experts from the National Radiological Protection Board of radiation exposures resulting from the transport of radioactive material is an excellent practice, consistent with the radiation protection provisions of the IAEA Transport Regulations (TS-R-1) and the responsibilities and functions of the regulatory body contained in the Legal, Governmental and Infrastructure requirements document (GS-R-1).
- It was determined that the Radioactive Materials Transport Division has developed extensive and detailed documentation covering Quality and Compliance Assurance; this is viewed as an excellent practice consistent with the IAEA's guidance documents on quality and compliance assurance.
- It was determined that the UK has a comprehensive emergency response plan and that effective emergency arrangements are in place for all modes of transport.
- It was determined that the UK has gone well beyond what has been and is currently required in the area of maritime transport of radioactive material covered in the International Maritime Organization IMDG, INF and ISM codes, implementing recommendations that have since or are later anticipated to become mandatory, and often imposing additional requirements beyond those specified in these codes to enhance the actual or perceived level of safety for the maritime transport of these materials.
- It was determined that, based on an appraisal at Dungeness A and B power stations, the facility operators have established comprehensive Quality Assurance programmes and procedures related to the storage, handling and transport of fuel flasks on site and to and from the railhead.
- It was determined, after reviewing Amersham's packaging data, packagings, and package test facilities, that the documentary evidence maintained was of the highest calibre and recommends

that Amersham be consulted if guidance material on Type A package documentation is to be developed for other applications.

- It was determined, based on its assessment of the air transport mode, that an excellent safety culture consistent with that recommended in the Basic Safety Standards was fostered and maintained by Amersham, Exel, and Lufthansa in their multi-modal (road/air) operations.
- It was determined that the UK competent authority monitors trends of large shippers of the more dangerous forms of Class 7 (radioactive) material, identifies when the performance of the consignors, carriers and consignees may be a trend toward non-compliance, notifies the shippers of the potential area of non-compliance, and works with them to facilitate their definition of root causes and corrective actions. It then continues to monitor the situation to ensure the corrective actions are achieving the desired effect.

5. Conclusions and follow-up

The UK has responded openly and positively to the General Conference resolutions encouraging Member States to make use of the Transport Safety Appraisal Service to the expressed satisfaction of General Conference in September 2002, Resolution GC(46)/RES/9. The TranSAS considered all modes and many types of radioactive materials, but emphasis was placed on demonstrating the safety arrangements applied to sea transport of nuclear materials, as these operations have given rise to most concern among some coastal states. The TranSAS mission has provided an effective tool in support of the UK's commitment to ensuring compliance with the Agency's Transport Regulations and all related international standards and guidelines. For the first time observers from concerned states were included in the TranSAS Team; which helped ensure maximum openness and transparency.

The review did not reveal any shortcomings in safety critical areas.

The recommendations have been fully implemented and the suggestions are being implemented on a priority basis. The UK will continue to work with the Secretariat on ways to share and encourage the adoption of the good practices identified by the TranSAS. To this end UK experts are expected to participate in future TranSAS missions.

TranSAS has enabled a wide ranging and transparent review of radioactive material transport safety to be achieved, which looked critically at both the regulators and the regulated, across the full range of transport modes and transport activities, from design through approval, manufacture, use and maintenance.

Experience of the UK TranSAS mission has shown it to be an effective and transparent means for states to demonstrate their commitment to the safe transport of radioactive material. All states similarly committed to a high level of safety are encouraged to avail themselves of the service.

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U. S. NUCLEAR REGULATORY COMMISSION QUALITY ASSURANCE ROLES AND RESPONSIBILITIES FOR RADIOACTIVE MATERIAL TRANSPORT

R. Temps, J. Pearson, F. Jacobs, P. Narbut

U.S. Nuclear Regulatory Commission
Office of Nuclear Materials Safety and Safeguards
Washington, DC
United States of America

Abstract*

The U.S. Nuclear Regulatory Commission's regulations include requirements for quality assurance (QA) programs for entities that engage in activities involving the transportation of radioactive materials in Type B and fissile material packages. Prior to commencing activities subject to the QA requirements, a QA program description must be submitted to the NRC for review and approval. The QA program user must also develop implementing procedures for the user's QA program to ensure compliance with the NRC's QA requirements. The NRC conducts independent periodic safety and compliance inspections of QA program users to assess the adequacy of program implementation.

1. Radioactive material transport regulatory framework

In the United States, the Nuclear Regulatory Commission (NRC or Commission) and the Department of Transportation (DOT) share responsibility for the regulation of radioactive material transport. While DOT's regulations apply to all types of radioactive material transport, NRC imposes additional safety requirements on commercial transport involving Type B packages and fissile material packages. NRC's packaging and transportation requirements are codified in Title 10 of the Code of Federal Regulations (CFR) Part 71, "Packaging and Transportation of Radioactive Material."

NRC's regulations state that a license to transport radioactive material that is granted under the provisions of 10 CFR Part 71, Subpart C, "General Licenses," applies only to a licensee who has a QA program approved by the Commission as satisfying the provisions of Subpart H, "Quality Assurance," of 10 CFR Part 71. The granting of a license also affords NRC an opportunity to perform inspections and to take appropriate regulatory action should safety issues or noncompliance with license conditions be identified.

QA requirements are also imposed on those who submit an application for approval of a package design under the provisions of Subpart D, "Application for Package Approval," of 10 CFR Part 71. Specifically, an application for an approval under Subpart D must include, for each proposed package design, a quality assurance program description as required by Subpart H, or a reference to a previously (NRC) approved quality assurance program. After NRC staff's technical review determines that the QA program description and package design meet regulatory requirements, a Certificate of Compliance (CoC) is issued.

*The views expressed in this paper do not necessarily reflect those of the U.S. Nuclear Regulatory Commission.

There are two general exceptions to the imposition of NRC's QA program requirements. The first involves radioactive material transport conducted by the US Department of Energy (DOE). DOE transports radioactive material under the auspices of their own regulations. DOE's transportation activities must also meet DOT transportation requirements. The second exception involves radioactive material transport within and between Agreement States. These are States to which, under the Atomic Energy Act of 1954, NRC relinquishes portions of its (NRC's) regulatory authority to license and regulate byproduct materials (radioisotopes); source materials (uranium and thorium); and certain quantities of special nuclear materials. However, this does not obviate the need to transport in NRC certified Type B or fissile material packages. After designation as an Agreement State, the NRC reviews Agreement State programs for continued adequacy to protect public health and safety and compatibility with NRC's regulatory program.

2. Quality assurance program requirements

Subpart H of Part 71 contains QA requirements that apply to the design, purchase, fabrication, handling, shipping, storing, cleaning, assembly, inspection, testing, operation, maintenance, repair, and modification of components of packaging that are important to safety. As used in 10 CFR Part 71, "quality assurance" comprises all those planned and systematic actions necessary to provide adequate confidence that a system or component will perform satisfactorily in service. QA includes quality control, which comprises those quality assurance actions related to control of the physical characteristics and quality of the material or component to predetermined requirements.

Prior to the use of any package for the shipment of licensed material subject to 10 CFR Part 71, each licensee must obtain Commission approval of its QA program. Each licensee is required to file a description of its QA program along with a discussion of which requirements of Subpart H are applicable and how they will be satisfied. There are a total of eighteen criteria delineated in Subpart H that must be addressed by the licensee to the extent applicable. These criteria are (corresponding 10 CFR Part 71 Section in parentheses) as follows:

Quality assurance organization (71.103)
Quality assurance program (71.105)
Package design control (71.107)
Procurement document control (71.109)
Instructions, procedures, and drawings (71.111)
Document control (71.113)
Control of purchased material, equipment, and services (71.115)
Identification and control of materials, parts, and components (71.117)
Control of special processes (71.119)
Internal inspection (71.121)
Test control (71.123)
Control of measuring and test equipment (71.125)
Handling, storage, and shipping control (71.127)
Inspection, test, and operating status (71.129)
Nonconforming materials, parts, and components (71.131)
Corrective action (71.133)
Quality assurance records (71.135)
Audits (71.137)

3. Quality assurance program implementation expectations

In their program description submittal, the licensee or package design applicant (hereinafter referred to as QA program user) must identify to the NRC how each of the eighteen criteria above apply to their particular situation and how the criteria will be satisfied. Thus, the information supplied to the NRC for review varies as a function of the nature of the activity the QA program user will be engaged in. For example, someone using a general license solely for the transportation of radioactive material in packages purchased or leased for that purpose, would be expected to address criteria governing activities such as procurement, shipping and handling, whereas someone who designs and fabricates packagings would be expected to address criteria on design and testing, as well as material procurement activities. Examples of elements common to all QA program descriptions include the quality organization and program, corrective action, QA records, and audits.

In developing their QA program, users can refer to general guidance provided by NRC in Regulatory Guide 7.10, "Establishing Quality Assurance Programs for Packaging Used in the Transport of Radioactive Material." In developing their program, the QA program user is required to apply each of the applicable eighteen criteria in a graded approach, i.e., to an extent that is consistent with its importance to safety. Additional guidance on graded QA is provided by the NRC in NUREG/CR-6407[1], "Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety."

Following a technical review and a determination by the NRC staff that the QA program submittal meets regulatory requirements, NRC issues a Quality Assurance Program Approval. The approval expires five years from the month of issuance and may be renewed prior to expiration at the QA program user's request. Any changes to the approved QA program description require NRC approval. Therefore, if a QA program user desires to make a change in the QA program description that was used as the basis for NRC approval, the change must be submitted for review and approval by the NRC before the change can by implemented. Requests for review and approval of such changes are handled through an amendment of the Quality Assurance Program Approval and do not affect the five year renewal date.

Based on approval of their QA program description submittal, QA program users will translate the eighteen criteria discussed in its program description submittal into lower-level (working level) implementing procedures governing the conduct of QA activities that are important to safety.

It should be noted that while there are some parallels between the eighteen Subpart H QA program criteria and those of ISO 9000, there are differences between the NRC's regulatory requirements and ISO 9000, in that some NRC criteria are not specifically addressed, either in part or wholly, in ISO 9000. Thus, a QA program submittal based solely on ISO 9000 may not address all of the criteria of Subpart H. (For example, ISO 9000 does not specifically address the following two Subpart H criteria; 10 CFR 71.109, "Procurement document control," and 10 CFR 71.111, "Instructions, procedures, and drawings"). For that reason, if not already provided in the QA program description provided to the NRC, the NRC will require the submittal of additional information regarding how all of the applicable Subpart H criteria will be met.

[1] This document as well as 10 CFR Part 71 and Regulatory Guide 7.10 are all publicly accessible through NRC's website at http://www.nrc.gov/reading-rm/doc-collections/.

4. Compliance assurance

While it is incumbent on each Quality Assurance Program Approval and CoC holder to ensure proper implementation of their NRC-approved QA program description, NRC conducts periodic inspections to assess the adequacy of such implementation. Inspections may be reactive; i.e., they may occur in response to a specific event, or, as is often the case, they may be conducted at periodic intervals.

NRC has developed a program and procedures[2] for these reactive and planned inspections and is responsible for their implementation. Inspections are conducted by trained and qualified safety inspectors well versed in assessing QA program implementation adequacy. Inspection teams usually consist of two to three safety inspectors and are sometimes augmented by NRC technical staff if there is a specific, complex, technical issue that needs to be looked at during an inspection. Inspections are typically conducted over a multi-day period and involve in-depth review of QA program documents, interviews with personnel, and observation of field activities. Inspection results are communicated verbally at the end of the inspection and subsequently documented in a written report. QA program nonconformances to NRC requirements are dispositioned according to their severity and in accordance with NRC written policy. Simple nonconformances typically require a response by the QA program user as to why the nonconformance occurred and what actions they will take, or have taken, to prevent its recurrence. For severe nonconformances, monetary fines may be imposed, and in some cases, the user's QA Program Approval may be suspended or terminated. Suspension or termination of NRC's approval of the user's QA program effectively precludes the conduct of NRC-licensed activities involving the transport, design or fabrication of radioactive material packagings.

5. Summary

The U.S. Nuclear Regulatory Commission's regulations include requirements for QA programs for users and designers of Type B and fissile material packages. A QA program description must be submitted to the NRC for review and approval and the QA program user must also develop implementing procedures to ensure compliance with the applicable NRC QA requirements. Trained NRC safety inspectors conduct independent periodic safety and compliance inspections of QA program users to assess the adequacy of program implementation. QA program nonconformances to NRC requirements are dispositioned according to their severity and in accordance with NRC written policy.

[2] NRC Inspection program Manual Chapters and Inspection Procedures are all publicly accessible through NRC's website at http://www.nrc.gov/reading-rm/doc-collections/insp-manual/.

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FRAMEWORK OF THE BNFL INTERNATIONAL TRANSPORT MANAGEMENT SYSTEM

G. K. Fisher
BNFL,
United Kingdom

Abstract

BNFL International Transport has implemented and operates a fully Integrated Management System designed to meet the needs of BNFL's international transportation business for the safe transport of new and spent nuclear fuels throughout the world. The history, documented processes, documented system and audit are described.

1. Introduction

BNFL International Transport, a function of BNFL Spent Fuel Services within the Nuclear Utilities Business Group, has implemented and operates a fully Integrated Management System. The management system has been designed to meet the needs of BNFL's international transportation business for the safe transport of new and spent nuclear fuels throughout the world.

The management system is modelled on the requirements of several UK national and internationally recognised management systems standards, they are:

- ISO 9001:2000 'Quality Management Systems - Requirements';
- KTA 1401 - Safety Standard of the Nuclear Safety Standards Commission (KTA) Allgemeine Forderungen an die Qualitätssicherung (General requirements regarding quality assurance);
- IAEA Safety Standards Series, Safety Guide No. TS-G-1.1 (ST-2) – published 2002 Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material;
- ISO 14001:1996 'Environmental Management Systems';
- UK HS(G)65 'Successful Health and Safety Management'.

In order to demonstrate an acceptable level of compliance to our customers, regulators and stakeholders, BNFL International Transport implemented a programme of work to enable third party certification of the management systems to be obtained.

2. History

The formal acceptance of the then quality management systems began in 1994 when BNFL Transport applied for and obtained certification by Lloyds Register Quality Assurance to the then Quality Assurance Standard ISO 9001:1994. At the same time the BNFL Transport subsidiary Company, Pacific Nuclear Transport Limited which owns and operates a fleet of ships for the marine transport of nuclear material obtained certification to the Quality Assurance Standard ISO 9002:1994.

During 1995 the BNFL Transport subsidiary Company Direct Rail Services was formed, the Company's remit being to operate a fleet of railway locomotives and rolling stock in the UK nuclear and non-nuclear markets. The first transport of nuclear material on behalf of BNFL

Transport took place in January 1996. To demonstrate a level of management system compliance Direct Rail Services obtained certification by LRQA to the Quality Assurance Standard ISO 9002:1994 in September 1996.

The Direct Rail Services business has now been transferred to BNFL Spent Fuel Services.

Also during 1996, developments in the European theatre of operations resulted in the formation of another BNFL Transport subsidiary 'BNFL SA' Management systems were developed whereby third party certification by TÜV Pfalz to the ISO 9001:1994 was obtained in December 1996. This was further enhanced in 1998 by the addition of certification to the Environmental Management Systems Standard ISO 14001:1996

Also during 1996 and 1997 the BNFL Transport and Pacific Nuclear Transport Limited Management Systems were further enhanced to formally encompass Health and Safety and Environmental requirement. This culminated in 1997 when BNFL Transport and Pacific Nuclear Transport Limited both obtained third party certification to the Environmental Management Systems Standard ISO 14001:1996.

During 2002 BNFL International Transport (BNFL Transport), Pacific Nuclear Transport Limited, Direct Rail Services and BNFL SA management systems were reviewed to meet the requirement of the new ISO 9001:2000 standard 'Quality Management Systems'. In September 2002 Direct Rail Services converted to the new standard, BNFL International Transport, Pacific Nuclear Transport Limited and BNFL SA converted to the new standard in January 2003.

The ISO 9001:2000 standard introduces a more Process-based approach to management systems, leading to a greater emphasis being given to Customer Focus and the Continual Improvement of the management system processes.

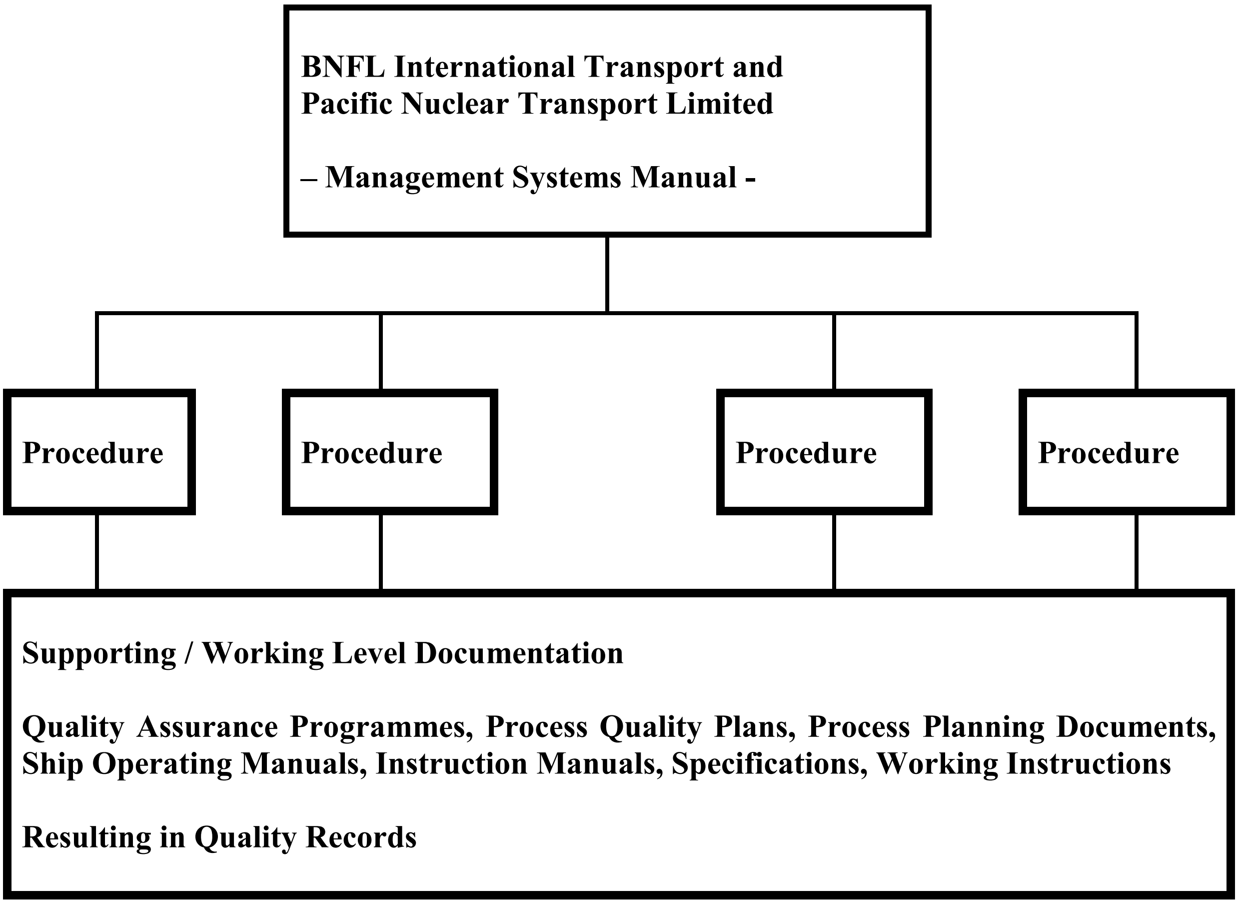
3. Documented processes

The top tier document of the BNFL International Transport Integrated Management System is the *BNFL International Transport and Pacific Nuclear Transport Limited – Management Systems Manual* This manual has been prepared to identify and describe the management systems applied by management to ensure that transport activities are carried out in a safe and efficient manner. Also included are the interface arrangements between other BNFL business groups, suppliers, and customers.

The manual is supported by *Management Procedures*, the requirements of which are mandatory on all BNFL International Transport personnel and other supporting/working level documentation;

- Quality Assurance Programmes
- Process Quality Plans
- Process Planning Documents
- Operating Manuals
- Maintenance Manuals
- Specifications
- Working Instructions.

4. Documented system



5. Audit

The Management systems of BNFL International Transport and its subsidiaries are under constant review from both internal and external sources.

Internally

- Spent Fuel Services Quality function performs internal quality audits;
- Environment, Health and Safety function perform internal health and safety audits and environmental audits:
- BNFL Corporate centre audit compliance with BNFL Group Policies.

Externally

- Lloyds Register Quality Assurance performs systems audits to verify the continued compliance with the ISO 9001:2000 standard (Quality) and ISO 14001:1996 (Environment)
- Customer audits where the management systems are examined by customers or customer representatives in order to demonstrate continued compliance with contractual requirements. BNFL Transport currently holds certification to the German KTA 1401 quality assurance requirements (issued by Siemens NP GmbH on behalf of the German nuclear utilities) and has been formally audited by other European and Japanese customers
- Regulator audits to demonstrate that BNFL International Transport and Pacific Nuclear Transport Limited meet their regulatory obligations.

6. Conclusion

BNFL International Transport and its subsidiaries all maintain independent management systems certifications for both quality and environmental management. In all aspects of the Transport business the management systems have been developed to a level, which is in excess of the ISO 9001 and ISO 14001 requirements.

With all parts of the BNFL International Transport business covered by third party quality certification, we are able to demonstrate the ability to provide a world class service to all customers in the transportation of nuclear materials world-wide.

KOZLODUY NPP SPENT NUCLEAR FUEL TRANSPORT EXPERIENCE

S. Tzochev, P. Peev, D. Bekriev

Kozloduy NPP,
Safety and Quality Management Division, 3321 Kozloduy,
Bulgaria

Abstract

Transportation routes and experience gained with the transportation of spent nuclear fuel are given. The transportation containers and vehicles used for transport packages are described. The emergency plan developed for the transport of spent nuclear fuel is outlined and information is provided on classification of accidents during spent nuclear fuel transportation, on organization of the emergency response actions, and on other activities included in the emergency plan.

1. Introduction

At present, the KNPP spent nuclear fuel is stored in 'by the reactor' spent fuel pools and 'away from the reactor' wet storage facility. The capacities of the wet storage facilities allow us to store the spent fuel generated by all 6 units until the end of 2004. A new dry spent fuel storage facility is to be built within the frames of the decommissioning process of Units 1 and 2. This project is funded jointly by the European Bank for Recreation and Development (EBRD) and Kozloduy NPP. Together with the building of this new spent fuel dry storage facility, we continue to transport, on annual basis, spent fuel back to Russia for reprocessing. The first transportation was performed in the autumn of 1979 for spent fuel from Units 1 and 2. In the period 1979 –1988, 21 transportations of spent fuel from Units 1 to 4 were carried out. After ten years interruption, the transport operations have been resumed for fuel from WWER-440 as well as for WWER-1000 fuel. The transport scheme is from Bulgaria along the Danube River to Moldova – Ukraine - Russia. The same scheme is used for the fresh fuel delivery. Additional auxiliary scheme for transportation by the Black Sea is in a process of development.

2. Transport containers

The transport containers used for spent nuclear fuel transportation are: TUK-6 for WWER-440 spent fuel and TUK-13 for WWER-1000 spent fuel.

TUK-6 transport packaging consists of shielded container and a canister. The container, itself is a thick-wall steel vessel hermetically sealed by a lid. The inner cavity of the container is filled with a cooling agent. There are welded on fins on the outer surface of the container body, aiming to increase the container heat emission surface and a supporting ring to place the container to the attachment plate in the car-container.

Packaging capacity, FA, pcs.		**30**
Mass of a packaging, t,	not more than	**81.0**
Mass of a loaded packaging (package), t,	not more than	**92.0**

TUK-13 is thick-walled cylindrical vessel of forged steel shells hermetically sealed by a massive lid. A metal shell is welded outside the vessel. The space between the vessel and the shell is filled with a liquid (ethylene glycol solution), acting as a neutron shielding. Inner cavity of the container is filed with air or a mixture of helium with air.

Packaging capacity, FA, pcs.		**12**
Mass of a packaging, t,	not more than	**104.0**
Mass of a loaded packaging (package), t,	not more than	**113.0**

3. Vehicles for packages transport:

3.1. Road transport vehicles:

The containers with SNF are transported by special heavy load platform for each type of containers. Container TUK-6 is transported in vertical position and TUK-13 in horizontal position. During transportation a special convoy is arranged for the transportation, including fireman's vehicle, ambulance, security and police vehicles.

3.2. Water transport vehicles:

For spent nuclear fuel shipment along Danube River a special trail barge is used, which capacity is 8 containers TUK-6 or TUK-13. The barge is equipped with cooling system; decontamination system; radiation monitoring system and equipment, instrumentation and means for control of containers parameters. In this barge containers are transported in vertical position.

3.3. Railway transport vehicles:

The containers with SNF are transported in special railroad train consisting of up to eight freight wagon-containers with natural ventilation system and heating system, two escort wagons for accompanying persons, instrumentation and means for control of containers parameters and two protection wagons.

4. Emergency preparedness

The emergency plan [1] covers the route from Kozloduy NPP to the Ukraine-Russian border for road, water and railway transport schemes. In case of general radiation accident the Bulgarian national emergency plan will be actuated. In case of general radiation accident involving foreign territories the emergency plans of the affected countries will be actuated. The plan defines the activities of the accompanying and emergency centre teams, further instruction aiming to limitation and elimination of the consequences if having accident during transportation. The emergency plan is developed in accordance with the Bulgarian legislation and international conventions, it is agreed with the due state authorities, including Nuclear Regulatory Authority (NRA) and Service "Civil Protection of the Republic of Bulgaria" – Ministry of Defence and is approved by the Executive Director of Kozloduy NPP plc. This plan is harmonized with Bulgarian, Romanian and international legislation. It is negotiated by representatives of Kozloduy NPP, NRA, the Romanian nuclear energy regulatory body (NCNAC) and the Romanian Civil Protection Command.

4.1 Classification of accidents during spent nuclear fuel transportation

These accidents are classified by level of danger, pursuant to the Safety Assessment Report for that transportation. There are three categories of possible accidents regarding TUK-6 and TUK-13.

Level 1 accident:

- the packages suffered mechanical impacts without visible damages;
- the packages suffered heat impact due to fire outside the transporting vehicles.

Accidents of this type present no risk for personal and environment, as the containers passed all tests under IAEA rules and meet the radiation safety standards.

Level 2 accident:

- the packages suffered mechanical impacts and obtained significant damages;
- the packages suffered fire and obtain visible surface burns.

The increased radiation level due to these accidents does not exceed the emergency limits defined by IAEA rules.

Level 3 accident

- the package is partially or totally destroyed, the radiation level and release of radioactive products from it exceed the emergency limits defined by IAEA rules.

The assumption in case of Level 3 accidents is that 10% of fuel elements occurred to be with leakages and the container is totally unsealed. At this assumption 4.44×10^{14} Bq of Kr-85, 2.13×10^{10} Bq of Cs-134 and 2.13×10^{10} Bq of Cs-137 activity will be released in the environment

The organization of the emergency actions in response of the nuclear events is divided in three types depending on the contamination areas:

- local radiation accident - the radiation level is increased only around the container within the vessel holder or the platform of the vehicle;
- medium sized accident - radioactive contamination within the whole vessel or on the road;
- general radiation accident - radioactive contamination of the river or areas outside the roads with consequences to the population and environment and possible transmission to other countries.

Events of non-radiation nature are also considered in the emergency plan, as they affect the safety of the transportation such as:

- damages of the barge or pusher;
- flooding of the barge hold or pusher;
- terrorist attack on the vessel;
- fire on board of the barge or the pusher.

4.2 Organization of the emergency response actions.

The basic steps in case of an emergency situation are as follows:

Ensure people's safety by:

- defining and marking the contaminated areas through detection of leakage location by radiometric and dosimetric measurements and
- limitation of the access to the contaminated areas, providing dosimetric pass control;

Elimination of the accident:

- defining measures for: elimination the reasons for the activity leakage; cleaning and decontamination of the contaminated area; collecting and storage of the wastes from the accident.
- decontamination of the equipment and tools used, as well as the personnel;

Continuous dosimetric control of all activities and control of the personnel radiation exposures is to be assured trough all the processes. Information for the emergency response actions is regularly submitted to Kozloduy NPP emergency centre. Bulgarian Nuclear Safety Authorities inform Romanian National Commission for Nuclear Activities Control. They inform the Romanian border forces, police and security forces which provide the necessary physical protection. The rescue activities have priority over all other activities related to eliminating or limiting the accident consequences.

4.3 Other activities included in the emergency plan.

Measures regarding population and environmental protection

- limitation and mitigation of the emergency consequences;
- public protection and medical aid.

Provisions for personnel protection

- personnel training.
- means for individual protection;
- radiometric and dosimetric equipment.

Detailed procedures for:

- organization of the communications;
- decontamination methods;
- radiation control during transportation;
- description of the necessary emergency equipment;
- reviewing and updating the emergency plan.

5. Conclusions

Since 1979 we had successfully applied the transportation scheme over 20 times. We have gained substantial experience in transportation of spent nuclear fuel. As illustration of the capabilities of the transportation system, consisting of transportation scheme, equipment, personnel training and emergency planning, can serve the fact that we have never experienced accidents during transportation. We are now preparing a new transportation scheme to back-up the already proven one, in case it could not be applied for some reason.

IAEA-CN-101/34

TRANSPORT SAFETY RECORD AND MEASURES TAKEN FOR THE UNITED STATES FOREIGN RESEARCH REACTOR SPENT NUCLEAR FUEL ACCEPTANCE PROGRAM

M. Clapper

United States Department of Energy
United States of America

Abstract

The United States Department of Energy (DOE), in consultation with the Department of State (DOS), adopted the Nuclear Weapons Non-proliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel in May 1996. As of January 2003, the Foreign Research Reactor (FRR) Spent Nuclear Fuel (SNF) Acceptance Program has completed 25 shipments. Over 5,500 spent fuel assemblies from eligible research reactors throughout the world have been accepted into the United States under this program. Shipments are continuing on schedule, amidst a climate of heightened vigilance following the terrorist attacks of September 11, 2001. Recent guidance and an associated Order from the United States Nuclear Regulatory Commission (NRC) pertaining to security and safeguards issues deals directly with the transport of irradiated nuclear fuel. As the Acceptance Program consistently worked above and beyond basic regulatory requirements to provide additional safety enhancements in transporting spent nuclear fuel, the new guidance did not adversely effect the Program. Other global SNF shipping campaigns and the recent recommendation to proceed with the licensing application process for Yucca Mountain as the geologic repository for spent fuel have increased media and public interest in SNF transport. The Acceptance Policy is planned to expire in May 2006, per the 1996 Programmatic Record of Decision on the Policy, but some shipments will continue until May 2009. Currently, there are no plans to renew the Acceptance Policy. This paper examines the safety record of the Acceptance Program, and discusses the measures that have been taken to ensure future shipments are safe and uneventful.

Introduction

The Foreign Research Reactor (FRR) Spent Nuclear Fuel (SNF) Acceptance Program, now in the seventh year of implementation, has to date completed 25 shipments safely and successfully. 27 countries have participated thus far, returning a total of 5,537 spent nuclear fuel elements to the United States for management at Department of Energy (DOE) sites in South Carolina and Idaho, pending final disposition in a geologic repository. 21 of the 25 shipments, containing aluminium-based spent nuclear fuel from research reactors, were transported to the Savannah River Site (SRS) in South Carolina. The most recent shipment arrived, without incident, at SRS on September 27, 2002. The remaining four shipments, containing Training, Research, Isotope, General Atomic (TRIGA) spent nuclear fuel, were transported to the Idaho National Engineering and Environmental Laboratory (INEEL). The FRR SNF Acceptance Program focuses on the planning and implementation of these shipments of research reactor spent fuel to the United States in support of world-wide nuclear non-proliferation efforts. Along with shipment logistics, the Department continues to address many other issues of importance to the program. Resolution of these issues is important in helping to improve our implementation activities.

The FRR SNF Acceptance Program works closely with federal, State and international contacts during planning for each shipment, thus ensuring that when the time comes for a shipment, the transports occur smoothly and without incident. Open and responsive communication among international participants is essential, especially with regard to cask licensing. The Acceptance Program enjoys a very good working relationship with NRC staff and as such, wishes to take every measure possible to respect this relationship by ensuring that cask applications are timely and complete. In the past the Acceptance Program may have been able to rely on NRC to readjust its workload to accommodate a special request for package review and certification under less than optimum deadlines. However, the post-September 11 environment now has U.S. federal staff spending additional time on evaluations into historical safeguards practices and analyzing preventive measures.

Security issues are now occupying a central focus as a result of the September 11 terrorist attack. The DOE, working in conjunction with international, federal, State, Tribal and local authorities, is re-examining procedures and requirements for transport of radioactive material, particularly commodities such as spent fuel. A temporary halt on all DOE-owned shipments of radioactive material in the U.S. was ordered by senior DOE management immediately after the September 11, 2001 attack, and again in October 2001 after commencement of the air campaign over Afghanistan. This action was taken in conjunction with other security measures throughout the DOE weapons complex and the nation at large. DOE was, and remains, in close contact with the Federal Bureau of Investigation, the Department of Defense, the NRC and other federal agencies responsible for transportation and infrastructure safety. The NRC implemented a series of Interim Compensatory Measures for its licensees to follow in enhancing security for SNF shipments; the measures were later incorporated into an NRC Order for its licensees. These new measures are not expected to impact the FRR SNF Acceptance Program adversely; in fact, many of the proposed measures are based on additional security measures the Program has been following since its inception. While the changed security climate requires additional time and resources to co-ordinate among different law enforcement agencies, we are confident they will continue to ensure that these are among the safest and most secure shipments undertaken throughout the world.

Historically, spent nuclear fuel shipments have not been considered attractive targets for terrorist attack or sabotage, and threat assessments undertaken by law enforcement since September 2002 seem to corroborate this view. However, across the globe spent fuel shipments are a matter of high concern for public officials due to the perceived perception that spent fuel transportation presents a heightened risk as compared to transport of other hazardous materials (e.g. propane and liquid natural gas). In addition, inspection, escort and other enforcement duties related to safe, routine transport can tax law enforcement and emergency response assets that could otherwise be deployed elsewhere. During the summer of- 2002, the return of mixed-oxide (MOX) fuel from Japan to the United Kingdom gained international attention when Greenpeace organized a global protest flotilla which pursued the transport vessels along parts of the shipping route, and urged nations along potential routes (notably southern Pacific nations, Caribbean nations in proximity to the Panama Canal, and Ireland) to voice opposition to the shipment. This attention culminated in the Irish Sea, where vessels of the Irish Navy appeared and, apparently, policemen were stationed on uninhabited islands past which the vessels steamed, presumably to enhance the already formidable security in place. Despite the unprecedented level of protests attracting attention to this shipment, which included large banners, speeding dinghies crammed with protesters, circling aircraft, BBC commentators and condemnations from rock stars, the vessel docked and the material was unloaded safely.

The United States believes the stringent security employed was more than sufficient to ensure the safety and security of the MOX shipment, and further strongly believes that lawful shipment of nuclear cargoes on the high seas should not be impeded, either by nations along potential routes or by non-governmental organizations. Fuel shipments related to the FRR SNF Acceptance Program have experienced localized controversy from time to time, but for the most part these shipments are conducted with little attention, perhaps because the ultimate goal of the Program is to support nuclear non-proliferation efforts. We will, however, continue to follow shipping campaigns of other types of nuclear material with interest.

Within the United States, discussions and advances concerning the Yucca Mountain permanent geologic repository have renewed and invigorated ardent support, both pro- and anti-nuclear. Congress ultimately voted to continue the siting process at Yucca Mountain, and a repository may become operational as early as 2010. The public has voiced opinions on both ends of the anti-nuclear spectrum; they are not comfortable with transport of nuclear material across interstate roadways, nor are they comfortable with having spent fuel and other high level radioactive waste stored at the 131 temporary storage facilities across the United States…yet Americans love their electronic conveniences. A responsible sort of quid pro quo rationale seems to be emerging in which some consumers realize that their everyday convenience – and in some cases luxuries – can be utilized guilt-free, so long as the nuclear energy sector conducts itself safely. Yet there is the other side of the house that believes radiation can not be had safely in any form or with any enhanced measures. The contentious debate over SNF transportation safety can be expected to continue, and likely increase, as the licensing process continues. Proposals of varying complexity have been made in Congress to enact additional measures related to SNF transport; however, none have been enacted to date and it is impossible to determine at this time what effect, if any, such measures may have on current transport requirements of SNF in the United States. Like others interested in permanent disposition of spent fuel, the Program continues to monitor closely developments in this issue.

Some reactor operators and contractors have voiced support for extension of the program expiration date beyond 2006. While the United States has had a fuel acceptance program of some type in place for many years, it should be understood by all involved parties that the DOE has no plans, at this time, to seek extension of the FRR SNF Acceptance Policy. Renewal or extension of the Acceptance Policy, if it were to be undertaken, would involve complex legal, regulatory and political efforts that have become even more difficult since the changed security climate and the recent vote to site a repository at Yucca Mountain. Fuel acceptance and eventual geologic disposal have been contentious issues in Congress, among States hosting fuel management facilities, and in the court of public opinion. Even if a renewal of the policy were to be undertaken, there could easily be substantial delays while requisite environmental studies, and the litigation that could likely result, are completed.

We will have many challenges as we continue to plan for shipments during the remainder of the Acceptance Program. The United States, and likely as well for the international nuclear transport community, will have a more watchful public. Some of the issues DOE and other agencies are examining now include impacts for State, Tribal and local resources should shipments be halted again, or additional requirements imposed. Advance notification and information are emerging as important related issues given the stricter climate of security; communication via electronic mail, conference calls and fax machines have done much to improve the means by which shipment planning and operations are accomplished, but the need for safeguarding sensitive information may change how these functions are performed. In addition, we can expect increased international co-ordination amongst security officials in order to ensure safety of the ship, its crew and cargo. In short, while DOE does not anticipate that security concerns will have a long-term impact on the schedules of the FRR SNF Acceptance Program, there may be short-term delays as a new concept of operations emerges. DOE expects to continue to work closely with reactor operators and others to ensure spent fuel continues to be safely transported.

ENVIRONMENTAL IMPACTS OF TRANSPORTATION TO THE POTENTIAL REPOSITORY AT YUCCA MOUNTAIN

R.L. Sweeney

United States Department of Energy,
Office of Civilian Radioactive Waste Management,
Office of National Transportation, Las Vegas, Nevada,
United States of America

Abstract

The Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada analyzes a Proposed Action to construct, operate, monitor, and eventually close a geologic repository for the disposal of spent nuclear fuel and high-level radioactive waste. As part of the Proposed Action, the EIS analyzes the potential impacts of transporting commercial and DOE spent nuclear fuel and high-level radioactive waste to Yucca Mountain from 77 sites across the United States. The analysis includes information on the comparative impacts of transporting these materials by truck and rail and discusses the impacts of building a rail line or using heavy-haul trucks to move rail casks from a mainline railroad in Nevada to the site. The potential transportation impacts were evaluated from two perspectives: transportation of spent nuclear fuel and high-level radioactive waste by legal-weight truck or by rail on a national scale and impacts specific to Nevada from the transportation of these materials from the State borders to the Yucca Mountain site. In order to address the range of impacts that could result from the most likely modes, legal-weight truck and rail, the EIS employed two analytical scenarios – mostly legal-weight truck and mostly rail. Estimated national transportation impacts were based on 24 years of transportation activities. Approximately 8 fatalities could occur from all causes in the nationwide general population from incident-free transportation activities of the mostly legal-weight truck scenario and about 5 from the mostly rail scenario.

1. Introduction

The Nuclear Waste Policy Act (NWPA) of 1982 established a comprehensive national program for the permanent disposal of spent nuclear fuel and high-level radioactive waste from commercial nuclear reactors and defense programs. In addition to tasking DOE with developing a repository for the disposal of these materials, the NWPA also requires DOE to provide for the transportation of the spent nuclear fuel and high-level radioactive waste from the storage locations to the repository. The NWPA, as amended in 1987, established a process leading to a decision by the Secretary of Energy on whether to recommend that the President approve Yucca Mountain in Nye County, Nevada for development of a geologic repository. Part of this process included preparation of an Environmental Impact Statement. A draft *Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* was published in July 1999. As part of the Proposed Action, the DEIS analyzed the potential impacts of transporting commercial and DOE spent nuclear fuel, including potential commercial spent mixed-oxide fuel, and high-level radioactive waste, including some that could contain immobilized surplus plutonium, to Yucca Mountain from 77 sites across the United States. Approximately 3500 comments were received on transportation. The Final EIS is available at www.ymp.gov. The transportation analyses in the FEIS were revised to respond to comments received on the DEIS and to reflect new information that had become available since publication of the DEIS.

This paper discusses the impacts of transporting spent nuclear fuel and high-level radioactive waste to the potential repository by rail and legal weight truck. It looks at the impacts from incident free transport as well as the impacts from accidents with each mode. In addition, it discusses in more detail, the impacts specific to transportation within the State of Nevada.

2. Impacts of national transportation

The EIS was prepared many years before shipments to a repository could begin. Therefore it was not possible to accurately predict the number of shipments that would be made by rail or truck. In order to ensure that the potential range of environmental impacts associated with the transportation of spent nuclear fuel and high-level radioactive waste was analyzed, DOE evaluated two scenarios for moving these materials to the potential repository:

- transport using mostly rail;
- transport using mostly legal-weight truck.

Under the mostly rail scenario, DOE would transport most of the spent nuclear fuel and high-level radioactive waste by rail, with the exception of spent nuclear fuel from 6 commercial sites that do not have the capability to load rail shipping casks. Spent nuclear fuel from these sites would be shipped by legal weight truck. In addition, 24 commercial sites that have the capability to load rail casks but do not have rail access were assumed to ship their spent nuclear fuel by barge or heavy-haul truck to the nearest rail line. The Navy would ship its spent nuclear fuel from INEEL to the repository by rail also. Over the 24-year period used in the analysis there would be approximately 9600 rail shipments and 1100 truck shipments under this scenario. The mostly legal-weight truck scenario has most of the spent nuclear fuel and high-level radioactive waste being shipped to the potential repository by legal-weight truck. The one exception to this would be the shipment of Navy spent nuclear fuel by rail from INEEL to the repository. Over the 24-year period, this would amount to about 53,000 truck shipments and 300 rail shipments.

DOE expects that the mostly rail case, in which more than 95 percent of spent nuclear fuel and high-level radioactive waste would be shipped by rail, would most closely approximate the actual mix of truck and rail shipments. In reaching this conclusion, DOE has assessed the capabilities of the sites to handle rail casks, the distances to suitable railheads, and historical experience in actual shipments of nuclear fuel, waste, or large reactor-related components. In addition, DOE considered relevant information published by sources such as the Nuclear Energy Institute and the State of Nevada.

2.1. Analytical approach

Three types of impacts to the public and workers could result from the transportation of spent nuclear fuel and high-level radioactive waste and other transportation activities associated with the repository construction and operation. The first of these analyzed in the EIS were radiological impacts, measured by radiological dose to populations and individuals and the resulting estimated number of latent cancer fatalities caused by radiation from shipments under normal and accident conditions. The second impact analyzed were the potential fatalities caused by vehicle emissions. Finally, the EIS looked at potential fatalities from vehicle accidents. The analysis employed a database and widely accepted analytic tools, latest reasonably available information, and conservative but reasonable assumptions where there were uncertainties. The computer programs listed below were used in the analysis:

- CALVIN was used to estimate the number of shipments of spent nuclear fuel from commercial sites. For DOE spent nuclear fuel and high-level radioactive waste, the analysis used inventories and characteristics reported by DOE sites in 1998.
- HIGHWAY, using rules contained in U.S. Department of Transportation routing regulations, was used to select for analysis highway routes that are representative of ones that could be used to ship spent nuclear fuel and high-level radioactive waste from the 77 generator site locations.
- INTERLINE was used to identify representative rail and barge routes for the analysis.
- RADTRAN 5 in conjunction with the database was used to estimate radiological dose risk to populations and transportation workers during routine operations. The analysis also used this program and the database to estimate radiological dose risks to populations and transportation workers from accidents.
- RISKIND was used to estimate radiological doses to maximally exposed individuals from routine transportation and doses to populations and maximally exposed individuals from severe transportation accidents and acts of sabotage.

2.2. *Number of shipments*

As stated previously, DOE could not accurately predict the actual mix of rail and legal-weight truck shipments that would occur many years prior to the start of operations. Therefore the mostly rail and mostly legal weight truck scenarios were developed to bound the ranges of shipments that could occur over the 24 years of repository operations. Shown below is a summary of estimated numbers of shipments for the various inventory and national transportation analysis scenario combinations:

	Mostly Truck		Mostly Rail	
	Truck	Rail	Truck	Rail
Commercial Spent Nuclear Fuel	41,001	0	1,079	7,218
High-level radioactive waste	8,315	0	0	1,663
DOE and Navy spent nuclear fuel	3,470	300	0	765
TOTAL	52,786	300	1,079	9,646

2.3. *Incident-free transportation impacts – mostly truck scenario*

The EIS analyzed the radiological and non-radiological impacts to populations for the mostly truck scenario which also included 300 rail shipments of Navy spent fuel which were assumed to be moved to the repository using heavy haul trucks. Incident-free impacts could occur from exposure to external radiation in the vicinity of the transportation casks or vehicle emissions. RADTRAN 5, in conjunction with a database used to manage the large amounts of shipment, accident, and state-specific data, was used to estimate collective doses to the public residing within 0.5 miles of either side of the transportation route. In addition, the analysis also estimated doses to people who could be closer to shipments than the resident population along the route and to people who would be exposed for longer periods of time. Included in this group would be truck or rail crews, others working near the cask, people in vehicles sharing the route with the shipment, people at truck stops, and residents living near truck and rail stops. The estimated radiological impacts would be 11.7 latent cancer fatalities for workers, including workers who would load shipping casks at generator facilities, and 2.5 latent cancer fatalities for the public over 24 years of operation. The potential impacts from increased levels of vehicle emissions could result in 0.95 fatalities. The EIS also analyzed impacts to maximally exposed individuals, people who would receive the highest dose. The following were included in the analysis of national transportation impacts:

- Crew Members
- Inspectors
- Railyard Crew Member
- Resident
- Individual Stuck in Traffic
- Resident Near a Rail Stop
- Truck Service Station Attendant.

Inspectors and crewmembers would receive the highest radiation dose over 24 years.

In addition, the EIS analyzed impacts to maximally exposed individuals who could live or work near potential rail, heavy-haul truck, and legal-weight truck transportation routes in Nevada. These residents are assumed to be present at the nearest location in their residences or work places when each shipment passes during 24 years of operations. The following were included in the analysis:

- Resident living 15 meters from an intersection in North Las Vegas where heavy-haul trucks are postulated to stop for 1 minute during each trip and where traffic congestion would delay movement of a heavy-haul truck for a total of 30 minutes each year. The resident is assumed to be present when each shipment passes during a 10 year period while the North Las Vegas Beltway remains under construction.
- Resident who lives approximately 5 meters from U.S. 93 in Alamo, Nevada and who is assumed to be present when each heavy-haul truck shipment passes at a speed to 10 miles per hour.

- Worker at the courthouse or fire station in Goldfield, Nevada who could be as close as 5 meters to U.S. 95 and who is assumed to be present when each heavy-haul truck shipment passes at a speed of 5 miles per hour.
- Resident living 30 meters from a branch rail line in Nevada and who is assumed to be present when each rail cask shipment passes.
- A resident who lives 11 meters from a primary highway in southern Nevada and who is assumed to be present when each legal-weight truck shipments passes.

2.4. Incident free transportation impacts – mostly rail scenario

To estimate radiological and non-radiological impacts to populations for the mostly rail scenario, the analysis assumed all generator sites having the capability would load and ship spent nuclear fuel and high-level radioactive waste using rail casks. For those sites that are not served by a railroad, the analysis assumed that either heavy-haul trucks or barges would be used to move the rail casks to nearby railheads. About 24 sites would need to use barges or heavy-haul trucks; seven of these could only use heavy-haul trucks. The analysis includes impacts from legal-weight truck shipments from the six commercial facilities that would not have the capability to load rail casks. In addition, since there is currently no rail access to the repository, this analysis assumed that DOE would either build a branch rail line or use heavy-haul trucks in Nevada to move the casks from the main line railroad to the repository. Therefore the results of the analysis indicate a range of impacts depending on the alternative selected. The estimated radiological impacts would be 1.5-1.9 latent cancer fatalities for workers and 0.6 – 0.8 latent cancer fatalities for the public over 24 years of operation. The potential impacts from increased levels of vehicle emissions could result in less than 1 (0.6 to 0.8) fatalities. In the analysis of maximally exposed individuals, truck and rail crew members, along with escorts traveling with rail shipments, would receive the highest dose over 24 years.

2.5. Transportation accident scenarios

Three types of accidents could occur during the transportation of spent nuclear fuel and high-level radioactive waste to a repository: (1) accidents in which the damage to a cask would not affect its safety functions, (2) accidents that release radioactive materials, but in which there is no loss of shielding, and (3) accidents that release radioactive material and where a fraction of the cask's radiation shielding is lost. The Nuclear Regulatory Commission estimates that in 99.99 percent of rail and truck accidents no cask contents would be released and the primary gamma shielding would remain in place. The EIS also estimated the impacts from an unlikely but severe accident scenario called a maximum reasonably foreseeable accident. The accident analysis evaluated radiological impacts to populations and to hypothetical maximally exposed individuals and estimated fatalities that could occur from traffic accidents.

2.6. Accident impacts – mostly truck scenario

This analysis included impacts and risks associated with legal-weight truck shipments and Navy rail shipments plus the heavy-haul of the rail shipments in Nevada. Total number of accidents in this scenario would be 66 over the 24-year period of operation. The radiological accident dose risk, which is the product of the population dose from potential accidents and the probability of the accidents occurring, would be 0.5 person-rem for the population within 50 miles along the transportation routes. This is equivalent to a 0.02 percent (0.0002) risk of one latent cancer fatality in a population of more than 10 million. The maximum reasonably foreseeable truck accident, which is an accident having the greatest consequences whose frequency of occurring would be greater than once in 10 million years, would be a long duration severe fire that fully engulfed a cask. The analysis estimated this truck accident could cause a population dose of about 1,080 person-rem, which is equivalent to 0.55 latent cancer fatality. In this accident, the analysis estimated that a maximally exposed individual member of the general public would receive a dose of about 3 rem. The analysis also estimated the maximum consequences of the crash of a commercial airliner into a legal-weight truck cask. Estimated impacts of this hypothetical accident - 1,140 person-rem (0.57 latent cancer fatalities) were nearly the same as those for the maximum reasonably foreseeable accident. Approximately 5 traffic fatalities would result over the 24-year operating period. These would all be from truck shipments; none would be attributed to the 300 Navy rail shipments.

2.7. Accident impacts – mostly rail scenario

The analysis of accidents in this scenario included accidents that would involve the truck shipments for the six reactors that cannot handle a rail cask. The analysis of the mostly rail scenario estimated that about 10 accidents would occur over the 24 years of operation. The collective radiological accident dose risk (dose risk is the sum of the products of the dose consequences of accidents and probabilities the accidents would occur) would be approximately 1 (0.89) person-rem for the population within 50 miles along transportation routes. This dose risk is equivalent to a 0.05 percent (0.0005) increase in the risk of one additional latent cancer fatality in the population within 50 miles of the routes used. In this scenario rail transportation would account for most of the accident risk to the public.

The maximum reasonably foreseeable rail accident, which is an accident having the greatest consequences whose frequency of occurring would be greater than once in 10 million years, would be a long duration severe fire that fully engulfed a cask. The analysis estimated this rail accident could cause a population dose of about 9,900 person-rem, which is equivalent to 5 latent cancer fatalities. In this accident, the analysis estimated that a maximally exposed individual member of the general public would receive a dose of about 29 rem. The analysis also estimated the maximum consequences of the crash of a commercial airliner into a rail cask. Estimated impacts of this hypothetical accident - 1,350 person-rem (0.7 latent cancer fatalities) are less than those for the maximum reasonably foreseeable accident.

Under this scenario, there could be 3 traffic fatalities over 24 years, essentially all involving train operations.

2.8. Impacts from acts of sabotage

The EIS considered the impacts of a successful attack on a cask with the attack postulated to occur in the center of a highly populated metropolitan area. The analysis used data from a study of the effects of high-energy-density devices directed against casks containing spent nuclear fuel conducted by Sandia National Laboratories. DOE had Sandia do the study because of comments provided by the state of Nevada and others. The Sandia study estimated releases of radioactive materials under conditions where the action of a high-energy-density device was assumed to be optimally directed against a cask's shield wall. The analysis evaluated consequences for events involving both a truck cask and a rail cask.

The analysis estimated that an attack on a truck cask in an urban area could result in a maximally exposed individual receiving a lifetime-committed dose of 110 rem. This would increase the risk of a fatal cancer for the individual from about 23 percent from all other causes to about 29 percent.

The impacts from an attack on a rail cask would be less than those estimated from a truck cask because less material would be released. A maximally exposed individual in this case could receive a lifetime-committed dose of 40 rem which could increase the risk of a fatal cancer from about 23 percent form all other causes to about 25 percent.

3. Impacts of transportation in Nevada

Spent nuclear fuel and high-level radioactive waste entering Nevada on legal-weight trucks would continue on to the repository on those trucks. There currently is no rail line to the potential repository site; therefore, material traveling to Nevada by rail would travel to the repository on a newly built branch line or, if no line was constructed, move by heavy-haul truck. For this reason, the EIS evaluated three scenarios in Nevada: (1) mostly legal-weight truck, (2) mostly rail, and (3) mostly heavy haul.

3.1. Legal-weight truck scenario

The impacts from the mostly legal weight truck, which includes heavy haul of rail casks containing Navy spent nuclear fuel to the site, would correspond to the Nevada portion of the national impacts for the mostly legal weight truck scenario. Incident free impacts would be 0.75 latent cancer fatalities to workers and 0.18 latent cancer fatalities to the public. Crewmembers and inspectors would be the maximally exposed individuals. There would be about a 9 percent (0.09) chance of one fatality in Nevada from exposure to transport vehicle emissions over the 24-year operational period.

The radiological impacts from accidents would be 0.00003 latent cancer fatality to the exposed population within 50 miles of the routes. The results of a maximum reasonably foreseeable accident would be the same as that calculated for the national transportation scenario although the frequency for this accident to occur in Nevada would be less than once in 10 million years.

3.2. Impacts of the Nevada rail implementing alternatives

For this scenario, DOE evaluated the impacts of building a branch line and operating trains for each of five candidate corridors. The corridors range in length from 159 to 520 kilometers (98 to 320 miles). In addition to estimating health and safety impacts, DOE assessed impacts that could occur in eleven other environmental resource areas for construction and operation of a branch rail line from a main line railroad to the Yucca Mountain site. The EIS presents DOE's analysis of impacts to land use; air quality; surface water and groundwater resources; biology and soils; cultural resources; socioeconomics; aesthetics; noise; waste management; utilities, energy, and materials; and environmental justice concerns. The analysis found that construction and use of a branch rail line in each of the candidate corridors would have unique impacts. Notable among these unique impacts are that corridors:

- cross or incur into the Air Force's Nellis Test and Training Range,
- cross wilderness study areas,
- conflict with lands set aside by acts of Congress, including the Timbisha Shoshone trust lands near Scotty's Junction, Nevada and the Ivanpah Valley Airport lands near Jean, Nevada,
- corridors cross desert tortoise habitat and approach habitat for other threatened and endangered species,
- cross areas having cultural resources such as the Pony Express Trail,
- cross potential flood areas and wetlands,
- require use of water for construction in areas where use of groundwater resources has been fully allocated,
- cross land areas BLM has designated as having valuable (Class II) visual resources whose disturbance should be limited,
- cross land areas where the current natural setting is valued as part of the recreation experiences, and
- introduce construction and train noise into areas where preservation of natural background sound may be valued and a part of the cultural heritage of Native American Indians in the region.

DOE concluded that impacts to regional socioeconomics; waste management; and utilities, energy, and materials would be small for all of the counties in the region of influence. It also concluded that construction and use of a branch rail line in any of the corridors would not lead to impacts to environmental justice concerns.

Incident-free health and safety transportation impacts to people who lived along candidate rail corridors would be unique for each corridor although the impacts to maximally exposed individuals would be similar for each corridor with shipment inspectors receiving the highest exposure. DOE anticipates that a radiation protection program would be implemented for inspectors who would have the potential to receive such doses.

Under the national mostly rail scenario, the radiological impacts to populations in Nevada from transporting spent nuclear fuel and high-level radioactive waste from the borders of the State and ultimately on a branch rail line would be small, ranging from 19 person-rem to 130 person-rem (0.009 to 0.06 chance of a latent cancer fatality in the exposed population) over the 24 years of operations.

Accident risks would be nearly the same for all potential corridors. Estimated impacts from potential accidents ranged from 0.0000009 to 0.000004 latent cancer fatalities over the 24-year period.

3.3. Impacts of the Nevada heavy-haul alternatives

This scenario evaluates the impacts of building and operating an intermodal transfer station and upgrading associated highways for use by heavy-haul trucks. Three potential station sites and five-associated highway routes were examined. The routes range in length from 183 to 533 kilometers (114 to 331 miles). In addition to estimating health and safety impacts, DOE assessed impacts that could occur in eleven other environmental resource areas. The impacts were assessed for upgrading highways and constructing and operating an intermodal transfer station located along a main line railroad and operating heavy-haul trucks to transport rail casks to the Yucca Mountain site. The EIS presents DOE's analysis of impacts to land use; air quality; surface water and groundwater resources; biology and soils; cultural resources; socioeconomics; aesthetics; noise; waste management; utilities, energy, and materials; and environmental justice concerns. The analysis found that upgrading highways, constructing and operating an intermodal transfer station, and operating heavy-haul trucks would have unique impacts. Notable among these unique impacts are:

- one route would cross the Air Force's Nellis Test and Training Range,
- routes would cross desert tortoise habitat and approach habitat for other threatened and endangered species,
- routes would cross or pass near potential flood areas and wetlands,
- upgrading highways would require use of water in areas where use of groundwater resources has been fully allocated, and
- heavy-haul trucks would interfere with free flow of traffic on Nevada highways that would be used.

DOE concluded that impacts to regional socioeconomics; waste management; and utilities, energy, and materials would be small for all of the counties in the region of influence. It also concluded that upgrading highways and constructing and using an intermodal transfer station and operating heavy-haul trucks would not lead to impacts to environmental justice concerns.

Personnel working at the intermodal transfer would be exposed to radiation from the shipping casks being transferred from rail cars to heavy haul trucks. It is estimated that there would be an 11 percent chance (0.11) of one latent cancer fatality among the worker population at an intermodal transfer station from exposures incurred over the 24-year operating period.

Incident free transportation impacts to workers and people who lived along routes would be unique for each of the implementing alternatives. Estimated impacts to a maximally exposed individual, which in this case would be a crewmember, would be the same for all alternatives. DOE anticipates that radiation exposure of heavy-haul vehicle crews would be managed under a radiation protection program with exposures maintained as low as reasonably achievable.

Under the national mostly rail scenario, the radiological impacts to populations in Nevada from transporting spent nuclear fuel and high-level radioactive waste from the borders of the State to an intermodal transfer station and ultimately by heavy-haul trucks would be small, ranging from 61 person-rem to 300 person-rem (0.03 to 0.15 chance of a latent cancer fatality in the exposed population) over the 24 years of operations.

Accident risks would be nearly the same for all potential alternatives. The estimated impacts would range from 0.000001 to 0.00006 latent cancer fatality.

4. Summary

DOE believes that the EIS provides the environmental impact information necessary to make certain broad transportation-related decisions, namely the choice of a national mode of transportation, the choice among alternative transportation modes in Nevada, and the choice among alternative rail corridors or heavy-haul truck routes and intermodal transfer stations. DOE has identified mostly rail as its preferred mode, both nationally and in Nevada. However, the Department has not identified a preference among the potential rail corridors at this time.

Over time, transportation will move to the forefront as a major part of the waste management program. DOE is committed to complying with all applicable Federal, state, tribal, and local regulations concerning transportation and believes that the excellent safety record of spent fuel shipments over the past 30 years will continue.

CASK DESIGN FOR THE SAFE TRANSPORT OF CO IRRADIATION UNIT AND SPENT FUEL FROM ETRR-2 RESEARCH REACTOR

M. Aziz Ibrahim

National Center for Nuclear Safety,
Nasr City, Cairo, Egypt

Abstract.

MCNP and ORIGEN II codes were used to determine gamma ray dose-rates outside two casks which have been used to transport radioactive ^{60}Co and spent fuel from the ETRR-2 research reactor. Both, shielding and criticality calculations were performed to ensure safe transport of radioactive materials.

1. Introduction

ETRR-2 is the second Egyptian research reactor. The reactor is used for the purpose of research and radioisotopes production[1]. Cobalt is irradiated at the central position of the reactor core. After the end of irradiation processes, the cobalt unit is transported to the manufacture. In this paper MCNP code[2] was used to design two casks: the first to contain and transport the cobalt unit from the reactor core to the irradiation facility, the second, to transport the spent fuel from ETRR-2 reactor core to the spent fuel storage pool of the ETRR-1 reactor.

In the first case, the cobalt cask, shielding calculations were performed to evaluate the gamma ray dose rate from activated Co^{60} source outside the surface of the lead shield. For the second cask, which contains fissile and spent fuel, both criticality and shielding calculations were performed to ensure safe transport of radioactive and fission materials. ORIGEN-II code[3,4] was used to calculate the spectrum of gamma rays from the burned fuel from ETRR-2 reactor and MCNP code was used to calculate the attenuation of gamma radiation through lead shielding. Criticality calculations were performed to ensure that the fuel is sub-critical during transport.

2. Cobalt Cask Design

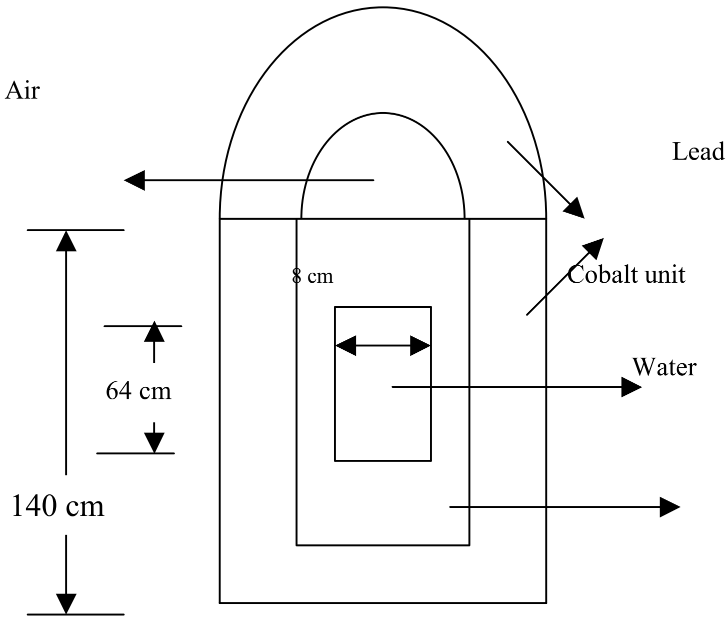


FIG. 1: dimensions of cobalt cask

The cobalt cask is used to transport the cobalt irradiation device from the reactor core. The device contains 16 tubes of aluminium (internal diameter 0.385 cm, thickness 0.125 cm) which are filled with cobalt pellets. The active height of the cobalt unit is 64 cm. The cobalt device contains 600 g of cobalt ^{60}Co with a specific activity 200 Ci/g. Figure 1 shows the cobalt irradiation device and the lead shielding. MCNP code was used to model cobalt device and lead shield. Co^{60} emits two photons[5] with energy 1.33 MeV and 1.17 MeV. The gamma ray total dose-rate at one metre from the surface of the lead shielded cask was calculated using MCNP code. Figure 2 shows the gamma ray dose-rate (µSv/h) as a function of the thickness of the lead shield. The results indicate that as lead thickness increases, the dose-rate at 1 m from the lead surface decreases. At a lead thickness of 25 cm, the dose-rate is approximately 10 µSv/h.

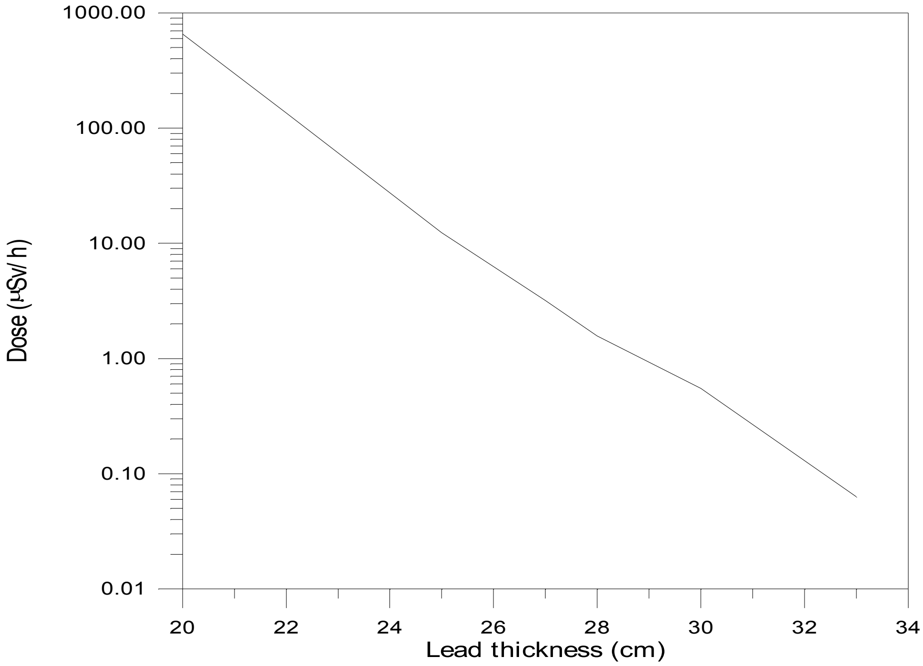


FIG. 2: Dose-rate (µSv/h) versus lead thickness

2. Spent Fuel Cask

ETRR-2 research reactor fuel is of MTR type. The maximum burn up in the reactor fuel is 100,000 MWD/T. ORIGEN II [6,7] code was used to burn the fuel element up to the maximum burn up, and the fuel is cooled for one month. The emitted gamma rays from all activation products, fission products and actinides of burned fuel after one month of cooling is considered as a source to the lead shield. MCNP code was used to attenuate gamma rays and determine the dose at 1 m from the surface of the shield. Lead thickness was increased to reduce the dose outside the lead shield to a level less than the maximum permissible dose. Table 1 indicates that a lead thickness of 28 cm reduces the dose to approximately 10 µSv/h

3. Criticality Calculations

Criticality calculation was performed to calculate the multiplication factor of the spent fuel during transport. The fuel are maintained in fuel cell, each cell contains 4 fuel elements (2x2). The wall of the cell consists of 3 layers (stainless steel, cadmium and stainless steel), each layer of a thickness of 0.1 cm. The multiplication factor of the storage cell was calculated using two codes, CITATION and MCNP. The results[8] are shown in Table 2. The results indicate that $K_{eff} < 1$ for the storage cell, to ensure that the fuel is sub-critical during transport[9,10,11].

Table 1: Calculated dose (µSv/h) versus lead thickness (cm)

Lead thickness (cm)	**Dose (µSv/h)**
20 cm	374.85
22 cm	151.265
25 cm	112.313
27 cm	24.642
28 cm	11.9665
30 cm	2.8731

Table 2: Storage cell multiplication factor

Code	$\mathbf{K_{eff}}$
MCNP 4A	0.77385
CITATION	0.7747

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DESIGN DEVELOPMENT AND TEST PERFORMANCE OF CONSTOR® TRANSPORT AND STORAGE CASKS FOR SPENT FUEL ASSEMBLIES

R. Diersch, K. Gluschke, S. König

GNB Gesellschaft für Nuklear-Behälter mbH (GNB)
Essen, Germany

Abstract.

Transport and storage casks of the CONSTOR® (***CON***tainer for ***S***torage and ***T***ransport of ***R***adioactive Material) type have a cask body of two steel liners with heavy concrete in between and a double lid system. The CONSTOR® was developed with special consideration to an economical and effective way of manufacturing by using conventional mechanical engineering technologies and common materials. The main objective of this development was to fabricate these casks in countries not having highly specialized industries for casting or forging of thick-walled casks. Up to the end of 2002, 27 CONSTOR® casks for low heat load RBMK-fuel are loaded in the Ignalina INPP. The analyses of nuclear and thermal behaviour as well as of strength according to IAEA examination requirements and of the behaviour during accident scenarios at the storage site were carried out by means of approved calculation methods and programmes as well as of extensive test programmes. Since the year 2000, an advanced CONSTOR® has been developed at GNB to meet the requirements for the storage and transport of higher active fuel assemblies. For the advanced CONSTOR , another safety test program had been developed. It was shown that CONSTOR® casks can be used for the safe transport and storage of spent nuclear fuel. The concept can be flexibly adapted to different kinds of spent fuel specifications.

1. Introduction

The CONSTOR® was developed with special consideration to an economical and effective way of manufacturing by using conventional mechanical engineering technologies and common materials. The main objective of this development was to fabricate these casks in countries not having highly specialized industries for the casting or forging of thick-walled casks. Nevertheless, the CONSTOR® concept fulfils both the internationally valid IAEA criteria for transportation and the criteria for long-term intermediate storage. The Ignalina Power Plant (INPP) ordered 60 casks for low level heat load RBMK fuel, 40 of them are already delivered. Up to the end of 2002, 27 CONSTOR® casks were loaded at the Ignalina INPP.

2. The CONSTOR® Cask Design

The cask body of the CONSTOR® V/32 for spent PWR fuel assemblies (see Figure 1) consists of an outer and an inner shell made of steel. The space between the two shells is filled with heavy concrete for gamma and neutron shielding. The CONSTOR® design does *not* rely on the concrete for structural integrity. The cask bottom has the same sandwich design as the wall. At the top end, the shells are welded to a ring made of forged steel. The trunnions for lifting and handling are attached to this ring.

The lid system is designed as a multi-barrier system in two versions. In the first version, the bolted primary lid fulfils strength and shielding functions. For temporary sealing, this lid is made leak-tight with the aid of an elastomer seal. The sealing plate and the secondary lid are welded to the forged steel ring after loading and servicing of the cask. These two welded lids together with the inner and outer shell (including their bottom plates) constitute the double barrier system. In the second version, both the primary and the secondary lid are metal-sealed and bolted.

The welding of the shells and the lids was made by a qualified welding technique according to a certified QA-plan and checked by a special QC-programme. The welds have the same properties as the basic material. Consequently, a leak tightness monitoring system is not necessary for the CONSTOR® cask during the long-term interim storage. During public transport, wooden impact limiters will be attached to the bottom and the lid sides of the cask in order to fulfil the IAEA safety criteria. The spent fuel assemblies are positioned in a basket inside the cask.

Since the year 2000, an advanced CONSTOR® has been developed at GNB to meet the requirements for the storage and transport of higher active fuel assemblies. Compared to the initial CONSTOR® RBMK design, adaptations have been made for different types of spent fuel in order to meet the enhanced requirements. Both the heavy concrete and the design of the reinforcement was modified to improve the shielding properties and the possible heat transfer capacity. The capacity of the standardized basket for PWR fuel assemblies of the Westinghouse type is 32. The total mass of the loaded CONSTOR® V/32 cask, including impact limiters, is approx. 132 000 kg. The CONSTOR® BWR adaptation has also been made for 69 fuel assemblies. The total mass in the transport version is also about 132 000 kg. Further adaptations do exist for RBMK and VVER fuel.

For the cask metal parts, a weldable steel material has been chosen, which has excellent properties against brittle fracture and fatigue at temperatures down to -40 °C. The mechanical properties of the steel are sufficient to guarantee the required strength.

The long-term corrosion protection is guaranteed by

- application of stainless steel at the inner liner
- special anticorrosive paint system (outside)
- dried inert gas atmosphere inside the cask
- hermetically sealed concrete space between the inner and outer shell.

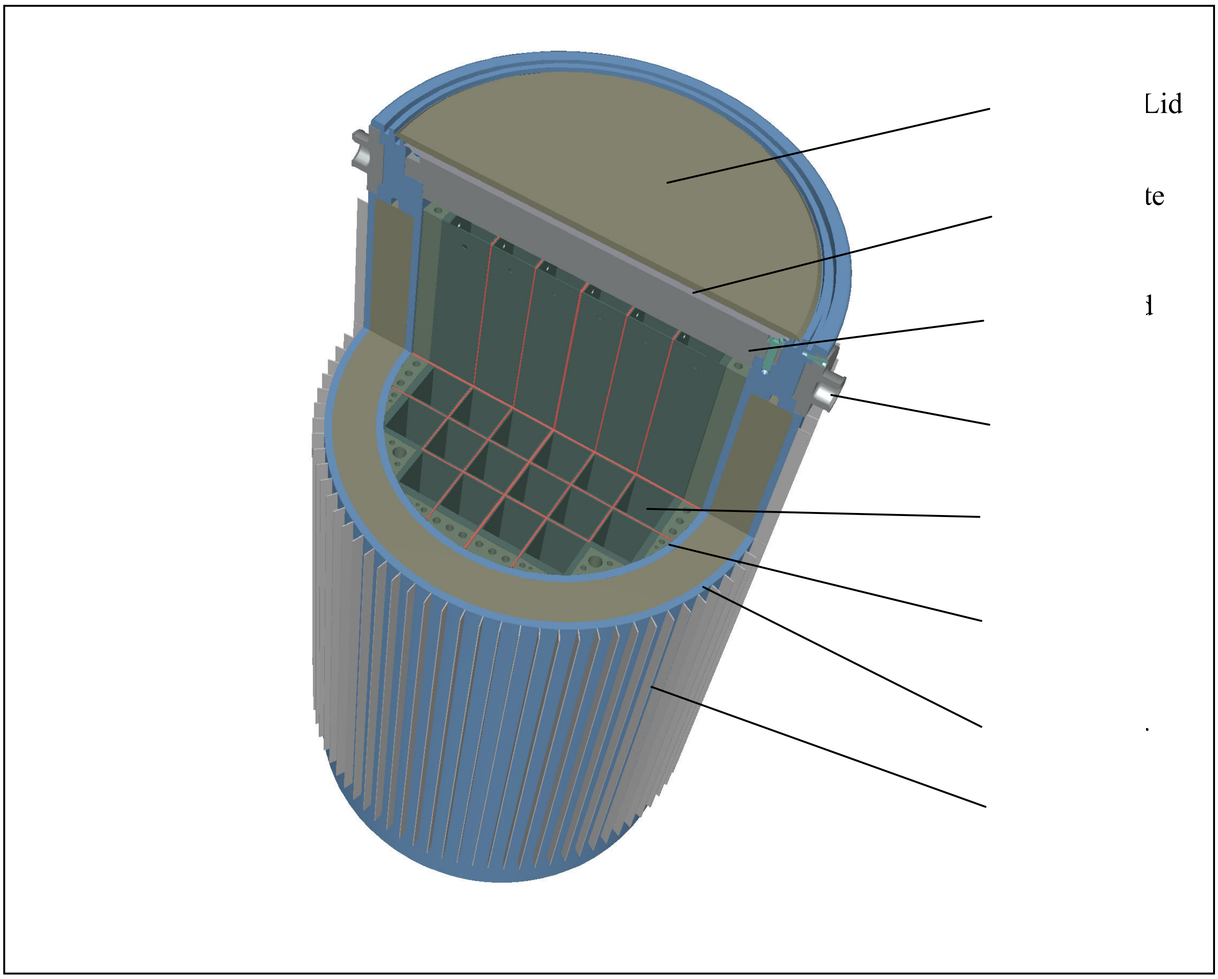

FIG. 1. CONSTOR® cask design

The heavy concrete is based on steel granules and bounded by normal cement. To improve the heat removal properties, special heat conducting elements are arranged in the concrete layer between the inner and the outer steel shell. In this way, the heat capacity of the content can be increased up to approx. 30-35 kW per cask.

3. Safety analyses for the CONSTOR® design

For the CONSTOR® design, analyses of nuclear and thermal behaviour as well as of strength according to IAEA examination requirements (9-m-drop, 1-m-pin drop, 800 °C-fire test) and of the behaviour during accident scenarios at the storage site were carried out by means of approved calculation programmes as well as of extensive test programmes using a 1:2 scale model. A specimen for those drop tests is shown in Figure 2.

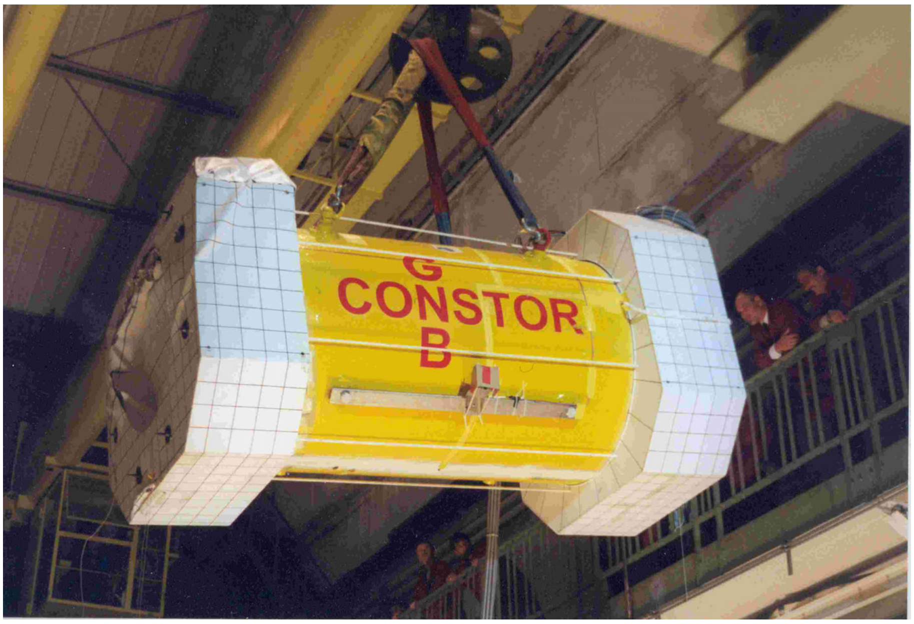

FIG. 2. CONSTOR® 1:2 model cask

All the typical drop orientations were investigated:

(a)	9-m-drop onto the IAEA target	(i)	side end
		(ii)	vertical end
			- bottom end
			- lid end
		(iii)	drop onto the corner
			- bottom end
			- lid end
		(iv)	oblique drop (slap-down)
(b)	1-m-drop onto the IAEA pin	(i)	side end
		(ii)	bottom end

The strength analyses have shown that the mechanical stresses under both normal operational and test/accidental conditions are below the respective allowable stresses. The results of the safety analyses after the drop tests according to IAEA-regulations as well as after a hypothetical 1-m-drop at the storage site were confirmed by means of a test programme using a scaled model [1]. The post-test inspection programmes of the model casks have shown that the cask integrity and leak tightness were maintained after the drop test series.

The thermal behaviour of the CONSTOR® cask was analyzed for the normal transport conditions and for the IAEA fire test conditions. The respective analyses were performed by the numerical-analytical method for the calculation of the assemblies' steady-state thermal conditions. Under fire accident conditions, a non-steady-state thermal analysis was used for the cask [2]. The methods were verified by experimental benchmarking programmes and by thermal tests and the 800 °C fire test using the above-mentioned 1:2 scaled-down model of the CONSTOR® cask. It was shown that the calculated temperatures are consistent with the experimental results.

The mechanical calculations were mainly performed by Ove Arup in London. As an example for LS-DYNA analysis results, the cask model with impact limiters used for the oblique drop is shown in Figure 3.

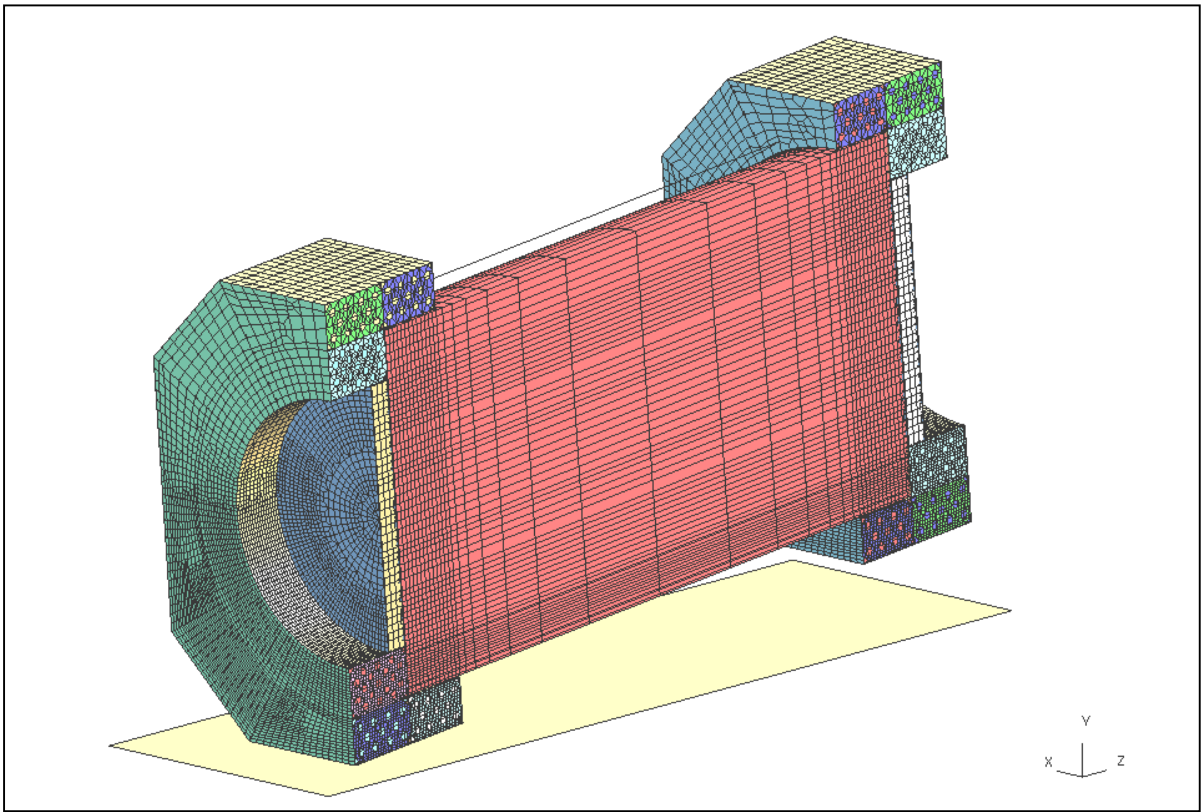

FIG. 3. CONSTOR®: LS-DYNA cask model with impact limiters during the 9-m-oblique drop

4. Conclusions

Using detailed analyses and tests, it has been shown that the CONSTOR® cask concept can be used for the safe transport and storage of spent nuclear fuel.

The concept can be flexibly adapted to different kinds of spent fuel specifications. It can be manufactured in an economic way in countries with normal machining equipment.

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INDIAN EXPERIENCE WITH DESIGN, FABRICATION AND TESTING OF LEAD SHIELDED CASKS FOR TRANSPORTATION OF RADIOACTIVE MATERIAL

K. Agarwal*, B.K. Jain*, H.B. Kulkarni*, S. Vedamoorthy**

*Bhabha Atomic Research Centre, Nuclear Recycle Group, Mumbai-400085
**Nuclear Power Corporation of India Ltd., Mumbai-400094
India

Abstract

There are a variety of transport casks used in India for transportation of radioactive material ranging from small packages for radioactive sources to Type–B package for spent fuel transportation. Most of these casks are lead shielded type with Carbon steel on outer shell providing the required integrity. The first ever spent fuel shipping cask for PHWR fuel transportation by rail and road was designed and fabricated based on then available safety guide/standard 10 CFR-72 of USAEC and ORNL -TM-2410. There is a sufficient knowledge gained in last 30 years in design, fabrication and testing of casks specially to meet new challenges for safety and requirement of regulatory authorities. Subsequent designs are being carried out taking into account of these aspects. With the increasing need for transportation of spent fuel and other radioactive material and also to gain confidence of public, we have embarked upon a programme for testing of transport casks using scale models to validate the analytical methods and also setting up a test facility for drop tests, fire test and submergence tests for type A and B packages. This paper describes the design analysis, scale model testing and fabrication aspects of lead shielded casks for spent fuel and waste canisters.

Introduction

Transportation of radioactive material is one of the important activities of our nuclear industry. This activity in public domain is monitored and regulated by the regulating authority (Atomic Energy Regulatory Board). The national/international regulations are followed which specify performance standards for the packages against postulated scenario during off-normal/accident conditions. Drop tests, exposure to fire for duration of 30 minutes and submergence are the tests for which the regulatory safety codes stipulate the necessary compliance. The new IAEA regulations for Transport of Radioactive Material TS-R-1 which has come into force from 2001 has also introduced Type 'C' packages used for air transport and this has generated new set of challenges before the designers.

Present status of cask design and qualification

There are wide variety of transportation casks of various design used for transportation of different type of radioactive material. Around 80 types have been designed and are in operation. Some of the major ones are:

(i) transportation cask for radioactive sealed sources being used for irradiators,
(ii) gamma chambers of various capacities e.g. GC 5000, GC 4000, GC 1200, GC 900, GC 400,
(iii) cask for coolant channel transport,
(iv) cask for transport of spent fuel bundles for PHWR reactor,
(v) gamma radiography cameras (Rolli –I),
(vi) vitrified waste product shipping cask,
(vii) cask for transportation of Co^{60} (CoF- 285),
(viii) absorber rod transportation flask.

There are some casks, which do not move in public domain and are designed to meet normal condition of transport e.g.

1. hull disposal cask,
2. spent resin transportation cask,
3. liquid waste disposal cask,
4. off gas filter disposal cask.

There are large number of packages of different weights and sizes used in India for transportation of radioactive material both within the nuclear establishment and outside through public domain. Most of them are constructed of lead and steel. They were designed/analysed for accidental conditions using the flow pressure technique described in an ORNL design literature of 1970s. However, this technique cannot be applied to configurations other than lead and steel. It needs lots of approximations too, when the shapes get slightly deviated from cylindrical. Against this background, some attempts were made to demonstrate compliance as per regulation specified methods of testing or through numerical analysis. Efforts are being continuously made to get confidence on the analytical methods of analysis by drop testing scale models, actual casks in some cases and also conducting the thermal tests and then benchmarking the analytical codes for design analysis.

Transportation of cask for spent fuel

These transport casks (Fig.1) are designed for transportation of spent fuel from PHWR reactor to reprocessing plant or AFR storage facility and are designed for transportation by road or rail as type B(M) package.

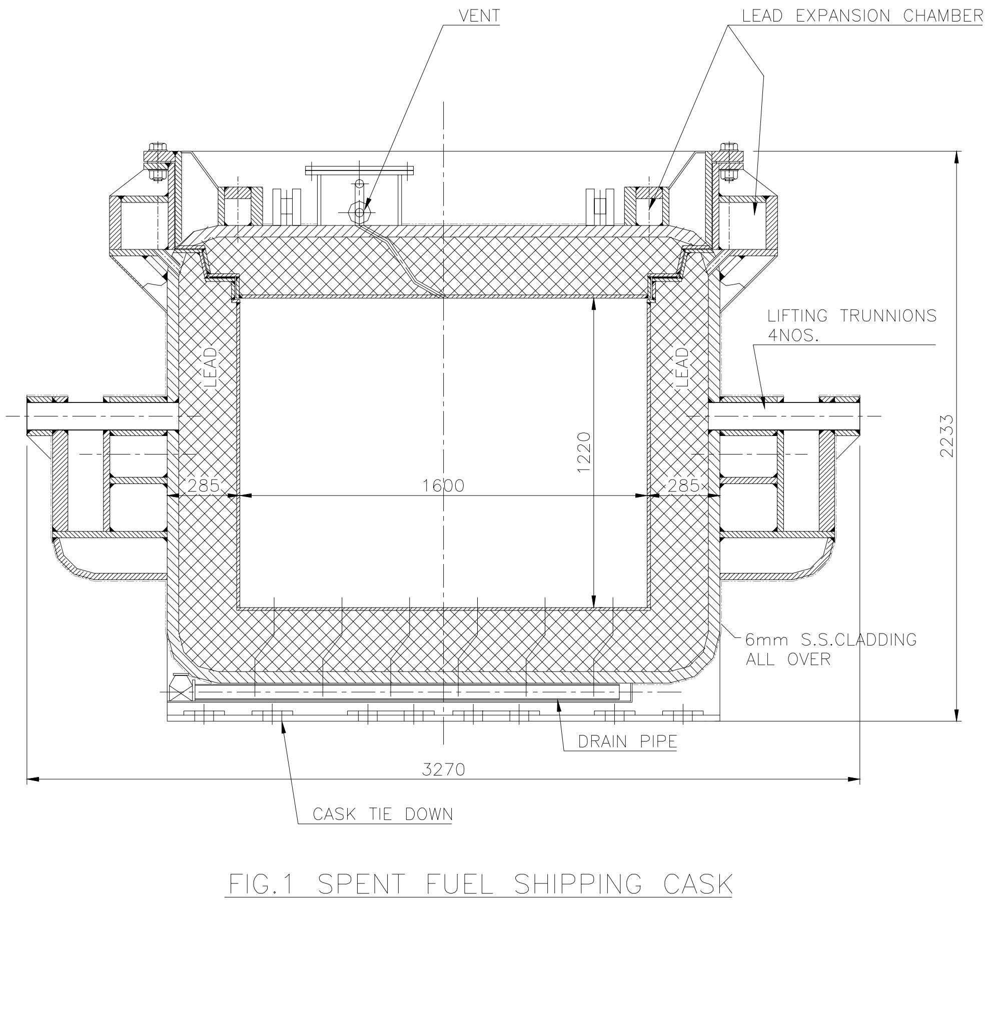

FIG.1 SPENT FUEL SHIPPING CASK

The capacity of cask is based on shielding, thermal and load handling considerations. The cask weighs around 60 Te and is made of 45 mm thick carbon steel as outer shell and 12 mm thick stainless steel as inner shell. The lead shielding thickness is 230 mm all around. An outer cladding of 6 mm SS 304L is provided over carbon steel for ease of decontamination. The cask has four lifting trunnions and bolting tie – down brackets by using M68 (8 Nos.) bolts. The cask lid has lid tie – down bolting arrangement using M33 x 44 Nos. bolts. It has lid tie – down lugs for handling the lid under water remotely with the same cask lifting yoke. The cask is provided with suitable drain & vent. It also has lead expansion chamber for body & lid for taking care of expansion of lead during 1/2 hr. fire test. The design has been found to meet the 9 m drop criteria except for the drop on trunnion.To qualify the design for a 9 m drop on the trunnion, the design of the trunnion has been modified and it is also proposed to use energy absorber on the trunnion to minimize the effect of impact.

Transportation casks for waste canister

The high active liquid waste is vitrified into glass matrix in a SS canister. Such three canisters are loaded into an SS overpack which can be handled inside the shipping cask (Fig.2).

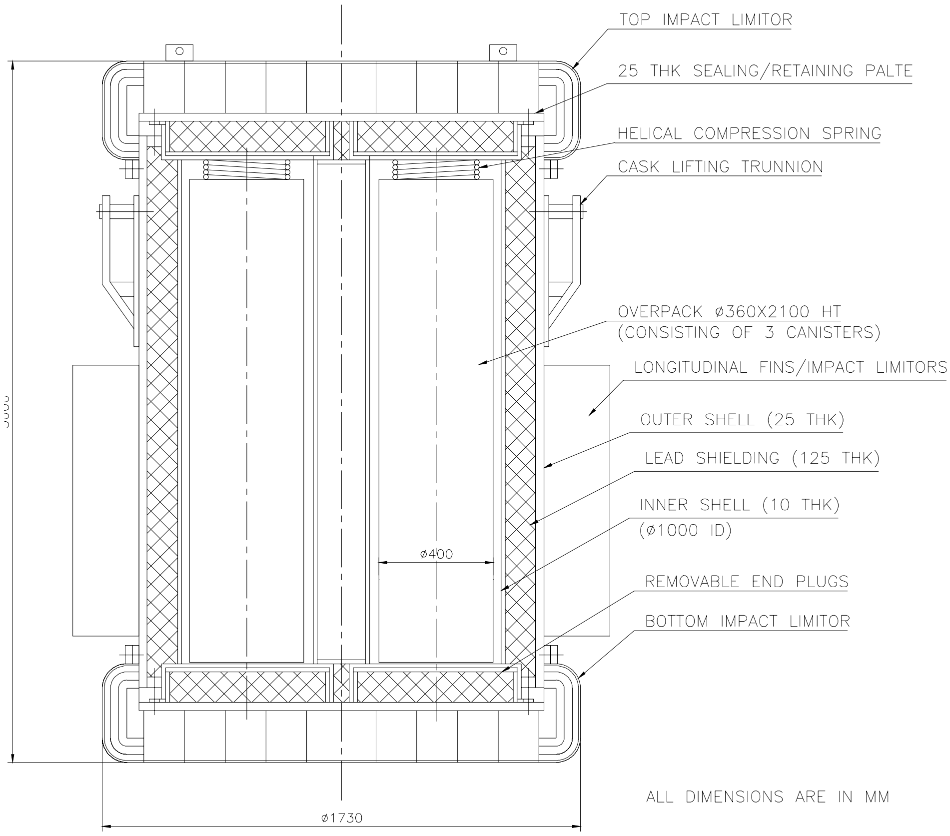

FIG.2 SHIPPING CASK FOR VITRIFIED WASTE PRODUCT

Shipping cask has been designed to transport 3 such overpacks having 3 canister each for transportation from Waste Immobilization Plant, Trombay to Solid Surveillance Storage Facility at Tarapur. This cask has been designed to meet requirement of type B (M) packages. The important aspects are heat load from the canisters, radiation shielding from the inventory of activity in canisters and impact resistant for 9 m drop of cask in worst orientation. The detachable energy absorbers (impact limiters) made of CS pipes have been provided to absorb most of the energy of 9 m fall.

Design methodology

***Shielding analysis*:** The analysis is done using two dimensional Point Kernel build up factor technique code GS – EXT. The shielding is modelled in R-Z geometry and calculations are based on 18 removable neutron groups and 7 gamma energy groups. Build- up factors are included for different materials. The source is modelled according to the cask geometry. The dose rates at various distances from surface of cask are estimated for normal condition of transport. The shielding thickness required for accidental condition of transport is also estimated.

Thermal analysis: As per regulation, it is mandatory to limit the surface temperature of cask to 85 degree C and also the cask has to withstand half hour fire test at 800 degree C for accidental condition. A transient analysis is carried out to determine the temperature distribution across the cask using finite element approach and as well as lumped parameter approach. The temperature of inside lead is estimated for finding out melting and expansion of lead which will exert external pressure on the inner shell of the cask.

***Impact analysis*:** The most important condition of design for shipping cask for impact is that the shipping cask has to withstand 9 m drop on an unyielding target in a worst orientation such that integrity of the containment system and shielding are retained to the extent specified by regulation. However the facilities for experimentally performing 9 m drop test on shipping cask and thereby investigating the design modification for improvement of structural integrity of cask are very expensive and time consuming task. Such facilities are being developed indigenously for testing scale models up to 10 Te weight. All previous transportation casks have been analyzed for drop test and thermal test using FEM methods and drop tested on make shift targets.

Recently an attempt has been made to test the 1:4.5 scale model of spent fuel shipping cask for 9 m drop test in horizontal, vertical and corner drop orientation. This facility has been developed with the help of an outside agency. The FEM dynamic code was qualified using bench mark problem and verification of actual drop tests with analytical results to estimate the effect of drop test using non linear finite element method. The loss in shielding thickness is predicted by the analysis to assess the radiation levels after the drop test. This includes lead slumping, bolt’s failure, drop on trunnions, total impact duration etc. The simultaneous analysis is applied to full scale cask. A relationship between the results of main model and scaled model are established. The target is defined by using rigid wall option. The actual target was made of a concrete block of about 16 Te for cask model of 700 Kg (23 times the cask weight) and target size is 1.8 m x 1.8 m x 1.8 m with a 200 mm thick mild steel plate at top surface. The result of this simulation analysis co-relate well with the drop test both in flat and corner drop and overall deformation at various locations with lead shielding was within 1-2%. Some of the grey areas having constraints in design analysis are as follows,

- the contribution of stay rods towards the structural integrity of the cask;
- the thermal effects like heat transfer due to Tin-Zinc coating on Steel shells before pouring of lead;
- consideration of molten lead solidification as a design criterion for Inner shell needs some experimental studies. However, it is recommended as a fabrication practice that stiffeners may/shall be used to overcome the distortions during lead pouring;
- modelling of the gasket for predicting leak rates after drop and fire tests.

Lead filled casks are difficult to analyse in non-cylindrical shapes. Hence, new materials like forged steel, ductile cast irons, depleted uranium or a hybrid shield of any of them are being developed for complex designs. Similarly shock-absorbing materials like polyurethane foam, wood and gasket materials like Grafoil are being looked into for material characterization for use in transport casks.

Fabrication

These devices/equipments contain radioactive material and are used in public domain. Therefore stringent quality assurance such as raw material inspection and testing, welder qualification and radiography and die-penetrant testing, pressure test for lead chambers & cask cavity, volumetric efficiency testing and radiometry of lead filled casks are employed to ensure the desired quality during manufacture of casks.

Well defined procedures are followed during welding and lead pouring of cask to avoid distortion and voids. Pre- heating of job is carried out by controlled induction heating. The annular space between inner and outer shell is leak tested for molten lead pressure before the lead is filled in. The sequence of lead pouring of heating/cooling is adjusted in such a way that there is no distortion and formation of voids. Sufficient vent holes are provided during lead pouring for expulsion of trapped air. The cask is cooled gradually in air after the lead pouring before final inspection by radiometry. The defect, if any found during radiometry are repaired by suitable technique and rechecked for shielding integrity.

Cask testing facility

Most of the earlier drop tests were done in make shift arrangements for a particular package. With the increase in volumes of transportation, requirement for casks of different designs has increased. Thus to meet latest regulatory codes and guidelines and also to gain public confidence in the safety of transportation of radioactive material, a permanent cask testing facility for various tests is being set up in India which would cater to analysis and testing of all types of packages including newly introduced type-C packages before certification from the regulatory authority. Two high-speed video cameras placed perpendicular to each other, assisted by motion analysis software is expected to ensure the orientation of drops. High capacity and speed data acquisition and processing system will receive data from strain gauges and accelerometers. A chilling facility to simulate $-40\ ^{0}C$ ambient condition, leak testing set up and dimension control facility are other essential systems being planned in the facility.

TRANSPORT OF NUCLEAR FUEL CYCLE MATERIAL IN JAPAN - *Packaging, Method, Experience*

T. Saegusa[a], S. Hamada[b], T. Kitamura[c]

[a] Central Research Institute of Electric Power Industry, Chiba,
[b] Ministry of Economy, Trade and Industry, Tokyo,
[c] Japan Nuclear Cycle Development Institute, Ibaraki,
Japan

Abstract

In Japan, nuclear fuel cycle materials (UF_6, UO_2, fresh fuel, spent fuel, radioactive waste, etc.) are transported on land and sea. For the transport, containers (approved packagings) conforming to the Transport Regulations in Japan based on the IAEA Regulations are used. Those packagings are designed in consideration of viewpoints of structural strength, heat removal, containment, shielding, and criticality safety, etc. In order to assure more safety of the transport, containment and shielding performance of the packages are confirmed prior to each transportation. For the land transportation of nuclear fissile packages, a convoy of transport vehicles is formed to assure safety, to which a person responsible for the transportation and an expert of radiation control, etc. accompany. For sea transport of spent fuel and high-level radioactive wastes, a dedicated ship with double hull structure that conforms to the INF code of IMO is employed.

1. Transport of nuclear materials

In Japan, uranium for nuclear fuel used at nuclear power plants is mainly imported in either form of natural/enriched uranium hexafluoride (UF_6) or uranium dioxide (UO_2) powder from abroad. Through enrichment, reconversion, and fuel fabrication processes, the fresh fuel assemblies are transported overland to respective nuclear power plant. Spent nuclear fuel generated at nuclear power plants are cooled for a certain period in the reactor pools and transported to the reprocessing plants* in Ibaraki prefecture and Aomori prefecture. High-level radioactive wastes generated from reprocessing of spent fuel are sea-transported to the High Level Wastes Management Facility in Rokkasho-mura in Aomori prefecture. For the transport, containers (approved packagings) conforming to the Transport Regulations in Japan based on the IAEA Regulations are used. The safety of the packagings are strictly examined by the competent authority if they conform to the technical criteria considering the characteristics of the contents, and are confirmed if they are fabricated as designed. On top of that, in order to assure more safety of the transport, containment, shielding performance and surface contamination, etc. of the packages are confirmed and controlled prior to each transportation. Transport method and selection of transport route are also important factors. Further safe transport is assured by thorough investigation of transport route and proper selection of transport date and time, speed of the transport vehicle, formation of the convoy of the vehicles, etc. Table 1 shows the amount of nuclear fuel materials transported for nuclear power plants and nuclear fuel cycle facilities from 1996 to 2000[1].

* The reprocessing plant is being constructed at Aomori Prefecture for the planned operation from 2005 and the storage pool is being operated.

2. Packagings for nuclear materials

Packages for nuclear materials are classified depending on the radioactivity and existence of fissile materials, etc. in the content. Those packagings are designed and fabricated in consideration of viewpoints of structural strength, heat removal, containment, shielding, and criticality safety, etc. in accordance with the characteristics of the content. Currently, packagings used in Japan are successively confirmed if they conform to the new technical criteria based o the 1996 Edition of the IAEA Regulation for the Safe Transport. All packagings will conform to the IAEA Regulations by the end of December 2003. FIG. 1 shows examples of packages for nuclear material transport used in Japan.

Table 1: Amount of Transportation of Nuclear Fuel Cycle Material in Japan

		1996		1997		1998		1999		2000	
		T	Q	T	Q	T	O	T	Q	T	Q
Fresh fuel	UF_6	50	720	52	704	34	418	32	534	32	387
	$U0_2$ etc	79	747	74	745	83	731	70	556	66	475
	Fuel Assemblie	77	1217	51	825	66	1101	65	902	64	1085
Fresh fuel Subtotal		206	2684	177	2274	183	2259	167	1992	162	1947
Spent fuel		22	199	9	127	6	69	10	107	8	102
HLW (Unit : tons)		1	20			1	30	1	20		
Others		27	1.6	23	2.7	10	0.3	12	0.2	9	

T: Number of transportatron, Q: Total quantity (Unit: tons of uranium)

NOTE

1.This table shows nuclear fuel materials transported subject to confirmation by code, which are type A.

2.UF_6 refers to enriched uranium hexafuoride,

$U0_2$ refers to uranium dioxide, uranium trioxide and other uranium oxides.

Fuel Assemblies refers to bundles of U02 fuel and MOX fuel.

HLW refers to high-level radioactive waste.

Others refers to LLW (low-lever radioactive waste) etc.

2.1. UF_6 Packagings

The 48 Y cylinder is used for the transport of natural UF_6 as raw material to uranium enrichment plant. The package of natural UF_6 is classified as H(U) package and is strictly examined by the competent authority in Japan based on the new technical criteria. Most of the UF_6 imported from the oversea uranium enrichment plants is low enriched (less than 5% enrichment) and is transported the 30B cylinder as a packaging of Type A fissile package. The 30B cylinder is overpacked by a steel container that is pressure resistant and has containment performance. The container is inner-layered with thermal insulator/mechanical shock absorber (phenolic foam). The enrichment of uranium content is less than 5% and the maximum radioactivity per cylinder is approximately 245GBq.

2.2. UO_2 Packagings

The UO_2 powder is transported as Type A package for fissile material. The packaging consists of an inner container and an outer container that is heat resistant and mechanical impact resistant. Conventionally steel drums have been used for the packagings, but now a large packaging consisting of an outer container with a form of rectangular solid made of stainless steel and inner container of nine columns has been developed and used for transport in order to conform to the 1996 Edition of the IAEA Regulations.

2.3. Packagings for fresh fuel assemblies

The radiation from the fresh fuel assemblies is weak and transported as Type A package for fissile material. A packaging for BWR type fuel consists of winner and outer containers. The inner container is a long rectangular solid that holds two fuel assemblies in parallel and the outer container holds the inner container with mechanical shock absorbers in-between. The maximum radioactivity per packaging for both BWR and PWR fuel is less than 150GBq.

2.4. Packagings for spent fuel

Packages for spent fuel are classified as Type B package for fissile material. They are designed to assure safety under the normal (stacking test, penetration test, etc.) and accident (9m drop test, thermal test of 800° for 30 minutes, immersion test under a head of water of 200m, etc.) conditions. An example shown in Fig. 1 is a typical packaging for spent fuel. The packaging consists of container body made of stainless steel, fuel basket to assure sub-criticality, shielding materials such as lead and resin, surface fins to discharge heat, etc. Mechanical shock absorbers are attached to the both extremities of the container.

2.5. Packagings for low level radioactive materials

Low level radioactive wastes (bearing negligible radioactivity such as laundry water, paper trash, used work clothes, plastics, metals, etc.) generated with operation and periodic inspection of nuclear power plants are incinerated or compressed and packed into drums with mixture of cement, asphalt, etc. The low level wastes are transported as Industrial Type Package. In order to transport many solidified wastes safely, securely and quickly, the packages are installed in a container resistant to mechanical impact, which holds 8 solidified wastes.

2.6. Packagings for high level radioactive materials

Wastes (high level radioactive wastes) bearing strong radioactivity generated with reprocessing spent fuel are mixed with glass, sealed in a special container and transported as a form of stable vitrified solid (canister). The high level radioactive wastes are classified as Type B packages. For transport, packagings with performance of containment, shielding, heat removal, etc. are employed.

3. Transport methods for nuclear fuel cycle materials

3.1. Land transport

For the land transport of packages containing fissile materials, etc., a convoy of transport vehicles is formed with escort vehicles in front of and after the loaded vehicles, in order to assure more safety of public. The vehicles are equipped with wireless set, automobile telephone, etc. In order to secure safety by constant communication with the other vehicles and transport headquarter. In the convoy, an expert of radiation control, etc. other than a person in charge of transport accompany.

3.2. Sea transport

For the sea transport of spent fuel and high level radioactive wastes, dedicated ships of double hull structure complying with the damaged stability requirement (FIG. 2) are employed in order to conform with the regulations of Ministry of Land, Infrastructure and Transport that incorporated the INF Code (International regulations for safe sea transport of irradiated fuel, etc.) of IMO (International Maritime Organization).

4. Summary

In Japan, the safety of transport of radioactive materials is assured through the confirmation of its conformity to the regulations by the competent authorities at each step of design of package, fabrication of packaging, transport measures, etc. In particular, it is a unique system that the competent authorities approve the packagings every 3 years; hence the integrity of those in-service packagings is periodically confirmed.

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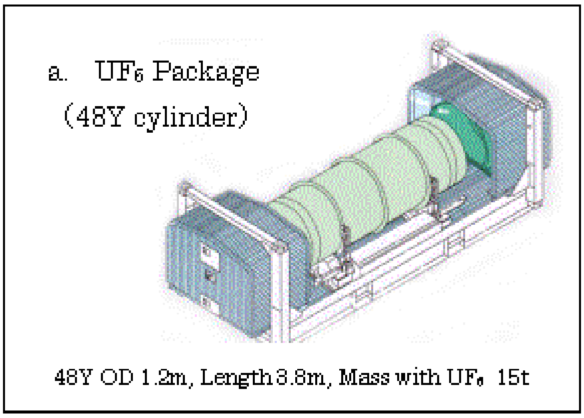

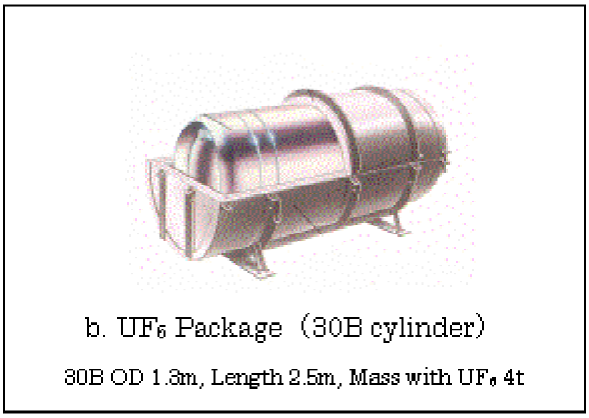

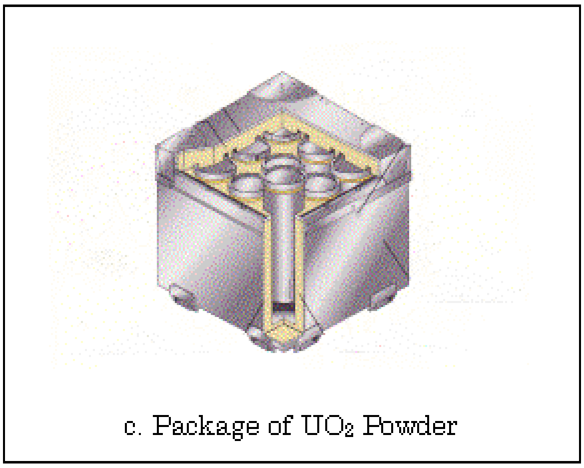

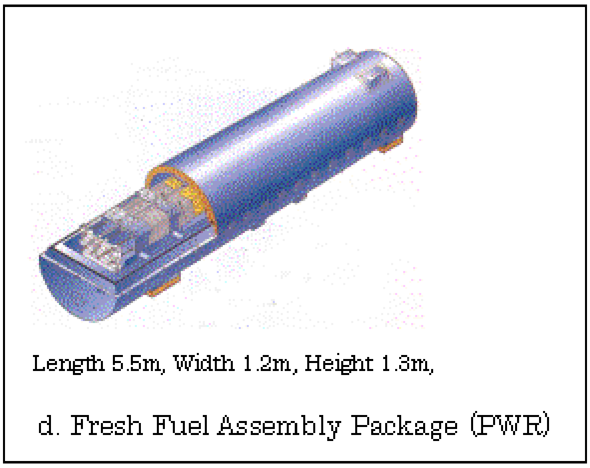

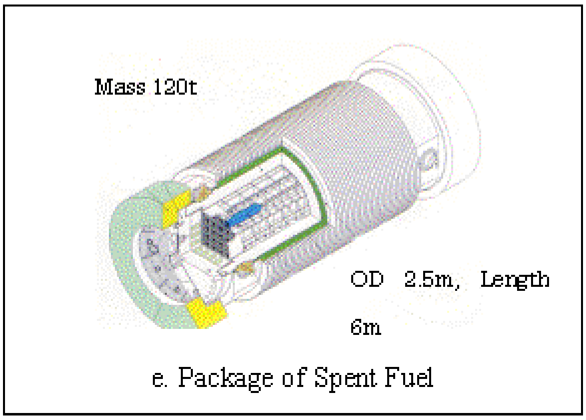

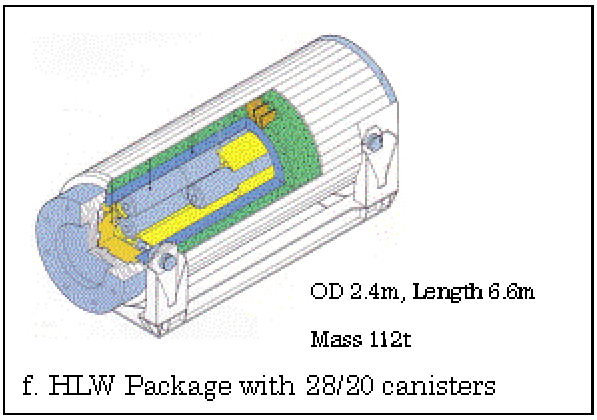

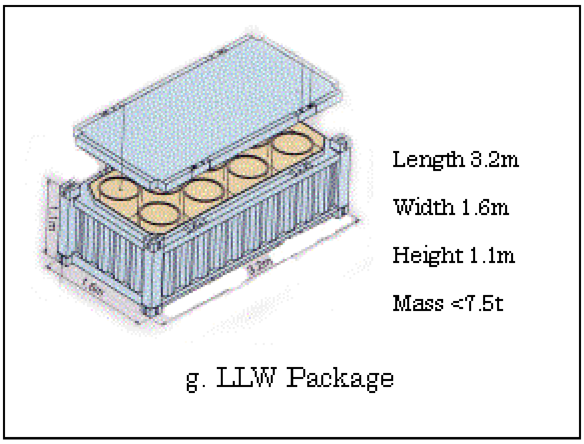

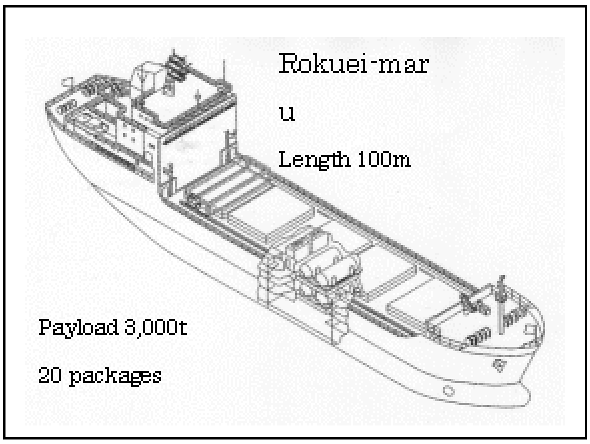

Figs.1 a-g: *Examples of Packages for Nuclear Fuel Materials.* ***Fig..2***: *Dedicated Ship for Spent Fuel*
(Figures 1 and 2 show approximate dimension and mass with contents.)

PACKAGING OF THE BN-350 SPENT FUEL FOR FURTHER TRANSPORTATION TO THE DEPOSITARY PLACE

T.S. Dairbekov

Kazakhstan Atomic Energy Committee,
4, Chaikina st, Almaty, 480020,
Kazakhstan

Abstract.

This paper describes Kazakhstan's experience in the packaging of spend fuel of the fast breeder reactor BN-350 during the decommissioning process and in preparing the spend fuel for transportation from the site.

1. Introduction

The fast breeder reactor BN-350 was in operation from 1973 to 1999. In April 1999 the Government of the Republic of Kazakhstan made a decision to stop the operation and to start the decommissioning process. In this connection some technical questions were arising.

2. Description of packaging

One important part of the BN-350 decommission process was the question of removing fuel from the reactor and transporting them to a place of long term storage. Transportation should be done in accordance with the Regulation for the Safe Transport of Radioactive Material [1] which was adopted and put in force on the territory of Kazakhstan in 2002.

During the preparation of the transportation it was necessary take in to account that spent fuel is not only highly irradiated but also that it contains plutonium and enriched uranium. In this respect safety and safeguards measures needed to be considered.

It was decided to package spend fuel into canisters. The canisters (Fig.1.) consist of an outer body and an insert, which is loaded into the outer body. The spent fuel assemblies are loaded into the insert of the canister and after that it is loaded into an empty body. A shield plug is placed in the canister on top of the insert, and the lid welded on the canister. The canister is then dried by heating and vacuumization, filled with inert gas, and placed in the pool for temporary storage. Eventually the canisters will be transported to the storage facility where they will be placed for long-term storage.

The canister is designed to provide remote handling during packaging operations, drying, and minimization of radiation exposure to workers during closure operations. The canister has the capability to withstand normal handling loads, transportation loads, abnormal pressure loads up to ten atmospheres at temperatures up to 350 C and impact loads associated with 4 m drop on the bottom end.

The canister has two safety functions precluding formation of a critical situation. The first function occurs under any external impacts retaining position of fuel in a canister within the given limits and thereby, providing the required sub-criticality level. The insert tubes prevent hazardous dilation between pins of a bundle holding the whole bundle within the space limited by a tube. They also prevent a fuel bundle from displacing into the empty location in the canister center. The second safety function is to maintain a confinement barrier to the release of radioactive products into the environment during dry storage. The fuel cladding provides the first barrier; the canister duct provides the second barrier. A canister tight duct allows creating inside the canister an inert gas (argon) atmosphere to prolong the cladding life.

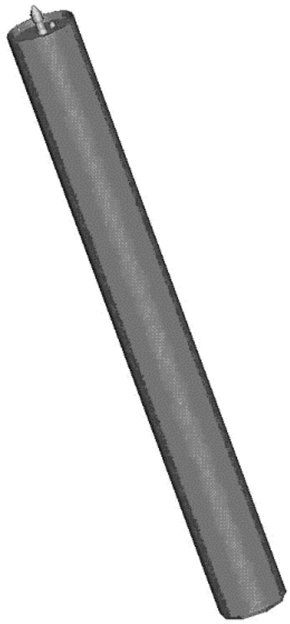

FIG. 1: Canister

Two types of inserts (Fig. 2.), the 6-pack and the 4-pack, are required for the operation. The 6-pack insert is used for loading the majority of the spent fuel assemblies. It consists of six tubes, each of which holds one fuel assembly. The 4-pack insert is used for loading spent fuel, which is in two different configurations.

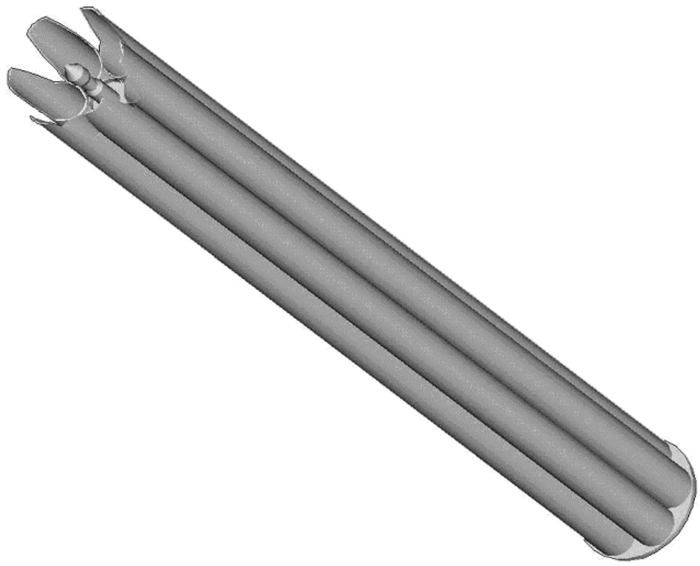

FIG. 2: Canister Insert

The first configuration consists of non-failed assemblies which have significant bowing and do not fit into the 6-pack insert.

The second configuration consists of failed or fragile fuel assemblies or rods which are placed in a sealed stabilization capsule. The stabilization capsule is then placed in one of the tubes in the 4-pack insert. The Canister Insert maintains geometric control of the assemblies within the canister and provides a handling feature before the canister is closed.

To the 6-pack Canister Insert, three fuel assemblies and three blanket assemblies were loaded. In accordance with the Regulation for the Safe Transport of Radioactive Material the criticality safety index for each canister was determined.

The lid has a lifting pintle in the top center which is used for all handling operations. Also, there is an evacuation port in the top of the lid. This port is a stainless steel quick-disconnect type, to expedite closure operations, which will be seal- welded and closed when all closure operations are complete. The lid and shield plug reduce general area radiation background during weld operation.

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DEVELOPMENT OF DUAL-PURPOSE TRANSPORT PACKING SET WITH BIOLOGICAL PROTECTION MADE OF DEPLETED URANIUM FOR TRANSPORTATION AND LONG-TERM STORAGE OF 36 RFRA OF WWER-1000”

R.I. Il’kaev[a], V.Z. Matveev[a], V.I. Shapovalov[a], A.I. Morenko[a], L.V. Barabenkova[a], V.K. Orlov[b], V.M. Sergeev[b], A.G. Semenov[b], N.S. Tikhonov[c], Yu.V. Kozlov[c], A.I. Tokarenko[c].

[a] RFNC-VNIIEF, [b] SRC VNIINM, [c] SI VNIPIET
Russian Federation

Abstract

The report is devoted to the problem of development of a promising design of a dual-purpose transport packing set (TPS-117) with biological protection made of depleted uranium for transportation and long-term storage (not less than 50 years) of RNF of WWER-1000 reactors. Use of depleted uranium as effective gamma-protection and use of siloxane rubber as a solid neutron protection in TPS-117 design allow to reach the maximum loading of container with retired nuclear fuel at the given dimensions of TPS with compliance to all requirements of the IAEA on safety.

1. Introduction

As a result of activities under various military and civil programmes involving use of atomic power, a great amount of depleted uranium is presently piled in Russia. Finding no application, the piled stocks of depleted uranium are stored causing risk for the environments. So, the problem of re-use of stored depleted uranium is urgent for Russia. In the opinion of Russian and American experts, one of the promising solutions of this problem is the application of depleted uranium as radiation protection in designs of multipurpose transport packing sets (TPS) intended for transportation, dry storage and disposal of used nuclear fuel from NPP reactors.

Since February of 2000, under the framework of a Project of the International Science and Technology Center, RFNC-VNIIEF together with SRC VNIINM and SI VNIPIET is performing development of a transport packing set with biological protection made of depleted uranium and siloxane rubber with increased loading of used nuclear fuel of WWER-1000 reactor (TPS-117). The funding party is USA. Project efforts will be completed in January of 2003 with issue of technical documentation for TPS-117 design. The project will result in development of design of a dual-purpose TPS-117 for transportation and long-term storage of 36 RFRA of WWER-1000 that will 3 times exceed loading of TPS TK-13V, which is presently in service. This TPS TK-13V has small capability for loading RNF (12 RFRA), and it is greatly metal-intensive (~100 tons). Besides, it does not meet all IAEA requirements for safety. Therefore the development of an advanced design of TPS for transportation and dry storage of RNF from WWER-1000 complying with all safety requirements and providing large loading of RNF is an urgent problem in Russia. Also it should be emphasized that the TPS-117 biological protection, including gamma-protection against depleted uranium and solid neutron protection made of siloxane rubber used in ТУК-117, allows to perform safe transportation and long-term storage of 24 RNF from WWER-1000 after three-years holding and 18 FRA of retired MOX-fuel from WWER-1000 reactor within the same dimensions of TPS-117.

The necessity for consideration of the possibility to transport and store retired MOX-fuel of WWER-1000 reactors in TPS-117 is caused by that the agreement between USA and Russian Federation is presently concluded about recycling of weapon plutonium by transition of it into MOX-fuel, which mostly is supposed to be used in WWER-1000 reactors. In this connection, very soon Russia will face the need for transport packing sets intended for storage and transportation of retired MOX-fuel. Currently Russia has no such TPSs, and, as far as we know, such containers are not under development yet. It is suggested for the first time in the Russian practice to use depleted uranium as protection against γ-radiation and siloxane rubber as a solid neutron protection in the TPS design for RNF transportation and storage.

2. General specifications

The container TPS-117 as a transport packing meets the requirements to packing of type B(U) containing fissile material, according to the IAEA classification. The packing design meets the safety requirements regulated by the normative documents for transport containers and storehouses of RNF. TPS-117 consists of a protective container and basket for ordered location of RFRA of WWER-1000. Weight-size characteristics of TPS-117 provide realization of required procedures with the container and basket in the appropriate rooms of NPP and in container storehouse of RNF, as well as TPS-117 transportation by trains of general use.

Basic characteristics of TPS-117:

Weight of loaded TPS-117	149980kg;
Weight of TPS-117 basket	16000kg;
Height of TPS-117, including non-removable dampers	6009mm;
Height of TPS-117 without dampers	5089mm;
Outside diameter of TPS-117	2700mm;
Overall sizes of TPS-117 regarding to pivots	2750mm;

RFRA of WWER-1000 having the following characteristics can be located in TPS-117:

Initial enrichment for U^{235}, equal or less	4.4%;
Average depth of fuel burnout	43 MWDay/kgU;
Maximum depth of fuel burnout, equal or less	50 MWDay/kgU;
Time of keeping in reservoir, equal or less	5 years;
Total heat release of assemblies in TPS, equal or less	32.4 kW

The internal cavity of the container is filled with helium at atmospheric pressure.

3. Description of TPS-117 design

The developed design of TPS-117 is shown in Figures 1 and 2. The design of TPS-117 presented in Figures 1 and 2 consists of two basic elements, namely, a protective container and basket, where retired heat-releasing assemblies of WWER-1000 reactor are placed.

The protective container is a thick-walled, multi-layer cylindrical casing closed by two covers. They are the internal cover for tight sealing, and the external cover for protection. The sealing cover of the protective container is made of steel 12X18H10T and it includes two gaskets for sealing. One of them is made of rubber of the type 51-11r-99op, the other is a spirally coiled gasket. The protective cover is made of steel 09G2S. It is lined by a sheet of steel 12X18H10T, and it is also sealed by two gaskets, but they are made of rubber of the type 51-11r-99op.

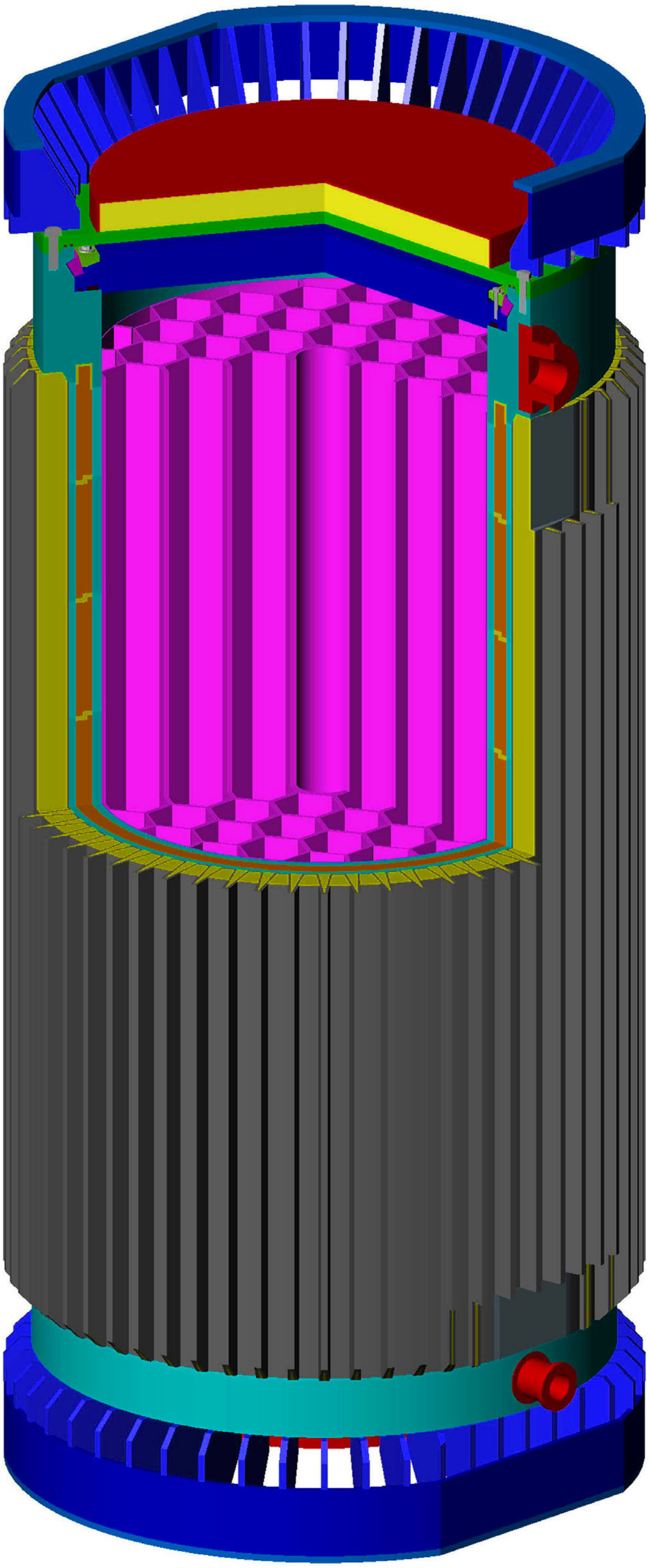

Fig.1: Design-assembly scheme of protective container TPS-117.

The casing of the protective container has an internal load-bearing shell. Coaming and bottom are welded to it. The coaming is made of steel 12X18H10T, and the bottom is made of steel 09G2S. It is lined by a sheet of steel 12X18H10T from within. The load-bearing shell of TPS-117 is a set of rings made of uranium alloy BZ-2 and covered by stainless steel of the type 12X18H10T. Internal covering of a uranium ring has thickness of 40mm, and external covering of a uranium ring has thickness of 30mm. The rings made of alloy BZ-2 are welded among themselves by ring seams on material of the internal and external coverings of the rings. The bottom and internal sealing cover play the role of protection against radiation at end faces of the container.

Solid neutron protection made of siloxane rubber of the type KL-1505 is placed directly behind the external covering of the gamma-protection. From the outside, the side neutron protection is covered with a thin-walled shell made of steel 12X18H10T. The solid neutron protection is also placed in the bottom part of the TPS-117 casing and on the protective cover. From the outside, it is covered with a thin-walled sheet of steel 12X18H10T. Removal of residual heat release of RNF is performed by vertically arranged thermal bridges made of steel 09G2S located through the neutron protection and ribbing of the external surface of the casing of the protective container made of steel 12X18H10T, which serves simultaneously for side amortization.

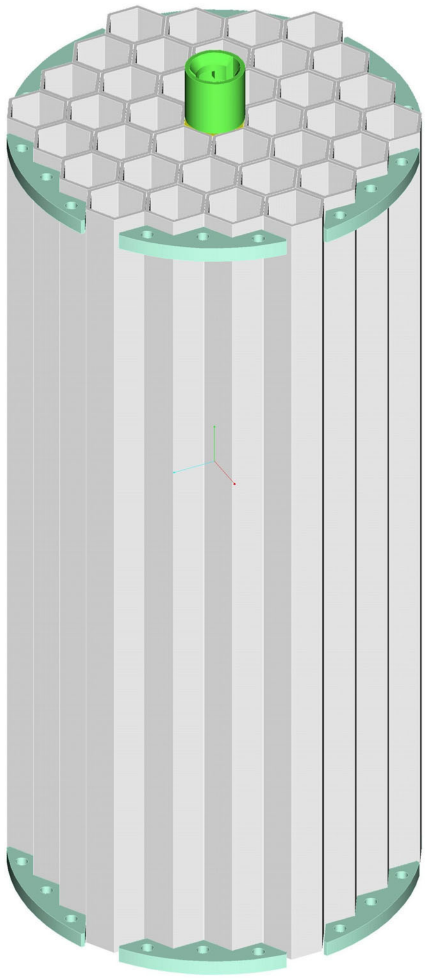

Fig.2: Design-assembly scheme of basket for ordered location of RFRA of WWER-1000 in the internal cavity of TPS-117.

The role of axial and angular amortization is played by ribs having various rigidities, and the supporting ring connecting them. They are welded to the bottom and the protective cover of the container. The ribs and ring are made of steel 12X18H10T.

The basket is used for the ordered location of RFRA of WWER-1000 in the internal cavity of TPS-117. The basket is a set from 36 hexahedral aluminium pipes (alloy AMG-6) having a thickness of 17mm, which are connected among themselves by welding (Fig.2).

The basket design provides nuclear safety in normal conditions of operation and in abnormal environments, the allowable level of the maximal temperatures on shells of fuel rods due to good transfer of heat from assemblies to the casing of the container, fixing of the basket in the container, possibility of its placement in the container and motion of it outside the container by the device to a standard capture of the reloading machine.

The suggested unique design of the container, basket and the design-technological solutions providing fulfillment structural functions alongside with effective anti-radiation functions by depleted uranium allowed to create a dual-purpose TPS for transportation and dry storage of RFRA of WWER-1000 with improved safety. The TPS has maximal capacity of retired fuel and rather low cost. The developed unique design of the amortization system provides keeping less than the overloading level equal to ~ 80-100g on basic elements of TPS-117 and RFRA of WWER-1000 in abnormal environments.

4. Justification of safety of the developed TPS-117 design by calculation.

The dual-purpose transport packing set under development intended for transportation and long-term storage of RFRA of WWER-1000 should be designed so that it would be in compliance with the safety requirements of OPBZ-83 Rules and IAEA-96 both in normal environments of operation and abnormal environments at storage and transportation according to the requirements for the container showed by the rules both to the transport packing and to element of the storage system. The calculation justification of safety of the TPS-117 design under development was performed in the following directions:

1. justification of anti-radiation protection;
2. justification of nuclear safety;
3. justification of thermal regimes of TPS-117;
4. justification of strength and sealing of the container design.

4.1. Anti-radiation safety of TPS-117.

Analysis of anti-radiation and nuclear safety of TPS-117 was performed by the Mote-Carlo method with use of the program complex (PC) S-90 developed in RFNC-VNIIEF. PC S-90 was subjected to overall testing, it is certificated. It is intended for calculations of joint transfer of neutrons and γ-quanta, activation and critical parameters. The used modeling algorithm allows to take into account thermal motion of nuclei in Maxwell approximation of free molecular gas, there is possibility to take account for chemical relations in S(α, β) model from ENDF/B-IV library.

For the analysis of anti-radiation safety of TPS-117, we took into account gamma and neutron radiation of RNF in view of secondary neutron radiation formed during reactions (α, n) on oxygen inside RFRA. The calculations consider both normal conditions of operation and abnormal environments (absence of neutron protection as a result of a fire; local damage of gamma neutron protection as a result of accidental fall against a bar). The calculations show compliance with the requirements for anti-radiation safety (equal or less 200mrem/hour on TPS surface and equal or less 10mrem/hour at distance of 2m from surfaces limiting a vehicle, as well as equal or less 1000mrem/hour at distance of 1m from TPS surface).

In normal conditions

- on TPS surface – 25.7mrem/hour;
- at distance of 2m – 7.2mrem/hour.

In abnormal conditions

- at distance of 1m – 664.8mrem/hour.

4.2. Nuclear safety of TPS-117.

Calculations of anti-radiation safety of TPS-117 were performed by the Mote-Carlo method for most conservative conditions in accordance with requirements of the ruling documents. In the calculations, estimation of statistical error was performed up to value c that was equal or less than value of 0.1%. So, the actual value of $K_{eff.}$, according to the rule of "three sigma particles", can be determined in the range $K_{eff.}=K_{eff.}(1 \pm 3c)$. The calculations showed that TPS-117 design loaded with 36 RFRA of WWER-1000 complies with the nuclear safety requirement ($K_{eff.}<0.95$). In both the normal conditions of operation and in all abnormal environments, TPS-117 subcrit will equal or less than the value:

$$K_{eff.}=0.915.$$

4.3. Thermal regimes of TPS-117.

Calculations of thermal state of TPS-117 were performed with use of program complex (PC) named AJAX_69. It is based on the method of final elements. Solution of thermal problems concerning PC AJAX_69 was performed with account for heat-exchange by radiation and convection, phase transitions, internal heat release, heat release of chemical reactions and Joule heat. The program module of radiation is realized basing on the Stephane-Boltzmann law for gray surfaces, and convection is taken into account by the engineering methods with involvement of the experimental or experimental-calculation data and recommendations for heat transfer factors or Nusselt numbers. Calculations of thermal state of TPS-117 were performed for normal conditions of operation and abnormal environments.

(a) Thermal state of TPS-117 caused by internal source of heat of 36 RFRA of WWER-1000:

The calculations were performed up to the stationary state occurrence. Helium at atmospheric pressure was considered as a heat-carrier in the container cavity. The calculations revealed that:

– - maximum temperature on central RFRA is equal or less than ~ 241°C.
– - maximum temperature of neutron protection is equal or less than ~ 150°C.
– - maximum temperature of outside surface of TPS-117 is equal or less than ~ 85°C.

(b) Thermal state of TPS-117 in fire conditions from $T=800^0C$, t=30 min, as well as from $T=800^0C$, t=60 min, followed by cooling down at $T_{med}=38^0C$ (for ~24 hours) with account for internal heat source of 36 RFRA of WWER-1000:

The calculations revealed that maximum temperature on fuel rods in fire conditions from $T=800^0C$, t=30 min does not exceed value of 300°C, and it does not exceed value of 320°C in fire conditions from $T=800^0C$, t=60 min that is less than limiting allowable temperature of 350°C.

(c) Thermal state of TPS-117 in conditions of total failure of heat removal from external surface of the container (for ~ 24 hours) with account for stationary source of heat of 36 RFRA of WWER-1000. Helium at atmospheric pressure was considered as a heat-carrier in the container cavity.

The calculations revealed that:

- maximum temperature on fuel rods reaches 285°C that is less than limiting allowable temperature of 350°C;
- maximum temperature of neutron protection (siloxane rubber) is ~ 200°C that is slightly higher than the limiting allowable value of 150°C.

4.4. Justification of TPS-117 durability.

Calculation justification of TPS-117 design durability was performed by the method of final elements with use of the program complexes (PC) named DINAMICS-2 and DINAMICS-3 intended for solving in coherent statement the geometrically and physically non-linear problems of non-stationary contact interaction of elastic-plastic designs and non-deformable bodies with surrounding and filling matters. PC DINAMICS-2 and DINAMICS-3 were subjected to overall testing, they are certificated.

The calculation justification of TPS-117 durability and tightness was performed with regard to effecting loadings occurred under normal conditions of operation and in abnormal environments. The following calculated cases of TPS-117 loading were considered:

- effect of internal pressure in container cavity;
- sharp lifting of TPS-117 using its load pivots;
- sharp drop of TPS-117 using its canting pivots;
- strength of TPS-117 against vibrations at transportation by trains;
- drop of TPS-117 from height of 0.3m against non-deformable barrier;
- drop of TPS-117 from height of 9m against non-deformable barrier;
- drop of TPS-117 from height of 1m against a bar;
- submergence of TPS-117 into water to depth of 200m.

Results of the calculations point to the fact that TPS-117 design meets the requirements of keeping its durability and tightness at the considered kinds of external effects.

5. Possible plants-manufacturers of TPS-117 and duration of project completion.

5.1. Plants-manufacturers of TPS-117.

The plant Atommash of Volgodonsk, plant Krasnyi Oktyabr of Volgograd, as well as Izhorsk plants of St. Petersburg can be plants-manufacturers of large-sized steel details for TPS-117 (cowlings, coaming, bottom, covers, etc.), and they can perform final assembly of TPS-117.

Chepetsk mechanical plant (ChMZ) of Glazov is a plant-manufacturer of the gamma-protection of TPS-117. As a result of workshop held at ChMZ in May of this year, it was revealed that available ChMZ foundry equipment and equipment for fur processing allow manufacturing gamma-protection for TPS-117 dimensions.

Any pipe-rolling plant manufacturing large-sized aluminum pipes can be a manufacturer of the basket for RFRA of WWER-1000.

5.2. Time required for manufacturing a pilot TPS-117.

Time required for manufacturing a pilot TPS-117, including preparation of manufacturers participating in TPS-117 manufacturing, is estimated as ~1.5 years.

Cost of TPS-117 will not exceed cost of a container made of metal. More exact costs of TPS-117 will be presented in the technical project in the section entitled "Technical and economical justification of TPS-117".

5.3. TPS-117 certification.

In the beginning of 2003, the materials of the technical project on TPS-117 will be submitted to Gosatomnadzor of the Russian Federation for preliminary expert examination. It will allow to simplify in the transition to the stage of manufacture of a pilot TPS-117.

6. Conclusion

In conclusion, the following should be noted:

The TPS-117 design complies with all requirements for containers intended for transportation and storage of RFRA of WWER-1000, both in normal conditions of operation and in abnormal environments. TPS-117 can be used at Russian and foreign NPP with reactors of the type WWER-1000. Also TPS-117 can transport and store RFRA of WWER-1000 of three-years holding and FRA of retired MOX-fuel of WWER-1000.

The efforts intended for development of the dual-purpose TPS-117 with biological protection made of alloy BZ-2 basing on depleted uranium and siloxane rubber having the maximal loading of RNF of WWER-1000 provide solution of the following problems:

- the consumer qualities of TPS will be improved because of fuel capacity increase;
- the needs for TPS and vehicles for the same scope of transportations will be decrease, and it will provide economy of funding;
- a small storehouse for RNF of WWER-1000 will be created on the base of TPS-117 with compliance to all requirements on safety at storage;
- due to reduction of number of transportations, probability of accidents and probability of terrorist attacks will be decreased as well, and risk of TPS operation will be consequently decreased;
- wastes of dividing and procuring manufactures of uranium will be applied (recycled), which are not commonly used and are stored causing ecological hazard for the environments. About 50 tons of depleted uranium will be required for manufacturing one container;
- high-alloy stainless steel will be saved. Manufacturing of a container with uranium protection requires two times less steel in comparison with manufacturing of an all-metal container.

TRANSPORT OF NUCLEAR MATERIALS IN THE SLOVAK REPUBLIC

J. Václav,

Nuclear Regulatory Authority of the Slovak Republic
Division of Nuclear Materials
Slovak Republic

Abstract

The experience gained in the transport of fresh and spent nuclear fuel, and of other radioactive material, in the Slovak Republic is described. The current status of transport operations together with the regulations governing the safe transport of radioactive material are outlined.

1. Introduction

Transport of nuclear materials in an industrial extent started in Slovakia in the seventies within commissioning of the first nuclear power plant A-1 at Jaslovské Bohunice. Fuel assemblies of this heavy water moderated gas cooled reactor were assembled from fuel rods transported from the former USSR. Due to lack of legislation these early transports were approved by the former Czechoslovak Atomic Energy Commission (CSKAE) using IAEA recommendations incorporated into Safety Series No. 6. Later in eighties the status of the CSKAE as a state regulatory authority in the area of transport of nuclear materials was confirmed in the Act No. 28/1984 on Nuclear Safety of Nuclear Facilities. The CSKAE approval for transport of nuclear materials and use of transport means was required. Unfortunately no other legal document describing in details requirements on transport of nuclear materials has been issued. Thus all transport activities in this period, mainly transport of fresh fuel assemblies for WWER-440 reactors in Jaslovské Bohunice area from the USSR and spent fuel assemblies to the USSR, respectively, were analyzed and decisions made on the base of above mentioned IAEA Safety Series No. 6.

2. Current status

After dissolution of former Czechoslovakia in 1993 activity in the area of transports of nuclear material is regulating the Nuclear Regulatory Authority of the Slovak Republic (ÚJD SR). Moreover its competency was extended on transports of radioactive wastes originating in nuclear facilities and of institutional radioactive wastes prepared for disposal. As in the first few years legislation of former Czechoslovakia was used in the Slovak Republic the ÚJD SR clearly declared in 1994 that requirements of the IAEA Safety Series No. 6 “Regulations for the Safe Transport of Radioactive Material, 1985 Edition, As Amended 1990” will be used as a guiding document in the area of transport of nuclear materials and radioactive wastes.

In 1998 the Act No. 28/1984 was replaced by the Act No. 130/1998 on Peaceful Use of Nuclear Energy, which more comprehensively defined rights and responsibilities of subjects participating in utilization of nuclear energy, including position of the ÚJD SR. According to § 11 of the Act nuclear materials may be transported only with approval of the ÚJD SR and only in transport means/packages approved by the ÚJD SR. One year after the ÚJD SR succeeded to issue the Regulation No. 284/1999 on Transport of Nuclear Materials and Radioactive Wastes.

The regulation describes in details conditions for the safe transport of this kind of materials and covers also transport inside the territory of nuclear facilities (except of interior of buildings). The regulation is based on the IAEA safety standard ST-1 " Regulations for the Safe Transport of Radioactive Material, 1996 Edition" but due to competency of the ÚJD SR the scope is reduced to nuclear materials and to those radioactive substances that could be produced as wastes from nuclear facilities. The safety documentation that is required as a part of an application for the ÚJD SR approval should consist of set of measures to assure nuclear and radiation safety during transport as well as of transport arrangement and emergency procedures prepared usually by carrier. The application should also contain the package certificate issued or validated by the ÚJD SR. The regulation also defines requirements on physical protection of transport and in this part it is reflecting the IAEA recommendations incorporated into INFCIRC/225 "Physical Protection of Nuclear Materials" and some other requirements formulated by involved Slovak ministries in 1995 as an Agreement on Physical Protection of Nuclear Material Transports and tailored to specific conditions in Slovakia.

In drafting of the regulation the ÚJD SR faced known problems with the acceptance of the IAEA document ST-1 into national legislation. The Slovak Republic as a member of all important international conventions in the area of transport of dangerous goods has taken documents like RID, ADR and so on into its national legislation over. As these documents are based on requirements of the IAEA Safety Series No. 6 they are not comply fully with the ÚJD SR regulation. However, the governmental commission for legislation approved the regulation because it was based on the newest knowledge in the area of radiation protection and the international documents would be modified in the near future.

3. Experience

Periodical transports of nuclear material, which covers about 95 % of transport activities, consists of

- import of fresh fuel assemblies from the Russian Federation for 4 reactor units WWER-440 in NPP Bohunice and from 1998 also for 2 reactor units WWER-440 in NPP Mochovce,
- shipment of spent fuel assemblies from NPP Bohunice to the Interim Spent Fuel Storage (ISFS) at Bohunice site,
- transfer of uranium concentrate via Slovakia.

Radioactive waste transport as a part of radioactive waste management system enables linking among its individual elements. In this area seven types of transport equipment were approved by ÚJD SR as well as respective transportation permits were issued for transport of different radioactive waste among individual treatment and conditioning technologies. Since 2000 transports of low and intermediate level radioactive waste packages from Bohunice site to the Mochovce near surface disposal facility have been launched.

At present the transport by road is used for all types of radioactive waste. Combination of rail and road transport modes is under preparation for transport of radioactive waste to repository. This mode of transport is considered as more safe and provides for increasing of transport capacity.

All transports of radioactive waste were performed in accordance with conditions of ÚJD SR decisions and no event was occurred. During 2001 approximately 365,5 t of solid radioactive waste and 474 m^3 of liquid radioactive waste were shipped for further processing. 115 filled FRC containers that means 356,5 m^3 of solid and solidified radioactive waste were shipped to repository. Concerning future activities of ÚJD SR, decisions on permit for transportation of radioactive ashes, sludge and ion-exchange resins are under preparation in order to provide for transport of such kind of radioactive waste, too.

In recent history some important international transports of spent nuclear fuel have been accomplished:

- in 1995 several hundred partially irradiated WWER-440 assemblies were transported from Germany to Hungary via Slovakia,
- in 1995 – 1997 more then one thousand spent fuel assemblies were transported from the ISFS Bohunice to NPP Dukovany in the Czech Republic. Containers C-30 and CASTOR 440/84 were used,
- in the period 1997 - 1999 last 132 spent fuel assemblies from the shut-down NPP A-1 at Bohunice site were transported in 9 transports to the Russian Federation using modified transport containers T-15.

Almost all transports (95 %) are carried by the Slovak Railways and physical protection is assured by the Railway Police of the SR in cooperation with security guards in transports of fresh fuel inside NPPs and with the Police of the SR in transports of spent fuel, respectively.

The ÚJD SR carries out inspections of every transport of spent nuclear fuel and some selected transports of unirradiated nuclear materials. The ÚJD SR inspectors are concentrating on completeness of transport documentation, measures of physical protection, authorization of persons involved, and also surface contamination of randomly selected wagons and packages and radiation level is measured.

According to the Act No. 130/1998 the ÚJD SR issues approval for each individual transport and in the case of identical transports the approval is valid at least one year. In the most cases a certificate for package design is issued after validation of certificates issued by competent authorities of the country of the package design origin. The certificate issued by the ÚJD SR is usually valid five years or its validity is adjusted according to the original certificate. If some requirements on safe transport are not fulfilled the ÚJD SR approval is issued in the form of special arrangements and its content is consulted and agreed with competent authorities of involved countries. In this way the ÚJD SR issued approval for transport of spent fuel assemblies temporarily stored at the ISFS Bohunice to NPP Dukovany in the Czech Republic in containers C-30 with certificate expired in 1996 issued by a competent authority of the former GDR. Conditions of this approval was consulted with the competent authority of the Czech Republic.

4. Conclusion

So far all transport activities were carried out safely without any accidents having negative impact on the environment and personnel. Such a positive status is a result of very responsible attitude of all involved subjects namely carriers and consignors as well as competent authorities that have been requiring strict fulfillment of conditions and criteria for safe transport of radioactive materials. Throughout the history of radioactive material transports in Slovakia these requirements have been based on the IAEA recommendations, which were finally incorporated in 1999 into Regulation No. 284/1999. Some discrepancies between the regulation and other international conventions dealing with transports of dangerous goods and based on the former IAEA Safety Series No. 6 will be resolved modifying of these documents with a new set of the IAEA recommendation published in ST-1 what could be achieved at the end of 2003.

PACKAGING AND TRANSPORT OF NUCLEAR FUEL CYCLE MATERIALS: *A Practitioner's View*

M. C. Mann

Transport Logistics International[1],
4000 Blackburn Lane, Suite 250,
Burtonsville, Maryland 20866, U.S.A.

Abstract

Nuclear fuel cycle materials, particularly natural and enriched uranium hexafluoride (UF_6) and enriched uranium dioxide (UO_2), are routinely transported internationally in large volumes. Uninterrupted movement of these materials is critical not only to commercial nuclear power programs, which rely on these materials as the building blocks for nuclear fuel, but also to significant non-proliferation programs such as the U.S.-Russian Megatons to Megawatts program. Clear communication between regulators and practitioners is beneficial in clarifying what types of fuel cycle materials are being transported, the manner and routes by which such materials are physically moved, and how such transports are impacted by regulatory changes.

1. Introduction

High-volume transports of nuclear fuel cycle materials routinely occur between processing facilities located in nearly all regions of the world. Due to the physical location of such facilities and the nature of the contracting arrangements – both governmental and commercial – under which materials are transferred, fuel cycle materials may cross international borders several times in different forms prior to ultimate use as reactor fuel.

A number of factors drive the physical movement of such materials:

- Availability of feasible modes of transport;
- Availability of carriers;
- Contracting arrangements;
- Geography;
- Packaging considerations;
- Trade issues and regulatory factors in addition to regulations for the transport of radioactive materials;
- Security considerations.

Each of these "puzzle pieces" influences the final transportation scenario for individual shipments or shipment campaigns. The results, however, may not represent the anticipated manner or pathways in which radioactive materials are assumed to move.

2. The practice of "just-in-time" delivery

For members of the commercial nuclear fuel cycle, there exists considerable market pressure to reduce lead times for reload fuel deliveries. As a result of this practice, fuel cycle facilities have reduced inventories to avoid significant carrying costs for high value feed cycle materials. Reduced inventories have resulted in the practice of "just-in-time" deliveries of fuel cycle materials between processing facilities worldwide.

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[1] Transport Logistics International (TLI) provides transportation management services to the international community. TLI handles radioactive cargoes including uranium ore concentrates, natural and enriched uranium hexafluoride, low and highly enriched uranium, uranium dioxide powder and pellets, fresh fuel rods, by-product materials including tritium, heavy water and a wide range of isotopes, and irradiated materials. TLI is based in the United States with additional offices in St. Petersburg, Russia.

While parties involved in such transactions work to reduce overall shipments times, the industry has historically relied on the availability of air transport – albeit more expensive than ocean transport for international deliveries – as a "safety valve" in the event that immediate shipments were required. The introduction of the TS-R-1 Paragraph 680 requirements for packages used to transport fissile materials by air has removed air as a viable mode of transport, pending further criticality reviews for package designs utilized by this sector of the industry.

3. Ocean transport – the backbone of international transport

Where geography allows, road and/or rail, and sometimes barge, transport may prove viable on a regional basis, however ocean vessels necessarily provide the bulk of the transport services internationally. Several observations are noteworthy in this regard:

- The majority of fuel cycle material shipments are multi-modal. Such shipments routinely involve transport by road, rail or barge – or a combination of such modes – to an ocean port facility for onward transfer to an ocean vessel. The process is reversed upon arrival at the country of ultimate destination, with the radioactive cargo being off-loaded from the ocean vessel onto road, rail or barge (or a combination) conveyances for final delivery to the consignee.
- Under this transportation model, intermodal transfer facilities – especially ocean ports – represent part of the critical infrastructure necessary for safe, secure and efficient transport of radioactive materials.
- Transfer between modes involves some storage incident to transport, whether for a few minutes or a few days. Such facilities form a critical interface between national and international boundaries – and regulatory jurisdictions. Harmonization between requirements for storage incident to transport is therefore necessary to protect against shipments being held at ports or aboard ships awaiting discharge at ports. Storage incident to transport should not create bottlenecks to efficient movement of radioactive cargoes.
- As vast numbers of shipments are being made aboard ocean vessels, consistent and timely harmonization between the International Atomic Energy Agency's Regulations for the Safe Transport of Radioactive Material, the International Maritime Organization's International Maritime Dangerous Goods Code, and national regulatory systems becomes an imperative.
- The efficiency of ocean transport hinges on the availability of carriers willing to accept radioactive materials, including fissile cargoes. A variety of factors impact corporate decisions to accept Class 7 commodities, including trade volumes, economic factors, in-house expertise in the transport of hazardous and radioactive materials, corporate policy, insurance issues, timing of deliveries and political considerations. Fuel cycle materials are currently carried by commercial liner services and dedicated vessel fleets.
- Commercial liner services accept a very broad range of cargoes, not just radioactive materials. Economic factors and global trade patterns dictate the routing of container vessels; vessel rotation schedules for such carriers typically involve port stops in a number of countries. These vessel rotation patterns are particularly important for transporters of fuel cycle materials, as they drive the need for third-country transit and packaging approvals in addition to those required in the countries of origin and destination. As such, the burden for review and approval of such transit shipments may be high in these transit countries.
- The international nature of the nuclear fuel cycle demands transport between geographic locations that may not be fully serviced by ocean carriers for Class 7 commodities. Fuel cycle material shipments may therefore be divided into several transport legs, wherein inland transshipments occur between ocean voyages. While such transports may not be the most geographically direct, they may represent the most feasible means of completing a transport.
- World events may also direct shipments routings, as efforts are typically made to avoid areas of high tension or difficulty that may arise from time to time.

4. Regulatory approvals and interpretation – matching approvals to routing

In developing a transportation scenario for fuel cycle materials, it is necessary to match regulatory approvals with the routing. This is a critical function, as the lead-times involved in pursuing some regulatory approvals, such as package design approval certificates and corresponding validations, can be quite lengthy, usually requiring several weeks to several months.

As noted above, some carriers call at a variety of ports in numerous countries during their vessel rotations. As such, a shipment of fuel cycle materials must be made in compliance with the regulatory systems for the countries of origin and ultimate destination, as well as with all countries en route. For some routings, this may involve multiple countries other than those directly involved in the transaction. The transport of fuel cycle materials is most definitely an international undertaking, potentially involving countries without domestic fuel cycle industries of their own.

A single shipment may therefore be subject to a range of multi-national controls in addition to the international requirements (both TS-R-1 and the corresponding modal requirements). Harmonization between regulatory schemes – and between interpretations of individual provisions – is necessary to ensure that consistent requirements are imposed on shipments of like commodities.

Where time frames for implementing revisions to the regulations are out of synch, shipment planning becomes much more difficult and may require additional input by regulators in all countries to, from or through which a shipment takes place. Similarly, differences in regulatory interpretations and practices can drive the overall process to a "lowest common denominator" approach to planning.

5. Trade and security – impacts on shipment timing

The transport of fuel cycle materials is not managed in isolation. A variety of other regulatory and policy factors impinge on shipments and may affect the timing of movements, as well as related aspects of individual transports. These include the following:

- Fuel cycle materials, like all other commodities, are subject to trade-related activities such as routine Customs clearance processes. Depending upon workloads and political factors, clearance processes at international borders may add several days to individual shipments. These layovers are important, as they typically occur at modal transfer points, such as port facilities.
- Due to the nature of fuel cycle materials, additional controls are placed on the movement of these commodities for export control purposes. The associated import and export licensing processes can impact the timing of shipment. Further, such approvals may place constraints (for example, quantity limitations per consignment) on shipments that must similarly be taken into account for shipment.
- Market pressures can fuel competition between fuel cycle entities; these pressures have led in some cases to trade controls, such as antidumping duties and related restrictions, placed on fuel cycle materials. Additional regulatory reviews may be necessary; these regulatory processes can similarly add to the overall time frames required for completing shipments.
- In the post-September 11th environment, significant attention, particularly in the United States, is being given to the security of global transports, particularly for commodities arriving by ocean. Container security initiatives, advance notification requirements, and new vessel and port security programs are further shaping the context in which fuel cycle materials are being delivered.

6. Conclusion

The transport of fuel cycle materials is far more complicated than many may imagine; single shipments or shipping campaigns are shaped by a variety of regulatory, logistical and political factors. On-going communication between regulators and practitioners is beneficial to an environment in which safe, secure and efficient transportation is ensured.

THE PACKAGING AND TRANSPORT OF NUCLEAR FUEL CYCLE MATERIALS

L. Green

World Nuclear Transport Institute (WNTI)
7 Old Park Lane, London,
United Kingdom

Abstract

Nuclear power is important if the world is to satisfy its growing demand for electricity and at the same time meet its environmental obligations, particularly the need to curb carbon dioxide emissions. In order to sustain nuclear power it is essential that nuclear fuel cycle materials continue to be transported internationally both safely and efficiently. This paper describes the major nuclear fuel cycle materials and the means by which they are packaged and transported. These transport operations have been carried out safely for over 40 years and during the whole of this period there has never been an incident which has given rise to significant radiological damage to man or the environment.

1. The nuclear fuel cycle

Nuclear power currently supplies some 16% of the world's demand for electricity from over 400 reactors in 32 countries. The majority of these reactors are either pressurised water reactors or boiling water reactors and in both cases the primary fuel is enriched uranium oxide. The fuel core for these light water reactors contains typically many fuel assemblies consisting of sealed fuel rods each filled with sintered uranium dioxide (UO2) pellets with a concentration of the fissile component of uranium, U235, of 3-5%.

The nuclear fuel cycle consists initially of the processes for the preparation of the new fuel for loading into the reactor starting from mined uranium ore, the so-called *front end processes.* When the spent fuel is discharged from the reactor there are two *back end options.* The spent fuel can either be reprocessed *to* recover the unused uranium and the plutonium generated in the reactor, both of which can be recycled, or it can be stored for eventual direct disposal, which is the once-through concept. The various operations are briefly described below.

1.1. Mining and milling of uranium

Uranium ore is widely distributed. The main sources are North America, Australia, South Africa and Eastern Europe. After mining the processes used are similar to those for the beneficiation of other metals, typically chemical leaching and concentration, followed by precipitation to yield a dry powder of natural uranium oxide known as uranium ore concentrate, or UOC.

1.2. Conversion of UOC to Uranium hexafluoride, Hex

UOC is transported worldwide from the mining areas to conversion plants. It is first chemically purified and then converted by a series of chemical processes into natural uranium hexafluoride (Hex), which is the form required for the following enrichment stage.

1.3. Enrichment of Hex

The concentration of the fissile isotope in natural uranium hexafluoride is 0.71%. This is increased to the level required, about 3-5% for light water reactors, either by a gaseous diffusion process or in gas centrifuges. Commercial enrichment plants are in operation in the

USA, Western Europe and Russia and this gives rise to extensive international transport operations involving Hex between conversion and enrichment plants.

1.4. Fuel fabrication

The enriched uranium hexafluoride is first converted into uranium dioxide powder which is then processed into pellets by pressing and sintering. The pellets are stacked into zirconium alloy tubes which are then made up into fuel assemblies for transport from the fabrication plant to the reactor site.

1.5. Spent fuel storage

Fuel is discharged periodically from nuclear reactors, typically after about 3-5 years, and this highly radioactive spent fuel is first stored, usually under water to provide both cooling and shielding, at the reactor site. After a period of temporary storage the spent fuel can either be sent to a reprocessing plant or prepared for long-term storage prior to permanent disposal.

1.6. Spent fuel reprocessing

Spent fuel consists typically of 96% unused uranium, 1% of plutonium formed in the reactor and 3% of highly radioactive fission product waste. These can be separated in a reprocessing plant by a series of chemical processes. The uranium can then be recycled in enrichment plants and the plutonium converted into new mixed uranium/plutonium oxide (MOX) fuel. The fission product wastes are processed into stable forms for disposal, the highly active stream being converted into glass by a vitrification process. Following commercial reprocessing all the products have to be returned to the country of origin.

1.7. Waste disposal

The radioactive wastes from reactor and fuel processing operations have to be disposed of safely by isolating them from the biosphere. Current plans are to achieve this by geological disposal. When spent fuel is reprocessed the wastes arising are immobilised for disposal. In the once-through cycle the spent fuel has to be disposed of directly as a waste.

2. The safe transport of nuclear fuel cycle materials

Nuclear power is expected to be called upon to continue to play an important role in meeting the world's increasing demand for affordable and sustainable electricity and to sustain the nuclear power industry fuel cycle materials have to be transported safely and efficiently. The nature of the industry is such that most countries with important nuclear power industries cannot provide all the necessary fuel cycle services themselves and consequently nuclear fuel cycle transport activities are international.

The IAEA Regulations for the Safe Transport of Radioactive Materials set the basis for nuclear fuel cycle materials transport. The basic concept is that safety is vested in the package which has to provide shielding to protect workers, the public and the environment against the effects of radiation, to prevent criticality excursions and also to provide protection against dispersion of the contents. All this has to be achieved under both normal and accident conditions of transport. In addition it is important to reduce radiation doses to workers and the public as far as reasonably achievable by adopting best practice at the operating level.

The Regulations provide for five different primary packages; that is, Excepted, Industrial, Type A, Type B and Type C and set the criteria for design based on the nature of the radioactive materials they are to contain. The Regulations also prescribe the appropriate test procedures. The graded approach to packaging whereby the package integrity is related to the potential hazard; that is, the more hazardous the material the tougher the package, is important for efficient commercial transport operations. This is the case with nuclear fuel cycle materials.

Road, rail and sea transport are all commonly used for nuclear fuel cycle materials. Air transport has been used to a limited extent.

2.1. Uranium ore concentrate, UOC

UOC is a low specific activity material. It is normally transported in sealed 200 litre drums (an Industrial package) in standard containers. These can be transported by road, rail or sea. Loading is by crane or fork-lift truck with limited access by workers. The total world annual requirements for UOC amount to about 70,000 tonnes, all of which has to be transported to conversion plants mainly for manufacture into uranium hexafluoride.

2.2. Uranium hexafluoride, Hex

The natural Hex produced from the conversion of UOC is a very important intermediate in the manufacture of new reactor fuel. There is large commercial trading in it which involves extensive international transport. In the production process Hex is condensed as a solid directly into universal 48Y cylinders, which are large cylindrical steel transport cylinders some 1.25 m (48 inches) in diameter, each holding about 12.5 tonnes of UF6. It can be stored in these cylinders prior to being transported, normally bolted down in standard containers, to an enrichment plant by either road, rail or sea, or more likely, by a combination of modes of transport. Although Hex is a low specific activity material there are significant hazards due to its chemical nature. It produces toxic by-products on reaction with water or water vapour and there also is a danger that cylinders could rupture if subjected to high temperatures. For these reasons Hex packages are subjected to appropriate extra requirements beyond those required because of the radioactive inventory and have to be approved.

For enriched Hex for water reactors the concentration of the fissile isotope, U235, is increased to about 3-5% and at this enrichment it is necessary to transport it in smaller universal 30B cylinders. These cylinders are some 30 inches in diameter and are transported in overpacks in order to guard against criticality excursions. The cylinders in overpacks can be bolted into containers for transport to fuel fabrication plants.

2.3. Uranium dioxide powder, UO2, and fabricated fuel

Uranium dioxide powder derived from Hex of less than 5% enrichment is also classified as low specific activity material. The fuel assemblies manufactured from it are some 4m long. They are transported in specially designed packages normally designed to Type A standards (but with the additional requirements for packages containing fissile materials). The configuration of packages during transport guarantees that criticality excursions could not occur.

2.4. Spent fuel

Spent nuclear fuel is intensely radioactive. It is transferred first from the reactor to the on- site storage ponds for shielding and to allow radioactivity to decay. For subsequent transport off the reactor site, either to off-site storage or to reprocessing facilities at home or abroad, it is transported in high integrity Type B flasks. These flasks are massively constructed from steel weighing typically around 100 tonnes. The large steel thickness is needed to attenuate the very high levels of gamma radiation and additional shielding is also needed to reduce the neutron flux. The flasks may incorporate cooling fins to allow the residual heat to be dissipated and keep surface temperatures to acceptable levels. They may also provide protection against impact.

Spent fuel is transported extensively by rail across Western Europe and also by sea in Sweden and from the Far East to reprocessing plants in France and the UK. Sea transport is by dedicated ships designed and operated according to the INF Code of the IMO.

2.5. High level wastes

High level vitrified waste from the reprocessing of spent fuel is stored temporarily at the reprocessing plant to allow fission product heating to decay before it is returned to the country of origin. The transport flasks are similar in design and construction to those for spent fuel and the transport operations whether by rail or sea also are similar. Several sea and rail shipments of vitrified waste have been successfully carried out.

2.6. Mixed oxide fuel, MOX

The plutonium derived from the commercial reprocessing of spent fuel is normally returned to the country of origin in the form of new mixed plutonium/uranium oxide fuel elements in which the enriched uranium isotope is replaced by plutonium. They are transported under special conditions by road or rail and in dedicated vessels for sea transport. Extensive experience in MOX transport has been built up in Western Europe over many years and recently also by sea from Europe to the Far East.

3. Experience in nuclear materials transport

The IAEA Regulations for the Safe Transport of Radioactive Material have provided a sound basis for the design of equipment and procedures for the safe and efficient transport of nuclear fuel materials. On this foundation the nuclear transport industry, both those organisations solely dedicated to nuclear transport, as well as the many transport companies for which nuclear transport is only a part of their business, have operated safely and successfully for over 40 years. No incident has occurred which has resulted in significant radiological damage to man or the environment. It is important that all those involved in nuclear fuel cycle transport that is the industry, the IAEA, the modal organisations and the regulators, should continue to co-operate closely to ensure that these high standards are maintained. Industry worldwide, through the World Nuclear Transport Institute (WNTI), is co-operating to ensure that it fully meets the requirements of the international transport safety regulatory regime.

LICENSING OF A TYPE B(U) PACKAGE DESIGN FOR THE TRANSPORT OF INDUSTRIAL ^{60}CO SEALED SOURCES AND THE USE AS IRRADIATOR FACILITY IN ARGENTINA

J. López Vietri, D. Vidal, N. Capadona, E. Piumetti

Nuclear Regulatory Authority, Buenos Aires
Argentina

Abstract.

This paper points out the relevant regulatory issues related to the licensing process of a Type B(U) package design, EMI-9 model, approved for the transport and the use as irradiator facility. The radioactive contents is ^{60}Co sealed sources of up to 2,96 PBq, as a special form radioactive material for industrial use. The correspondent Approval Certificate was issued by the Nuclear Regulatory Authority of Argentina in accordance with the Regulatory Standard AR 10.16.1 that is coincident with the 1985 Edition (As Amended 1990) of the IAEA Regulations. It is described the most significant activities performed during the licensing process as well as brief comments are made on the experience gained from previous Type B(U) package design developments.

1. Introduction

As a result of a CANDU nuclear power reactor operation, since 1984 Argentina become an important exporter of ^{60}Co, and has developed industrial and medical sealed sources as well as package designs for their containment, handling, transport and use. The EMI-9 Type B(U) package was designed and manufactured by an accredited Company from Argentina with an appropriate experience and training. The project includes the installation of gamma irradiating plants for the treatment of pathogenic wastes, sterilisation of biomedical materials and investigation, see Fig. 1. The paper analyses the ARN requirements that had to be fulfilled by the applicant to certify that Type B(U) EMI-9 package design, complies with the IAEA Regulations under both normal and accident conditions of transport.

The whole licensing process took about three years. Then, the documentation submitted to the Nuclear Regulatory Authority (in Spanish Autoridad Regulatoria Nuclear, ARN) by the applicant, was fully studied and assessed. At the end of that process the ARN issued the Approval Certificate, RA/0090/B(U)-85 in accordance with the Regulatory Standard AR 10.16.1 [1] that is coincident with the 1985 Edition (As Amended 1990) of the IAEA Regulations [2]. It is noted that the EMI-9 design also complies with the provisions of the Revision 1 of the AR 10.16.1 [3] that is coincident with the 1996 Edition (Revised), TS-R-1, of the IAEA Transport Regulations [4].

2. The EMI-9 package design description

EMI-9 is a package designed for containing no more than 2,96 PBq of ^{60}Co sealed sources as special form radioactive material for industrial use. The package is a 6,500 kg cylindrical cask consisting of a main body and a fire shield. The approximated overall external dimensions are: 1.4 m length and 1.3 m diameter see Fig. 2. The main body has an annular lead-filled stainless steel walls encased, as a primary containment and shielding, with a central cylindrical void-space for irradiation purposes. The axial and radial cylindrical shielding is a 22 cm lead thickness. Bolts to the main shielding body fix the wedge gates, which provide adequate labyrinth shielding against the radiation.

The main body has cylindrical stainless-steel fire shield and two cylindrical lids in opposite sides of the cylinder, with insulating material to prevent heat transfer in case of an external fire. Both end-lids are dismountable. The outer cylinder has helicoidally fins to permit the adequate heat dissipation of the radioactive contents of the package in normal conditions of transport and to provide impact-limiting properties in case of accidents. The central cylindrical void-space for irradiation is 0.26 m diameter and 0.46 m length, and it is rounded by an annular cylindrical stainless-steel grid with 16 positions for inclusion of radioactive sources.

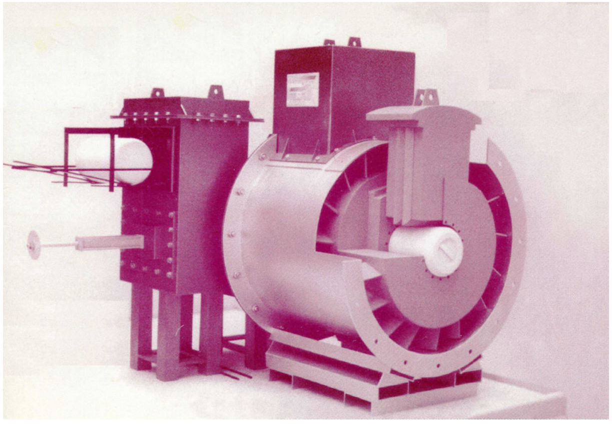

Figure 1 Figure 2

3. Development of the licensing process

At the beginning of the licensing process, discussions were held between the ARN and the applicant. The general characteristics of the package design were analysed and definitions were made on the package structure, shielding and thermal performance to fulfil the requirements of IAEA Regulations.

Further on, discussions were held concerning mechanical testing programmes, calculation methods, testing prior first package shipment and general manufacturing procedures. In that stage, clear definitions were made on the mechanical evaluation (requirements of the scale model, number of tests proposed, sequence and drops attitude, strain-stress calculation), thermal analysis (computational codes, analytical models, hypotheses conservatism), and shielding analysis (computational codes). In every case, the results obtained were analysed and validated.

During the whole licensing process, the applicant was requested to perform experimental tests and calculations, whose results were continuously reviewed and assessed by the ARN and discussed with him. After about three years the ARN performed a thorough and independent review and assessment of the overall information submitted by the applicant.

We ought to mention that during the EMI-9 licensing process the personnel involved were 15 technicians and professionals between designers, manufactures and applicant and 6 professionals from the competent authority (ARN), all of them with proved proficiency, training and experience.

4. Design and test development

The Type B(U) package must comply with the functional performance requirements and also be fitted to maintain the containment and shielding integrity against radiation after being submitted to tests simulating both normal and accident conditions of transport.

The ARN requested that compliance assurance must be carried-out as stated in the IAEA Regulations and in their support documents IAEA Safety Series Nos. 7[5], 37[6], 112[7] and 113[8]. On the other hand, the ARN as well as the applicant had been gathering experiences from previous licensing process of Type B(U) package design, see papers of Refs [9] and [10].

4.1. Tests for normal and accident conditions of transport

In complying with the tests for normal conditions of transport required by the IAEA Regulations, the applicant had proved that: water spray test was not relevant and free drop and penetration tests can be disregarded when compared with those for accident conditions, and stacking test is not applicable because, for operational reasons, these package do not be stacked on each other.

The ARN requested to the applicant the performance of experimental mechanical tests, since neither validated computational models for their simulation were enough confidence nor results from other tests with similar package models were available in the country. The target used is described in the paper of Ref. [11]. A specimen built at a 1:2 scale was prepared for testing. The applicant and the ARN outlined and defined the total number of drops, its dropping sequence and orientation, so as to obtain the greatest specimen damage. Six drops were performed in different angles with respect to the target: 4 were free drops from 9 m height, and 2 were punctured from 1 m height. After the most unfavourable testing sequence and orientation, first the free drop on an edge and second puncture on a lateral side, the integrity of shielding and containment were verified. Therefore, and under ARN supervision during preparation and development performance the tests were satisfactorily carried out.

Related to the thermal test, the EMI-9 package was particularly designed to prevent fire heat from entering into the main body, in case of fire, considering that, if lead fusion occurs (327ºC), a loss of shielding could take place due to the hydraulic steel wall breakage. The thermal analysis under normal conditions of transport was modelled assuming a 1.33 kW as the maximum thermal power and that heat is transferred out by conduction, convection and radiation. The hypotheses considered by the applicant were: undamaged package after the mechanical test, initial temperature distribution at a steady state the same as that calculated under normal conditions; ambient temperature of 800°C and emission of 0.9 were assumed during the 30 minutes heating period; during the 2 hour natural cooling time, ambient temperature was assumed to be 38°C. With the worst hypothesis, the results obtained indicated the verification with the acceptance criteria about the containment and shielding integrity.

The applicant demonstrated the package integrity through calculations after the water immersion test, since hydrostatic pressure does not affect its external components.

The shielding was evaluated by a computational code and submitted to an optimisation process, taking into account ^{60}Co sources of 2,96 PBq annularly and uniformly located.

4.2. Quality assurance, manufacture and tests before first shipment

The design, documentation, material purchasing, tests and manufacture of the EMI-9 transfer case have been carried-out in accordance with the applicant's Quality Assurance Manual.

The ARN carried-out inspections to verify that the manufacture of packaging was performed in a controlled manner and in agreement with the design specifications. The most important procedure assessed was the lead melting, since its design requires lead-steel adherence. The non-destructive assays were performed to verify the adequacy of welding and adherence. On the other hand, control over adequate material purchasing was made, especially to verify steel ductility even at –40°C, for avoiding the possibility of brittle fracture during transport and in-transit storage operations.

The ARN made evaluations and inspections over the tests performed prior first package shipment, verifying their handling, containment and shielding behaviour evaluated in the design. A transfer test with simulated sealed source was performed to verify package operation with a cobalt source, and a shielding test with radioactive contents for verifying radiation level values. These tests allow to verify the validation of operation and preparation for shipment procedures as stated in the EMI-9 Operation Manual.

4.3. Assessment by the Nuclear Regulatory Authority of Argentina

The ARN personnel performed an independent analysis and, in some cases, a re-calculation of the information contained in the following documentation presented: Final Safety Analysis Report; Operation, Inspection & Maintenance and Quality Assurance Manuals; Production and Control Programme; Tests Before the First Shipment Program; Emergency Procedures, as well as protocols and results from manufacturing controls and tests. These analyses confirmed that the EMI-9 package design has been developed using appropriate conservative criteria, so as to insuring a high level of compliance with the IAEA Regulations.

The comparison between the results obtained by calculation and from tests, and those required by IAEA Regulations in relation to the temperature figures for maximum radioactive contents, for normal conditions of transport, determines that the package shall be transported under exclusive use.

5. Conclusions

The following conclusions were reached after the licensing of EMI-9 Type B(U) package:

(a) The package design is used for both the transport and the use as irradiator facility of ^{60}Co sealed sources of up to 2,96 PBq uniformly distributed in 16 annular circular positions.

(b) During the licensing process the ARN, Competent Authority of Argentina supported continually designer, manufacturer and applicant with informal advice without commitment, while the independence and objectivity between them were clearly understood and maintained.

(c) The applicant established and implemented an appropriate quality assurance programme for the design, documentation, manufacture and use of EMI-9 package design.

(d) The ARN was fully satisfied with the EMI-9 Type B(U) package design fulfilment with the provisions of the 1985 Edition (As Amended 1990) of the IAEA Regulations by reviewing and, in some cases, re-calculating the design by using different methods. The applicant also demonstrated package design compliance with the requirements of the 1996 Edition (Revised) of IAEA Regulations, TS-R-1, that is in force in Argentina since 17^{th} July 2001.

(e) In December 2000, EMI-9 was approved by the ARN: Approval Certificate RA/0090/B(U)-85 under the provisions of the 1985 Edition (As Amended 1990) of the IAEA Regulations.

(f) EMI-9 was the fourth Type B(U) package design in Argentina. On-going with benefits obtained from the development and experience of the local nuclear industry, EMI-9 has resulted in a product with appropriate quality and comparable to international level.

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THE TRANSPORT OF RADIOACTIVE WASTE IN CUBA

M. Salgado, J.C. Benítez, R. Castillo, R. Barceló

Centre for Radiation Protection and Hygiene, Havana,
Cuba

Abstract.

In Cuba radioactive waste are generated from nuclear applications in medicine, industry and research. The Centre for Radiation Protection and Hygiene (CPHR) is responsible for radioactive waste management in the country. The CPHR has the operational capabilities for this purpose, including a Waste Treatment and Storage Facility (WTSF). Radioactive wastes are collected and transported from the generator institutions to the WTSF. The Regulatory Body authorizes the transport of radioactive waste through a License for Systematic Transport of Radioactive Materials, granted to the CPHR. This authorization is according to the regulation existing in Cuba for controlling the transport of radioactive materials.

1. INTRODUCTION

Technologies that make use of radiation continue to spread around the world. In Cuba, ionizing radiations are employed in medicine, industry, agriculture and research. These applications may always produce radioactive wastes that required safe and proper management. The Cuban national system for radioactive waste management includes the operational capabilities and the regulatory framework. The Centre for Radiation Protection and Hygiene (CPHR) is in charge of waste management and therefore is responsible for centralized collection, transportation, treatment, conditioning, long term storage, and disposal of radioactive waste. The CPHR has a Waste Treatment and Storage Facility adequate for the type and amount of radioactive waste generated in the country. The National Centre for Nuclear Safety, as the Regulatory Body, is responsible for establishing the regulations that control the radioactive waste management. The Centre for Radiation Protection and Hygiene collects radioactive waste generated around the country and transport them to the Waste Treatment and Storage Facility. The Regulatory Body through a License for Systematic Transport of Radioactive Materials authorizes this practice.

2. ORIGIN OF RADIOACTIVE WASTES

The wastes arisen from the applications of radioisotopes in medicine are mainly liquids and solid materials contaminated with short-lived radionuclides and sealed sources used in radiotherapy. Radioactive wastes from industrial applications are generally spent sealed sources, which were used in level detection, quality control, smoke detection and non-destructive testing. The principal forms of wastes generated by research institutes are miscellaneous liquids, trash, biological wastes, and scintillation vials, sealed sources and targets. Solid radioactive wastes are produced mainly during research works, cleaning and decontamination activities and consist of rags, paper, cellulose, plastics, gloves, clothing, overshoes, etc. Laboratory materials such as cans, polyethylene bags and glass bottles also contribute to the solid waste inventory. Small quantities of non-compactable wastes are also collected and received for treatment. They include wood pieces, metal scrap, defective components and tools.

3. RADIOACTIVE WASTE TRANSPORT

The collection of wastes consists in their transference from the place of origin to the place where they will be treated, conditioned and/or stored: the Waste Treatment and Storage Facility. Collection takes place periodically by the CPHR. Transportation of radioactive waste is carried out in accordance with National and IAEA Regulations [1,2] and the License for Systematic Transport of Radioactive Materials granted to the CPHR by the Regulatory Body.

This License establishes the types of materials that can be transported (solid and liquid radioactive waste and disused sealed sources), the packages and vehicles that should be used, as well as radiation protection measures to be taken for transportation and in case of emergency situations.

3.1. Procedures applied to conform the packages for transportation

Transportation of radioactive waste is one of the main activities included in the Quality Assurance System implemented by the CPHR for the Radioactive Waste Management Service. All the activities are carried out according to established procedures and are adequately registered.

Once the generator institution requests the Centre for Radiation Protection and Hygiene the collection of radioactive waste, a visit to the institution is carried out by CPHR specialists in order to evaluate the quantities and types of wastes and to define the types of packages required for transportation. After this visit a register is completed with the type, quantity and specific activity of radioactive waste, the radionuclide contained, the radiation levels, the packaging and the total activity in a package. The type of package required for transportation is then determined according to the limits established in the regulations [1,2]. Figure 1 shows this procedure.

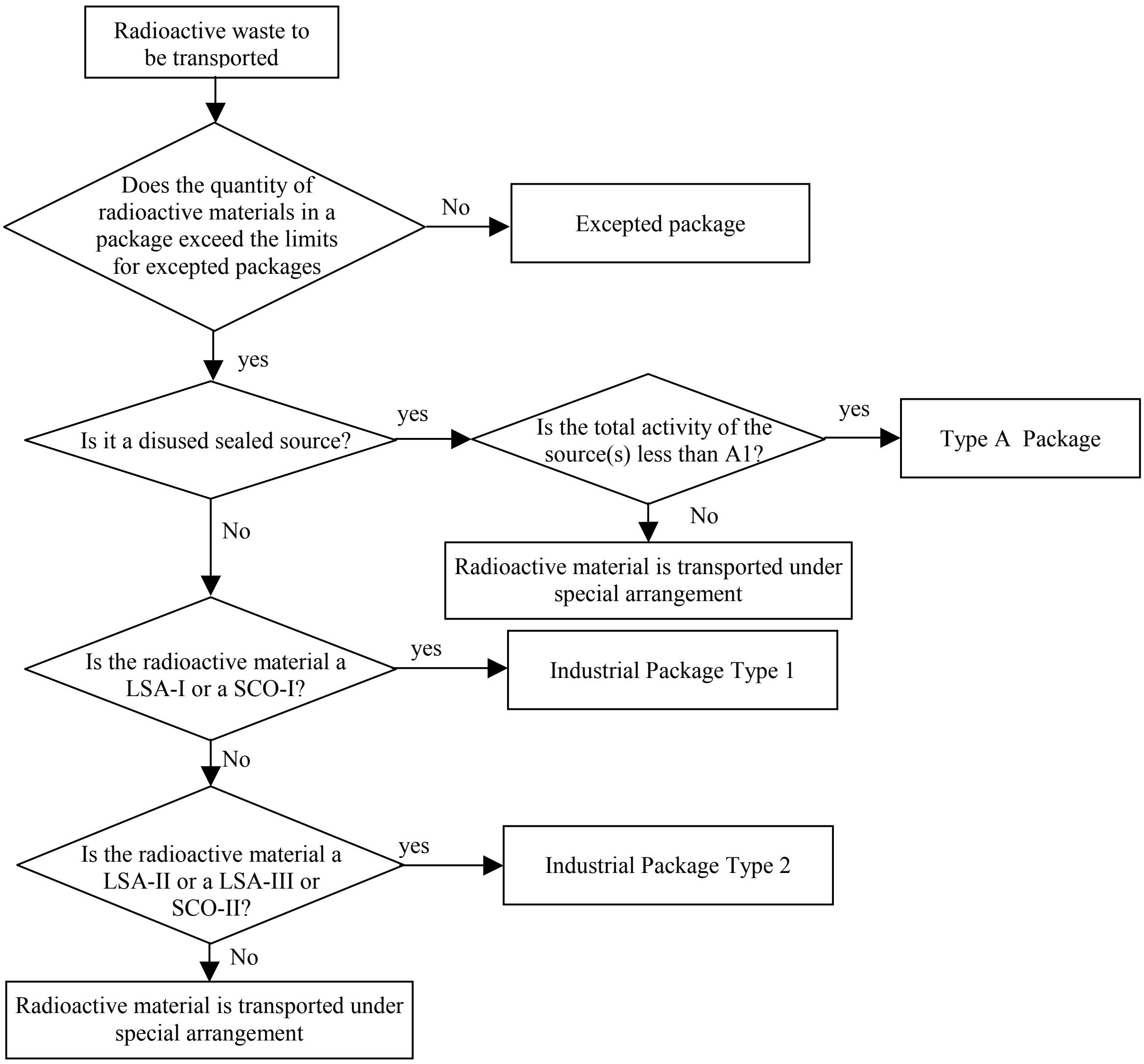

Fig.1 Procedure to determine the type of package for radioactive waste transport

The requirements of each package (radioactive materials and packaging, radiation and contamination levels permitted, labelling and marking, placarding, as well as special requirements, if needed, according to category of packages: I-white, II-yellow and III-yellow) are clearly described in the established procedure. Excepted packages are used for small quantities of non-fissile radioactive materials: low activity disused sealed sources, solid and liquid radioactive wastes and empty packaging which have previously contained radioactive materials.

Solid and liquids radioactive waste that may be classified as LSA-I materials or SCO-I are transported as Industrial Packages Type 1 (IP-1). Industrial Package Type 2 (IP-2) is used for the transportation of radioactive wastes that meet the requirements of LSA-II or LSA-III materials or SCO-II. The License establishes that radioactive wastes should be always transported under exclusive use.

In order to conform the packages (excepted, IP-1 or IP-2), liquid radioactive wastes are collected in plastic containers and the solid wastes in plastic bags. Both are placed into metallic 200-liter drums. The drums, as well as the plastic containers and bags are adequately closed and identified (fig. 2). Labelling and marking depend on the type of package and it is clearly described in the established procedure.

Disused sealed sources are transported in their original transport container (Type A or B package) when it is available. If not, the sources are placed in metallic containers and a Type A package is conformed (fig.2). When sealed sources do not meet the requirements for a Type A package they are transported under special arrangement, which should be approved by the Regulatory Body. In order to apply for special arrangements it has to be demonstrated that the conformity with the other provisions of the License and regulations is impracticable. In this case alternative provisions are taken to guaranty, at least, the basic safety standard demands established in the regulations.

Fig. 2: Packagings used for transport of liquid and solid radioactive wastes and disused sealed sources

3.2. Requirements for packages

The packages designed by the CPHR for the transportation of radioactive waste and disused sealed sources meet the general requirements established in the national regulations for all packages. Additional requirements for Industrial packages Type 2 (IP-2) and Type A packages should be demonstrated through specific tests. The packages have not been subjected to these tests yet. The Transport License establishes that they should be performed within one year after the License was granted (i.e. July 2003).

The CPHR is planning to perform the tests using samples of the packagings prepared as presented for transport. Industrial packages Type 2 will be subjected to free drop test at a distance of 1.2 meter and stacking test to a compressive load equal to 330 kg, this is the equivalent of 13 kPa multiplied by the vertical projected area of the package.

In addition to the former tests, Type A packages will also be subjected to water spray and penetration tests. The compressive load proposed for the stacking test is 2500 kg. The same specimen will be used for all the tests. The order of performance of the tests is specified in the regulations.

3.3. Radioactive wastes transported by the CPHR

Table I shows the amount of wastes collected by CPHR in the country in the last seven years. It is also shown the number of institutions where these wastes were collected. Most disused sealed sources collected in the last years were smoke detectors.

Twelve teletherapy units were collected from hospitals between 1999 and 2002, and transported to the Waste Treatment and Storage Facility. The original transport containers were not available; therefore the sources had to be transported under especial arrangement. Alternative provisions were taken to guaranty, at least, the basic safety standards established in the national regulations. Among the most important actions taken it worth to mention: the mechanism to open and close the radiation bean was fixed in such a way that it could not be open during handling and transport, the whole unit was fixed within the transport container, the container was tightly fixed into the truck, the transportation was guarded by the police, etc.

Table I: Radioactive Wastes Collected and transported by the CPHR

Year	Number of Institutions visited	Radioactive Wastes Collected and transported				
		Disused Sealed Sources	Solid Waste, dm^3		Liquid waste, dm^3	
			$T_{1/2} < 100$ d	$T_{1/2} > 100$ d	$T_{1/2} < 100$ d	$T_{1/2} > 100$ d
1996	19	395	1 060	310	0	1
1997	15	16	555	2 201	110	445
1998	29	70	3 090	552	32	233
1999	27	6 277	2 600	60	0	22
2000	21	768	888	615	99	17
2001	32	2 226	4 800	2 000	17	207
2002	23	373	13 400	1 800	45	30

The authorizations granted to the Centre for Radiation Protection and Hygiene before the year 2002 for radioactive waste transport were in form of a simple special permission. At present the new national regulations [1,3] establish that for systematic transport of radioactive materials a License is required. The present authorization granted to the CPHR is valid for a period of two years. From the technical and safety viewpoints the new licence process is more demanding. This demonstrates a new improvement achieved in the national waste management system.

4. Conclusions

The Centre for Radiation Protection and Hygiene has the capabilities to guarantee the safe transportation of radioactive wastes and disused sealed sources in the country.

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TRANSPORT OF INDUSTRIAL RADIOGRAPHY SOURCES – INDIAN SCENARIO

K.R.K. Singh, Arunkumar, C.P. Raghavendran, S.P. Agarwal

Radiological Safety Division, Atomic Energy Regulatory Board,
Niyamak Bhavan, Anushaktinagar, Mumbai – 400 094,
India

Abstract

One of the main applications of radioisotopes in industry is non-destructive evaluation for the integrity of structures and weld joints. ^{192}Ir is the most commonly used source for its many suitable physical characteristics for this application. The sources used in industrial radiography are housed in a specially designed well-shielded container which can function as an exposure device as well as transport package. Such exposure devices are frequently transported from one place to another for use at different sites. These exposure devices are transported in accordance with the applicable regulations for the safe transport of radioactive material. In this paper, the current scenario of transport of the industrial radiography sources, the related regulations and the unusual incidents occurred and their possible causes, during the transport of these sources in the last three decades, are discussed in detail.

1. Introduction

Non-destructive evaluation (NDE) is one of the main applications of radioactive material in industries, where a suitable radioisotope of sufficient activity is used for the detection of a flaw or defect present in the structure, weld joints, castings with the help of a recording photographic film. Some of the sources used for this type of application are ^{60}Co, ^{192}Ir, ^{170}Tm, ^{137}Cs. ^{192}Ir is the most commonly used source due to its many physical characteristics suitable in NDE. The activity of the sources used ranges from tens of megabequerel to hundreds of gigabequerel. These sources are housed in specially designed well-shielded containers with built-in-safety and used as exposure devices known as *Industrial Gamma Radiography Exposure Devices(IGRED).* Such IGRED as whole are also used as appropriate transport packages for carriage of the radioactive sources and meet all the requirements of a Type B(U)/(M) packages in addition to those standards specified for IGRED. As such these IGRED are approved as Type B(U)/(M) packages by the respective Competent Authorities of the countries of origin of the design of the devices. Because of the need of the IGRED for use in industries at different places, they are frequently transported from one site to another, institution to the site and site to the institution by the user. In this paper, the current scenario of the safe transport of industrial radiography sources, its regulations and some unusual incidents occurred during the transports in India, are discussed in detail.

2. Regulations controlling industrial radiography and transport

In India, regulatory activities, which include licensing, approval of equipment, approval of installations, personnel and operation, are governed by 'The Industrial Radiography (Radiation Surveillance) Procedures, 1980', notified by the Competent Authority in pursuance of rule 15 of the Radiation Protection Rules, 1971, issued under the Atomic Energy Act, 1962(33 of 1962). Only those persons licensed by the Competent Authority are allowed to *handle* the sealed radiography sources. Industrial radiography operations are required to be carried out only by trained, certified and approved personnel using the approved IGRED at sites or installations duly approved by the Competent Authority. The licensee shall ensure that any industrial radiography work is carried out strictly following radiography procedures including emergency preparedness as laid down by the Competent Authority. The responsibility for safety and security of the sealed radiography sources lies with the licensee. No radiography source shall be leased or loaned by any person to any other person and no exposure device shall be transferred from one site to another without the specific prior approval of the

Competent Authority. Decayed radiography source in an IGRED is transported by the licensee back to the domestic supplier of RAM for safe disposal. The above mentioned transfer or transport of the IGRED are governed by the regulations for the safe transport of radioactive material through a *code*[1], which is based on the IAEA "Regulations for Safe Transport of Radioactive Material"[2] with modifications to suit the conditions of transport specific to India.

3. Transport of industrial gamma radiography exposure devices

Table I gives the list of IGRED type approved by Atomic Energy Regulatory Board(AERB), currently used in India. There are 430 nos. of industrial radiography institutions using 1180 IGREDs. Out of this, 1096 IGRED are of ^{192}Ir source, 2 of ^{170}Tm and 82 of ^{60}Co sources. Table II summarizes the quantum of transport of industrial radiography sources by different modes for different purposes. Both road and air modes play a big role as far as the quantum of transport of sources are concerned by different modes. It is seen that the transport of the sources involving domestic supplier and institutions as consignor or consignee or vice versa, is mainly by air. Those institutions located near to the domestic supplier prefer to transport by road due to economic and other convenience reasons. As far as transport of sources from institution/site to site/institution is concerned road is the dominant mode because of India's good road network and most of the institutions prefer to transport the sources by their *exclusive use* private vehicles. The contribution from rail to the quantum of transport of the industrial radiography sources is very small since the Indian Railways did not accept the radioactive consignments till 14.7.2001. Now, Indian Railways have started accepting radioactive material for transport by rail by including provisions for transportation of radioactive material in their *Red Tariff*.

Table I: Type of Industrial Radiography Exposure Devices Used in India

Model	Source	Maximum Activity	Type of Package
Teletron SU-50A	^{192}Ir	1.85 TBq	Type B(U)
Teletron SU-100A	^{192}Ir	2.22 TBq	Type B(U)
Amertest 676	^{60}Co	7.40 TBq	Type B(U)
Amertest 680	^{60}Co	2.40 TBq	Type B(U)
Amertest 741	^{60}Co	0.66 TBq	Type B(U)
Amertest 660 B	^{192}Ir	5.20 TBq	Type B(U)
Amertest 660	^{192}Ir	4.44 TBq	Type B(U)
Gammamat TI	^{192}Ir	0.925 TBq	Type B(U)
Gammamat TI-F	^{192}Ir	2.22 TBq	Type B(U)
Gammamat TK-30	^{60}Co	0.666 TBq	Type B(U)
Gammamat TI	^{60}Co	1.85 TBq	Type B(U)
ROLI-1 (Sr. no.91001 to 91059)	^{192}Ir	1.30 TBq	Type B(M)
ROLI-1 (Sr. no.94060 & up)	^{192}Ir	1.30 TBq	Type B(U)
SPEC-2T	^{192}Ir	2.22 TBq	Type B(U)
SPEC-150	^{192}Ir	3.70 TBq	Type B(U)
Gammarid-192/120	^{192}Ir	3.70 TBq	Type B(U)
IHERC	^{170}Tm	185 GBq	Type A

Table II. Quantum of Transport of Industrial Radiography Sources in India

From	To	Purpose for Transport	Shipments/Year by Road	Air	Rail
Domestic Supplier	Institution	New source replacement	190	510	-
Institution	Domestic Supplier	Disposal	192	520	-
Institution/Site	Site/Institution	Source movement for use at sites	970	5	15

4. Quality assurance (QA) in the transport of exposure devices

In view of the large number of IGRED subjected to frequent movements in India, the transport of such devices can lead to significant radiological impact in case of accidents unless appropriate precautions are taken. It is, therefore, required to have a systematic programme of controls and inspections in the transport of the radiography sources. The regulations [1] provide a well-established quality assurance programme to be implemented by the licensee/consignor to ensure that the standards of safety for transport of radioactive sources prescribed in the regulations are achieved in practice. For an industrial radiography exposure device to be transported in the public domain various quality assurance programs are applied during (1) preparation of the package (2) labeling (3) marking and (4) documentation, as summarized in Table III.

Table III: QA applied in Transport of Radiography Exposure Devices

QA to be applied	Subsequent steps of action
Preparation of package	Verification of proper source position in IGRED, Locking of IGRED, Packing of IGRED in an outer wooden/metallic box, Locking , Sealing and Metal-stripping of the box .
Labeling	Measurement of Transport Index, Selection of category, Pasting of appropriate category label.
Marking	Names of consignor and consignee, Type of package, UN No., Proper shipping name, Competent Authority identification mark, Sr No., Gross wt.(if > 30kg).
Documentation	Consignor's declaration, Instructions to the carrier, TREMCARD, Possession of certificate of package design/special form, Traceability and confirmation of the package reaching destination.

5. Unusual incidents occurred during transport of IGRED

Table IV summarizes the unusual incidents occurred during the transport of industrial radiography sources in the last three decades. There were 35 unusual incidents of various nature. There were two incidents of sources coming out of the inner containers of the packages due to improper locking of shielded container of sub-standard design. In two incidents, the decayed sources sent by the user to the domestic supplier for safe disposal were found in the respective guide tubes, instead of inside the exposure devices, resulting radiation levels of about 0.03 Sv/h on the surfaces of the respective packages. The user had not properly checked the position of the sources inside the exposure devices before dispatch. There was an interesting incident of returning the package to the consignor due to loading of the package in a wrong train at a transit station. In 1 incident, an employee of a transport company had stolen the source pencil by breaking open the package kept in a godown, which was recovered later. There were four incidents of the packages getting damaged while handling roughly by cargo handlers at airport and in one of the incidents the lid of the lead pot(which was not properly closed) was found open there by resulting in an exposure of 1.5 Sv/h on the surface of the package at the time of receipt by supplier. In another incident, the package arrived without any source inside the container. There were thirteen incidents of non-receipt of radioactive packages by the consignees due to misplacement and transshipment problems faced by the concerned airlines. However, all the packages were recovered later. In three incidents, radioactive packages were delayed in delivery due to strikes by transporters, pilots and non-transmission of the details of the transporter to the consignee respectively. There was only one incident of involving fire, where the package caught fire during storage at a transport company's godown. In one incident the exposure device carried by an exclusive vehicle of the user to the site passing through a city area was seized by the police due to ignorance about the provisions of *exclusive use* in the regulations. There were five incidents of loss of packages during transport. Coincidentally, three incidents happened during transport by train without declaring the consignment as radioactive material and only one package could be recovered. The other two incidents of loss of packages during transport by air and bus are not still recovered in spite of several efforts.

Table IV: Summary of unusual Incidents occurred during transport of radiography sources.

Year (1)	Type of Incident (2)	Possible reasons (3)	Remarks (4)
1973	Decayed ^{192}Ir source came out of lead pot at supplier's place.	User had not tightened the side screw and locked the lead pot.	No serious exposure was observed and source was not supplied to the user for sometime.
1979	Non-receipt of package containing ^{192}Ir,296 GBq by consignee.	Package was not properly marked and Labeled and misdirected.	Package came back to consignor, while changing the train it was wrongly loaded.

Table IV continued

Year (1)	Type of Incident (2)	Possible reasons (3)	Remarks (4)
1979	Storage of package containing ^{192}Ir of 370 GBq for extended period without proper warning.	User dispatched the package without regulatory authority's permission.	Thorough investigation was done. User was reprimanded.
1980	Pilferage of package containing ^{192} Ir of 296 GBq from godown.	One employee from the transport company stolen it seeing the shining of the source pencil being attractive.	'Warning'legend started inscribed on source pencil and the source was recovered from the same godown later.
1981	Coming out two of eight ^{192}Ir source pellets of total activity 296 GBq from the package.	Lead pot used was not of standard design, safety procedures not followed.	Source pellets were recovered and user was penalized.
1983	Receipt of ^{192}Ir decayed source of 65.49 GBq in the package containing guide tube instead of inside camera(Techops).	User had not checked properly source position in the exposure device and guide tube was separately packed.	Level of 0.03 mSv/h was observed on the surface of the package. Strong instructions of safety precautions were issued to user.
1983	Receipt of package containing ^{60}Co source of 35.9 GBq with very high dose rate on the surface(CRC-1 camera).	Source was found in the guide tube, improper checking of source position in the camera.	Level of 0.03 mSv/h was observed on the surface of the package. Strong instructions of safety precautions were issued to user.
1988	Damage of wooden case containing exposure device(Teletron ^{192}Ir, 1.81 TBq) at airport.	Rough handling by cargo staff.	Concerned airlines was informed about the need to handle such packages properly.
1988	Damage of wooden case containing exposure device(IRC-4, ^{192}Ir, 222 GBq) at airport.	Rough handling by cargo staff.	Concerned airlines was informed about the need to handle such packages properly.
1989	Receipt of package without decayed ^{192}Ir source(12.9 MBq) at supplier's place.	Lead pot presumed containing decayed source found empty. Package was not monitored before dispatch.	User was strongly cautioned about the incident not to repeat.
1989	Non-receipt of decayed source (^{192}Ir, 111 GBq) at supplier's place.	Transshipment problem.	Later, the package was collected from from the airport.
1989	Non-receipt of decayed source (^{192}Ir, 111 GBq) at supplier's place.	Transshipment problem.	Package was traced and recovered from the airport.
1989	Non-receipt of decayed source (^{192}Ir, 296 GBq) at supplier's place.	Transshipment problem.	Later, the package was collected from from the airport.
1989	Non-receipt of decayed source (^{192}Ir, 259 GBq) at supplier's place.	Transshipment problem.	Later, the package was collected from from the airport.
1989	Non-receipt of decayed source (^{192}Ir, 8.1 GBq) at supplier's place.	Details of transport company were not transmitted.	Later, transport company was identified. Package was delivered.
1989	Non-delivery of package (^{192}Ir, 296 GBq)at user's place.	Offloaded at transit airport.	The package was traced and handed over to user later.
1989	Non-receipt of package(^{192}Ir, 249 GBq) by supplier.	Transshipment.	Package was received later.
1990	Receipt of damaged outer portion , lead pot lid came off., of the package(^{60}Co,107.3 GBq).	Rough handling during road transport and lead pot lid not properly closed.	High level radiation of 1.5 Sv/h was found on the surface of the package, matter was being thoroughly investigated.
1991	Package containing ^{192}Ir, 296 GBq in lead pot not received by user.	Misplaced at storage-in-transit.	Package was recovered later.
1992	Package from site not reached at user's another site.	Strike by pilots of concerned airlines.	Package was brought after strike was over.
1992	Package(^{192}Ir,207 GBq in lead pot) lost during transport in train.	Package was carried as personal luggage, not booked in brake van.	*Not recovered even after extensive search.*
1992	Package(Techops,^{192}Ir, 740 GBq) not received by user in time.	Misplaced during transshipment.	Package was traced out later and handed over.

Table IV continued

Year (1)	Type of Incident (2)	Possible reasons (3)	Remarks (4)
1993	Package involved in fire. (^{192}Ir, 7.4 GBq in a lead pot).	Transport company's godown caught fire.	Package was found out and checked its shielding integrity.
1993	Non-receipt of the package (^{192}Ir , 296 GBq in lead pot) by user.	Delayed in loading of package at airport.	User later collected the package.
1993	Decayed source(^{192}Ir, 74 GBq) not received by supplier.	Strike by transporters.	The carrier later delivered the package after the strike was over.
1993	Non-receipt of the package (^{192}Ir ,1.5 TBq in Techops) by user.	Misdirected during transshipment.	User later collected the package.
1993	^{192}Ir, 1.6 TBq in Techops-660 packed in steel trunk lost in train.	Consignment not declared as radioactive material while booking in brake van.	*Not recovered even after extensive search.*
1993	Damaging of outside package. (^{60}Co, 394.1 GBq&168.4 GBq) at airport.	Rough handling by cargo handlers.	Minor damage, repacking was done.
1995	Non-receipt of package (Teletron,^{192} Ir, 2.22 TBq) by user.	Misplaced during transshipment	Later the package was traced and collected by user.
1995	Non-receipt of decayed source (^{192}Ir,16.84 GBq in lead pot) by supplier.	Misplaced during storage in railway godown.	Package was later recovered and collected.
1995	Non-receipt of package (Teletron,^{192} Ir,1.48TBq) by user.	Misplaced during transportation and storage-in-transit.	Later the package was traced and collected by user.
1997	Loss of package(^{192}Ir,48 GBq in SPEC-2T)during transport in train by user.	Not declared as radioactive material, off-loaded at transit station.	Package was recovered later without any damage.
1999	Non-receipt of package by supplier (SPEC-2T,^{192}Ir, 74 GBq)	Probably package was lost at airport of embarkation.	*Package could not be recovered.*
2001	Seizure of Gammarid camera (^{192}Ir, 925 GBq) by police during transport by vehicle.	Police's ignorance about the exclusive use provisions in regulations.	Police were explained, camera was released.
2002	Loss of package during transport by user(Techops,^{192}Ir 740 GBq) illegally by a bus.	Improper locking of the door of luggage hold compartment of the bus.	*Package still untraceable*.

6. Conclusion

Industrial radiography is one of the applications of the radioisotopes in industries involving high potential exposure. Even though there is a high potential for radiation hazard, such hazard is controlled to an acceptable level by following the technical standards and regulations stringently as laid down by the Competent Authority in every stage of operation and transport of the industrial gamma radiography exposure devices. Since the exposure devices are generally portable, they are susceptible to misplacement, theft and loss during their transport. Strict control measures are necessary by the consignor and the carrier to ensure safety of consignment containing radioactive material.

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TRANSPORT PACKAGING COMPLETE SETS FOR SAFE TRANSPORTATION OF RADIONUCLIDE SOURCES OR EQUIPMENT WITH RADIONUCLIDE SOURCES

B.M. Vaniushkin, E.R. Kartashev

Russian National Technical Physics and Automation Research Institute (VNIITFA) of the Ministry of the Russian Federation on Atomic Energy, Moscow,
Russian Federation

Abstract

Use of radionuclide sources of radiation in various spheres of human activity demands application of safe equipment for transportation of these sources to a place of their operation and replacement of the used sources. For these purposes in VNIITFA the transport packaging complete sets (UKT) of various types are developed. Some types of such UKT are described in this paper.

1. Introduction

The Russian National Technical Physics and Automation Research Institute (VNIITFA) of the Ministry of the Russian Federation on Atomic Energy is one of the leading Russian institutions on development and manufacturing of the transport packaging complete sets (UKT) intended for storage and transportation of different type radionuclide sources of ionizing radiations (SIR). This work is conducted in two directions:

- development of new types UKT;
- modernization of UKT, not meeting the up-to-date international and Russian state requirements (rules) of radioactive materials transportation and their adjustment to these rules [1,2].

By development of new UKT we have done the analysis of now used and perspective types of radiation sources, and also the technical data of equipment on sources manufacturing (carrying capacity, the sizes of apertures, etc.) both design features of radiation installations and ways of loading in them these sources. For convenience of operation UKT (loading, a unloading of sources, transportations, deactivation, etc.) the transport complete sets developed by institute AREL consist of two parts: the shielding container in which the radionuclide sources are placed, and the protective box providing mechanical and thermal protection of UKT in normal conditions of operation and at failures (see Fig. 1 and 2).

The protective box is a capacity of the cylindrical form made off carbonaceous steel with a cover or the pallet. As heat protection we use wood with thickness of 40-60 mm, impregnated with the special compound raising its fire resistance and antiseptic properties. On the basis of calculations and experimental researches we have optimized the sizes of radiation shielding of UKT and determined the necessary thickness of heat protection for the maximal activity of transported radionuclide sources have been optimized.

All the packaging complete sets have been tested for conformity to the "Rules of safe transportation of radioactive materials" (ST-1, IAEA, 1996) and have corresponding certificates.

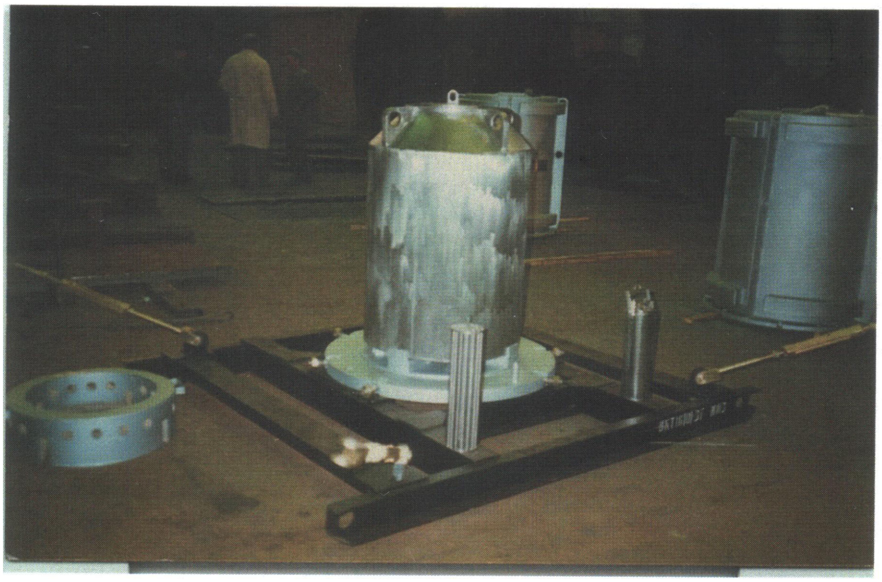

Fig. 1: Transport packaging set UKTIB(U)-96- for storage and transport of Co-60 sources or Cs-137 sources with activity up to 6,29 PBq (170kCi)

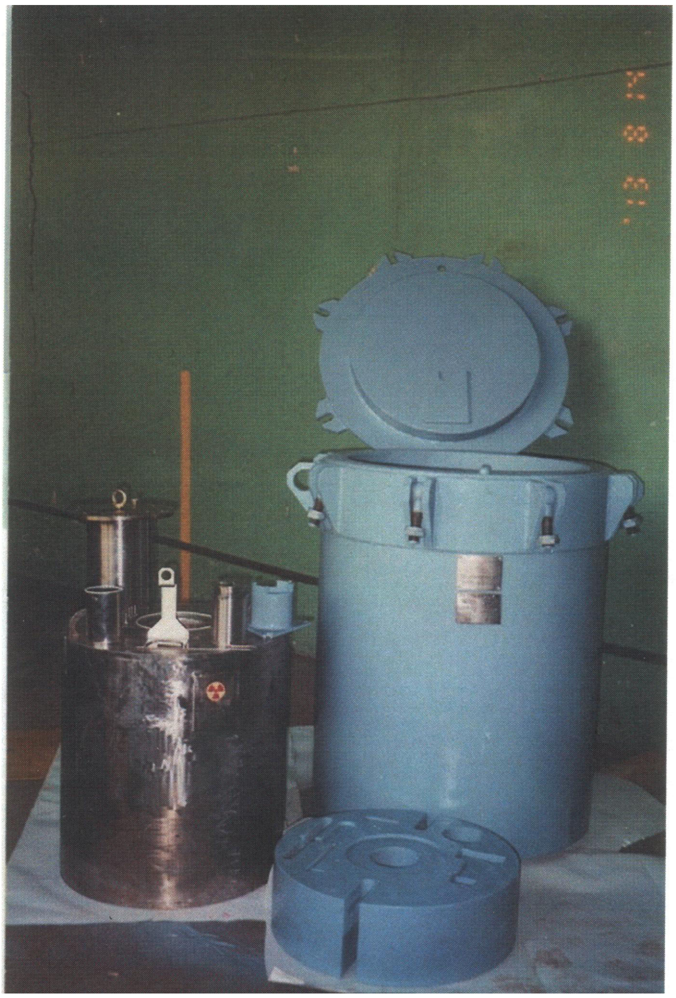

Fig. 2: The transport packaging set UKTIB (U)-96-26M for storage and transport of Co-60 sources, with activity up to 740 TBq (20 kCi) or Cs-137 sources with activity up to 888 TBq (24 kCi)

2. UKT for gamma radiation sources

Last years users of radioactive materials aspire to transport in the same UKT as great activity of radioactive materials as possible. Our institute has developed UKT for storage and transportation of cobalt-60 and cesium-137 radiations sources with activity up to 6,29 PBq (170 kCi) and heat power up to 2,55 kW, meeting the requirements to a special form of radioactive material (SFRM), as well as sources which do not meet the requirements to SFRM and consequently been placed in tight case. Now we are developing UKT for transportation of radionuclide sources of ^{152}Eu and ^{154}Eu by activity up to 350-400 kCi which can be alternative to ^{60}Co and ^{137}Cs. Sources on a base of ^{152}Eu and ^{154}Eu radionuclides are characterized by the long half-life , 13,5 and 9 years respectively, and good values of gamma-constant 6,35 and 6,7 respectively. These sources are supposed to be used in industrial gamma-installations, both existing and the projected, intended for processing of medical, food and agricultural products, processing of sewage with the purpose of disinfection, modifying of polymer products, and also other radiation installations for use in technology and medicine. Besides of UKT for transportation of separate radiation sources our institute has developed the special types of UKT, which are intended for storage and transportation of radiation heads for gamma therapy devices, for self-protected gamma-irradiators with radionuclide sources in them, Fig. 3 (see Tab. 1).

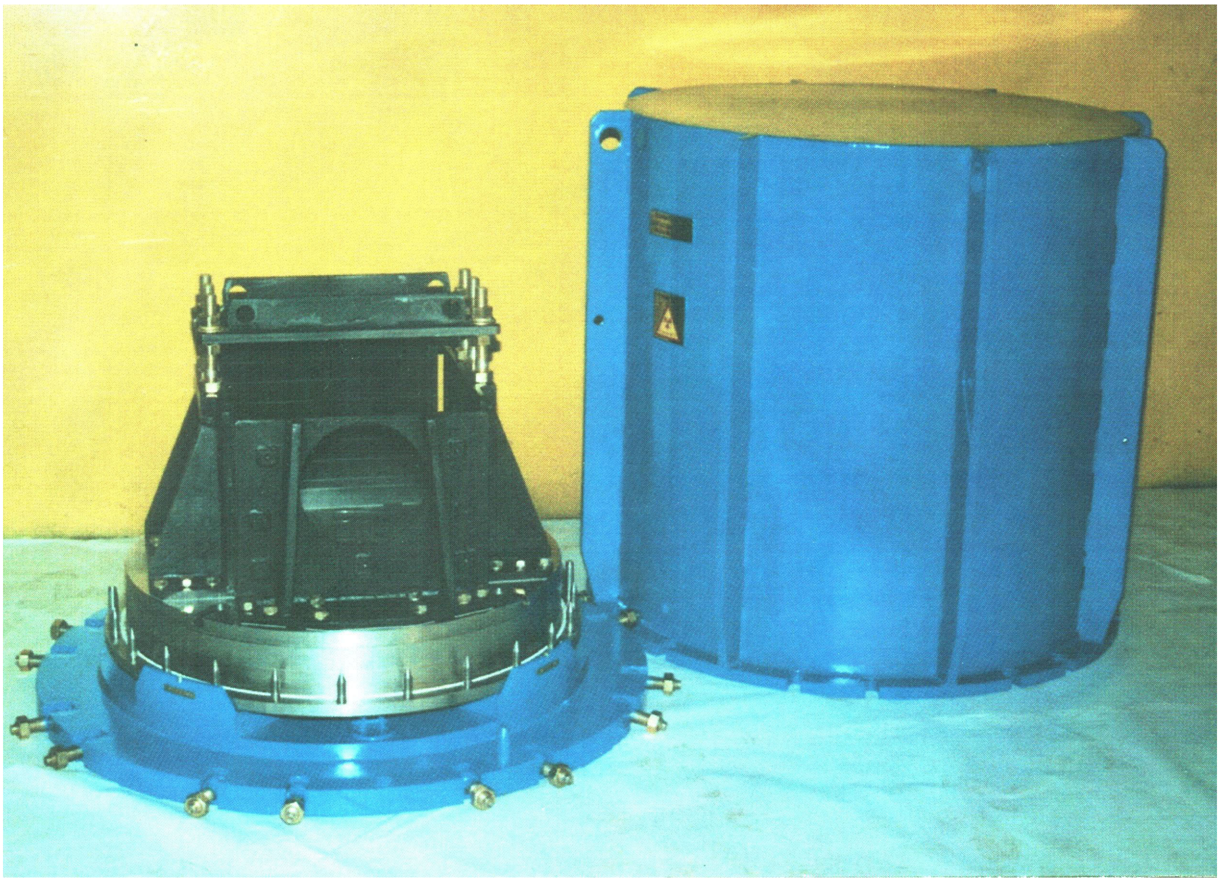

Fig.3: UKTIB(U)-85-4 for storage and transport of radiation heads and small size irradiators with Co-60 or Cs-137 radiation sources with activity up to 370 TBq (10 kCi).

Table 1. Basic data of UKT for gamma radiation sources

Type of UKT	Designation	Dimensions, mm	Weight, kg	Nominal dimens. of jacks for sources mm
UKTIB(U)-96-26M	For storage and transport of Co-60 sources, with activity up to 740 TBq (20 kCi) or Cs-137 sources with activity up to 888 TBq (24 kCi)	Length - 1000 Width - 900 Height- 1100	No more 2400	Diameter - 110
UKTIB(U)-96-3	For storage and transport of Co-60 sources or Cs-137 sources with activity up to 6,29 Pbq (170kCi)	Diameter - 1050 Height - 1350	No more 4800	Diameter - 125 Height - 480
UKTIB(U)-85-4	For storage and transport of radiation heads and small size irradiators with Co-60 or Cs-137 radiation sources with activity up to 370 TBq (10 kCi)	Diameter - 1500 Height - 1350	No more 2100	
UKTIB(U)-96M	For storage and transport of self-protected irradiators (containers) or radiation heads, containing Co-60 or Cs-137 radiation sources with activity up to 3,7 PBq (100 kCi)	Length - 2150 Width - 2150 Height - 2150	Weight (net) no more 6000 kg, gross 12300 kg	
UKTIB(U)-96-14	For transport, reloading into radiation heads of therapy devices and unloading from them Co-60 radiation sources with activity up to 444 TBq ($12\cdot10^3$ Ci) or Cs-137 with activity up to 110 TBq (3 kCi)	Diameter - 1100 Height - 900	No more 2150	
UKTIB(U)-96-7	For storage and transport of radionuclide preparations with radionucildes of Molybdenum-90 or Iodine-131 with activity no more than 185 TBq (5 kCi)	Diameters - 320 Height - 390	No More 85	Diameter - 60 Height - 90

3. UKT for radionuclide neutron sources

The institute has developed also the unified line of containers for transportation of neutron sources, Fig. 4, 5 (see Tab. 2).

In view of the nomenclature of neutron sources produced in Russia there were developed the packaging complete sets of A and B types for transportation and storage of sources, as relating to special form of radioactive materials, and sources that not relating to them. Technical data of these UKT and their components resulted in Table 2. The thickness of a shielding in UKT was defined accordingly for lines of ^{252}Cf sources with a neutrons flaw 2.10^{10}; 2.10^{9}; 2.10^{8}; 2.10^{7} s^{-1} for the III transport category. To this transport category there meet maximum permissible an equivalent dose rate of radiation in any point of an external surface of radiating packing 2 mSv/h (200 mrem/h) and on distance of 1 m from any point of a surface 0,1 mSv/h.

Fig.4: The unified line of containers for transportation of neutron sources

Fig. 5: Transport packaging set UKTIIB-4 for transportation of neutron sources of ^{252}Cf with neutron flow up to 2.10^{10} neutrons per second.

The choice of the specified transport category is caused by aspiration to develop UKT with the minimal dimensions and the minimal weight, and at the same time providing the haul of neutron sources of from the manufacturer up to the consumer by any kind of transport.

Table 2: The basic data of UKT for neutron sources.

Type of UKT	Designation	Maximal neutron flow (for the III transport category) s^{-1}		Dia-meter mm	Height mm	Weight kg, (jacks quantity)	Jacks dimensions mm
		^{252}Cf	^{210}Po-Be $^{238+239}$ Pu-Be				
UKTIIA	Transport Packaging Set	4.10^7	1.10^7	487	562	92(1)	Ø60×85
KTII-1	Shielding Container	4.10^7	1.10^7	440	510	77(1)	
TOA-450/525	Protective Box	-	-	487	562	15	
UKTIIA-2	Transport Packaging Set	2.10^8	6.10^7	665	765	272(1)	Ø60×85
KTII-2	Shielding Container	2.10^8	6.10^7	570	690	250(1)	
TOA-570/708	Protective Box	-	-	665	765	22	
UKTIIA-3	Transport Packaging Set	1.10^9	3.10^8	1065	1150	1180(10)	Ø7,5×14
KTII-3	Shielding Container	1.10^9	3.10^8	950	1035	950(10)	
TOA-965/1045	Protective Box	-	-	1065	1150	230	
UKTIIB-1	Transport Packaging Set	5.10^7	$1,5.10^7$	644	754	225(1)	Ø60×85
KTII-1	Shielding Container	4.10^7	1.10^7	440	510	77(1)	
TOB-450/535	Protective Box	-	-	644	150	150	
UKTIIB-2	Transport Packaging Set	3.10^8	1.10^8	882	918	530(1)	Ø60×85
KTII-2	Shielding Container	2.10^8	6.10^7	570	690	250(1)	
TOB-580/708	Protective Box	-	-	882	918	280	
UKTIIB-3	Transport Packaging Set	2.10^9	-	1300	1270	1600(10)	Ø7,5x14
KTII-3	Shielding Container	1.10^9	-	950	1030	950(10)	
TOB-980/1060	Protective Box	-	-	1300	1270	650	
UKTIIB-4	Transport Packaging Set	2.10^{10}	-	1950	1720	4600(3)	Ø7,5x25
KTII-4	Shielding Container	1.10^9	-	950	1030	1156(3)	
TOB-1000/1057	Protective Box	-	-	1950	1720	3440	

Structurally transport packaging set for neutrons sources also consists of the shielding container and protective box. Our institute has developed 4 types of containers for neutron sources. Containers of 1-st and 2-nd types are of single-jack type. Unloading of the container is carried out by extraction of a plug together with sources. The jack by diameter 60 and height 85 mm in the bottom part of a plug allows to place sources both from Californium-252, and on the base of polonium and plutonium.

Containers of 3rd and 4th types are multi-jack drum type, they are intended for transportation of neutron sources made of Californium-252. The container of the 3-rd type has 10 jacks, and the 4-th type - 3 jacks. The design of containers of these types allows to make loading and unloading of sources both from the top, and from the bottom in hot chambers or water-pools as at the factory, where sources are manufactured, as well as at the user's enterprise directly from the transport container into the irradiation installation. For convenience and reliability of loading and unloading the containers of these types are supplied with special gripping device and necessary adaptations.

As the basic biological neutron shielding it is used the polyethylene wax with addition of lithium carbonate. Application of polyethylene wax (temperature of fusion 130^{o}C) instead of paraffin (the melting temperature is 60^{o}C) allows to increase the reliability of the container at emergencies. The lithium addition in wax reduces a doze of neutron capture gamma radiation..

With a view of increase in efficiency of shielding and optimization of dimensions and weight of containers of the 3-rd type in the central part of the container it is entered the layer of lead which absorbs the own gamma radiation of Californium-252 and reduces a neutron flaw owing to inelastic scattering . The rotary drum is made of steel.

It is important to not increase a diameter of the shielding container of the 4-th type. For that a part of the polyethylene wax layer, which is essential for maintenance of the III transport category at transportation UKT, is placed in protective box, and the central part and a drum of the container are made of tungsten. Using of tungsten instead of lead has allowed to redouble the efficiency of shielding and to provide radiation safety at possible accidents during transportation. Containers for all type neutron sources are tight. For convenience of decontamination the external surfaces of containers are made of stainless steel and polished. The protective box of packaging complete sets of A type represents the metal capacity of the cylindrical form closed by a cover. Its destination is the prevention the contacts of the shielding container with an environment and possible mechanical damages at transportation.

The protective box of packaging complete sets of B type represents double walls box, with a wooden layer heat as a protection, placed between the walls the, and the top cover of the same structure. The protective box of the 4thh type is provided extra with 20 cm layer from polyethylene wax. The protective box in the B type UKT protects the shielding container with sources from mechanical and fire influences in an accidents.

4. Conclusion

The packaging complete sets, described above, meet the up-to-day requirements on reliability, radiation safety and they are successfully used in an economy of the country. Besides of that our institute has developed transport packaging complete sets for transportation of gamma radiography devices and radionuclide heat sources for radionuclide thermoelectric generators (RTEG), and also for other purposes.

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TRANSPORT AND CONDITIONING OF DISUSED RADIUM SOURCES IN BANGLADESH

A. Jalil, M.M. Rahman, M.M. Hossain, A. Kuddus, M.K. Alam, G. Rabbani, M. Mizanur Rahman, S. Yesmin

Institute of Nuclear Science and Technology,
Atomic Energy Research Establishment,
GPO Box No. 3787, Dhaka-1000,
Bangladesh

Abstract

Under an IAEA model project (INT/4/131:Sustainable Technologies for Managing Radioactive Waste), disused radium sources used as calibrators, applicators and needles were collected, transported, conditioned and stored for the safe management of radioactive wastes used in medical, industrial and research applications in Bangladesh. About one gram of disused known radium sources was collected from various hospitals and nuclear medicine centers as a part of the inventory of radiation sealed sources in the country and transported to the Atomic Energy Research Establishment (AERE) Campus, Savar for conditioning. IAEA transport regulations and Nuclear Safety and Radiation Control Rules (NSRC, Bangladesh) were followed during transportation for the safety and to avoid unwanted radiation exposure. These wastes were conditioned into two 200 L MS drums and safely stored in an isolated interim storage room in the AERE campus, Savar under the auspices and help of the International Atomic Energy Agency expertise. This paper describes the inventory, transportation, conditioning, storage and radiation monitoring as well for the safe management of disused ^{226}Ra sources in Bangladesh.

1. Introduction

Radium used in medicine, research and industry is in the form of sealed sources (mostly as salts), luminescent material, silver foils, radium bromide solutions etc. In medicine, they are used in the form of needles and tubes for brachytherapy or applicators for external betatherapy while radium sources are also used as a calibrator in research. In the 1950s, a large number of radium (^{226}Ra) sources were produced for various purposes. For the use in medicine, industry and research, Bangladesh like many other countries imported ^{226}Ra sources in the decade of 1950. With the production of a number of new radioisotopes, the production of radium sources was stopped in the 1960s [1] and the used sources became disused sources. These sources were then stored in the corresponding hospital/center.

^{226}Ra is an alkaline earth metal and is highly reactive even with nitrogen. In radiation sources radium is therefore always present in the form of salts, such as bromides, chlorides, sulfates or carbonates which is considerably less reactive. All are sufficiently soluble in water to give rise to radiological problems. The salts may easily be dispersed as powder if the source encapsulation is leaking. Leakage may be caused by overpressurization of or physical damage to the source. It is generally believed that due to the high specific activity of the sources and high radiotoxicity having a low annual limit of intake and long physical and biological half-life of ^{226}Ra, final disposal in a suitable geological repository is necessary [1]. Since such a repository does not yet exist anywhere in the world, and probably will not be in operation for some decades into the next century, it is impartial to conceive a long term interim storage facility for this type of waste until such time as a suitable final disposal solution becomes available. The radioactive characteristics of ^{226}Ra and its daughters, particularly the gas ^{222}Rn, necessitate that radium sources are suitably conditioned before interim storage. Therefore, special attention should be given during the management of disused ^{226}Ra sources especially during transportation and conditioning.

With the auspices and help of the International Atomic Energy Agency (IAEA) expertise under the IAEA model project (INT/4/131:Sustainable Technologies for Managing Radioactive Waste), all of known disused ^{226}Ra sources used as calibrators, applicators and needles have been collected from various hospitals and nuclear medicine centers in Bangladesh and transported to the AERE campus for conditioning. Accordingly a national inventory of disused ^{226}Ra sources has been established as a part of the safe management of radioactive wastes in the country. In the present paper, emphasizes on the inventory, transportation, conditioning, storage and radiation monitoring as well have been given for the safe management of disused ^{226}Ra sources in Bangladesh.

2. National inventory of known disused radium sources

Disused ^{226}Ra sources are probably the oldest radioactive waste produced in Bangladesh. For that reason, there is often a lack of data concerning their existence, location and nature. However, it is necessary to establish a national inventory of all disused radium sources distributed in the country. This is achieved by sending a questionnaire and personal communication as well to the authority of the corresponding hospital/center [2]. Due to the lack of sufficient information, the amounts of ^{226}Ra being used by the corresponding hospital/center were measured during encapsulation prior to conditioning into two 200 L MS drums. The inventory is shown in Table 1.

Table 1: Inventory of disused ^{226}Ra sources collected from various hospitals/centers in Bangladesh.

	Hospital/Center	Number of Sources	Activity	
			mg	GBq
(i)	DMCH	73	307	11.34
(ii)	RMCH	58	264	9.78
(iii)	CMCH	60	238	8.79
(iv)	SSMCH	17	102	3.77
(v)	AECD	1	50	1.83
(vi)	NMCC	2	1	0.04

DMCH= Dhaka Medical College & Hospital, RMCH= Rajshahi Medical College & Hospital, CMCH= Chittagong Medical College & Hospital, SSMCH= Sir Saleemullah Medical College & Hospital, AECD= Atomic Energy Center, Dhaka and NMCC= Nuclear Medicine Center, Chittagong.

3. Packaging and transport

The preparation of sources prior to transportation to a centralized facility is a crucial issue for the protection of workers, the population, and the environment [3]. In fact, the disused ^{226}Ra sources were stored in different containers (for example, Pb) and shielding arrangements such as Pb container surrounded by concrete, MS steel and wooden box (Figures 1 and 2). Due to insufficient data of the sources and packages made by the corresponding hospital/center, appropriate Pb container was used during transport of all known disused ^{226}Ra sources from the hospitals/centers to the AERE campus using vehicle (Figure 3) for conditioning.

4. Conditioning and interim storage

Source conditioning is required before long-term interim storage to avoid the release of radioactive material and to limit radiation exposure. An IAEA expert team accomplished the conditioning of all known disused ^{226}Ra stocks of Bangladesh in accordance with the IAEA TECDOC-886 [1] in presence of the IAEA Model Project Technical officer and the relevant personnel of Bangladesh Atomic Energy Commission. The ^{226}Ra conditioned in two 200 L MS drums weights 962.00 mg and is equivalent to 35.6 GBq emplaced into Pb shielding devices (Figures 5 and 6). These conditioned drums will be stored in the Central Radioactive Waste Storage Facility (CWPSF) in the country which is now under construction located in the AERE campus.

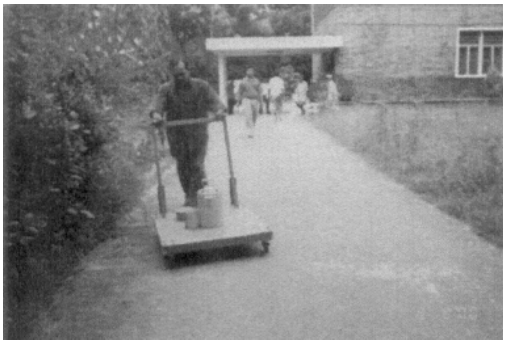

Figure 1: Lead (Pb) container containing disused ^{226}Ra sources.

Figure 2: disused ^{226}Ra sources in a Pb container surrounded by concrete and MS-Steel shielding.

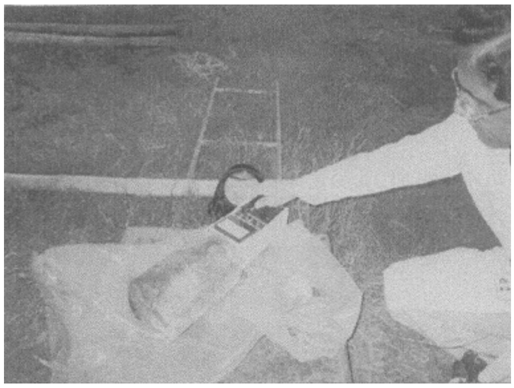

Figure 3: A vehicle for transporting disused ^{226}Ra sources to AERE campus.

Figure 4: Radiation monitoring during opening of disused ^{226}Ra sources.

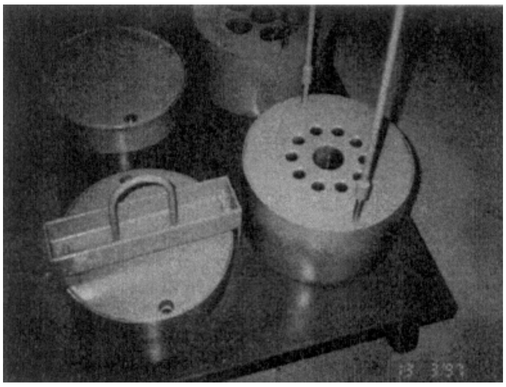

Figure 5: Pb shielding devices for emplacing disused ^{226}Ra sources.

Figure 6: Conditioned disused ^{226}Ra sources in two 200 L MS drums.

5. Radiation monitoring

During transportation, opening, encapsulation and shielding process of all known disused ^{226}Ra sources, precautions were taken to restrict internal and internal radiation exposures to a minimum according to the ALARA principle [4]. Work involving the handling of radioactive materials was carried out in a controlled area. Special precautions were taken to prevent inhalation of airborne contamination during leak-testing and encapsulation. Prior to transportation of the shielded sources from hospitals/centers to the AERE campus, radiation levels at the surface of the container and at 1 m distance were recorded (Table 2) and found well below the recommended value prescribed elsewhere [4, 5]. Desired radiation monitoring was performed throughout all handling and transport operation. The dose rates at different positions of the conditioned drums were found to be satisfactory as shown in Table 3 which are also well below the recommended value (2 mSv/h) prescribed by IAEA [3].

Table 2: Dose rate during transporting of disused ^{226}Ra sources from various hospitals/centers to AERE campus, Savar.

Hospital/Center		Dose rate (μSv/h)	
		Surface	1 m distance
(i)	DMCH	150.0	6.0
(ii)	RMCH	40.0	4.0
(iii)	CMCH	50.0	2.0
(iv)	SSMCH	100.0	5.0
(v)	AECD	15.0	1.5
(vi)	NMCC	2.0	0.3

Table 3: Package information of conditioned disused ^{226}Ra sources in 200 L MS drums.

Package No.	Activity		Lead shield Dose rate (mSv/h)	Package dose rate (μSv/h)	
	mg	GBq		Surface	1 m distance
(i) BD-401	530	19.6	4	190	22
(ii) BD-402	432	15.95	3	150	21

6. Conclusions

Disused ^{226}Ra sources used as calibrators, applicators and needles in medicine and research were collected, transported, conditioned and stored for the safe management of radioactive wastes in Bangladesh. About one gram of disused known radium sources has been collected and transported to the Atomic Energy Research Establishment (AERE) Campus, Savar for conditioning. IAEA transport regulations and NSRC rules were followed during transportation for the safety of the sources, workers and the environment as well. During transportation and handling of disused ^{226}Ra sources, special precaution was taken to avoid unwanted radiation exposure. The dose rates at the surface of conditioned drums were well below the prescribed dose limit recommended by IAEA and NSRC rules. These wastes were conditioned into two 200 L MS drums and safely stored in an isolated and well maintained interim storage room in the AERE campus, Savar under the auspices and help of the International Atomic Energy Agency expertise. These conditioned drums will be stored in the Central Radioactive Waste Storage Facility (CWPSF) in the country which is now under construction located in the AERE campus.

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THE IN-SITE REGULATIONS IN FRANCE FOR THE SAFE TRANSPORT OF RADIOACTIVE MATERIAL

J.Y. Reculeau[a], D. Delmont[a], J.C. Niel[b]

[a] Direction de la Sûreté Nucléaire et de Radioprotection, Délégué à la Sûreté Nucléaire et à la Radioprotection pour les activités intéressant la Défense (DSND)[1], Paris,

[b] Président de la Commission de Sûreté des Transports (CST), Institut de Radioprotection et de Sûreté Nucléaire (IRSN); Fontenay-aux-Roses,

France

Abstract

The aim of this paper is to present the method used by the French authorities to implement regulations to ensure the control of the safety of the in-site transport of radioactive and fissile material inside large sites. First, the regulatory background is presented for the in-site transport. Then, an overview of the situation of such transports, which has lead the competent authority to develop a Directive as a regulatory frame, is given. Concerning the authorizations delivered by the competent authority, this Directive specifies the process and the requirements to be applied by the applicants for in-site transport. The technical justification of these requirements and their technical content are explained. Then, this paper summarizes how the applicants manage to meet in full the requirements of the in-site transport Directive and the experience feedback of this implementation. In conclusion, the improvements brought and the difficulties induced by the implementation of these regulations are discussed.

1. Regulatory background

For ADR-contracting parties and, moreover, for countries belonging to the European Union, the provisions of ADR (Agreement for the international transport of Dangerous goods by Road) are fully applicable for national and international transport in compliance with the European directive 94/55/CE [2]. These provisions apply, among other classes, for the transport of radioactive and fissile material on public roads. However, ADR states that some radioactive materials are not included in Class 7 for the purposes of ADR like: “radioactive material moved within an establishment which is subject to appropriate safety regulations in force in the establishment and where the movement does not involve public roads or railways” (ADR 2003, § 2.2.7.1.2.b). So that in-site transport[3] are not regulated by ADR.

On the other hand, the operator is required to define the relevant safety rules applicable to the different facilities of the site. This includes mainly the carriage and operations of handling, loading and unloading of radioactive material inside the facilities. But the transport of radioactive material between facilities, if located on the same site, are not fully covered by the safety analysis report of the different facilities. Then, the transport on internal roads of an “establishment” or the so-called “in-site transport” is not regulated by ADR or by the regulations applicable to the facilities.

2. Overview of the situation

The sites concerned by in-site transports are large centres, on which are located many reactors and laboratories for research or many facilities for nuclear fuel production. These sites were created in the

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[1] DSND ensures the control of nuclear safety and radiation protection for activities and facilities of interest to the Defence. As such, DSND is the competent authority in France for the in-site and public road transport of radioactive and fissile material, which are of interest to the Defence.

[2] Directive 94/55/CE du Conseil du 21 novembre 1994 relative au rapprochement des législations des Etats membres concernant le transport des marchandises dangereuses par route.

[3] In the following, in-site transport means transport that does not use public roads or railways, and that is performed on a single site and out of a given facility.

late 1950s to the early 1970s and expanded quickly, the first ones to perform multiple experiments and the latter to reach a production level. In the 1960s and 1970s, most of the facilities helped by subcontractors developed and manufactured their own array of packages to store and transport the radioactive and fissile material. Some packages were not available for transport on public roads and were dedicated to in–site transport between the different facilities of the same site. The level of performance for the design of these in-site packages was not consistent with the one required for the transport on public roads, because of the restricted and dedicated in-site use. For example, in some sites there were several hundreds of package designs, the corresponding packages being mostly unique, adapted to the facilities and built for specific need often limited in time and in frequency.

The lack of quality assurance, including the lack of traceability, which were not then requirements, were often synonymous with lack of safety justification. For example, when the packages were designed and manufactured the relevant documentation of these packagings generally was not provided. So that, a large number of packagings designed during that period did not possess a complete safety analysis report, rigorous procedures of carriage, loading, unloading and maintenance to prevent from criticality, radiation and loss of containment hazards. This brought uncertainties on the conformity of the packaging to the package design; for example, on the maximum authorized contents to be carried.

The general standard of rigor, justification and formalization in safety is increasing and leads to a change of practice and regulations in many fields including that of transportation. For example, the IAEA regulations incorporated general requirements like quality assurance from design to dismantling of the packagings in its 1973 edition, 1979 as amended. Then, the packages designed according to 1967 and 1973 editions of IAEA requirements didn’t fulfil the QA requirements necessary to be able to justify the level of performance and safety.

In the absence of precise regulations for in-site transport of radioactive and fissile material, operators or applicants did not invest to renew and update their packagings. The first reason given by the operator was cost: as mentioned above, the operator had developed many packagings with limited and very specific use, the change of which requiring important means. The second reason was interface between the package and the facilities: indeed, the packagings were designed to allow the loading and unloading of the material from one facility to another and to allow the carriage of radioactive and fissile material between facilities taking into account the safety functions for in-site transport scenarios. On other hand, no specific regulations required the applicants to declare non conformances and incidents involving in-site transports of radioactive and fissile material. In particular, this concerned incidents occurring due to recurrent problems, among others: default of maintenance, insecure stowage of packages on the vehicle or incorrect use of the packaging and its accessories. Then the regulator considered that it was necessary to make the regulations for in-site transport of radioactive and fissile material more precise and prescriptive.

3. A regulatory frame

In 1985, internal documents specified the regulations to be applied to in-site transport. Nevertheless, the process to make the regulations more precise and prescriptive for the in-site transport of radioactive and fissile material was initiated in 1990 by the President of the Transport Safety Commission (CST). The objectives of this Commission were to provide technical advice and appraisals for the French competent authority for all transports of radioactive material and to implement the relevant provisions for the external and in-site transports of radioactive material for large nuclear centres, essentially the ones of CEA or COGEMA.

In the late 1980s, the President of the Transport Safety Commission demanded that operators and applicants provide an inventory of all packages including the ones used for in-site transport. A system of authorizations was created and implemented, which was applicable for the in-site transport material exceeding three thresholds:

- 100 A_1 for special form radioactive material,
- 100 A_2 for other radioactive material, and
- the exception levels for fissile material as defined in IAEA Regulations.

These thresholds were defined regarding the available inventories of packages and took into account, in a qualitative approach, the reduced risk associated to in-site transport compared with transport on public roads (reduced speed, availability of on-site radiation protection and emergency units).

The process related to the implementation of in-site transport authorizations was slow until 1998, when the Transport Safety Commission developed a Directive[4] for in-site transport of radioactive and fissile material. This Directive, which is approved by the competent authority (DSND) and is mandatory inside large sites, requires:

(1) in-site rules to be written and defined by the applicant, which should be approved by the competent authority and revised regularly to take into account the changes of the sites organization and the evolution of the IAEA regulations. These rules include safety rules such as:
    - the classification of the material,
    - the manufacturing, maintenance, homologation and dismantling of packages or transport devices;
    - the manufacturing, approval and maintenance of vehicles and equipments;
    - the training of persons involved in the transport activities;
    - the follow-up documentation, the instructions in writing and the safety schedules.

(2) an annual safety summary of activities related to transport (quantification of the shipments, types of used packages, summary of non compliances and incidents, and associated actions);

(3) the definition of the organization to perform in-site transport, with the different obligations of the participants to the transport (the site director, the consignor unit, the consignee unit, the carrier, the persons in charge of controls before and after shipment and the owner of the packaging).

(4) the types of authorizations of the competent authority and of the site director for the in-site transport of radioactive and/or fissile material over identified limits.

(5) the declaration of any non conformance affecting the safety, incident or accident, related to the in-site transport of radioactive or/and fissile material.

The Directive, issued by the Delegate for Nuclear Safety and radiation protection for activities and facilities of interest to the Defence (DSND), is applicable to sites having activities of interest to the Defence. The equivalent requirements were put into force by the competent authority in charge of the control of the safety for the transport of civil use radioactive and fissile material. Therefore, complete consistency between the in-site transport regulations for civilian and defence purpose sites was obtained.

4. System of authorizations

The in-site transport regulations defines the applicable level of performance of the packages and the site organization to prepare and achieve in-site transports. To complete these in-site transport regulations of each site, a system of authorizations similar to the one existing for public road transport was developed. The individual authorizations of package designs, delivered by DSND on the basis of the appraisal of his technical support, guarantee a minimum level of performance and a satisfactory level of design. Two types of authorizations were introduced.

First, homologations (equivalent to approval for public road transport) are pronounced under the same conditions as the approvals, on the basis of an appraisal of the safety analysis report which comply with the requirements of the in-site transport rules of each site. A certificate of homologation is issued for a determined period, by the competent authority if the content overpasses one of the thresholds, and by the site director otherwise. This certificate includes the reference to the relevant applicable texts, the description of the packaging or transport device, the description of the authorized content(s) and the specific conditions of the package use, package transport, package maintenance and transport achievement (itinerary).

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[4] Directive HC n°12 of the 1st October 1999 related to the in-site transport of radioactive or fissile material of interest to the Defence.

Second, exceptional authorizations are for in-site transport the equivalent of special arrangement for public road transport. Relevant compensatory measures must be developed to obtain an overall level of safety in transport at least equivalent to that which would be provided if all the applicable requirements had been met.

To complete the authorizations dealing with designs, the competent authority requires information on the real packages, which exist and are used to perform transport. For the purpose of operations liability, this includes:

- an inventory of all package (or transport device) designs and their status for authorization;
- an inventory of all packagings in compliance with package designs, their serial number and the date of last maintenance.

A follow-up of each individual package is available and is given on request to the competent authority; It includes all data on the performed shipments, a history of maintenance and its level. Similarly, to ensure quality in transport operation associated to packagings of each package design, the operations of loading, unloading and maintenance, the conditions of transport and the different authorized contents should be precisely defined.

5. Technical justification of the thresholds and the in-site regulations

Historically, a working group studied in 2000 the relevance of the threshold applicable for radioactive material for in-site transport. On the basis of the Q-system, the group studied different scenarios of in-site transports, which may induce loss of containment or reduction of the radiation protection. Similarity in the organization of the large sites allowed to define statements for the time and the means of the intervention (for example, a minimum fire test duration of 10 minutes was considered). The group concluded that as limits for authorizations by the safety authority, the limits of 100 A_1 for special form radioactive material and 100 A_2 for the other radioactive material were acceptable. This conclusion is different with the threshold defined by the President of of the Transport Safety Commission in 1990 on one point: the threshold for radioactive material in gas, liquid or powder form is A_2, except special case authorized by the competent authority on the basis of technical justification.

The basis for the in-site regulations are the provisions included in the ADR in all domains: level of performance, use (labelling, marking, placarding, documentation), maintenance, transport and in-transit. The aim is the consistency as far as necessary with the requirements for public road transport. The applicants had to justify for the definition of their in-site rules any softening to all of the ADR provisions, in particular to the performance level. Basis for the justification is :

- the specific organization of the site, among others, the availability of intervention units (trained staff, measurement and intervention devices, protection equipments, firework truck) and the traffic rules on the site,
- and the site typology (no bridge, no deep-water ponds, …).

The main evolution, compared to ADR, in the definition of the in-site rules proposed by the applicants, were focused on tests conditions and on the thresholds over which an authorization of the competent authority is required. The proposals of the applicants (CEA and COGEMA for the sites of interest to the Defence) were discussed in the common meeting of Transport Safety Commission (for transport of interest to the Defence) and Transport Permanent Group (for civilian transport) held in October 2001. The conclusions of the meeting were the following :

- applicants should determine for their in-site transport rules the requirements related to quality assurance, extreme climatic conditions of transport (temperature, insolation), representative tests for normal conditions of transport, contamination limits, radiation levels criteria in normal and accidental conditions of transport, and exceptional authorizations;
- For packages requiring containment system, the leaktightness criteria could be softened to 10^{-4} A_2/h before each shipment if the design criteria for routine use conditions is 10^{-6} A_2/h and the carriage out of the controlled radiation zone of the facility is limited to 24 hours;
- Any modification of the in-site transport rules provided by the applicant should be approved by the competent authority;

- The sequences of tests for in-site transport are the same as the public road transport (ADR);
- The mechanical tests in accidental conditions of transport include:
  - A punch test as defined by ADR,
  - A drop test from a height h(m) of minimum 2,5 metres and depending on the maximum in-site speed Vmax for the vehicle, according to the following formula: $h(m) = Sup\ [0{,}018\ .\ Vmax^2(m/s)\ ;\ 2{,}5\ m]$
  - The drop test could be replaced by dynamic crush test from the here above calculated height formula if the package has a mass not greater than 500 kg, an external density of 1 and a radioactive content greater than 1000 A_2.
- The fire test has a minimum 15 minutes duration, depending on the particularities of the transports and the site.
- The threshold to require an authorization of the competent authority for the in-site transport of special form radioactive material is 100 A_1, and of non special form radioactive material is 100 A_2, (except for radioactive gas for which the threshold is A_2), if equivalent authorization is required on public road transport.

6. Steps followed by the applicants

The implementation of in-site transport regulations and associated changes need from the applicant a significant and graded effort to comply with new regulations.

First, the applicants and operators in large sites had to define their own in-site transport rules. For that purpose, the Transport Safety Commission (CST) developed and approved, in parallel with the Directive, a Guidance to prepare and to write the in-site transport rules of the sites. This document lists, as a frame, the minimum content of in-site transport rules and is a support document to the Directive for in-site transport.

Then, the applicants performed an accurate inventory of packages to propose priorities to obtain authorizations. These authorizations are called “homologations” for the in-site transport to be differentiated from approval used for the transport on public roads. Approved packages do not require homologation. Among the packages subjected to homologation, three types of packages were identified:

- the packages for which the conformity to performance requirements can be demonstrated or could be reached reasonably with minor changes or minor compensatory measures;
- the packages for which the conformity to performance requirements can be demonstrated if subjected to consequent changes or consequent compensatory measures;
- the packages for which the conformity to performance requirements can not be demonstrated. These packages must not be used any longer for the in-site transport.

A transitional period of a few years was implemented to give the applicants time to find alternative solutions, for packages belonging to the first and second categories. Each applicant was required to define a realistic schedule to provide the safety analysis reports and to obtain the regularization of all types of packages used for in-site transports. At least fifty package designs are concerned by authorization of the competent authority for all sites of interest of the Defence.

Finally, an effort to produce a complete documentation (e.g. safety analysis report, follow-up schedule for each single packaging) in accordance with quality assurance standards was performed.

7. Feedback on the implementation of in-site regulations

The implementation of in-site regulations brought improvements and induced difficulties at the management and at the safety levels of the sites, but also for competent authorities and their technical support.

On a management level, the written definition of the responsibilities for all participants involved in the transport of radioactive material modified significantly the organization of the site for the activity of transport. The organization of any transport, the follow-up of all packages and the management of the occurrence of non compliances, incidents or accidents is now organized at the level of the site. In some cases, the organization is even at the national level to perform maintenance of all packagings, to manage the availability of the packagings and to plan the needs in authorizations, with the associated management of priorities. It induced too a considerable change of strategy at the site or national levels to design or to acquire new authorized packagings, with a dedicated and planned budget to the activity of transport.

On a safety level, the process of implementing in-site transport regulations for competent authority and in-site transport rules for applicants helped to distinguish the packagings or transport devices with an acceptable level of performance and to dedicate to another use (storage only or dismantling) the others packages. It resulted in a significant scrapping of packages for which use could not continue: such packagings had structural deficiencies such as weak mechanical behaviour and a single gasket containment system. To fulfil its duties, each site created a Transport unit with well-trained staff (safety adviser), which acts at a verification level to ensure the compliance of all consignments with the in-site rules and the liability of the transport operations.

The implementation of the Directive with its related in-site transport regulations and the system of authorizations implies changes for the applicants. The transitional period of implementation of the Directive induced a strong need of reorganization and of definition of strategy for many activities depending on transport, for which the packaging or transport device could no longer be used. For example, some facilities may continue to store fuel assemblies or waste drums waiting for the availability of the relevant packaging. The implementation should have begun in 1990 (corresponding to the beginning of the transitional period) but in fact, it happened only in 1999. Considering the large amount of package designs and of real packagings used on the sites, the schedule for the regularization proposed by applicants was too short to develop all necessary package designs to allow all necessary transports.

Furthermore, the necessity of in-site authorizations, making the in-site transport similar to the public road transport, could lead applicants to use only approved packages to reduce the number of in-site package design authorizations to be obtained. However, the replacement of package dedicated to a facility with specific interface device and a single use by a more “generic” package is a heavy process in terms of time and cost. In most cases, a redesign is to be considered.

Concerning the competent authorities, the implementation of the in-site transport Directive makes the control of the activity of radioactive and fissile material in site transport more rigorous, it defines the line of responsibility for authorizing transport between the site director and the competent authority.

8. Conclusion

The implementation in large sites in France of the Directive requiring the definition of in-site transport rules by the applicants and defining a system of authorizations for the in-site transport drove the applicants to completely revise the management of transport of radioactive and fissile material inside the perimeter of these sites. It introduced regulations where none precisely applied before. The consequences were a significant cleaning-up of the existing packagings “fleet”. A significant number of package designs were abandoned and related packagings were dismantled or forbidden to in-site transport. A consistency of the requirements for the civil and defence competent authorities was obtained.

The implementation of the Directive on in-site transport induced a notable strengthening of in-site regulations, even if the required level of performance for the packages, compared to ADR requirements, is adapted to in-site transport conditions.

In conclusion; the applicants had to re-organize their management of the activity of transport taking into account the duties of the participants involved in the transport and the plan to replace and update the insufficiently safe package designs and to obtain a regularization of the corresponding authorizations.

PACKAGING AND TRANSPORT OF NON-STANDARD RADIOACTIVE MATERIALS (ORPHAN SOURCES) -FEEDBACK ON SMALL COUNTRIES RADIATION SAFETY IN EXTREME SITUATIONS

G. Nabakhtiani, L. Chelidze, S. Kakushadze

Nuclear and Radiation Safety Service,
Ministry of Environment.
Tbilisi, Georgia

Abstract.

Georgia has grave problems with so-called orphan radioactive sources. More than 200 such sources have been found, some of them quite powerful. There are different types of sources among them, mainly ^{137}Cs, ^{60}Co and ^{226}Ra (the ones have comparably low activities). The most significant orphan radioactive sources found in Georgia are ^{90}Sr used for special thermo-generators of electricity. There have been found six (three couples) such sources. Initial activity of each one was 129,5 TBq. Special containers (packages) were constructed for the safe transportation of those sources from finding place to secure storage installation. To regulate transportation of radioactive materials the draft law "On Transportation of Radioactive Substances" has been prepared.

1. Introduction

Packaging and transport of orphan radioactive sources is a serious problem, because they usually have non-standard shapes which makes it necessary to prepare special packages for safey transportation [1]. Georgian specialists have some experience in producing different non-standard packages (containers) for orphan radioactive sources. The main destination of these packages is safe transportation to temporary storage place where sources are kept in the same packages.

2. Construction of packages

As mentioned above, a lot of radioactive sources of different kinds were found in Georgia. Most of them are ^{137}Cs. A number of such sources were found in 1997, when the radiological accident took place in Lilo. The former owner abandoned them without any control [2]. There were found 12 ^{137}Cs sources, ^{60}Co source and 200 ^{226}Ra sources. 11 junior Georgian troopers received serious damages mainly from ^{137}Cs sources found in military barracks. The activities of some of them were 140 GBq and 7 GBq. They are usually installed in special containers with reopened collimators, but most of them were bare. It is simple to assess the near absorption dose rate (0.5m in air) of a ^{137}Cs point source with the same activity using the following equation:

$$D = E_\gamma A (4\pi r^2)^{-1} \mu/\rho \qquad (1)$$

where

D	is the dose rate (Gy/h)
A	is the activity 140 GBq
E_γ	is the photon energy 662kev=1.0592*10^{-13} J
r	is distance 0.5m
μ/ρ	is the coefficient 0.0027m^2 kg^{-1} .

The calculated dose rate equals 46.2mGy/h. This magnitude shows, how dangerous those sources are. Based on this result it is possible to assess the properties of package (dimension of shielding material). In the preparation of packages, usually lead is used as a shielding material. Taking into account properties of lead to absorb gamma rays and suitable price on that material it seems that using lead in producing packages for emergency situation is one of the best solution.

Using simple equations it is possible to assess the shielding properties of some packages. *FIG. 1.* shows data for lead packages into which a ^{137}Cs point source with an activity of 140 GBq is placed. Internal and external walls are made from iron with thickness 0.5 cm. The diameter of the internal hole is 10cm.

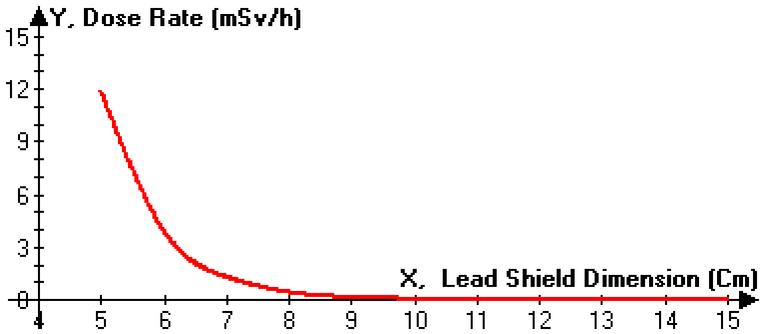

FIG.1. Depending dose rate on lead shield dimension

Data from Figure1 permitted us to construct optimal packages for ^{137}Cs orphan sources. These packages usually had lead shielding with radial dimension 0.07-0.08 m. In case of sources with 70 GBq of activity, the magnitude of lead shielding was smaller (0.04-0.05 m). There were also special packages for other types of sources constructed. In this technology unit-cast lead and lead powder were used for shielding that permitted to change, under field conditions, the diameter of the inner hole according to the necessity. These packages were used for low activity radioactive sources when the dimensions of them were previously unknown and urgent intervention had to be done.

Calculation of same type was done for constructing packages for the ^{90}Sr radioactive sources mentioned above. Taking into account high activity (129.5 TBq) and some other properties of these sources, special packages were constructed. The last radiological accident with these sources had happened in Tsalendjikha district in December of 2001, where two orphan sources were found. Unfortunately, three local inhabitants were irradiated (the dose rate from two bare sources at a distance of 1m was 150mSv/h). In a short time, a package with 0.24 m thick lead shielding was constructed. The height of package was 0.8 m, the diameter of the inner hole 0.315 m. Total weight of it was 5 500kg. The cover of the package was too heavy. Therefore a special three-layer cover was constructed that permitted to operate it easily. When two ^{90}Sr were placed into it, the measured dose rate on the surface of package was 0.8μSv/h.

Unfortunately Georgia does not have any special laboratory for packages testing till now. Therefore any testing of constructed packages, according to international rules [1] was not carried out; but transporting of these packages was done to implement main requirements of International Atomic Energy Agency (IAEA) safety standards [1]. Additionally, the traffic police provided non-stop movement of transport with radioactive materials in every case.

3. Legislative framework

Regulation of nuclear and radiation safety in Georgia is based on frame law ”On Nuclear and Radiation Safety” which was adopted by the Georgian Parliament on 30 October 1998 and came into force on 1 January 1999. According to para.48 of this law, the draft special law “On Transportation of Radioactive Substances” was issued. This law will establish responsibilities and functions of the regulatory body according to IAEA standards [3] and regulate common problems in the field of transportation of radioactive materials including transportation of orphan radioactive sources. Some aspects of orphan radioactive sources transportation, especially properties of responsible organization, are clarified in the law “On Radioactive Wastes and Wastes Storage”, the draft of which is also being prepared using main principles of IAEA requirements [4].

Based on the International Basic Safety Standards (IAEA), Georgia has adopted the national radiation norms [5]. The licensing system in Georgia is regulated by Decree “On Licensing of Nuclear and Radiation Activity”. This system is ever more restrict than international, because according to our legislation, all activities connected with ionization irradiation sources which are not exempt must be licensed.

4. Conclusions

A lot of non-standard orphan radioactive sources were found on territory of Georgia. Georgian specialists worked out special technologies to construct packages for transportation of non-standard orphan radioactive sources. Based on the worked out technologies, special packages for orphan radioactive sources were constructed. The legislative basis for radioactive material transportation is under elaboration in Georgia.

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CONTROL OF TRANSBOUNDARY MOVEMENT OF ORPHAN RADIOACTIVE SOURCE IN LITHUANIA

N. Skridaila

Radioactive Waste Management Agency, Vilnius,
Lithuania

Abstract.

The problem of transboundary movement of orphan radioactive sources needs a prompt solution. For clearance of Lithuanian competent authorities activities in case of detecting, at the state border, an illegal radioactive source a new legislative act is now being created. Although this problem needs much more attention, this is a step towards its solution.

1. Introduction

At this moment in Lithuania competent institutions are creating a legislative act [1], which will regulate activities of Lithuanian authorities in case of transboundary movement of orphan or illegal radioactive sources or nuclear material. In this draft document also activities will be described of authorities in case of illegal trading, illegal using, or illegal storing of radioactive material. After Lithuania declared independence, a lot of radioactive sources were left in the territory of Lithuania by the Soviet Union. Approximately 47000 sealed radioactive sources are registered today in the state registry of radioactive sources, but it was impossible to register them all. It is also impossible to avoid losses or stealing of radioactive sources. One of the main points where unregistered lost radioactive sources could be found is the state border, when orphan sources are being exported as scrap metal or in another way. For that reason it is very important to create a programme of seeking for orphan sources and in case of detecting them, rules of activities of competent authorities. According to that draft document, in case of finding an orphan source the competent authorities are: Procurator's Office, Police Department, Fire and Rescue Service, State Border Guard Service, Customs Criminal Service, Radiation Protection Centre, Radioactive Waste Management Agency, State Nuclear Safety Inspectorate.

2. Description of activities of competent authorities in case of detection of a radioactive source

2.1. Procurator's Office

When an orphan radioactive source is found, the responsibility of the Procurator's Office is to organize and manage the investigation. The investigation's aim is to find the owner of the radioactive source and in case of a crime activity determine to start a criminal case process.

2.2. Police Department

The Police should record accidents and inform all authorities, which should participate in the investigation. The Police goes immediately to the radioactive source finding place, secures the place, trying to determine causer and bystanders. Also the Police will do the screening of the place and look for evidentiary material.

2.3. *Fire and Rescue Service*

The function of the Fire and Rescue Service is similar to the Radiation Protection Centre. Fire and Rescue Service should make a place screening for radioactive material. This data should be used for decision how big place perimeter must be protected. In case of human injures the Fire and Rescue Service must give first-aid.

2.4. *State Border Guard Service*

The State Border Guard Service is responsible for guarding the state border, for checking people and means of transportation crossing the state border for undeclared goods. They are also looking for illegal radioactive material. The State Border Guard Service is measuring the dose rate near to doubtful goods and especially in scrap metal. In case of fixing a big dose rate between the goods the State Border Guard Service officers should apprehend suspects and isolate the goods which show increased radioactivity. State Border Guard Service officers should inform the Police department and all another authorities, which should participate in the investigation.

2.5. *Customs Criminal Service*

The Customs Criminal Service is participating in the investigation in case when a radioactive substance is found at the border like an orphan source or when a radioactive source is transported like contraband. The Customs Criminal Service closely co-operates with the Procurator's Office and Police. The Customs Department of the Ministry of Finance must weekly present information to the Radiation Protection Centre on all sources of ionising radiation imported to or exported from Lithuania as well as information about the companies that performed these procedures.

2.6. *Radiation Protection Centre*

When specialists from the Radiation Protection Centre get information about a detected orphan radioactive source they immediately go to incident place and constantly are in contact with Police and State Border Guard Service officers. Specialists from the Radiation Protection Centre make measurements at the accident place to evaluate radioactive contamination. They evaluate radioactivity influence to people's health as well. In case of radioactive contamination specialists from the Radiation Protection Centre give advice in connection with elimination of radioactive contamination and together with other competent institutions eliminate the contamination.

2.7. *Radioactive Waste Management Agency*

When the Radiation Protection Centre specialists decided that it is necessary to transport a detected radioactive source or contaminated substances to a storage facility, they should call the Radioactive Waste Management Agency for taking the orphan source for storage. According to the coming rules, specialists from the Radioactive Waste Management Agency should go immediately go to the accident place - outside working hours they should depart within two hours. The schematic plan of activities of the Lithuanian competent authorities in case of finding an orphan radioactive source at the state border is shown in Figure 1.

3. Situation today

There is no programme in place today with the task of finding orphan sources. Orphan radioactive sources are mainly being found in scrap metal at the state border at the moment of its exportation/importation or at the time of scrape collection. Also there are cases when people find some “strange” equipment with a sign of radioactivity and call the Radiation Protection Centre. Organizations witch have unregistered sources in storage are not interested to register them because of disposal expenses. According to Lithuanian Law, the owner should meet all expenses for radioactive waste disposal. Funds should be established with the task to cover expenses of orphan source disposal, otherwise scrape metal operating organizations are not interested in finding any orphan sources. Today, in case of finding something radioactive, scrap metal collection organizations throw it away or return it to the person which brings the radioactive substance. We can only guess what the person will do with “unqualified” scrap metal?

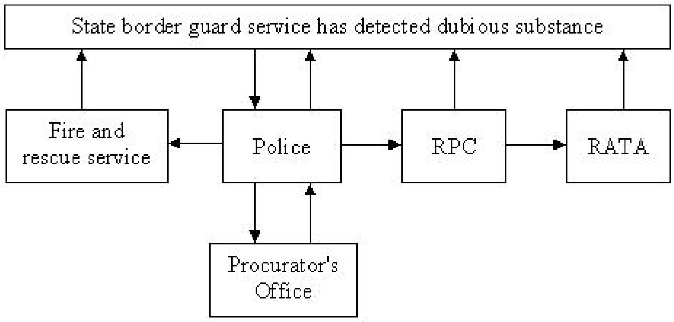

Figure 1: The schematic plan of activities of the Lithuanian competent authorities in case of finding orphan radioactive source
RPC – Radiation Protection Centre; RATA – Radioactive Waste Management Agency.

4. Problems

Sealed sources or their containers are attractive because of their appearance or apparent scrap value. Sources contained in scrap metal for subsequent recycling can lead to contamination of industrial plants and the environment, with serious economic consequences. Through international trade in scrap metal, orphan sources could be transferred from one country to another. A country’s effort against orphan sources can be lost, if neighbouring countries do not regain and maintain control of their sources. Sometimes but not always, orphan sources are found at the state border. When an orphan source is in the middle of scrape metal, e.g. when it is within the shielding container, the dose-rate outside the scrape metal is not high.

5. Conclusion

Lithuania has strict radioactive source registration rules, import, export and licensing rules for activities with sources, but it is impossible to avoid losses or stealing of a radioactive source. There should also be a lot of unregistered sources in Lithuania from the time of the Soviet Union. The movement of orphan radioactive source gives a chance to more easily find them if the country has complete respective legislation and if an orphan source finding programme is working properly. Orphan sources move mainly with scrap metal and scrap metal should be a most important target in the detection process. In Lithuania, detection of orphan sources at the state border needs to receive more attention. The legislation is not complete, with unclear or overlapping responsibilities between national supervision and enforcement authorities, leading to poor co-operation and co-ordination of preventing and detecting measures. Rules and regulations concerning authorities' functions and responsibilities, including requirements on internal control and quality assurance, are also incomplete. Security culture and individual responsibilities need more attention. There is also shortage of suitable modern detection equipment for radioactive substances, shortage of staff and training capabilities, and of financial resources concerning supervision at the state border. International activities for orphan radioactive sources control need to be strengthened.

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NIGER URANIUM CONCENTRATES TRANSPORT

B. Manou

Industrial Environment, Ministry of Mines and Energy
P.O. Box 11 700, Niamey
Republic of Niger

Abstract

Two mines produce yellow cake in Niger. The 'Compagnie Minière d'Akouta –COMINAK' produces magnesium diuranate while the 'Societé des Mines de l'Aïr –SOMAIR' produces sodium diuranate. Yearly, 1,960 mt and 1,000 mt of Uranium are shipped in the concentrates produced respectily by COMINAK and SOMAIR. All the yellow cake is exported to Europe. The concentrates are transported by road and rail to the nearest port at Cotonou in Benin and then conveyed by sea to Bordeaux in France. Niger Uranium concentrates transport is done according to the National 'Transport Regulations of Dangerous Goods' and the IAEA 'Regulations of the Safe Transport of Radioactive Material'. Most of the prescribed regulations are met in practice, but there is a lack of emergency response plans regarding nuclear safety. With the backup of IAEA, Niger is on his way strengthening its nuclear safety regulatory infrastructure.

1. Background

Niger is a landlocked country in Western Africa. The nearest port Cotonou, in the neighbour country of Republic of Benin, is 1,500 km far from the capital city –Niamey, and 2,500 km far from the Uranium mines. The Uranium mines are located in the Northern Central part of the country, at Arlit, 200 km north of Agades.

Two mining companies produce yellow cake: COMINAK and SOMAÎR. Two underground mining methods are used at COMINAK: room and pillar with backfilling and long wall stopping with backfilling. The processing plants are located on the mine site. COMINAK and SOMAIR plants are very close, 10 km apart. The uranium processing is quite the same in both plants: comminution, acid leaching, filtration, solvent extraction, yellow cake precipitation. Each year, about 1,960 mt of magnesium diuranate and 1,000 mt of sodium diuranate are produced respectively by COMINAK and SOMAIR. Table 1 shows the characteristics of concentrates batches shipped by COMINAK and SOMAIR.

The Uranium concentrates are transported through Niger and Benin and then shipped by vessel to France. The different steps of transport are as follows:

(a) By road over 1554 km
  - In Niger, Arlit – Border, 1236 km;
  - In Benin, Border – Parakou, 318 km;

(c) By railway in Benin, Parakou – Cotonou, 431 km

(d) By Vessel, port of Cotonou (Benin) to port of Bordeaux (France).

The transport of radioactive material is submitted to both national and IAEA regulations.

2. The legal framework of radioactive material transport

The main institutions involved in the transport of radioactive material transport are:

(a) The Ministry of Transport;

(b) The Ministry of Mines and Energy;

(c) The National Radiation Protection Centre.

The mining companies are the consignors and the other institutions are the competent or approval authority.

The transport of radioactive material is submitted to: (a) The national regulations through 'Dangerous Goods Handling and Transport Decree', (b) The IAEA 'Regulations of the Safe Transport of Radioactive Material'.

Table 1: Example of yellow cake characteristics at COMINAK and SOMAIR (1996).

Designation	SOMAIR	COMINAK
U grade %	72	75
Density	2.6 – 2.8	1.75
Moisture contents %	2.6	3
Impurities		
…Molybdenum	0.15	0.19
…Zirconium	0.23	0.065
…Sodium	6.6	1.63

Source: Mineral Economics Division, Ministry of Mines and Energy.

2.1. Dangerous goods handling and transport

Dangerous goods handling and transport is regulated by the Decree N° 70-98 MP/T/MU. Dangerous goods are classified in twelve categories, radioactive ones being ranked at the 9 th place. According to the decree, two licenses are required by the mining companies for handling and transport of their concentrates:

(a) a license delivered by the Ministry of Transport, and
(b) a license delivered by the Ministry of Mines.

The licenses certify that the vehicle assigned to the transport and the packaging of the concentrates meet the requirements of the regulation.

2.2. The IAEA regulations

COMINAK and SOMAIR stick to the IAEA regulations regarding safe transport of their uranium concentrates.

The radiation protection programme includes:

(a) packaging workplace dose rates recording;
(b) workers at packaging individual dose rates recording;
(c) radiation levels control for the safe transport of concentrates.

Quality assurance is established in the two mining companies, both being certified ISO 14 000 since 2002. The Ministry of Mines assures that the IAEA regulations of safe transport of the concentrates are met in practice. Each batch transport is submitted to the approval of the Ministry of Mines. As the example below mentions, the appropriate certificates are filled and approved by the Ministry and used for the transit of the Uranium concentrates in Benin and in France.

3. Packaging and transport of uranium concentrates

3.1. The packaging workplace

According to the radiation protection programme in Niger, COMINAK and SOMAIR present a yearly report to the Ministry of Mines. This report gives radiation levels of the packaging workplace and the individual dose rates of workers employed at the packaging of concentrates. The records shows compliance to the regulations. For example, for both companies, the individual dose rates remains under the prescribed value of 5 mSv/year.

3.2. Packaging

In order to meet packaging prescriptions, the concentrates are packaged in 200 l steel drums. The drums are 15/10 mm thick and are closed with metallic joint fixed with bolts (twin bolting).

3.3. The uranium concentrates transport

The different certificates needed are prepared and submitted to the Ministry of Mines:

(a) A certificate for the transport by road from Arlit to Parakou,
(b) A certificate for transport by railway from Parakou to the port of Cotonou;
(c) A certificate of transport by vessel from the port of Cotonou to the port of Bordeaux in France.

The consignor declaration is included in the first two certificates.

A batch of uranate is made of 72 drums of 200 l with an average weight of 570 kg. The batch is loaded in two 25 ton trucks, each carrying 36 drums. The Table 2 shows characteristics of the truck load for the transport of the sodium uranate batch '*Aïr N° 2285' of SOMAIR*. The Table 3 shows the information included in the transport certificate.

Table 2: Batch 'Aïr N° 2285' Transport. Characteristics of a truck load

Designation	**Value**
Batch N°	Aïr 2285
Drums	36
Gross Weight	21,600 kg
Net Weight	20,500 kg
Probable values	
…Moisture %	1.8
…U grade %	73.7
…Total Activity	362,96 10^9 Bq

Source: Mining Service of Arlit, Ministry of Mines and Energy.

Table 3: Some data of the certificate of the railway transport of the batch 'Aïr 2285'

Nature	**Value**
Destination	COMURHEX MALVESI
Label category	Yellow –III
Radioactive Material	Sodium Uranate
Activity	LSA-I
Activity Value	< 10 Ci
Dose rate at the surface of a wagon	1.00 mrem/h
Dose rate at 2 m from external surfaces	0.26 mrem/h
Consignor declaration	Included

Source : Mining Service of Arlit, Ministry of Mines and Energy

The values of the dose rates are under the limit values of 2 mSv/h at the surface of the wagon and 0,01 mSv/h at 2 m from the external surfaces of a wagon.

4. Conclusions

The mining companies COMINAK and SOMAIR are ISO 14 000 certified since 2002. The transport of their concentrates meet the national and the IAEA regulations. The competent authority, the Ministry of Mines and Energy is on its way strengthening the nuclear safety regulatory framework. Actually, implementing an emergency response programme is the top priority.

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TRANSPORT OF RADIOACTIVE MATERIALS IN TANZANIA: *A need for regulatory reforms.*

F.P. Banzi and A.M. Nyanda,

National Radiation Commission, P.O. Box 743, Arusha,
Tanzania

Abstract

Safety of individuals, society and environment from exposures to ionizing radiation in Tanzania is essentially assured though enforcement of compliance with the radiation protection law and its subsidiary regulations. However, as more radioactive sources are imported and transported across the country, the safety of public, property and environment is increasingly becoming of concern to Tanzania. Drawbacks were noted in the current legislation that key issues on transport of radioactive materials such as responsibilities for persons involved in carrying out transport operation were not addressed. This paper has outlined operational and legal procedures currently used by the regulatory authority (NRC) to regulate safe transportation of radioactive materials to and through Tanzania. The inherent drawbacks in the current legislation and what can be done to rectify them were discussed. Since the mining sector is growing rapidly, a need for expansion of regulatory scope to promulgate regulations for transport of tailings and ore was suggested to be included in the amendment of new radiation protection legislation.

1. Introduction

There is a noticeable increase of use of radioactive materials in developing countries. In Tanzania this increase is attributed to fast increase of volumes of imported radioactive materials destined to various institutions in the country including medicine, radiology, veterinary, agriculture, industry, hydrology, mining, research and teaching [1]. Since Tanzania and neighbouring counties do not manufacture radioactive materials, transport of such materials to and through Tanzania has comparatively increased in the past decade. Currently, there are two categories of packages shipped to Tanzania. The first category of packages has Tanzania as their final destination. The second category of packages is consigned to Tanzania but in transit to user in neighbouring countries.

Packages in category are regulated since they are cleared from the entry points (harbours, airports and postal offices) using an import licence from the National Radiation Commission (NRC), which is the only government regulatory authority empowered with such powers in the country. Unfortunately, however, packages in the second category are not subjected to such mandatory clearing regulations. Therefore they can be cleared at the entry point without import licences [2].

The international regulations and recommendations on the safe transport of dangerous goods requires that all radioactive packages meet the standards developed for transport of specific type of packages. The regulations also require consignors, carriers, and consignees of radioactive packages to comply with the requirements set forth in the state of destination in order to provide high level of safety during the transport of radioactive materials. In addition to this requirement, the packages and conveyance used to transport the radioactive material are required to meet specific requirements those recommended by the IAEA, IMO and the carrier should develop an emergence plan that must be made known to countries where the package is in route [3, 4]. Failure to meet these regulations, the safety of people, property and environment can be in danger, particularly in advent of a radiation accident when radioactive material is in transit. Currently there is no contingency plan in place for responding to such accidents to ensure that radiation safety is maintained.

The international regulations developed by international authorities including revised and up-to-date regulations have been adopted in the Tanzania legislation as regularly as desired. As a result, unlike the international regulations, responsibilities for carrier, conveyance and emergence system required for carrying out transport operations have not been prescribed in the currently used legislation [2]. For this reason, transport of packages from entry points to user destinations is still achieved by discretion of consignees.

To apprehend potential risks [5], there is an immediate need for regulatory reforms that will ensure that radiation protection principles are optimised by keeping radiation exposures during handling, storage and transport of radioactive material as low as reasonably achievable using the recent amendment to adopt the international regulations on transport of radioactive materials [6]. The first objective of the paper is to inform the public on operational and legal procedures currently used by the NRC to regulate safe transportation of radioactive materials to and through Tanzania. The second objective is to highlight the inherent drawbacks legislation and what can be done to rectify them.

2. Legal framework

2.1. Classification of packages

The packages consigned directly to user destinations in Tanzania are many and according to the IAEA classification for transport of class 7 dangerous goods [3], these packages can be placed into three categories: (1) IP Packages. (2) Type A packages and (3) Type C packages. The radioactive sources (Cs-137, Co-60, Ir-192, Sr-90, Cf-252, Am/Be-241, Tec-99m, P-32, H-3 labelled methyl thymidine, I-131, I-125, C-14) in the packages have radioactivity ranges from few Becqurels to tens Tela Becqurels used for medical, industrial gauge, density gauge, NDT, and research and teaching. In a licensing period between 2001 and 2002 (Table1) about 50 packages of variety of radiation sources containing more than 3,000 Curie were received. Unfortunately the type and number of packages consigned to neighbouring countries were not documented therefore cannot be categorized.

2.2. The legislation role of NRC

The Protection from Radiation Act No. 5 of 1983 [2] provide the legal framework for protection of individuals, society and environment from harm by establishing and maintaining effective safety against radiological hazards from radiation. The law establishes the regulatory authority i.e. National Radiation Commission. The NRC is a sole competent authority and is empowered to ensure that each package of radioactive sources that transported meet the standards of safety for transport of radioactive packages including proper packages, labelling with radiation hazard logo and precautions for safe transport of radioactive materials [2, 7].

The organization chart of the NRC is schematically presented in Figure 1. According to the organization the NRC is responsible also for the regulation of transport of radioactive material, which will be, used for medical, scientific, agricultural, commercial or industrial purposes and any radioactive waste arising from the use of such radioactive material.

2.3. The regulatory control role of NRC

According to the Basic safety standards for radiation protection, all activities relates to the use of nuclear and radioactive materials and technology are permitted only after the authority has determined that it can be conducted in a manner that does not pose on unacceptable risk to public health safety and the environment [8]. In order to fulfil this fundamental regulatory function, the NRC is empowered to administer and enforces the compliance of the radiation protection law and its subsidiary regulations through a system of licensing and inspections. Depending on the activities to be undertaken, the NRC currently issues eight types of licenses [2].

- (i) Import and export of radiation devices or radioactive materials.
- (ii) Possess or use radiation devices.
- (iii) Possess or use radioactive materials.
- (iv) Radiation Premises.
- (v) Modification of radiation premises or radiation devices.
- (vi) Sell, lease or deal with radiation sources.
- (vii) Administer ionizing radiation to persons.
- (viii) Transportation of radiation sources or nuclear plants including radioactive waste.

Table 1. A summary of packages received for a period between 2001 and 2002 showing consignee, location, licence number. and activity of sources.

Consignee	Location	Licence No.	Radionuclide	Activity
STEELCO -luminium Africa (ALAF)	Dar Es salaam	0051 0052	Am-241 Am-241	1Ci 1Ci
National Artificial Insemination Centre	Arusha	0053	I– 25 I–125	10 µCi 10 µCi
Tanzania Industrial Research Development Organization (TIRDO)	Dar Es salaam	0054	Ir-192 Co-60	100 Ci
Schlumberger Logelco Inc	Dar Es salaam	0055	Cs–137 Am-241/Be Am-241/Be	1.7 Ci 16 Ci 0.5 Ci
National Artificial Insemination Centre	Arusha	0057	I–125 I – 125	25µCi 25µCi
Muhimbili University College of Health (MUCH)	Dar Es salaam	0058	3H – Labeled Methyl thymidine	
Nyanza road project	Mwanza	0059	Cs-137 Am-241	0.3 GBq 1.48 GBq
National Artificial Insemination Centre	Arusha	0061	I-125 I-125	25µCi 25µCi
Nyanza bottling company limited	Mwanza	0062	Am-241 Cf-52	7.4 GBq 740 MBq
MUCH	Dar Es salaam	0063	3H–Labeled Mehyl thymidine	
MUCH	Dar Es salaam	0064	3H – Labeled Methyl thymidine I–125 I–125	
Ifakara health research and development centre	Morogoro	0065	P–32	3000 Ci
Africa Mashariki Gold Mine Ltd	Mara	0066	Density gauge	
Ocean Road Cancer Institute	Dar Es Salaam	0067	Tc-99m T4 & TSH tracers	
MUCH	Dar Es Salaam	0068	3H–Labelled Methyl thymidine	
Ocean Road Cancer Institute	Dar Es Salaam	0069	I–125 I–131 Tc–99m	
STEELCO	Dar Es Salaam	0070	Am-241	1 Ci
M.M. Integrated Steel Mill Ltd	Dar Es Salaam	0071	4HI mill	
MUCH	Dar Es Salaam	0072	3H–Labelled Methyl thymidine	
Malmo Montage Consult (T) branch	Dar Es Salaam	0073	Ir–192 Ir–192	
National Radiation Commission	Arusha		Multinuclides Standard sources	4.8 MBq
MUCH	Dar Es Salaam	0076	P-32	500 µCi
National Institute of Medical Research	Tanga	0077	C–14	
TseTse Research Institute	Tanga	0078	Cs–137 Co–60	
Tanzania Cigarette Company Ltd.	Dar Es Salaam		Sr–90 Sr–90 Sr-90	
Tanzania Breweries Ltd	Arusha	0090	Am-241 Am-241 Am-241 Am-241	
Kahama Mining Corporation	Shinyanga	0091	Cs–137 Cs–137 Cs–137 Cs–137 Cs–137	100 mCi 50 mCi 10 mCi 20 mCi 20 mCi

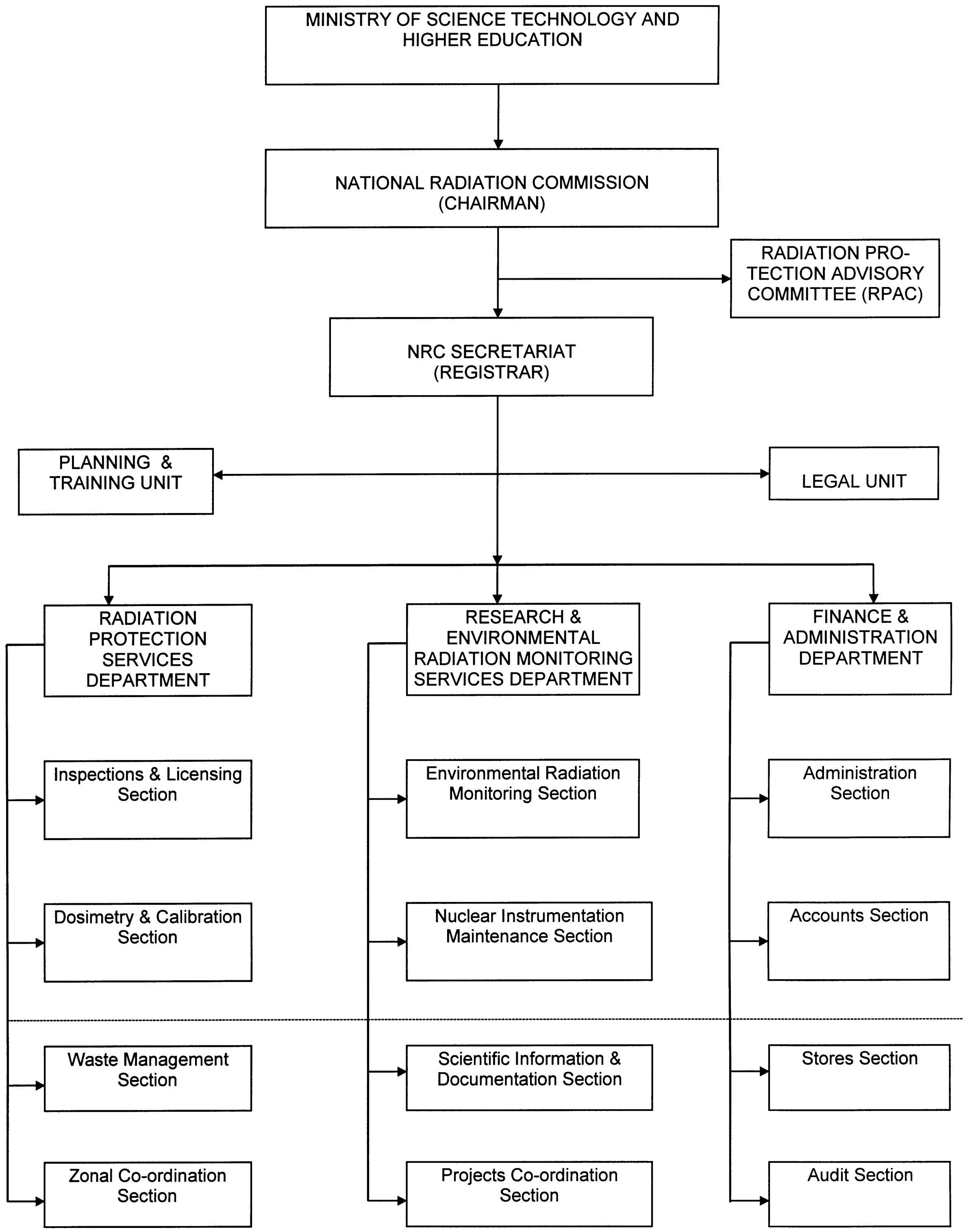

Fig. 1. National Radiation Commission organizational chart.

The licenses require that no person shall use, possess, produce, store, process, convey or dispose of radioactive material except under the authority of a licence. The licenses are issued in a cycle of one year. With exception to other licenses, the import and export licenses are valid only for three months from the date of issue or until consignment has been cleared. The limited period for the import and export license is to restrict multiple importations and facilitate tracking down of safety during importations of the radioactive packages. Nevertheless the transport of radioactive sources license is not yet practicable.

2.4. *Licensing guide*

The NRC establishes licenses to regulate and determine levels of practices according to the prescribed safety requirement. The applications for license is made by application forms whereby a licensee, among other things, is required to complete all necessary information and submit dully filled forms to the NRC with the appropriate payment to enable licenses to be evaluated before a consignment of radioactive material is transported. According to the Act 1983 [2] a licensee has to demonstrate expertise on the consequences of risks involving radiological accidents during transport of radioactive materials. The Licensing process necessitates that an assessment of all potential radiation hazard associated with the transport of radioactive material are submitted to the regulatory authority for review. The assessment must cover hazards to the workforce and the public and must take into consideration package handling and potential hazards. From the assessment the NRC establishes conditions of licence such that compliance with these conditions will provide the necessary assurance that the radioactive material consignment is safe.

2.5. *Enforcement and compliance monitoring*

In practice enforcement actions is a key element in correcting non-compliance of the standard requirement given in the law and regulations. In order to ensure compliance with the prescribed safety standards, the import and export license requires that each container of radioactive material met the IAEA transport standards for transport safety. The requirements include proper packages, labelling with radiation hazard logo and precautions for safe transport of radioactive materials [7]. The NRC therefore grant or renew a license subject to such conditions, limitations and exceptions as may be specified. During the currency of the license, the regulatory authority may vary, revoke or add any conditions, limitations or exceptions attached to the license. The NRC may also refuse an application for a license, suspend the licence for a period of time or cancel the licences [2].

In order to reasonably assure verification compliance of licence granted to company to perform according to the applicable law or regulations, the NRC performs announced or unannounced inspection to premises, vehicle, to examine records, register and other documents, to examine any radioactive materials or irradiating apparatus and the premises where they are kept and to seal, size and retain them if necessary. According to the Act 1983 [2], users and importers of radiation sources; makes it a criminal offence for any person who violates or does not comply with the provisions of the law; and provides for the related penalties. The maximum penalty for infringe of the Act is currently set to Tanzania shillings six thousands or 12 months jail or both.

The law gives powers to the minister for Science Technology and Higher Education who is responsible for atomic energy matters to make subsidiary legislations to elaborate in detail procedures, which are necessary to give full effects for the implementation and compliances of the law.

2.6. *Responsibilities of consignees*

According to the current legislation [2], the main responsibility for complying with transport regulations, and for radiological safety lies with the consignee. However, the regulations [7] demands that the consignee obtains, in advance, an approval certificates from the NRC. In addition, the consignee is required to satisfy the NRC that authorities involved in the transport are in possession of the necessary official approval certificates and permits from other relevant authorities according to legislations for the complete compliance with the requirement of the transport of hazardous materials [9,10]. The licence shall ensure members of the public are not exposed to risks to their health due to his undertakings or activities.

3. Inherent drawbacks

3.1. *Emergency planning and preparedness*

The perceptions of risk indicate that in spite of measures on transport in force, the trend in transport of radioactive materials worldwide show that accidents do occur. In such situation the regulatory authority has therefore a big role to establish communication channels to allow those who will arrive first on the scene of a transport accident to be able to define the hazard involved and hence determine how to respond properly [11]. In so doing it establish public confidence and assuring excellent maintenance of safety records, by dissemination of reliable information, and correcting of misinformation.

Tanzania currently lacks an emergency response system simply because there has been no experience of reported case for transport accidents involving radioactive material that have resulted in serious radiological consequences. However, despite this existing safety record, there is a need, as a precaution measures to define responsibilities and preparedness actions to be taken to ensure that an adequate emergency response capability is available when transport accidents involving radioactive sources do occur. In order to fill this gap, plans are current initiated with a vision from stakeholders to form emergence response system that Tanzania need. Members' composition in the emergence response system is thought to be one in each of the following list of ministries and institutions: (1) Ministry of Science and Higher Education. (2) Ministry of Health. (3) Ministry of Information. (4) Ministry of Defence. (5) Prime Ministers office responsible for disasters. (6) The Regulatory Authority. (7) Police Authority. (8) Attorney General Chambers. (9) National Environmental Management Council. (10) Metrological Services. (11) Fire Service department and (12) Red Cross. Whilst the emergence response system is not being initiated, the NRC has taken task and has continued to offer, trainings, seminars and workshops to workers responsible for handling radioactive sources in their facilities. The seminars were targeted to impart knowledge on radiation protection and also basic skills for safe handling of radioactive sources. It is believed that these trainings decreases public fear by creating public awareness of the useful uses of ionizing radiation and harmful effects associated with radioactive wastes. This paper is an initial step towards achieving the objective of establishing an emergence response system.

3.2. The existing legislation

According to the IAEA regulations, the responsibilities of all parties involved in the transport of radioactive package, specification of type of conveyance to be employed in transporting the radioactive sources and requirement for an emergence response system to be followed in the event of radiological accidents should be precisely described in the law to ensure that the safety of people, property and environment is maintained during transport [3]. Lack of sufficient detailed responsibilities and requirements in the current law for persons involved in the transport of radioactive packages sacrifices the principles of radiation protection. Consequences of non-exclusive use of public transport (i.e. rail, road, water or air) for transport of radioactive packages can be serious if: (1) radioactivity in package is leaking and cause contamination to members of public and properties on conveyance. (2) The conveyance is involved in a radiological accident and public is exposed. (3) The radioactive source is stolen and tempered.

4. Need for expansion of regulatory scope

Subsequent to trade liberalization launched in 1993 by the Tanzania Government, big companies appeared to invest largely in the mining sector. Phosphate, coal, gold, tanzanite and diamond, are among large-scale mining. The mining sector is predicted to contribute more than 10 % of national gross domestic products when the mining sector is full operational [12]. The problem associated with this sector is the transport of large quantities of ores or tailings from site to offsite for processing and backfill materials. Normally, when ore and tailings are taken offsite are loaded in open tracks on public roads or railways. Some of the minerals such as phosphate, coal, gold and monazite are potentially associated with uranium, thorium and their daughter series, which are radioactive. Typical cases for minerals, which are mined into Tanzania and known to associate with traces of radioactivity, are phosphate rock, gold and coal. The phosphate rock was transported on trucks using public roads from Minjingu phosphate mine to a store located in Arusha about 45 km and also to a processing fertilizer plant in Tanga about 500 km. in similar situation coal is currently being imported using tracks from Malawi across the border to cement factory in Tanzania. All these case the public roads were used. Using the IAEA definition [3] for packages, the mine ore and tailings can be classified into two categories of the surface contaminated objects refers as SCO-I and SCO-II. Both categories are required to be transported under exclusive use because ore and tailings, for example, can adversely affect public health through the four pathways. (1) Diffusion of radon gas directly to indoor air if the ore or tailings are stored. (2) Inhalation of suspended particulate aerosols in air from tailings due to wind erosion. (3) Direct exposure to gamma radiation in the vicinity of the tailings. (4) And drinking contaminated water that carry radioactivity of tailing origin. In view of these adverse complications, it is just about time Tanzania puts in place firm radiation protection laws for the transport of ore and tailings.

5. Conclusion

Safety of individuals, society and environment from exposures to ionizing radiation in Tanzania is essentially assured though enforcement of compliance with the radiation protection law and its subsidiary regulations. However, as more radioactive sources are imported and transported across the country, the safety of public, property and environment is increasingly becoming of concern to Tanzania because there is no regulation specifically covers the transport of radioactive materials. Consequently, roles and auditing checks for carrier, conveyance and emergence system required for carrying out transport operation were not defined in the current legislation. Therefore there is a need for Tanzania to promulgate regulations for transport of radioactive materials in parallel with those from the IAEA in order to increase safety of public during transport. This paper has outlined operational and legal procedures currently used by the NRC to regulate safe transportation of radioactive materials to and through Tanzania. Secondly it has highlighted the inherent drawbacks legislation and what can be done to rectify them. Since the mining sector is growing rapidly, a need for expansion of regulatory scope to promulgate regulations for transport of tailings and ore was suggested to be included in the amendment of new radiation protection legislation.

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THE TRANSPORT OF BULK QUANTITIES OF NATURALLY OCCURRING RADIOACTIVE MATERIALS – WITH THE FOCUS ON ZIRCON SAND.

J.H. Selby[a], K.K. Jutle[b]

[a]Richards Bay Minerals, Richards Bay;
[b]Regulatory Research Department, Centurion;
South Africa

Abstract

Zircon is a naturally occurring silicate of zirconium, which is used, in large quantities (~ 1 million tons per annum) for its refractory properties and its extreme chemical inertness. All zircons contain uranium and thorium bound into the crystal lattice, generally at levels up to 500 ppm of uranium plus thorium. This paper focuses on one aspect of the zircon industry – the ability to safely transport large quantities of the zircon sand. Currently zircon is not classified as a radioactive material for transport purposes. However this is because of a factor used in the exemption clauses of the IAEA Code on safe transport of radioactive materials. The objective of this study was to determine the validity of this factor, and was submitted as part of an IAEA CRP. The study is based primarily on measured rather than modeled data and covers the transport of large quantities of zircon from producers in South Africa to customers in Europe. Both occupational exposure of workers and exposure of members of the public have been considered. The transport routes studied cover rail, road, ocean going ship and inland barge transport of unpackaged bulk products.

The study showed that the most exposed member of the public would receive 10µSv/annum, whilst the most exposed worker would receive 144µSv/ annum of exposure. It is concluded that these levels are well below all regulatory limits for such activities involving naturally occurring materials. The study also showed that normal operational exposures are higher than those in accident scenarios, a feature which does not occur with higher activity materials. It is further concluded that the study validates the use of the factor of 10 in TS-R-1, as applied to zircon sand. Additionally it is also concluded that the exemption currently applied to the transportation of bulk zircon sand is valid.

1. Implications of zircon radioactivity on transportation

Zircon, as the naturally occurring silicate of zirconium is found in heavy mineral deposits. The global market for this mineral is of the of 1 million tons per annum, so the transport of this material is large scale and may be up to 10 000 tons in one consignment.

Commercial zircons contain the following typical levels of uranium and thorium, and secular equilibrium usually exists:-

	Concentration (ppm)	Activity (Bq/gm) Parent	Full Chain
Uranium	250 – 350	3.1 – 4.4	43 - 61
Thorium	100 – 200	0.4 – 0.8	4 – 8

In order to evaluate the implications of these activity levels on zircon transportation a comparison was done with the IAEA Code for safe transport of radioactive substances. Safety Series No.6 has given the operational standards governing transportation since 1990, however the new standard TS-R-1 was published in 1996.

The critical area of focus in these two codes with respect to transportation of zircon is related to the exemption clauses. The differences are reflected below:-

	S.S. No.6	TS –R-1
Exemption from Regulation	<70 Bq/gm	<10 Bq/gm U_{238} or <10 Bq/gm Th_{232}

The 70 Bq/gm in S.S. No.6 was not defined in its application i.e. use of parent or total activity.

When comparing the typical zircon activities with the above limits it is clear that the combined activity in zircon is close to the S.S. No.6 limit if total activity is considered. However when compared with the new TS–R-1 limits the zircon activities are less than half that required for the application of the regulations.

A more detailed study of TS –R-1 also shows that this standard is applied to all materials containing greater than the exemption levels specified in the Basic Safety Standards which for natural uranium and thorium are 1 Bq/gm of U_{238} or 1Bq/gm of Th_{232}. Under these conditions the transportation of bulk zircon would no longer be exempt from the conditions set out in TS-R-1. However clause 107 part (e) in TS-R-1 applies a factor of 10 to the BSS exemption levels, when dealing with natural materials or ores. The objective then, of the study was to perform a risk assessment on the transportation of bulk zircon to determine the following things:

1) Should bulk zircon transport be exempt from the conditions of TS-R-1;
2) Are the exemption levels given in the Basic Safety Standards appropriate for bulk transportation of naturally occurring radioactive material.;
3) To review the suitability of the factor of 10 used in clause 107 par (e) of TS-R-1.

2. The study – operational scenarios

A study was done on the transport of zircon sand in bulk from two producers in S.Africa to a customer in Europe. This included all forms of transport, including rail, road, ocean going vessel and barge, and all forms of storage from bulk loading facilities at the port to interim storage in sheds. The pathways of radiation exposure covered were external gamma, and inhalation in the form of dust, radon and thoron, and covered both occupational and public exposures. An actual emergency situation was investigated and the exposure of personnel and the public was monitored.

Where ever possible exposures where based on actual measured data and specific focus was given to the avoidance of modeled data unless measurements were not possible. This was done specifically to avoid the sometimes unrealistic conservativism introduced by modeling.

The dose assessment based on the extensive monitoring exercise done in IAEA CRP Project 11015 shows the following:

The maximum exposure of a worker was 144µSv per annum, and this occurred to members of the ship or barge crew, and was due to the thoron exposure. The thoron exposure was calculated using a conservative assumption that the air in a ship or barge hold would be well mixed, this is unlikely and therefore the short half life of thoron coupled with this assumption would result in an over estimate of the thoron exposure. In spite of this degree of conservatism the exposure is significantly below the limits set for persons being occupationally exposed.

Table 1: Total annual dose for occupational exposure in bulk transport scenarios

Exposure scenario	Total Rn dose [mSv/a]	Total Tn dose [mSv/a]	LLRD dose [mSv/a]	External dose [mSv/a]	Total dose [mSv/a]
Dispatch controller	3.24E-03	7.83E-03	6.45E-05	1.67E-02	2.78E-02
Loco driver	0.00E+00	0.00E+00	7.59E-05	0.00E+00	7.59E-05
Road truck driver	0.00E+00	0.00E+00	7.59E-05	2.12E-02	2.12E-02
Port controller	0.00E+00	0.00E+00	3.03E-04	3.67E-02	3.70E-02
Dock yard worker	0.00E+00	0.00E+00	7.42E-03	1.35E-02	2.09E-02
Ship crew loading	2.67E-05	6.29E-05	3.79E-06	4.60E-04	5.53E-04
Sampler loading	0.00E+00	0.00E+00	1.15E-04	2.04E-04	3.20E-04
Ship crew transport	4.21E-02	1.02E-01	0.00E+00	0.00E+00	1.44E-01
Ship crew off- loading	9.75E-05	2.30E-04	1.39E-05	2.94E-03	3.28E-03
Crane operator	0.00E+00	0.00E+00	0.00E+00	1.61E-02	1.61E-02
Loader operator	8.48E-03	1.19E-02	4.20E-05	1.12E-02	3.16E-02
Cleaning crew	1.30E-03	1.81E-03	4.95E-05	0.00E+00	3.16E-03
Quantity surveyor	4.78E-05	1.08E-04	0.00E+00	2.40E-03	2.56E-03
Supervisor	9.70E-04	2.28E-03	0.00E+00	3.33E-04	3.59E-03
Shipping agent	7.77E-05	1.76E-03	0.00E+00	8.35E-03	8.61E-03
Barge crew loading	7.74E-04	1.76E-03	0.00E+00	6.24E-02	6.49E-02
Barge crew transport	4.06E-02	9.81E-02	0.00E+00	5.40E-03	1.44E-01

Table 2: Total annual dose for public exposure in bulk transport scenarios

Exposure scenario	**Total Rn dose [mSv/a]**	**Total Tn dose [mSv/a]**	**LLRD dose [mSv/a]**	**External dose [mSv/a]**	**Total dose [mSv/a]**
Rail crossing	1.85E-05	3.41E-05	0.00E+00	1.12E-03	1.17E-03
Following road truck	1.38E-04	2.92E-04	0.00E+00	9.90E-03	1.03E-02
Public rural	2.28E-05	4.45E-05	0.00E+00	2.53E-04	3.20E-04
Public suburban	3.09E-07	6.63E-07	0.00E+00	1.05E-05	1.15E-05
Public urban	1.34E-07	1.03E-06	0.00E+00	2.60E-06	3.77E-06
Public stationary	3.30E-04	4.53E-05	0.00E+00	4.99E-04	8.74E-04
Public stationary	0.00E+00	0.00E+00	0.00E+00	8.75E-04	8.75E-04
Public barge rural	1.18E-07	1.57E-08	0.00E+00	1.45E-07	2.79E-07
Public barge suburban	1.18E-07	1.57E-08	0.00E+00	1.45E-07	2.79E-07
Public barge urban	1.18E-07	1.57E-08	0.00E+00	1.45E-07	2.79E-07

The maximum exposure to a member of the public was 10 μSv per annum and this was to a person driving behind a road truck on its way to the port. The assumptions were that this person followed the truck every day of the year, so is also conservative.

3. The study - accident scenario

The driver of a road truck lost control and overturned vehicle causing the entire load to be spilt in one large pile on a public road. A member of the public drove into the pile, collided with the stationary truck and was trapped inside his vehicle. The injured driver was trapped in a position directly on top of the zircon pile and remained there for 42 minutes before he was freed and transported to hospital. The clean-up operation lasted for 4 hours. The injured driver, emergency care workers, fire and rescue brigade members, as well as cleaning crews were all exposed to external radiation, internal exposures through inhalation. Doses for individuals from all pathways were:

a) Injured driver - 0.8 μSv

b) Emergency Care worker - 0.42 μSv

c) Fire and Rescue Brigade Member - 5.14 μSv

d) Cleaning Crew Member - 4.6 μSv

Of particular interest is that the radiation exposures incurred during the accident situation were much less than those occurring in normal operations. This is contrary to the situation for the transport of more active materials where the accident scenarios generated the highest exposures. It is postulated that below a certain level of activity the focus of radiation hazard assessments needs to switch from accident to normal situations. In the transport of most naturally occurring low activity materials this may be the case.

4. Conclusions

The results of the public exposure dose assessments have shown that the most exposed member of the public would be one who followed a road truck of zircon for a distance of approximately 20 kms. Under these conditions the exposure of such a member of the public would be 10 μSv/annum. ICRP in publication 60 noted that an exposure of the order of a few tens of micro sieverts per annum would not require regulatory control. It is therefore concluded that the public exposure risk of bulk zircon sand transportation is insignificant from a radiological point of view.

The dose assessments made on the many scenarios for worker exposure, showed that the most exposed worker is either a member of the ships crew or the barge crew. With the major contributor to this exposure being from thoron. The exposure level for this most exposed worker has been estimated at 144 μSv/a. ICRP 60 recommended that worker exposures be limited to 20 mSv/annum or 100 mSv over 5 years. The worker exposures identified in this study are 2 orders of magnitude lower than this limit.

It may then be concluded that:

1) The transport of bulk zircon sands does not pose a significant radiation risk and should be exempt from the conditions specified in TS-R-1

2) The exemption levels given in the Basic Safety Standards are not appropriate for the transportation of bulk zircon sand.

3) The use of a factor of 10 in TS-R-1 is appropriate for the transport of one type of naturally occurring ore or concentrate i.e. zircon sand.

4) For some naturally occurring radioactive materials, normal operational exposures are higher than those in accident scenarios.

A SAFETY STUDY ON SEA TRANSPORT OF RADIOACTIVE MATERIALS - INTEGRITY OF PACKAGES DURING ENGINE ROOM FIRE ACCIDENTS

H. Akiyama[a], I. Obara[a], M. Aritomi[b]

[a]Nuclear Fuel Transport Co.Ltd, 1-1-3 Shibadaimon, Minato-ku, Tokyo,
[b]Tokyo Institute of Technology, 2-12-1 Ohokayama, Meguro-ku, Tokyo,
Japan

Abstract

Recently, the sea transport of the nuclear fuel materials are playing important role in Japan. However several years ago, some opinions referring to validity of thermal test requirement for packages were raised. Therefore in 1996-98, IAEA carried out a Co-ordinated Research Programme (CRP) for studying the propriety of the thermal test during the sea transport of the packages. Under such background, in 1996-1999 the Shipbuilding Research Association of Japan carried out the safety assessment for fire accidents of nuclear fuel material packages during the sea transport. This paper deals with results of the study, integrity of packages for high-level radioactive waste in case of engine room fire accidents. It was clarified that integrity of packages can be kept under the hypothetical severest conditions.

1. Introduction

In Japan, a ratio of the nuclear power generating capacity to that of the total electric power has exceeded over 30% now. Sea transport frequencies of various nuclear fuel materials are also increasing with these situations.

INF materials such as Irradiated Nuclear Fuel, MOX, and High-Level Radioactive Wastes are packaged classified as TYPE B in the Transport Regulations of International Atomic Energy Agency (IAEA) [1], and carried by exclusive-ships complied with Japanese regulations based on INF Code [2] of International Maritime Organization (IMO). However, there are still some opinions that the package requirement of the thermal test "800°C, 30 minutes" is not sufficient for ship fire accidents. Therefore in 1996-98, IAEA carried out a Coordinate Research Program (CRP) for studying the propriety of the thermal test during the sea transport of the packages. [3].

Under such background, the Shipbuilding Research Association of Japan organized the Research Panel No.46 to assess the safety of the packages against fire accidents at sea in 1996-1998. This paper deals with integrity of packages in case of engine room fire accidents.

2. An exclusive ship and packages for analysis

2.1. A reference ship

A ship carrying Type B fissile packages should complies with the requirement of Japanese Ship Safety Law and related regulations based on INF Code of IMO when she comes into Japanese port. An INF ship complied with Japanese regulations was assumed for the purpose of above-mentioned study. The principal particulars of the ship are as follows:

(a) The overall length, breadth, depth, draft: about 100m x 16.5m x 10m x 6m.
(b) The deadweight is about 3,000ton.
(c) Radiation shielding structures are arranged in order to hold down radiation dose rate.

2.2. A reference package

The reference package was assumed in this work, which is complied with the requirement of the fissile packages Type B specified in the IAEA safety standards. In this work, the package for high-level radioactive waste returning from Europe to Japan was selected from the viewpoint of international transport. Main dimensions and features are as follows:

(a) The total height is about 6.6m and the diameter is about 2.4m.

(b) The packaging weight is about 100t and the whole package weight is about 112 t.

(c) The principal materials are composed of carbon steel, stainless steel, shielding materials of neutron (resin), copper plate and wood.

3. Scenario of sea fire accidents

3.1. Data of accidental fire from own ships

Within the records of previous ship fire accident, the data related to the exclusive ships such as an INF ship are not included. The exclusive ship for transporting nuclear fuel materials is operated with high-level safety control systems from the viewpoints of both hardware and software such as duplicate systems of the important safety components and well-trained crews.

Therefore, though the accidental examples for general ships are not directly applicable to create the scenario of the severe fire accident of the INF ship, these data were basically listed up from the integrating viewpoint to study the fire accident of ships. Having considered the summary of the accidental fires from the own ship, as the severest scenario in this work, the engine room fire during voyage carrying the packages was selected.

3.2. Scenario of engine room fire

From the event tree analysis for the engine room fire accident, the following scenario was taken into account:

(1) The first stage action of the fire fighting is unsuccessful, and emergency fire pumps and fixed fire-extinguishing equipments cannot work normally. As a result, the engine room fire continues and spreads.

(2) The thermal effect of the engine room fire on the nearest hold appears.

Based on the consideration that the scale of the fire would be as large as technically and actually estimated, the fire, which would spread in the whole area of the engine room, is dealt with in this work. For actual fire accidents of the engine room, the condition and phenomena of each accident is quite different due to the retained oil, supply of the air, arrangement of the fuel tanks, structures and materials between the engine room and the nearest hold. Therefore, the scale of the fire according to the quantity of the retained oil, and the temperature and duration of the fire were determined based on the experimental data [4].

Two cases of the engine room fires are dealt with in this paper as follows.

(1) One is the case where air is supplied into the engine room enough for compete combustion of the oil therein. The temperature data over 800°C were measured from the oil combustion test under the condition of enough air supply and in the closed area in 1981 [4]. For the purpose to evaluate the effect of the fire accident on the packages conservatively, it was assumed that the temperature of the flame is 1,000°C and that its duration is 2hours, as a hypothetical assumption that air is supplied into a closed area enough for complete combustion of the oil therein. (Case A)

(2) The other is the case where air is not supplied into the engine room enough for complete combustion of the oil therein. It was assumed that the temperature of the flame is 530°C and that the duration is 15hours based on the test data [4]. (Case B)

4. Integrity of pakages during engine room fire accidents

4.1. Analysis of thermal effect of engine room fire accidents in cargo hold

As to the conditions of the analysis, it is difficult to get the universal temperature histories because of the variation of the each arrangement of the engine room. Therefore, it was assumed that the historical temperature of the wall, which is heat source to adjacent cargo hold, is constant during the engine room fire accident.

In this work, temperature histories were analyzed by the ABAQUS code [5] on the assumption that the initial temperature in the cargo hold is 38°C, the initial surface temperature of the package is 85°C and the heat out put of the package is 42kW which was estimated for the package containing returned vitrified high-level radioactive waste. The assumed vessel can carry four or six packages in NO.5 cargo hold which is adjacent to the engine room.

In the analytical model, two kinds of package arrangement were assumed: One is on the lower deck and the other is on the middle deck of the NO.5 cargo hold. Total capacity of the service tanks in the engine room is $50m^3$. Shielding water tank is located between the engine room and NO.5 cargo hold. Although it is theoretically necessary to consider the latent heat of the shielding water, it was assumed conservatively that the shielding tank was filled with saturated steam of 100°C at the beginning of the fire accident. The computer simulation was carried out under the no operating condition of the hold cooling system as well as hold flooding system.

4.2. Analysis of thermal effect of engine room fire on adjacent cargo hold

The arrangement of the engine room and the adjacent cargo hold were modeled for analyzing the thermal effect of the engine room fire accident on the adjacent cargo hold. The assumed INF ship has actually unit coolers and some other components and thermal insulations in this space, but these components were not modeled to assess conservatively the integrity of the packages in this work.

On the basis of above mentioned scenarios, two cases of the engine room fire accidents were analyzed: One was Case A where the temperature and duration were assumed to be 1,000°C and 2 hours respectively, and the other was Case B where they were assumed to be 530°C and 15 hours respectively. The analytical results of temperature histories in the adjacent cargo hold shows that the maximum temperature in the nearest node of the package surface was about 115°C for Case A and about 165°C for Case B. If these temperatures are considered to be the maximum temperature in the cargo hold, it seemed to be clear that the temperature of the cargo hold atmosphere is enough lower than that of the requirement of the package thermal test, 800°C. Referring to shielding water, it was assumed conservatively that the tank was filled with saturated steam of 100 °C at the beginning of the fire accident.

4.3. Thermal evaluation of packages during engine room fire accidents

Based on the thermal evaluation of the cargo hold adjacent to the engine room, thermal analysis of the package in the cargo hold was performed. According to the engine room fire accident analysis, the center temperature of 151.3°C in the cargo hold for Case B is apparently severer than that of 78.9°C for Case A. It is clear that the temperature at the upper hold is higher than that at the lower hold. Accordingly, the thermal analysis was performed for the package located at the upper hold in Case B which is the fire temperature of 530°C and the duration of 15 hours.

The thermal behavior of the package was analyzed against the engine room fire accidents using the TRUMP code [6], which is generally utilized for the package analysis. The average temperatures between the point on the hold wall of engine room side and at that in the middle of the hold were selected as the reference ambient temperature of the packages for its conservative assessment. Thermal input by radiation from the wall was also considered. The shape factor of the package side surface area is assumed to be 1/2, because the radiation heating is contributed only from one wall.

Fig.1 shows the temperature histories of the packages under the fire accident. The gasket temperature, 118°C at the initial condition, reached 144°C at 10 hours and 168°C at 15 hours. The material of the gasket is the synthetic rubber and its allowable maximum temperature is 150°C for long-term use and 178°C for short-term use (about one week). The maximum temperature at 15 hours is lower than the above temperature 178°C and the containment of the packaging is considered integrity. According to another research work on allowable maximum temperature of gasket (elastomer-O ring) during short term (two days), it was clarified that the integrity can be kept under the temperature of up to 302°C.

It can be seen from the above discussions that the package loaded in the INF ship can be kept safe enough even though the ship encounters the severest engine room fire accidents assumed from their precedents and technically.

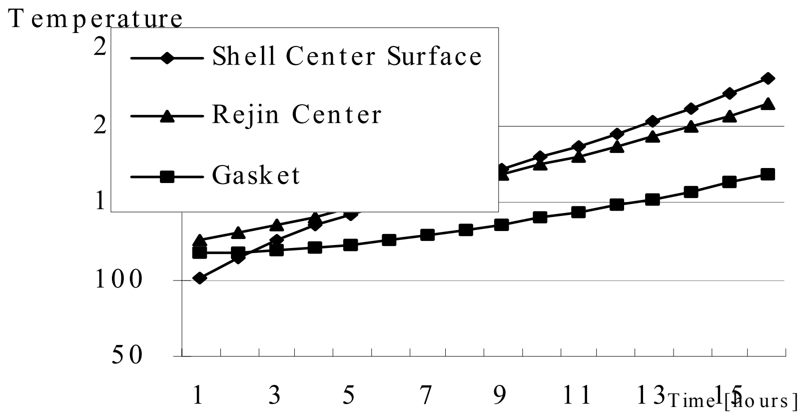

Fig.1: Package temperature history during engine room fire accident.

5. Conclusions

In this work, firstly the outer boundary conditions around the package in the cargo hold of the INF ship transporting vitrified high-level radioactive waste were evaluated and then the thermal integrity of the package was evaluated in the case that the ship encounters the hypothetical extreme engine room fire. The results of conservative evaluation clarified that safety of the package designed based on IAEA regulation was sufficiently maintained on an occasion of engine room fire accident.

Acknowledgement

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9 M DROP TEST AND REALISTIC ASSUMED DROP ACCIDENT OF PACKAGES

C. Itoh, S. Ozaki,

Materials Science and Structural Engineering Department, Abiko Research Laboratory,
Central Research Institute of Electric Power Industry (CRIEPI), Abiko, Chiba,
Japan

Abstract

This report describes the background and validity of test condition of the Drop Test I which demonstrate the impact incident such as crush and drop as one of the accident conditions stipulated in IAEA transport regulation. Also this report shows the results of the analytical evaluation on the influence of nature of target to impact and the conservatism of test conditions stipulated in IAEA transport regulation by comparing test results obtained from regulatory conditions with the ones from a hypothetical accident condition.

1. Testing conditions

The testing condition, "Dropping from the height of 9m onto a horizontal unyielding surface (rigid surface)" as specified in the Drop Test of IAEA regulation [1] to demonstrate the capability to withstand the accident condition during transportation is intended to simulate impacts, such as collision during running and dropping from a high place, with dropping test from a height of 9m onto the unyielding surface. In short, it does not assume dropping from a height of 9m as the accident condition, but it simulates the impact at the time of collision of a transported object to a rigid body at the velocity of about 50 km/h, that is assumed as the transportation velocity (free dropping velocity from a height of 9m is 48 km/h).

2. Validity of testing condition

An package is dropped from a height of 9m onto a unyielding surface (very hard surface of a steel plate placed over concrete block with the mass greater than 10 times of the package) in the Dropping Test. It is a test where the 100% of the dropping energy of the package is absorbed by the package itself, and then significantly severer load than actual collision is to be applied to the package. On the other hand it is unconceivable that the energy of collision is totally absorbed on the side of package in an actual accident of collision, but a large portion of the collision energy would be absorbed by the buffering effect brought about through the energy absorption by the surrounding structures, such as crush of vehicle structures and transportation rack, and the destruction of the colliding surface.

Some examples are shown below. An analytical study has indicated that, when two identical trucks loaded with objects for transportation are running at a speed of 80 km/h, and they are head-on collided (relative impact speed is 160 km/h), the impact applied to objects for transportation is a fraction of the impacting force applied in the above described test because these trucks take a role of buffer. It was also confirmed that damages caused in the dropping test of IAEA regulations was severer than damages resulted from an experiment conducted in U.S. in which a transportation cask that was designed to meet the drop test was collided to a very hard wall at a speed of about 130 km/h [2], and a demonstration test conducted in U.K. in which a locomotive was collided to a transportation cask that was also designed to meet the drop test in a similar way to the above at a speed of about 160 km/h (CEGB, 1984) [3]. To cause a damage equal to that of a collision onto a unyielding surface at a speed of 50 km/h, a speed of about 65-120 km/h is required for hard surfaces such as concrete and rocks, and about 100-300 km/h required for soil, water surface and vehicle structures. Furthermore, although the collision should be in the right angle to colliding surface in order to cause the maximum damage by a collision, there is a safety margin that such a case would hardly occur in reality.

3. Previous tests and analyses

3.1. Effects of collided surface on the response of impact [4]

3.1.1. General description. The drop height, which should cause an acceleration equivalent to the acceleration generated by a 9m dropping action onto unyielding surface specified by IAEA transportation regulations when an event of dropping occurred, is established for the property of collided surface taken as a parameter.

3.1.2. Method. Such drop height was determined by an analysis using the spent fuel transportation cask TN24. The analytical code LS-DYNA-3D was used in the analysis.

3.1.3. Results. Table 3.1 shows analytical results.

Table 3.1: Analytical results – equivalent dropping height

Colliding surface	Equivalent dropping height
unyielding surface	9
Sandy soil (N value = 10)	Approx. 72
Sandy soil (N value = 50)	Approx. 34
Asphalt pavement	Approx. 51
Concrete pavement	Approx. 48

3.2. Demonstration test to simulate real accident [5]

3.2.1. General description. The aim of the test is to demonstrate that transportation packages for radioactive materials such as spent fuels meet requirements specified in transportation regulations of IAEA and Japan, and establish the integrity of these packages under transportation in an event of real accident.

3.2.2. Method. The author evaluated the packages of high burn-up spent fuels (NFT casks) in regard to the dropping condition specified in IAEA transportation regulations and dropping accident conditions assumed to be experienced during their transportation by using demonstration tests and analyses on real scale test cask.

The evaluation was conducted on the drop test specified in IAEA transportation regulations where the test cask is dropped onto a rigid floor from 9m height, and a drop test which simulate accident during handling at ports (maximum lifting dropping height*: 7.8m, equipped with transportation rack, collision onto concrete floor). The latter was selected as the severest accident condition assumed during transportation of spent fuels in Japan (Fig.3.1).

3.2.3. Results. It was confirmed from stress generated in the tests that packages for the transportation were sound in all cases. It was found that values of stress generated in the test which simulates the assumed accident were less than the ones generated in the test conditions specified in transportation regulations, and that the casks tested under the condition of transportation regulations have enough safety margin even if they are encountered with such an accident (Fig.3.2).

* Maximum lifting dropping height of 7.8m, was set based upon the possible condition at the bays and ports of nuclear facilities in Japan

Fig. 3.1: Dropping test scene

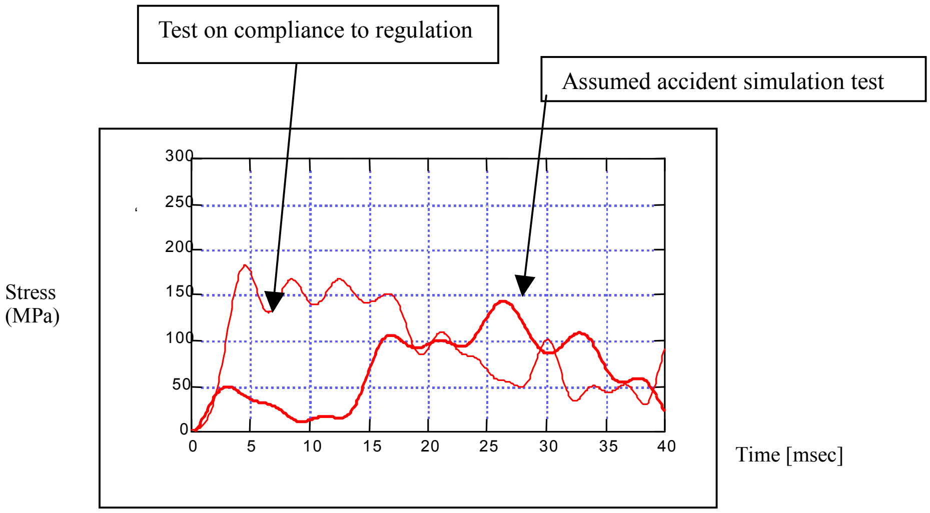

Fig. 3.2: Test on compliance to regulation and assumed accident simulation test

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COLLISION PROOF PROPERTIES ASSOCIATED WITH THE SHIPS OPERATED BY PACIFIC NUCLEAR TRANSPORT LTD AND DAMAGE SURVIVABILITY IN THE EVENT OF A COLLISION.

P. A. Booker
Marine Operations
Pacific Nuclear Transport Ltd.
United Kingdom

Abstract.

To date there have been many reports and papers presented considering the effects of ship fires and collisions on the transport packages (casks). The study presented is to explain the collision proof properties associated with the ships operated by Pacific Nuclear Transport Ltd. And to provide an explanation of their damage survivability in the event of a collision. This paper discounts the possible effects on the individual package but considers purely, the survivability of the vessel after a severe collision with another vessel.

1. Introduction

In the 1970's British Nuclear Fuels Limited (BNFL) decided to develop a design for purpose-built vessels for nuclear transport, which would provide enhanced protection for the ship, crew and cargo thereby increasing the safety and reliability of transportation operations. Following wide consultation with Lloyds of London, The Salvage Association and other leading salvage companies, and as a result of Japanese standards developed at the same time, today's Pacific Nuclear Transport Limited (PNTL) Fleet was constructed. Since construction, equipment such as radar, communication and monitoring equipment has been regularly upgraded in line with technological developments. These enhancements along with the operating experience have maintained the consistently high standards of operational safety.

The ships were constructed with collision resistant structures that provide additional protection around the cargo spaces[1]. Watertight longitudinal and transverse bulkheads form the inner shell surrounding the cargo space. The structure and sub-division of the hull is designed so that the vessel will stay afloat after it has sustained damage, which is in excess of the extent specified for Class 1 chemical tankers as required by the IBC Code (International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk)[2]. As previously mentioned, the wing tank and void spaces are structurally reinforced to prevent impact damage being sustained by the transport casks within the holds, in the event of a severe collision with another vessel. For the purposes of design, the colliding vessel was assumed to be about 24,000 tonnes displacement travelling at 15 knots. (Based on the type T2 Tanker).

A review of the longitudinal strength of the ship, taking account of both the static and dynamic stresses exerted on the vessel during service, showed that the maximum total bending stress was approximately 8kgf/mm^2 (78N/mm^2)which was about 40% of the permissible level as stated in the Classification society's Rules. The additional collision resistant structure in the wing and void spaces, is incorporated in the hull, where it contributes to the longitudinal strength of the vessel, hence the low value of bending stress. However this adds approximately 400 tonnes of additional steel to the lightweight of the vessels. The consequence of this is that the strength of design provides a good margin of safety to cater for increased bending moments arising from any loss of buoyancy following damage. It is also worth noting that the hatch covers have been designed and structurally strengthened to such an extent that it is possible to temporarily hold a transport flask during cargo operations, weighing up to 120 tonnes which gives a good example of the extraordinary strength of the overall structure.

2. Construction considerations

The construction of the present PNTL fleet takes in to account the requirements of all the relevant National and International regulations. All PNTL vessels comply with these regulations and are therefore no different to any other UK registered ship in that they are subject to statutory inspection and certification in order to guarantee their continued operation.

The INF Code (International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High Level Wastes on Board Ships)[3] became mandatory on 1st January 2001. Its origins can be traced back to the time when the construction of the present fleet was being considered. It could be said that the INF Code ***now*** was the blueprint ***then***, used by BNFL for the construction of their fleet. It is interesting to note that the first of these vessels came in to service in 1978, (fifteen years before the code was adopted and twenty three years before the code became mandatory).

The survivability of the vessels after grounding or collision was a major design consideration for the fleet at this time. A datum was established to ensure this requirement was met and, as previously stated, this was taken to be a collision with a 24,000 tonne tanker travelling at a speed of 15 knots. The collision was considered to impact the struck vessel at ninety degrees, amidships.

The original calculations were carried out using Minorsky's energy absorption theory [4] (an empirical formula based on the volume of damaged steel). Since this time, due to advances in computer technology, more involved calculations can now be undertaken in a much shorter time scale. Allowance can now be made in the calculations for the specific structural arrangement of a striking ships bow and that of the struck ships side.

3. Studies to support the above

With the passage of time, the above considerations still hold good. The original design specifications remain unchanged, however, the assumed colliding vessel (a T2 type oil tanker) no longer exists.

There have been several studies and papers produced which look into the effects of an INF Class ship being involved in a collision. Most of these papers seek to assess the effects on the transport flask and the potential impact on the environment.

In the paper, "Evaluation Method of Absorbed Energy in Collision of Ships with Anti-Collision Structure"[5], it is shown that the advanced analyses suggest that a PNTL ship can withstand a collision with ships far larger than a T2 Tanker and in these specific situations, the vessels can survive severe collision without the cargo being affected. There appear however, to have been no studies produced which specifically consider the survivability of an INF vessel, beyond the regulatory requirements, with respect to the vessel's stability following a collision.

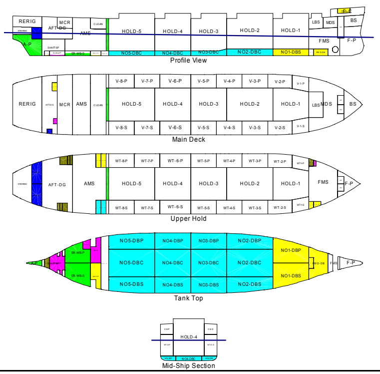
4. Survivability

BNFL has never claimed that their INF vessels are unsinkable. It is interesting to note however that these ships have been specifically designed so that in an emergency situation one, or even all of the five cargo holds can be filled with water to the level of the top of the uppermost cask and the vessel will still remain stable and afloat.

Differing accident scenarios have been considered over the years and what was once thought to be realistic or credible twenty years ago is now a very different case. The events of Sept 11th 2001 in the U.S. have opened up a new spectrum for fantastic accident scenarios to be considered as credible. Probability and risk have still however to be considered with a sensible and balanced approach.

It should be remembered that the original basis for the safe transportation of nuclear material is to ensure that the safety of the public and the environment is provided by the package alone regardless of the mode of transport. The fact that the ship provides additional protection to the package should not be forgotten. It is evident that the whole focus has moved away from this original concept and the ships are being identified, wrongly, as a potential weak link. This could not be further from the truth. With the regulatory requirements governing the construction of the vessels and flasks, it is difficult to envisage a safer design and means of transportation by sea.

Intact Departure



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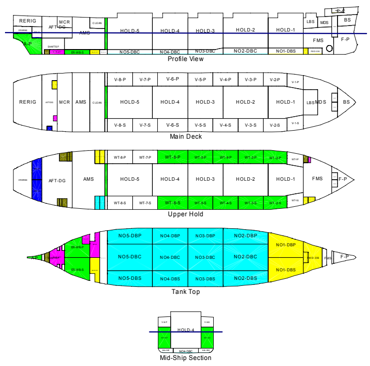
Heel:	0 Deg.
KGf:	6.036 m
GMf:	1.127 m

Intact Arrival



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Draft Mid:	5.910 m
Draft Fwd:	5.797 m
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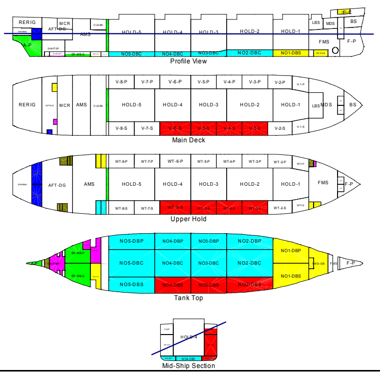
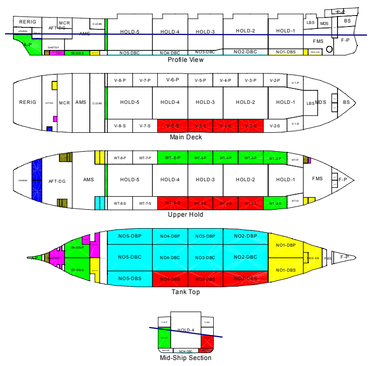
KGf:	6.315 m
GMf:	0.781 m

Damage Condition 1



Draft Aft:	6.242 m
Draft Mid:	6.163 m
Draft Fwd:	6.085 m
Trim:	0.158 m
Heel:	22.49 Deg.
KGf:	5.910 m
GMf:	1.841 m

Damage Condition 1



Draft Aft:	5.977 m
Draft Mid:	5.820 m
Draft Fwd:	5.663 m
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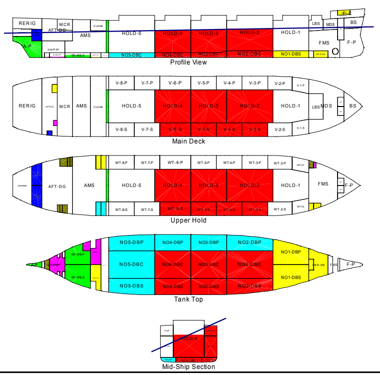
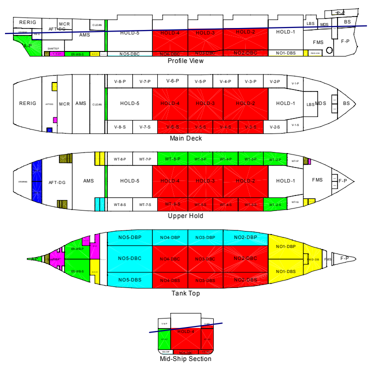
Heel:	7.15 Deg.
KGf:	6.324 m
GMf:	0.443 m

Damage Condition 2



Draft Aft:	6.668 m
Draft Mid:	7.469 m
Draft Fwd:	8.271 m
Trim:	1.603 m
Heel:	22.68 Deg.
KGf:	6.151 m
GMf:	1.470 m

Damage Condition 2



Draft Aft:	6.482 m
Draft Mid:	7.440 m
Draft Fwd:	8.397 m
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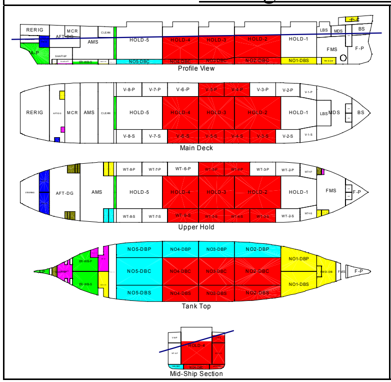
KGf:	6.317 m
GMf:	1.300 m

Damage Condition 3



Draft Aft:	6.796 m
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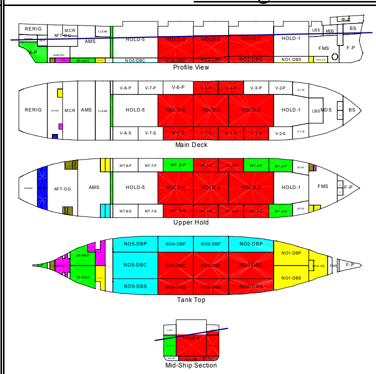
KGf:	6.158 m
GMf:	1.558 m

Damage Condition 3



Draft Aft:	6.464 m
Draft Mid:	7.411 m
Draft Fwd:	8.357 m
Trim:	1.893 m
Heel:	8.75 Deg.
KGf:	6.408 m
GMf:	1.106 m

KEY

- Fuel Oil
- Auxiliary Fuel Oil
- Fresh Water
- Water Ballast
- Lubricating Oil
- Miscellaneous Tanks
- Damaged Compartment

Considering PNTL's operational safety record and the mandatory requirements of the IBC Code, the INF Code and the Japanese Kaisa 520 [6], there is now an even stronger argument to support the case that transporting radioactive substances by sea is a safe operation. When conducted to the stringent requirements of the relevant International Governments, Regulators, Departments and Regulations, it should provide an example to all of how the business of sea transport should be conducted.

5. Collision

In case of collision between two ships, the damage to the struck ship and its cargo is mainly influenced by:

- The speed and displacement and the dimensions of the striking ship.
- The shape and material properties of the striking bow.
- The collision angle.
- The point of impact on the vessel under consideration.
- The structural properties of the vessel under consideration.

The double hull of a PNTL ship is designed to withstand at least the energy impact equivalent of the Type 2 Tanker. It is conservatively assumed that the penetration of the cargo hold is possible in a severe collision situation.

The following examples taken from actual data for the PNTL vessel, Pacific Sandpiper, show the effects likely to be encountered following a collision. The purpose of this paper however is to provide evidence of the survivability beyond the regulatory minimums and takes no account of any of the on board procedures which would undoubtedly take place to minimise these effects.

6. Collision proof properties of PNTL vessels
(How unlikely it is that transport vessels would sink after a collision)

The vessel under consideration was specifically built as a dedicated carrier of irradiated nuclear fuel, High Level Waste and Plutonium, in special transport casks. The casks are carried on transport frames, which in turn are bolted to the ship's structure. The vessel has a total of five cargo holds, each of which has space for a number of casks, and each hold has permanently installed cargo cooling machinery. The vessel has collision resistant structure fitted over the full length of the cargo spaces. This structure consists of the Main and Upper Decks outboard of the cargo holds being constructed steel plate. There are additional collision flats fitted above and below the Main Deck at approximately 1.5 metre spacing, and the tank top is constructed of very heavy steel plate. Access to the cargo hold is arranged below Upper Deck level by constructing a passageway along the full lengths of the cargo spaces. Access to this passageway is at the aft end of the cargo space through a Clean Room. The space outboard of the cargo holds is sub-divided, port and starboard, into eight wing tanks below the Main Deck. The bulkheads that form these wing tanks are continued above the Main Deck level to the Upper Deck. The attached information is taken from a damage stability study commissioned by BNFL, to investigate the extent of collision damage that a PNTL vessel will survive and still be afloat, with positive stability. The assumption is that progressive damage has been sustained however the causation has not been defined.

In addition to the different National requirements, in order to meet the requirements of the INF Code, with respect to damage stability, the vessel must comply with the following:

Type 1 ship survival capability and location of cargo spaces in Chapter 2 of the IBC Code or regardless of the ships length, the damage stability requirements in Part B-1, Chapter II-11 of the International Convention for the Safety of Life at Sea, 1974, as amended (SOLAS).

The following collision scenarios display the survivability after a severe collision. The results have been obtained by inputting data in to the damage stability program for the ship and progressively considering the instantaneous flooding of certain compartments and analysing the stability of the vessel at the new hydrostatic equilibrium. It must be remembered that this exercise has been conducted not to display compliance with the requirements of the regulations, but purely as a display of the survivability of a PNTL vessel in various stages of bulkhead damage. No account has been taken of the effects of sea state or wind strength.

Typical Loading Plans for Departure (Fuel Tanks Filled to 98%) and Arrival (Fuel Tanks Filled to 10%) have been selected with the vessel loaded with 20 casks, distributed throughout all 5 holds. The vessel is also loaded with ballast in order to ensure a realistic sailing condition

For each of the Loading Conditions three ‘Levels’ of damage have been investigated:

Damage Condition 1: An extensive mid-ships damage, extending over four Wing compartments, with the damage extending to the hold longitudinal bulkhead and from the bottom to the top of the vessel.

Damage Condition 2: The condition is as with Damage Condition 1, but, with the damage extending inboard to the centreline of the vessel.

Damage Condition 3: The condition is as with Damage Condition 2, but, with the damage partially extending the full width of the vessel.

A summary and diagram of the vessels conditions, for the Intact and Damage conditions investigated, is contained in the table that follows.

7. Conclusion

From the supplied data, it can be seen that the Pacific Sandpiper would survive damage far in excess to that required by the relevant codes. The vessel would remain afloat with positive stability thus ensuring valuable time for remedial action to be undertaken. The attached results in no way reflect any inadequacy of the respective codes but give a clear indication of the forward thinking of the design team at conception.

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IAEA-CN-101/59

ACCIDENT ENVIRONMENTS IN THE SEA TRANSPORT OF RADIOACTIVE MATERIAL

D. Ammerman

Sandia National Laboratories
Transportation Risk and Packaging Department
Albuquerque, New Mexico
United States of America

Abstract*

As part of an IAEA Co-ordinated Research Project, Sandia National Laboratories performed an extensive study into the accident environment associated with the maritime transport of radioactive materials. The severity of the mechanical loadings that can occur during ship-to-ship collisions was investigated via finite element calculations and compared with the resistance of transportation packages. The severity of fires onboard ships was also investigated via physical tests and finite element calculations. This paper will summarize the results and conclusions from the Sandia study.

1. Introduction

The severity of accident conditions that might take place during the sea transport of radioactive materials was investigated at Sandia National Laboratories as part of the U.S. contribution to an IAEA Coordinated Research Project [1] on sea shipments of radioactive materials. Specifically, the mechanical accident environment that exists during ship-to-ship collisions and the thermal accident environment that exists during ship fires were calculated. These accident environments were compared to the resistance of the packages used to transport spent fuel and vitrified high-level waste and to the IAEA hypothetical accident environment of TS-1 [2]. The impetus for this study was the concern by non-nuclear nations that the IAEA hypothetical accident conditions were not severe enough to assure the safety of maritime shipments.

2. Ship-to-ship collisions

The collision between another ship and a small (1675 tonne) charter freighter carrying spent fuel or vitrified high-level waste packages was considered [3]. A series of finite element analyses was performed using different masses and velocities for the striking ship and two loading cases for the charter freighter; a single package and a series of packages. For all of the analyses the geometry of the striking ship was identical to that of the charter freighter, but the mass was varied from equal to 10 times the mass of the charter freighter. The impact speed for the striking ship was 5.14 m/s (10 knots) for the case with equal mass and up to 15.6 m/s (30 knots) for the case with 10 times the mass. In all of the analyses the struck ship had no initial velocity and the resistance to sideways motion provided by hydrodynamic forces was modeled by increasing the inertia of the ship by 40%. The striking ship was assumed to be rigid, so all of the energy absorption is in the struck ship. The simulated RAM packages were modeled as rectangular elastic bodies, and were intended to act as force transducers in the analyses. No attempt was made to model the response of the packages.

* The views expressed in this paper do not necessarily reflect those of the U.S. Nuclear Regulatory Commission.

For the cases with only a single RAM package the penetration of the striking ship was never sufficient to result in crush loading on the package. It is certain that the magnitude of the impact load that can result from a ship-to-ship collision is less than that from the hypothetical accident conditions because the impact velocity is generally less and never much greater and the rigidity of a ship bow is much less than the "essentially rigid" target required for the hypothetical accident. For the cases with multiple packages the analyses assumed they were stowed in a manner that spanned 90% of the width of the charter freighter. In these cases the magnitude of the crush force applied to the packages was limited by the strength of the ship hull. The row of packages is pushed against the back of the ship and the hull is pushed outward until it eventually fails. Figure 1 shows the damage for the 15.6 m/s impact with striking ship mass equal to 10 times the charter freighter mass. Note the packages (shown in magenta) being pushed through the hull at the bottom of the figure.

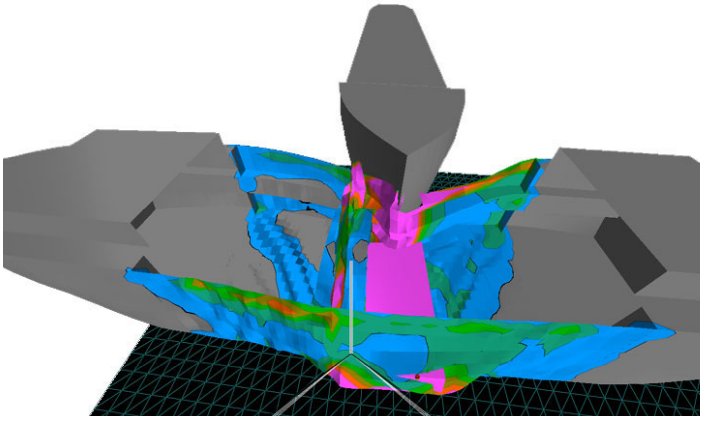

Figure 1: Damage to 1675-tonne charter freighter with a row of RAM packages caused by the collision of a 16,750-tonne rigid ship at 15.6 m/s.

The results of the ship collision analyses demonstrated that the crush force that could be applied to a RAM package was limited by the strength of the hull of the RAM-carrying vessel. More detailed analyses of the package hull interaction were conducted to better quantify the magnitude of this force [4]. In these analyses, a RAM package was pushed through a section of the hull bounded on both sides by bulkheads and at the top and bottom by decks.

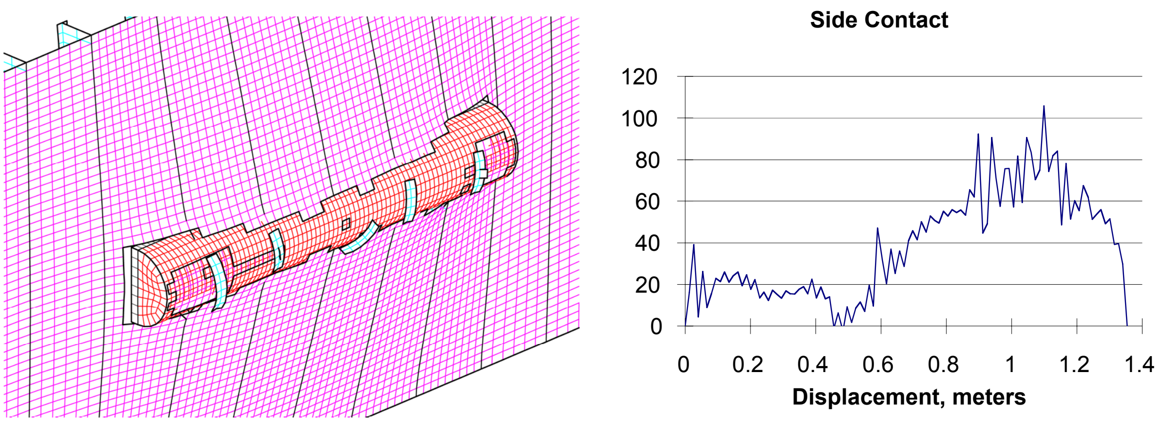

Figure 2: Detailed model of 22-tonne RAM package being pushed through the hull of a charter freighter and contact force between the package and the hull.

Two cases were considered, one with the RAM package in an end-on orientation (the most likely orientation during transport), and one with the package in a side-on orientation. The RAM package was modeled as an elastic solid and the ship hull and stiffeners were modeled with shell elements. Figure 2 shows the results for the side-on orientation analysis. At the beginning of this analysis the package is in contact with the hull. The package was given a constant velocity outward. The magnitude of the contact force between the package and the hull is initially limited by the buckling of the hull stiffeners at a load of about 20 MN. After the stiffeners all buckle, membrane tension in the hull and stiffeners leads to a contact force of about 80 MN before the hull tears. The conservatisms in the way the ship hull was modeled in this case assures that the actual contact force required to push a package of this size through the hull would be less than 80 MN. In this analysis it was assumed there was no other cargo in the hold with the RAM package, as would be the case for transportation in the charter freighter analyzed in the ship collision analysis. When there is no other cargo in the hold with the RAM package, there is no restraint to prevent the package from rotating from an end orientation to a side orientation.

A case with other cargo present in the hold with the RAM package was also analyzed [5]. In this case the other cargo would restrain the package and prevent it from rotating to a side-on orientation. Therefore, for this case only an end-on orientation was analyzed. The cargo was modeled as a homogenous crushable material. Three cases were considered, a crush strength of 13.8 MPa (2 ksi) and a shear failure strength of 13.8 MPa, a crush strength of 6.9 MPa (1 ksi) and a shear failure strength of 13.8 MPa, and a crush strength and shear failure strength of 6.9 MPa. These strengths are typical of relatively dense discrete cargo, such as lumber or automobiles. Light-weight cargo, such as consumer electronics, would have a much lower strength and would not result in response that is significantly different from the case with no cargo.

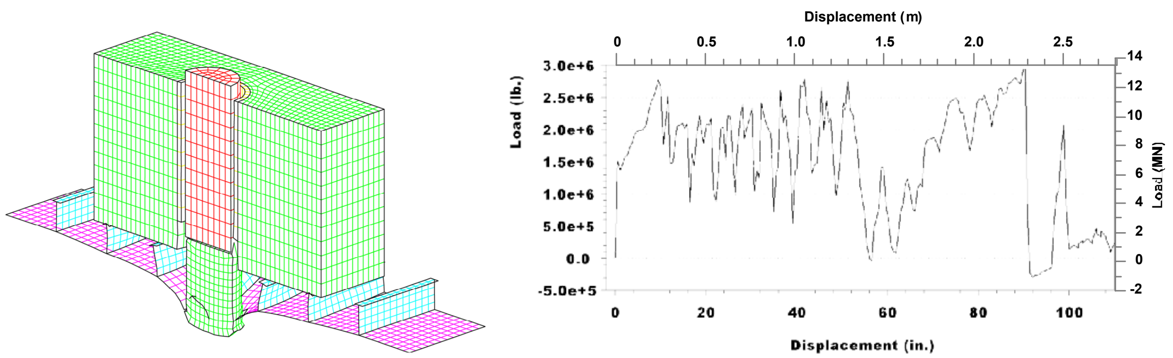

Figure 3: Crushing force for a RAM package when other cargo is in the hold with the package.

Figure 3 shows the force and deformation for the case with a cargo crush strength of 6.9 MPa and a shear strength of 13.8 MPa. For low displacements the response is controlled by the crushing and shear failure of the cargo. The cyclical response is due to each success row of finite elements failing in shear. The force drops off and then increases while the next row of elements is crushed. This behavior continues up to a package displacement of about 1.5 meters, when all of the cargo has failed in shear. At this point the shear plug of cargo and the package are being pushed together through the distance of the hull stiffeners and it takes very little force to continue the displacement. When the cargo contacts the ship hull the force increases again until hull failure. In this case the force required for hull failure is about equal to the force required to crush the cargo. The force for hull failure with cargo present is nearly identical to that required for the end-on orientation with no cargo.

3. Shipboard fires

The thermal environment experienced by RAM packages during shipboard fires was investigated primarily by conducting experiments onboard a U.S. Coast Guard ship at their research facility in Mobile, Alabama [6]. The experiments included simulated engine room fires, simulated cargo fires, and pool fires. In each test, a pipe calorimeter that was approximately the same size as a truck transport spent fuel package was used to measure the heat flux. The engine room fire was simulated by having the flame from four heptane spray burners impinge on a bulkhead. The calorimeter for this test was on the opposite side of the bulkhead. The cargo fire was simulated by having a standardized wood crib fire adjacent to the calorimeter. The pool fire was conducted by having a pan of diesel fuel burning in a hold adjacent to the calorimeter. The pipe calorimeter used for these tests was made from Schedule 60 (2.62cm wall thickness) steel pipe 1.52 meters long and 0.61 meters in diameter with 2.54 cm thick circular steel plates bolted to the ends and packed with Kaowool insulation. The total mass of the calorimeter was 719 kg (1585 lbs).

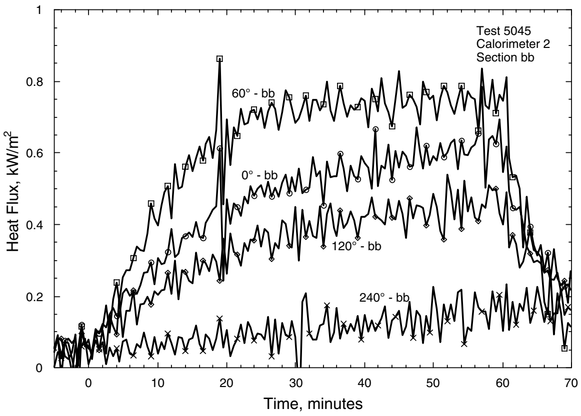

Figure 4: Heat flux on calorimeter for a 60-min. simulated engine room fire.

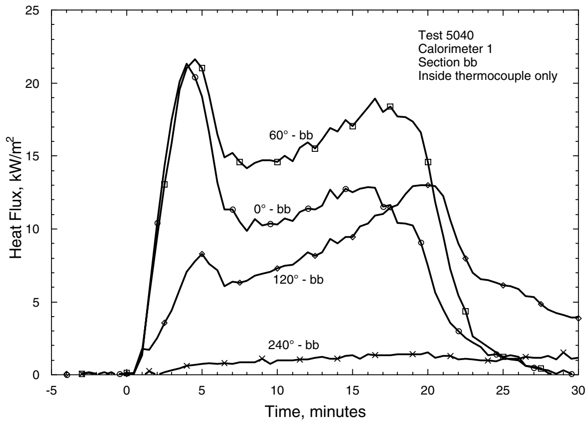

Figure 5: Heat flux on calorimeter for a simulated cargo fire.

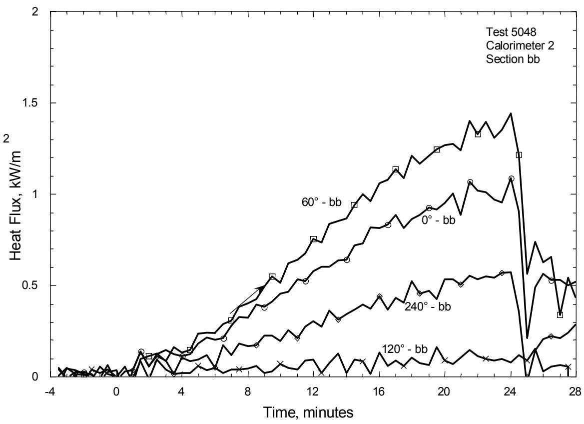

Figure 6: Heat flux on calorimeter for a pool fire in an adjacent hold.

The fire duration for the heptane spray test was one hour. The total heat output for the four heptane torches was approximately 5.6 MW. Figure 4 shows the heat flux at four locations on the pipe calorimeter. The maximum heat flux is less than 1 kW/m^2, much less than the 55 kW/m^2 heat flux due to radiation from the regulatory fire. During this test the temperature of the calorimeter increased approximately 25°C. The wood cribs were constructed from clear Douglas fir and were built to size 20-A of UL Standard 711 [7]. The burning of these cribs is initiated by the use of 17 L of heptane. The thermal output of this fire is approximately 4.1 MW for the first five minutes while the heptane is burning and 2.4 MW for the remaining 15 minutes of the fire. Figure 5 shows the heat flux at four locations on the pipe calorimeter that was adjacent to the fire. The maximum heat flux is about 22 kW/m^2. During this test the temperature of the calorimeter increased by about 200°C.

The fire duration for the in-hold pool fire was 27 minutes. To prevent a possibly explosive condition during this test, the hold with the pool fire was vented. This condition simulates a fire that may occur in port when the hatch covers of the hold are open. While at sea the holds are generally sealed, which would result in a reduced oxygen supply to the fire and lower fire temperature. The pool fire had a heat output of approximately 15.7 MW. Figure 6 shows the heat flux at four locations on the pipe calorimeter that was in the neighboring hold. The maximum heat flux is about 1.5 kW/m^2.

4. Conclusions

This investigation demonstrates that the mechanical and thermal accident environments associated with ship-to-ship collisions and onboard fires is not more severe than the hypothetical accident environment of TS-1. Even the most severe ship-to-ship collisions cannot generate impact or crush forces on a package that are higher than the impact forces from the certification impact test. The IMDG Code [8] prevents the transportation of flammable materials and RAM in the same hold. This means that a pool fire is very unlikely to occur in the same hold as a RAM package, but only in an adjacent hold. For pool fires or even spray fires directly onto a bulkhead, the bulkhead acts as a very good radiation shield and limits the heat flux to a RAM package on the other side. Combustible cargo may be transported in the same hold as a RAM package, but the heat flux from a combustible cargo fire adjacent to a package is less than for the certification fire.

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METHODS FOR THE ASSESSMENT OF RISK IN THE SEA TRANSPORT OF RADIOACTIVE MATERIAL

J. Sprung, D. Ammerman

Sandia National Laboratories[1]
Transportation Risk and Packaging Department, Albuquerque, New Mexico
United States of America

Abstract[*]

As part of an IAEA Co-ordinated Research Project, Sandia National Laboratories performed an extensive study into methods for assessing the risk associated with the maritime transport of radioactive materials. Ship accident event trees, ship collision and ship fire frequencies, cask-to-environment release fractions during ship collisions and fires, and illustrative consequence calculations are described in this paper.

1. Introduction

A method to assess the risks associated with the sea transport of radioactive materials was investigated at Sandia National Laboratories as part of the U.S. contribution to an IAEA Co-ordinated Research Project [1] on sea shipments of radioactive materials. This paper summarizes the results of that work [2]. Previous assessments of the risks associated with the maritime transport of radioactive materials may have substantially overestimated risks because these assessments:

- greatly overestimated the probability that an accident will lead to a release of radioactivity,
- significantly underestimated retention by deposition onto cask surfaces of the radioactive vapors and aerosols released to the cask interior as a result of the accident, and
- sometimes overestimated population exposures because real non-uniform population distributions were replaced by approximate uniform distributions, which caused the number of people situated near to the accident site, and consequently population doses both to be overestimated.

Because of the number of ocean shipments likely to occur during the near future and because of the widespread concerns expressed about these shipments, in 1994 DOE initiated a general study of ship accident risks with the intent of substantially enhancing the technical data and methods available for the assessment of these risks and the goal of allaying concerns about the safety of these shipments.

2. Ship accident event trees

Event trees are used to follow the sequence of events that could occur during a maritime accident. The event tree developed for this work was split into four sections; Ship Tree, RAM Ship Tree, Oil Tanker Tree, and Fire/Sink Tree. The Ship Tree considers accident types and always feeds into one of the other trees. The RAM Ship Tree is used when another ship strikes the vessel carrying the RAM. It is used to determine the location of the impact, the location of the RAM, and if the impact location and RAM location coincide, if the RAM package is damaged and to what extent. The Oil Tanker Tree is used when a RAM carrying ship impacts an oil tanker to determine if a long duration fire fueled by the oil in the tanker ensues. Finally the Fire/Sink Tree gives the possible outcomes of a maritime accident. No attempt was made to populate the event trees with all of the branch-point probabilities, but several end-point (scenario) probabilities were calculated and will be discussed later.

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[1] Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin company, for the United States Department of Energy under Contract DE-AC04-94AL85000.

[*] The views expressed in this paper do not necessarily reflect those of the U.S. Nuclear Regulatory Commission.

3. Accident probabilities

Ship accident data is gathered by many organizations. Most review accident data principally in order to identify the causes of accidents. Several organizations enter accident data into databases. For this study, accident data gathered by the U.S. Coast Guard, the U.S. National Transportation Safety Board, and Lloyd's Maritime Information Services was examined in order to develop accident frequencies for ship collisions, ship fires, and ship collisions that lead to fires. Data from the U.S. Coast Guard Marine Safety Management System (MSMS) ship accident database was used to identify the locations of ship accidents that occurred in the approach waters to the port of New York. Collision and fire frequencies were developed entirely from data in the Lloyd's casualty database [3].

Fifteen years of ship accident data covering the years 1979 to 1993 were purchased from Lloyd's Maritime Information Services. The data contained approximately 30,000 incident reports. Most of these incidents involved collisions with fixed structures and groundings. However, some 4500 of these incidents involved collisions with other ships, collisions with other ships that led to ship fires, and ship fires not caused by a ship collision. Queries utilizing the SQL database programming language were then constructed to extract the data utilized in the analysis of ship fires, ship collisions, and ship collisions that led to fires.

Searches of the 15 years of accident data showed that the data contained 1947 collision events, 702 of which occurred in ports, and 2547 fire events, 975 of which occurred in ports. Only 50 of the 1947 collision events led to fires, 39 fires resulted from collisions at sea and 11 from collisions in ports. None of the 2547 fire events involved collisions. For the accidents that occurred outside of port waters, 758 of the collision events and 812 of the fire events had associated latitude and longitude co-ordinates. The distance from each of these points to the nearest shore was measured. Figure 1 shows a histogram of that distance for both collision and fire accidents. The figure clearly shows that collisions are more likely to occur closer to shore and that fires are more uniformly spread over the ocean surface. This data indicates that ship collisions occur primarily where ship traffic is high and that the frequency of fires at sea depends principally on the time spent underway.

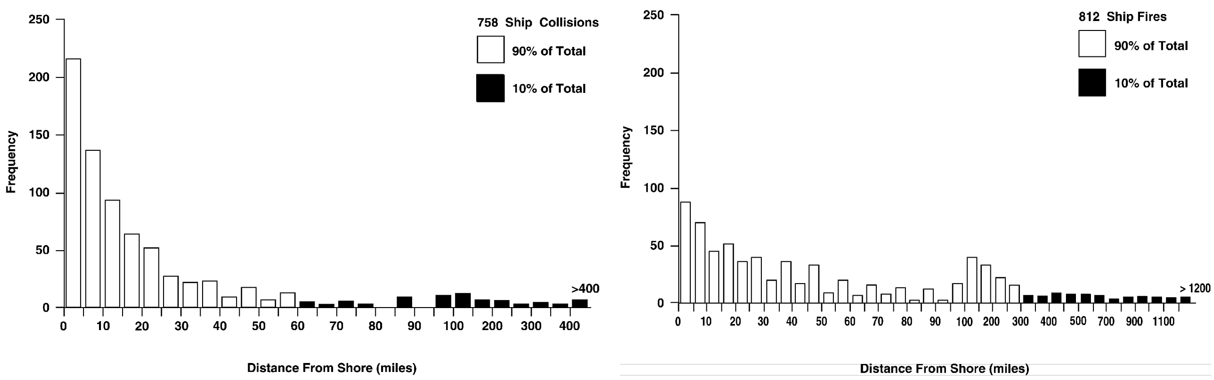

Figure 1: Histogram of ship accident locations by distance from shore.

The dependence of collisions on ship traffic indicates that accident probabilities for a given voyage will depend on how much of the voyage traverses an area with high traffic. In this study the collision frequencies for 19 high traffic regions, regions within 50 nautical miles of a coast (outside the high traffic regions), and the open ocean were estimated. The distances sailed within each region were determined for two non-contiguous years from the Lloyds Port Call Data. Table 1 gives the collision frequency for each of these 21 regions. The collision frequency for congested regions varies from 3.7×10^{-8}/nm in the Suez Canal/Red Sea/Gulf of Aden region to 1.9×10^{-6}/nm in the East Coast of Japan region. The coastal waters not in high-traffic regions have a collision frequency of 1.9×10^{-7}/nm and the open ocean has a collision frequency of 6.8×10^{-9}/nm. In addition to data about collision frequencies for voyages, collision frequencies for port calls were also calculated. Ports were divided into high-traffic, (>8900 port calls in 1988) medium-traffic (2700-8900 port calls), and low-traffic (<2700 port calls). For high-traffic ports the average collision frequency was 3.1×10^{-5}/port call, for medium-traffic ports it was 4.6×10^{-5}/port call, and for low-traffic ports it was 4.3×10^{-5}/port call. Because a port call includes an entrance to the port and an exit from the port, for a given voyage leaving the departure port and arriving at the destination port are only 1/2 of a port call. The probability of a collision on a voyage is calculated by the sum of the probabilities for a collision in each region of the voyage, any intermediate ports, and 1/2 that for the ports at either end.

Ship fires show little variation with ocean location, so their frequency was calculated independent of location. The results are 9.6×10^{-8} fires/nm and 5.4×10^{-5} fires/port call.

Table 1: Collision frequencies for 21 ocean regions.

Region	Distance Sailed (nautical miles)			Collisions 1979-1993	Collision Frequency (per nautical mile)
	1988	1993	Average		
Irish Sea	2,829,048	2,683,242	2,756,145	7	1.7×10^{-7}
English Channel	21,879,012	20,497,594	21,188,303	33	1.0×10^{-7}
North Sea	48,945,873	46,676,760	47,811,317	134	1.9×10^{-7}
Baltic Sea	26,150,331	30,410,544	28,280,438	76	1.8×10^{-7}
Western Mediterranean	12,527,256	12,508,332	12,517,794	29	1.5×10^{-7}
Tyrrhenian Sea	4,713,083	5,163,556	4,938,320	8	1.1×10^{-7}
Adriatic Sea	8,847,482	9,216,251	9,031,867	11	8.1×10^{-8}
Aegean Sea, Bosporus	6,979,278	7,521,944	7,250,611	59	5.4×10^{-7}
Eastern Mediterranean	9,717,480	11,511,423	10,614,452	21	1.3×10^{-7}
Suez Canal, Red Sea, Gulf of Aden	30,562,346	30,397,942	30,480,144	17	3.7×10^{-8}
Persian Gulf, Gulf of Oman	6,123,288	9,272,603	7,697,946	17	1.5×10^{-7}
Approaches to Singapore	30,056,459	43,928,308	36,992,384	41	7.4×10^{-8}
South China Sea, Taiwan Strait	16,959,614	24,003,990	20,481,802	42	1.4×10^{-7}
East China Sea	24,138,006	32,718,462	28,428,234	34	8.0×10^{-8}
Yellow Sea	7,483,030	10,559,045	9,021,038	13	9.6×10^{-8}
Sea of Japan, Korean Strait	6,223,109	7,748,095	6,985,602	35	3.3×10^{-7}
Inland Sea of Japan	12,440,950	14,106,520	13,273,735	193	9.7×10^{-7}
East Coast of Japan	4,169,250	4,497,723	4,333,487	120	1.9×10^{-6}
Western Gulf of Mexico	12,907,874	14,124,048	13,515,961	24	1.2×10^{-7}
Other Coastal Waters	80,737,497	97,489,242	89,113,370	253	1.9×10^{-7}
Open Ocean	655,875,934	709,598,653	682,737,294	70	$6. 8 \times 10^{-9}$

4. Scenario probabilities

To illustrate the application of the event trees and accident data an example scenario is shown below. For this case a shipment of spent fuel from Charleston, South Carolina, US to Cherbourg, France is considered. For there to be a significant release of radioactive material during this shipment the following sequence of events must occur: a ship collision, the RAM ship is the struck ship, the strike location is mid-ship, the spent fuel cask is located mid-ship, the hold containing the spent fuel cask is struck, cask crush occurs, cask puncture or shear occurs, a long-duration fire occurs in the hold with the spent fuel cask, and the ship does not sink. In this voyage there are 50 nm of non-congested region coastal waters (outside the port of Charleston), 3325 nm of open ocean, 197 nm in the English Channel, and 1/2 port call in the low density ports of Charleston and Cherbourg. The probability of collision is then:

$$P_{collision} = 0.5\times4.3\times10^{-5} + 50\times1.9\times10^{-7} + 3325\times6.8\times10^{-9} + 197\times1.0\times10^{-7} + 0.5\times4.3\times10^{-5}$$
$$= 9.5\times10^{-5}$$

Due to the high density of spent fuel packages, they are generally stowed as near as possible to the center of the ship. For this example it is assumed that the package is stowed mid-ship at centerline of a small, chartered break-bulk freighter with no other cargo. If there is a collision, the RAM ship can be either the striking ship or the struck ship. The way the collision data was developed does not distinguish ship sizes or types, so either possibility is equally likely. The accident data suggests that more ships are struck near the bow and near the stern than at mid-ship, but here we will assume the distribution of strike location is uniform along the length of the ship. Therefore, the probability that the strike location is mid-ship is 1/3. For the small freighter there is only one hold mid-ship, so the probability that the RAM hold is struck is one. The probability that the collision is severe enough to reach the centerline location of the cask is about 0.15, but this will usually not result in crushing of the cask, as demonstrated by Ammerman and Ludwigsen [4]. For this example we will conservatively assume that 20% of the collisions of this severity lead to package crush. Therefore the probability of a package being crushed is 0.03. During the collision, tearing of ship structure might produce pointed or sharp-edged objects that could puncture the package. A very conservative estimate of the probability that this could occur is 0.2. The probability that a long duration fire occurs in the RAM hold is about 6.0×10^{-5}. In order to have significant release, the RAM ship must not sink during this accident. The probability that it does not sink is estimated to be 0.996 (only 7 of the 1947 collisions in the Lloyds database led to fires followed by sinking). Multiplying all of these probabilities together leads to the resultant probability of 4.7×10^{-7} that there will be any release and 5.6×10^{-12} that there will be a large release during this voyage.

5. Radioactivity released and population exposure

Using the compartment model MELCOR [5], a calculation to determine release fraction for very unlikely, severe accidents was performed, considering the package geometry, the size distribution of fuel fines, the temperature profile of the package, release pathways, gravitational settling, plate-out, and internal pressure. The results indicate the release fraction is strongly dependent on the size of the leak pathway from the cask. For the collision only case a leak area of 4 mm2 results in release fractions of 0.16 for noble gases, 0.003 for CRUD, 2x10-8 for Cesium, 2x10-8 for ruthenium, and 2x10-8 for particulates. By way of comparison, the TS-R-1 acceptance criteria of 1A2 per week would be 0.0161 TBq (0.434 Ci), or a release fraction of 1.25x10-7. In the very unlikely case that a collision results in RAM release, and assuming the accident occurs in the coastal waters outside of a port, approximately 30 nm from the mainland (therefore, for the nearest 30 nm there is essentially no exposed population), the total population dose for this scenario is about 0.2 Sv for the collision only case (the collision plus fire case is not credible). If the accident occurs in the open ocean, the peak dose to man was calculated to be about 1 mSv/year, which is indistinguishable from background radiation.

6. Conclusions

The principal conclusions of this study are:

- Ship collisions depend on ship traffic density and thus on locale, fires don't.
- Ship collisions are unlikely to damage a RAM cask, because collision forces will be relieved by collapse of ship structures, not cask structures.
- Fires aren't likely to start in the RAM hold; if a fire starts elsewhere on the ship, its spread to the RAM hold is not probable; and, even if a fire spreads to the RAM hold, lack of fuel or air will usually prevent the fire from there burning hot enough and long enough to significantly increase the release of radioactivity from the RAM cask.
- Most radioactive materials released to the interior of the RAM cask will deposit on interior cask surfaces so cask retention fractions are large and cask-to-environment release fractions are small.
- Consequently, the risks of maritime transport of RAM are very small.

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TRANSPORT REGULATIONS FOR RADIOACTIVE MATERIALS IN JAPAN

M. Kubo [a], S. Hamada [b], S. Ishimaru [c], S. Fukuda [d],

[a] Japan Nuclear Cycle Development Institute, Ibaraki,
[b] Ministry of Economy, Trade, and Industry, Tokyo,
[c] Ministry of Land, Infrastructure and Transport, Tokyo,
[d] Central Research Institute of Electric Power Industry, Chiba,
Japan

Abstract

The IAEA Regulations for the Safe Transport of Radioactive Materials are taken as a basis for our national regulations to secure the safe transport of radioactive materials in Japan. The requirements for packaging and packages that are used to transport radioactive materials are based on the IAEA Regulations. Furthermore, in addition to the IAEA Regulations, the relative international regulations such as the IMDG code of IMO etc. are reviewed by our national authorities and applied to the conveyance such as the transport vehicle/vessel etc. that is used for the shipment. The transport system such as a transport caravan in Japan is intended to provide even greater safety during transport. The future activities to be discussed in the IAEA are how to adopt the IAEA Regulations to Member States as soon as possible and to evaluate the safety margin of the IAEA Regulations to the assumed accidents.

1. Circumstances of adopting the IAEA Regulations to Japanese national regulations

The International Atomic Energy Agency (IAEA) first published Safety Series No. 6 (1961 Edition) in May 1961 for application to the national and international transport of radioactive materials. Numerous persons, including the late Professor Aoki, Tokyo Institute of Technology Professor Emeritus, attended the specialist meetings and panel discussions representing Japan since around 1962. Subsequent reviews were carried out in consultation with Member States and the organizations concerned, result in comprehensive revisions being published as Safety Series No. 6 (1964 Edition) in 1965. The revised version was published in 1967 to apply to the transport of the spent fuels from nuclear power plants and radiation sources etc. that were becoming actual problems at that time.

Furthermore, technical and panel revision meetings were held about important issues such as test procedures, criticality safety the transport of spent fuels etc. because of increasing international transport as well as domestic transport of RAM. These meetings were actively joined by representatives from Japan. Safety Series No. 6 (hereinafter: the IAEA Regulations)(1973 and 1985 Edition) were published and adapted to our domestic regulations in 1978 and 1990 respectively in Japan. Many experts concerned, including those from our country, have actively taken part in the revision process of the IAEA Regulations. Technical committee meetings regarding the test procedures in the IAEA Regulations were held in Tokyo in 1981. The results from those meetings were reflected in the next edition of the IAEA regulations. These were reviewed and discussed by the Nuclear Safety Commission of our country and the IAEA Regulations (1985 Edition) were adopted Japan in 1990.

The most recent IAEA Regulations (ST-1, 1996 Edition) were discussed in our Nuclear Safety Commission and the Radiation Committee. The public comments from Japan and other nations were also reviewed. These regulations were approved and implemented in our domestic regulations without any problem. The IAEA Regulations (1996 Edition) were implemented July 1, 2001 in Japan.

2. Domestic review organization of the IAEA Regulations in Japan

2.1. Position of the IAEA Regulations

The IAEA Regulations are not binding to each of the Member States like a treaty but are positioned as "a principle rule" so to speak. However, from the viewpoint that the each Member State or each relative international organization such as the IMO, ICAO adapts the regulations fundamentally to each Member State's domestic regulations or each international rule. The regulations have the same effect on the international agreements. Similarly, those regulations are international, although they do not have compelling force like an international treaty. It is very important to adopt the regulations in each country so that smooth transport might be carried out. The international shipment of materials would be difficult if each country has significantly different regulations.

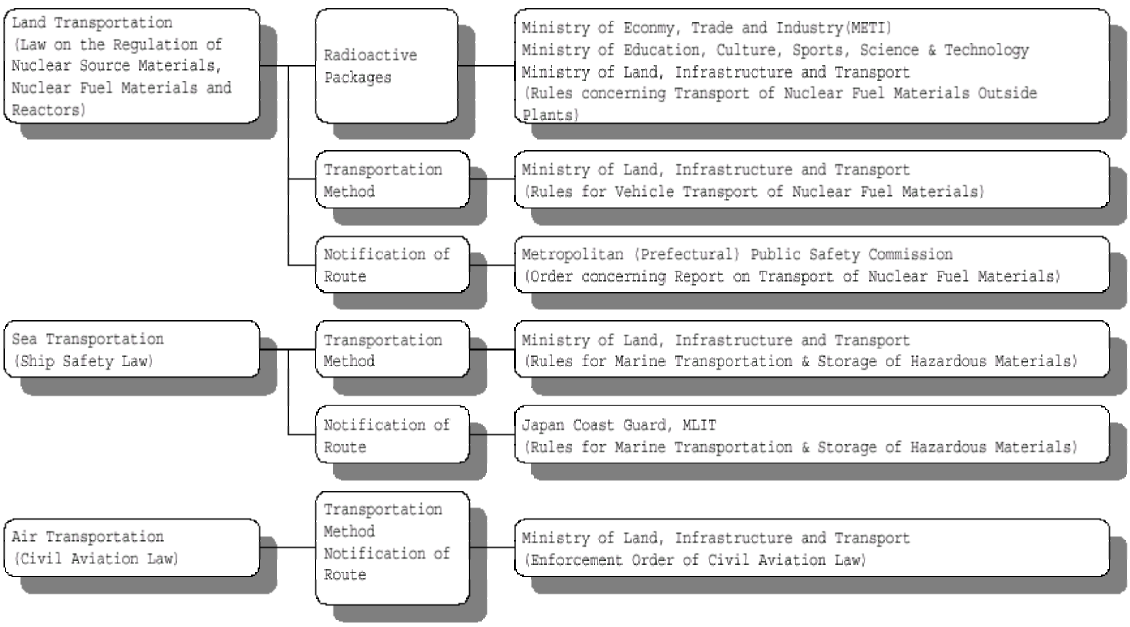
2.2. Reviewing organization of the IAEA Regulation in Japan

A safety transport expert group on the transport of radioactive materials that consists of about 25 experts in several fields was established under the Nuclear Safety Commission. This Expert Group reviewed The Regulations (1996 Edition) and discussed how to adopt them into Japanese domestic regulations since 1999 as mentioned above. The Safety Standard Working Group that consists of about 15 experts established under the Safety Transport Expert Group on Radioactive Materials carried out detailed discussions on individual items and the technical contents of the IAEA Regulations (1996 Edition). Furthermore, after confirming that there were no major problems with the IAEA Regulations and after receiving public comments from our nation, the IAEA Regulations were judged to be adequate for Japan's domestic regulations.

3. Japanese competent authorities and regulation system

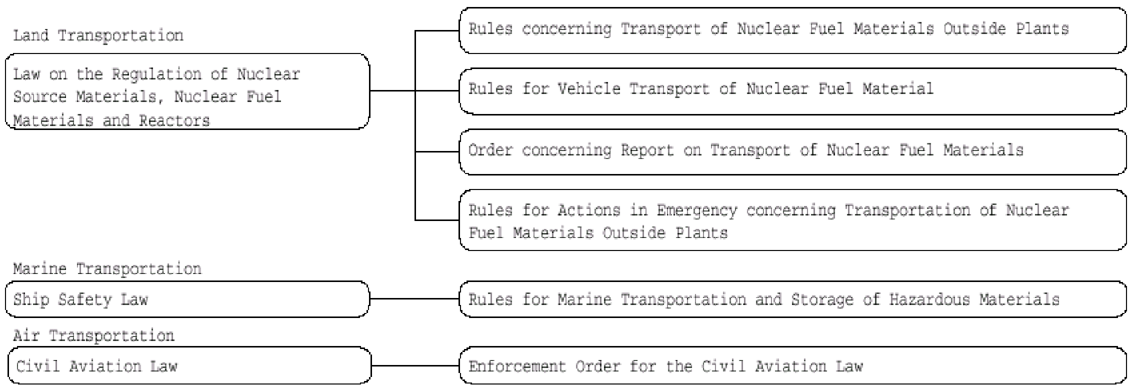
Our competent authorities reside in each transport mode such as land transport, sea transport and air transport in Japan. For example, the Ministry of Economy, Trade and Industry, the Ministry of Education, Culture, Sport, Science and Technology, and the Ministry of Land, Infrastructure and Transport has the competent authorities for land transport. The Ministry of Land, Infrastructure and Transport has the competent authorities for sea and air transport.

Fig.1 Radioactive Material Transport Mode and Regulation Assignment



The organization of the competent authorities for the design and approval of packages and operations under each transport mode are shown in Figure 1. The relationship of the rules regarding the transport regulations of RAM in Japan is shown in Figure 2.

Fig.2 Code System concerning Transportation of Nuclear Fuel Materials



4. Actual transport system in Japan

The special consideration for land transport in Japan is as follows; the transport caravan that consist of a vehicle loaded with RAM with a wagon for escort back and forth in a line is carried out to provide an even safer transport system for the public. The transport caravan may take a rest at suitable times during the actual shipment, and will investigate and obtain the latest information concerning climate, road condition, traffic situation etc. throughout the transport route. The caravan will be equipped with a telecommunication system between an operation center and the transport. An operation representative, radiation monitoring persons and guards are on board the caravan.

The surveillance for sea transport is carried out by the guard vessel of Japan's Coast Guard in a harbor to protect the transport vessel that is loaded with a type B package and/or package containing fissile material. The purpose is similar to the case of land transport. In addition, it is not included in the United Nations model regulations mentioned above, but the International Code for the Safe carriage of Packaged Irradiated Nuclear fuel, Plutonium and High-level Radioactive Wastes on Board ships (INF-code) is developed by the IMO. A ship following this INF code shall comply with very high-level safety requirements. For instance, in case of a class INF 3 ship, the ship is required to have a double hull system, very severe damage stability for collision or grounding damage, various fire safety measures, alternative electrical power supply source, etc. These special considerations are being utilized to ensure the safe and secure transport of nuclear material in Japan.

5. Future subjects to be discussed

The following two points should be discussed in the future

(1) It is important that each Member State adopt the IAEA Regulations to their domestic transport regulations and the relative international organizations as soon as possible, from the viewpoint of international harmonization among Member States.

(2) It is important to evaluate the magnitude of safety margin that the IAEA Regulations have to assumed accidents in order to acquire the confidence of the general public.

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DEVELOPMENT OF THE INF CODE AND ITS RELATIONSHIP TO THE SHIPS OF THE PACIFIC NUCLEAR TRANSPORT FLEET.

P.A. Booker
Marine Operations, Pacific Nuclear Transport Ltd.
United Kingdom

Abstract

Until the adoption of the INF Code as a voluntary instrument in 1993, there were no special construction or equipment requirements, of an advisory or mandatory nature, for ships carrying radioactive materials. Any cargo ship could be used for transporting virtually unlimited quantities of these materials. This paper gives a brief insight in to the development of the PNTL Fleet and the correlation to the INF Code.

1. Background

In 1985, Italy voiced concerns at the Maritime Safety Committee of IMO about the lack of special requirements and a need to ensure adequate fire protection in cargo spaces and damage stability for ships carrying irradiated nuclear fuel, particularly non-purpose built ships. The MSC delegated its sub-committees to consider the matters raised by Italy depending on the area of expertise required. The MSC widened the scope of consideration to include purpose and non-purpose built ships and cover issues such as hold cooling, ventilation and radiation protection. The Sub-Committee on Ship Design and Equipment (DE) was requested to oversee and develop what would become the INF Code. Interestingly, during this process the Working Group on Class 7 (radioactive materials) of the Sub-Committee on the Carriage of Dangerous Goods reported that additional fire protection measures were unnecessary on ships used for the carriage of irradiated nuclear fuel because of the protection provided by the packages used for such cargoes. However, the Sub-Committee would not accept that opinion.

The International Atomic Energy Agency (IAEA) is the United Nations agency responsible for formulating international regulations and standards that are designed to ensure adequate safety in all aspects of the civil nuclear industry's operations, including the transport of radioactive materials by any mode of transport. The IMO adopts IAEA standards in Class 7 of the IMDG Code, which covers radioactive materials. The philosophy of the IAEA is the safety during transport of radioactive materials should be ensured by the package regardless of the mode of transport. Packages containing INF Code materials when designed and tested to IAEA standards are capable of protecting people and the environment in very severe accident conditions without additional protection from the vehicle, in this case, the ship.

The eighth session of the IAEA Standing Advisory Group on the Safe Transport of Radioactive Material (SAGSTRAM) took the view that there was no need, on safety grounds, for specific ship design or fire protection requirements to be applied when transporting irradiated nuclear fuel in larger quantities. The Director General of IAEA wrote to the Secretary General of IMO in May 1991 proposing that the risk associated with sea transport of INF be assessed by IAEA in close collaboration with IMO and that modification of IAEA regulations should be considered, if it were found that such risk was indeed more severe aboard ship than on land. This led to the formation of a Joint IAEA/IMO/UNEP Working Group.

The Joint IAEA/IMO/UNEP Working Group sat for two sessions in December 1992 and April 1993 and, amongst other things, was tasked "To study the adequacy of existing provisions for the safe transport of irradiated nuclear fuel by sea. To take into account the impact of marine casualties, such as fire, explosion, or breach of the hull, on packaging integrity. To assess the probability of such casualties occurring." Both sessions were well attended by representatives from member Governments, intergovernmental organisations and non-government organisations including environmental groups.

The Joint Working Group agreed, by consensus, on the draft INF Code and to extend its coverage from irradiated nuclear fuel to plutonium and high-level radioactive waste. The member states agreed that there was no information or data in the papers submitted to both sessions that would cast doubt on the adequacy of the IAEA regulations. The papers submitted supported the existing experience and knowledge of member states and indicated low levels of radiological risk and environmental consequences from the marine transport of radioactive material.

The INF Code was adopted as a voluntary code by the IMO's 18^{th} Assembly in November 1993. It contained requirements for: damage stability, fire protection, temperature control of cargo spaces, structural considerations, cargo securing arrangements, electrical supplies, radiological protection equipment, management, training and shipboard emergency plans. It designated ships into the classes INF1, INF2 and INF3 which are each determined by a maximum level of aggregate radioactivity that can be carried, this is unlimited in the case of INF3. The requirements become more stringent for each class.

Following the adoption of the INF Code, a number of delegations at IMO continued to push for the addition of so called 'complementary measures' which related to the adequacy of the package design and tests, environmental impact and the consequences of severe accident scenarios, restriction and exclusion of ships from particularly sensitive sea areas, route planning, prior notification and consultation with coastal states, location and salvage of a sunken ship and lost flasks, emergency preparedness and response, liability, tracking of ships by a shore based authority, adequacy of requirements for marking and labelling and securing of flasks. They also pushed for the INF Code to be made mandatory.

In March 1996, at the request of the Secretary General of IMO, a Special Consultative Meeting was held at IMO in London, to which all entities with an interest in the transport of radioactive materials were invited to attend and discuss their concerns.In 1998 the INF Code was amended to include a specific requirement for ship-board emergency plans and notification to the nearest coastal state in the event of an incident. At the same time 'guidelines' for the compilation of these emergency plans were adopted.

The INF Code as such, presented no problems to BNFL. BNFL, through its subsidiary PNTL, had operated its own purpose built ships constructed and equipped in excess of INF3 standards, since 1979, fourteen years before the adoption of the voluntary code.

2. Development of the purpose built ship

For the early shipments, BNFL chartered general cargo vessels from James Fisher & Sons, which were converted to carry the types of flasks used for this business. Apart from the actual flask-related equipment the vessels were also equipped with powerful radio equipment and additional fuel oil storage tanks.

In the 1970's BNFL decided to develop a design for purpose-built vessels for nuclear transport which provided enhanced protection for the ships and crews, so increasing the safety and reliability of transportation operations. Following wide consultation with Lloyds of London, The Salvage Association and leading salvage companies,and as a result of Japanese standards developed at the same time, today's PNTL fleet was constructed. Since this time extra equipment has been added in line with technological developments and operating experience to maintain high standards of operational safety.

1979 saw the commissioning of the first purpose-built PNTL ship, the Pacific Swan. Not only did her design take into account the requirements of Japanese Ministry of Transport (JMOT) but also a whole host of added safety features were incorporated.

The ships were to have two principal safety features. First, the hull would be divided into a large number of compartments to form a double hull which surrounded the five cargo holds. This would enable the vessel to remain afloat, stable and able to function after sustaining a quite considerable amount of damage. Second, every essential system and equipment would be duplicated to guard against mechanical failure or damage. This is a principle used in the design of nuclear power plant were there is always a back-up to important systems and equipment. A prime objective for a nuclear materials transport vessel is to 'stay afloat' after sustaining damage from collision or grounding.

The ships are constructed with a double hull The inner shell embracing the cargo space is formed by watertight longitudinal and transverse bulkheads. The structure and sub-division of the hull is designed so that the vessel will stay afloat after it has sustained damage, which is in excess of the extent specified for Class I chemical tankers. The wing tanks formed by this construction are used for normal ballast and trimming requirements except for the tanks abreast of No. 5 Hold which are allocated for holding bilge water. This bilge water is not normally discharged directly to the sea.

The wing tank space is also structurally stiffened so as to prevent impact damage being sustained by flasks within the holds in the event of a collision with another vessel. For the purposes of design the colliding vessel is assumed to be about 24,000 tonne displacement travelling at 15 knots and that it will not enter the cargo area.

The wing space is also used to provide all weather passage-ways on both sides of the ship, immediately below deck level for access to the holds and forward plant rooms. These access ways are necessary for checking the flask securing arrangements in heavy weather and for the routine checking of the hold cooling systems, and radiation surveys. The passages also provide convenient routes for segregating electrical power cables, hold cooling system control panels etc. The sub-division of the hull is preserved throughout the passage ways by the use of water-tight doors.

3. Radiation shielding

The segregation between the cargo space and the normally occupied space is provided by radiation shielding (i.e. energy absorbing barriers) in the form of a water tank extending the full width and depth of the cargo hold at the aft end of No. 5 Hold. The tank is formed by two transverse bulkheads separated by 750mm of water space. The radiation shielding is extended forward from the bridge by concrete overlaid on the deck and beneath the hatch covers.

4. Power plant

The ship's power plant has been designed to provide a high degree of reliability. To this end, all the main plant is duplicated and installed in ways which avoid common mode failures. In addition to the main alternators situated aft, two other alternators capable of supplying all main power are located in a second machinery space forward. In addition there is an emergency alternator capable of supplying all essential functions (navigation equipment, lights, steering gear, fire pumps etc). Power cables are divided along different routes (eg along both sides of the ship) to prevent damage in one area severing supplies.

5. Cargo cooling

The ambient temperature in the cargo holds can be controlled within the limits -40°C to +55°C. This has been achieved by providing two forced circulation air chillers in each hold which reject the heat directly to sea. The chilled air is ducted to distributors low down in the hold and extracted at a high level using axial flow fans.

6. Fire detection/fire fighting

All ships are fitted with a fire detection system covering every space. The cargo holds and machinery spaces can be flooded with fire suppressant gases. Also, the cargo holds can be flooded from an array of water sprays in the top of each hold. Pumps to supply firefighting and hold spray systems are located in both the main engine room and the forward machinery space.

7. Emergency response

Another requirement of the IAEA regulations is an emergency response plan. An amendment to the INF Code of 1993 introduced a requirement for a shipboard emergency response plan, but this was already required by existing regulations.

The BNFL/PNTL ships carried detailed emergency response plans and procedures and the amendment caused no extra burden. Another amendment to the code introduced at the same time, required the nearest coastal state to be notified in the event of an incident. BNFL had always considered this to be a requirement anyway, and its procedures contained instructions to ships' Masters to give such notification, so again the amendment had no effect on policy.

8. Summary

BNFL developed ships in the 1970s whose construction and equipment exceeded requirements for what were later to become INF3 ships. Proposals for special requirements for ships carrying irradiated nuclear fuel were made to IMO in 1985. The original Italian proposals gave the initial impetus to the development of what became the INF Code.

The INF Code was adopted as a voluntary instrument in 1993 and became mandatory on 1st January 2001.

ADOPTION OF TS-R-1 IN THE UNITED STATES NUCLEAR REGULATORY COMMISSION REGULATIONS FOR TYPE B AND FISSILE MATERIAL

D. Pstrak, P. Brochman, J. Cook, R. Lewis, R. Temps

U.S. Nuclear Regulatory Commission
Office of Nuclear Materials Safety and Safeguards
Washington, DC
United States of America

Abstract*

The U.S. Nuclear Regulatory Commission (NRC) is currently conducting a major revision to its regulations on the transportation of radioactive material which are found in Title 10 of the Code of Federal Regulations, Part 71 (10 CFR Part 71). The NRC and the U.S. Department of Transportation (DOT) jointly share responsibility for regulating the transportation of radioactive material. Consequently, the NRC and DOT are both revising their regulations to be compatible with the latest edition to the International Atomic Energy Agency's (IAEA's) standard TS-R-1 (1996) for the transportation of radioactive material. Since the NRC and DOT share responsibility for regulating in this area, challenges arise in determining which provisions of TS-R-1 should result in conforming changes to the NRC's and DOT's respective regulations, while also ensuring that the NRC's and DOT's regulations remain consistent.

1. Rulemaking process

In the United States, the process of developing regulations is known as rulemaking. Within the NRC, this process generally consists of a Proposed Rule and a Final Rule. The proposed rule is published in the *Federal Register* and typically contains background information, an address for submitting comments, the length of the comment period (e.g., 30, 60, 75, or 90 days), an explanation of why the rule change is thought to be needed, and the proposed text of the regulations. For especially significant rules, one or more public meetings may be conducted to allow members of the public an opportunity to become more familiar with the issues and to make comments in person. Additionally, an Advanced Notice of Proposed Rulemaking (ANPR) may also be published in the *Federal Register* for important rules. The ANPR allows comments to be submitted well in advance of the proposed rulemaking stage. Once the comment period has closed, the staff analyzes the comments, makes needed changes, and forwards the Final Rule for final agency approval and publication in the Federal Register. While less complicated rules may go through this process in six to eight months, significant rules may take upwards of two to three years to complete their progression.

2. Background

In June 2000, the NRC began its process to incorporate TS-R-1 into its regulations by (1) use of an enhanced public-participation process (consisting of a website and facilitated public meetings) to solicit public input on the Part 71 rulemaking, and (2) publication of the staff's Part 71 "Issues Paper" in the *Federal Register*(1) for public comment. The Issues Paper presented the NRC's plan to revise Part 71 and provided a summary for the changes under consideration. The NRC published the Issues Paper to begin an enhanced public-participation process designed to solicit public input on the Part 71 rulemaking. This process included establishing an interactive website and holding three facilitated public meetings in 2000.

* The views expressed in this paper do not necessarily reflect those of the U.S. Nuclear Regulatory Commission.

After completion of the public meetings, the NRC developed a proposed rule. Oral and written comments received from the public meetings, by mail, and through the NRC website, in response to the Issues Paper, were considered in drafting the proposed changes. The NRC and DOT published their proposed rules in the *Federal Register* on April 30, 2002. A 90-day comment period was granted in order to allow ample time for the public and industry to review the proposed rule and provide comments. The comment period ended on July 29, 2002. Additionally, three public meetings were also conducted on the proposed rule in which both NRC and DOT participated. Currently, both agencies are reviewing the comments received from the meetings and those sent in by mail and electronically. Once the comment responses are developed, and after agency approval, a final rule will be published in the *Federal Register*.

This paper focuses on U.S. NRC proposed changes to 10 CFR Part 71, which primarily bear upon Type B and fissile material transport. Many additional changes are also being considered by U.S. DOT.

3. Past revisions to NRC regulations based on IAEA compatibility

Recognizing that its international regulations for the safe transportation of radioactive material should be revised from time to time to reflect knowledge gained in technical and scientific advances and accrued experience, IAEA invited Member States to submit comments and suggest changes to the regulations in 1969. As a result of this effort, the IAEA issued revised regulations in 1973 (Regulations for the Safe Transport of Radioactive Material, 1973 Edition, Safety Series No. 6). The IAEA also decided to periodically review its transportation regulations, at intervals of about 10 years, to ensure that the regulations are kept current. In 1979, a review of IAEA's transportation regulations was initiated that resulted in the publication of revised regulations in 1985 (Regulations for the Safe Transport of Radioactive Material, 1985 Edition, Safety Series No. 6).

The NRC and DOT also periodically revise U.S. regulations for the safe transportation of radioactive material to make them compatible with those of the IAEA and for other reasons. Compatibility in this regard means the NRC and DOT incorporate aspects of IAEA standards that make their respective regulations similar, but not necessarily identical to, the standards found in TS-R-1. In August 1983, the NRC published in the *Federal Register*(2) a final revision to Part 71, "Packaging and Transportation of Radioactive Material." That revision, in combination with a parallel revision of the hazardous materials transportation regulations of the DOT, brought U.S. domestic transport regulations into general agreement with the 1973 edition of IAEA transport regulations. The last revision to Part 71 was published on September 28, 1995(3) , to make Part 71 compatible with the 1985 IAEA Safety Series No. 6. The DOT also published its corresponding revision to Title 49 on the same date(4).

The last revision to the IAEA Safety Series No. 6 was named Safety Standards Series ST-1, published in December 1996, was revised with minor editorial changes in June 2000, and was re-designated as TS-R-1. This current rulemaking effort by the NRC is to evaluate TS-R-1 for potential adoption in Part 71 regulations.

Historically, the NRC has co-ordinated its Part 71 revisions with DOT, because DOT is the U.S. Competent Authority for transportation of hazardous materials. "Radioactive Materials" are a subset of "Hazardous Materials" in Title 49 regulations under DOT authority. Currently, DOT and NRC co-regulate transport safety for radioactive material within or through the Unites States. NRC is continuing with its co-ordinating effort with DOT in this rulemaking process.

4. Scope of 10 CFR Part 71 rulemaking

To start the TS-R-1 compatibility rulemaking, the NRC compared TS-R-1 to the previous version of Safety Series No. 6 to identify changes made in TS-R-1, and then identified affected sections of Part 71. Based on this comparison, the NRC identified eleven areas in Part 71 that needed to be addressed in this rulemaking process as a result of revisions in the IAEA standards.

The Part 71 rulemaking is being co-ordinated with DOT to ensure that consistent regulatory standards are maintained between NRC and DOT radioactive material transportation regulations and to ensure co-ordinated publication of the final rules by both agencies. In December 1999, the DOT published in the *Federal Register*[5] an advance notice of proposed rulemaking regarding adoption of ST-1 in its regulations.

The following list indicates the IAEA-related Issues that are included in the revision to Part 71:

Issue 1 Changing Part 71 to the International System of Units (SI) Only – The NRC proposed to not adopt this provision. NRC proposed to continue to use a dual-unit system (metric and customary) in Part 71.

Issue 2 Radionuclide Exemption Values – The NRC proposed to adopt the radionuclide exemption values to assure continued consistency between domestic and international regulations for the definition of radioactive material. The individual radionuclide exemption values will replace the single 70 Bq/g value currently associated with transportation of radioactive material.

Issue 3 Revision of A_1 and A_2 – The NRC proposed to adopt the new A_1 and A_2 values from TS-R-1. This would be consistent with TS-R-1 and based on IAEA's Q-System[6]. Some exceptions for domestic transport of molybdenum-99 and californium-252 are also proposed.

Issue 4 Fissile Uranium Hexafluoride Package Requirements – The NRC proposed a specific exception for UF_6 that would supercede the general exception that allows one to consider special features in criticality evaluations. The net effect is that the status quo will not change and water moderation will not be required for UF_6 packages that demonstrate special features (e.g., no contact between the valve body with the cylinder body under accident tests, and quality controls in place to demonstrate closure of the package prior to shipment). However, the exception was proposed to be limited to 5% or less enrichment.

Issue 5 Introduction of the Criticality Safety Index Requirements – The NRC proposed to adopt the Criticality Safety Index (CSI) for fissile material packages. The current radiation transport index (TI) would remain unchanged. However, the current definition of Transport Index would be split to address the radiation control (TI) and the transport index for criticality control (CSI).

Issue 6 Type C Packages and Low Dispersible Material – The NRC proposed to not adopt the Type C package and Low Dispersible Material provision in Part 71. The NRC is not aware of a need for Type C packages for domestic commerce, thus no provision was viewed as needed in Part 71. However, NRC will be able to review revalidation requests to TS-R-1 requirements.

Issue 7 Deep Immersion Test – The NRC proposed to adopt the deep immersion test requirement in Part 71 for packages with contents greater than 10^5 A_2. Thus, the existing provision for irradiated fuel at greater than 37 PBq would be removed and replaced with the 10^5 A_2 for all radioactive material.

Issue 8 Grandfathering Previously Approved Packages – NRC proposed to adopt the provision to discontinue use of those packages approved to the Safety Series No. 6 (1967) standards. NRC proposed to adopt this provision 3 years after issuance of the final rule. Thus, those packages designated as B( ) would be phased out over time.

Issue 9 Changes to Various Definitions – NRC proposed to adopt the definitions of Criticality Safety Index (CSI) from TS-R-1. Additionally, new definitions would also be added that are specific to the other Issues in the proposed rule.

Issue 10 Crush Test for Fissile Material Package Design – The NRC proposed to adopt the crush test for fissile material packages, and eliminate the 1,000 A_2 provision for fissile materials.

Issue 11 Fissile Material Package Design for Transport by Aircraft – The NRC proposed to adopt the provisions for transporting fissile material by air by incorporating the criticality evaluation for fissile material into Part 71.

In 1997, the NRC adopted the TS-R-1 fissile exceptions in Part 71. This action was prompted by criticality concerns for beryllium-bearing former weapons material being transported. The U.S. experience with the fissile exceptions has been that the consignment mass limit unnecessarily restricts transport of material that should be fissile exempt. The NRC proposed an alternate system based on the fissile-to-nonfissile mass ratios in the 2002 proposed rule.

Currently, NRC is co-ordinating with DOT on the details of the process for final rule promulgation. Current plans are to publish final rules in mid to late 2003. In the mean time, international commerce will not be affected, because U.S. DOT regulations permit use of current TS-R-1, International Maritime Organization, and International Civil Aviation Organization requirements for imports, exports, and transshipments.

5. Summary

The NRC is proposing to revise its regulations in 10 CFR Part 71 to be compatible with the IAEA's standards found in TS-R-1. Compatibility does not mean, however, that the United States requirements will be identical to TS-R-1. The NRC and DOT share responsibility for regulating the packaging and transportation of radioactive material. Therefore, the NRC and DOT will work together to ensure compliance between each agency's respective requirements.

References

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3. Federal Register (60 FR 50248; September 28, 1995).
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6. Advisory Material for the Regulations for the Safe Transport of Radioactive Material (1996 Edition) IAEA Safety Standards Series No. ST-2 Appendix I; February 19, 1999 Draft.

COMPLIANCE WITH REGULATIONS THROUGHOUT THE WORLD

F.M. Killar

Nuclear Energy Institute
1776 I Street Northwest, Suite 400
Washington, DC 20006,
United States of America

Abstract

One of the most difficult issues to resolve for shippers and other users of IAEA Safety Standards Series "Regulations for the Safe Transport of Radioactive Materials" (TS-R-1) are the differences of interpretations of TS-R-1 by the various Competent Authorities. For the most part this does not create impediments to transportation of radioactive materials, but it does result in some delays and higher cost for international shipments. The purpose of this paper is to present a proposal for a standard format and review process, including performance criteria for packaging. There are three benefits of this approach. First, the standard would place each aspect of the package into a consistent format with consistent performance criteria. Secondly, by including acceptance criteria, with the format, each package requirement will have an established expectation that the designer of the package can use as a means to assure the justification is adequate to meet the Competent Authority's regulatory requirement. The additional benefit is if a Competent Authority may want to impose a more restrictive requirement; this could be spelled out in the specific area. Therefore, when a shipper wishes to use a package approved by a different Competent Authority, the shipper will know any additional justification that may be required. Once it is completed, it would be available for other users. The third benefit is this would set the minimum standard for technical competent of the review by a Competent Authority. By having established acceptance criteria for each aspect of the package, all packages will receive a consistent review prior to approval. The balance of the paper provides an overview of the proposed standard format and content along with the acceptance criteria.

1. Introduction

Different interpretations of the IAEA's TS-R-1 *Regulations for the Safe Transport of Radioactive Materials* by national Competent Authorities are delaying and unnecessarily increasing the costs for international shipments of radioactive materials. If Competent Authorities would adopt a standard process for reviewing a package's performance data and for issuing Certificates of Compliance, a far more uniform application of TS-R-1 would result. Adoption of a standard format for presenting package performance data, testing methods, performance (and regulatory) standards against which the package was tested, and performance acceptance criteria would greatly expedite package certification. Specific information important to either a shipper, who must ensure that the contents of a package are compatible with its specifications, or to a Competent Authority from whom a Certificate of Compliance is sought would always be reported in a standard format and could be easily located even if written in a foreign language. A common format would also provide a means to ensure that all aspects of the package have been considered, even if some criteria are inapplicable. The following benefits will be realized through adoption of a universally accepted, standardized approach.

Package Certification: Presentation of performance data in a standard format would facilitate certification of a package by Competent Authorities other than that which issued the original Certificate of Compliance. A standard format would assist review staff to easily reference the performance acceptance criteria originally used to certify the package and determine if they meet the country's own regulatory performance standards. It would also assist both inspectors in checking shipment documentation and shippers in ensuring the compatibility of a package's contents with its specifications. Adoption of an internationally accepted standard format for package performance data would reduce the time and costs for certification by presenting pertinent technical data in a readily accessible manner and thereby by reducing the number of requests for additional information from the package manufacturer. Some shippers now include an index with package certification applications simply to cross-reference the locations of performance data on different forms used by different Competent Authorities. Introduction and adoption of a universally accepted format for package performance data would likely require a five-year transition period. As packages are generally approved for five years, upon submission of a Certificate of Compliance renewal application, the supporting documentation could be presented in the new standard format.

Uniformity of Certification Reviews: Inclusion of performance acceptance criteria in the standard form will enable package designers to clearly understand the regulatory requirements against which the Competent Authority will judge the package performance data. Standard acceptance criteria will provide a common basis for Competent Authorities to uniformly review package certification applications and enhance public confidence by demonstrating that a consistent level of safety is being maintained. Should a Competent Authority impose more restrictive requirements for certification, these may also be specified on the standard format document. Thus, whenever a shipper plans to use a package certified by one foreign Competent Authority for transport in another country, the shipper could immediately establish what additional justifications might be required to enable its use. Once the package performance has been reviewed and accepted by the foreign Competent Authority, this acceptance could also be included in the standardized package documentation.

Reciprocity of Certification Simplification: Adoption of a uniform set of package acceptance criteria will facilitate international shipments by setting minimum standards for the technical review of packages by Competent Authorities. By establishing acceptance criteria for each performance specification, all packages should receive consistent technical reviews in support of application for a Certificate of Compliance. Multiple technical reviews are often now required by Competent Authorities for use of the identical package in different countries and this unwillingness of one Competent Authority to accept the certification granted by another simply increases the costs for package reviews and approvals and, ultimately for the international shipment of radioactive materials. Adoption of an internationally accepted, common set of package performance acceptance criteria would save shipper and Competent Authority resources, facilitate reciprocity in the acceptance of other Competent Authority certifications and allow regulators to focus on truly important safety issues. By using common acceptance criteria, any deficiencies noted in one Competent Authority's review could be identified and remedied and thereby assist all Competent Authorities to work to the same level of safety.

2. Standard review plan

Internationally accepted package performance acceptance criteria and a standard format for reporting performance results would be facilitated by preparation of a Standard Review Plan document that would address each facet of package technical review. An eight-chapter guidance is foreseen that would include the following chapters and contents:

Chapter 1: General Package Information: this chapter would present general information such as the package description, regulatory requirements, acceptance criteria and review procedures.

Chapter 2: Package Structural Integrity: this chapter would include information on topics such as the structural design, materials of construction, descriptive information on weight and center of gravity, material properties and specifications, prevention of chemical, galvanic or other reactions, effects of radiation on materials, exterior and internal pressure considerations, test performance (water spray, free drop, crush, corner drop), structural evaluation under hypothetical accident conditions.

Chapter 3: Thermal Effects: this chapter would include information on topics such as description of the package thermal design, material properties, thermal evaluation under normal conditions of transport and hypothetical accident conditions, contents decay heat, tables of temperatures, and maximum pressures in the containment system, maximum thermal stresses, fire test conditions, description of test facilities, and test descriptions.

Chapter 4: Containment Properties: this chapter would include information on topics such as description of containment system, containment under normal conditions of transport (Type A and B packages) and under hypothetical accident conditions (Type B Packages), leakage rate tests for Type B packages, requirements for plutonium, combustible gas generation.

Chapter 5: Package Shielding: this chapter would include information on topics such as a description of shielding design and models, shielding evaluation, maximum radiation levels, gamma and neutron sources, configuration of source and shielding, material properties, flux-to-dose-rate conversion, transport index, external radiation levels.

Chapter 6: Criticality Safety Evaluations: this chapter would include information on topics such a description of criticality design, fissile material contents, evaluation of single package and package arrays under normal conditions of transport and under hypothetical accident conditions, benchmark evaluations, summary of criticality evaluations, Criticality Index, model configuration, computer codes and cross-section libraries, demonstration of maximum reactivity, confirmatory analyses, applicability of benchmark experiments, bias determination.

Chapter 7: Shipping Procedures: this chapter would include information on topics such as package loading, package unloading, preparation of empty package for transport, preparations for loading, loading of contents, preparation for transport, receipt of packages from carrier, removal of contents.

Chapter 8: Acceptance Tests and Maintenance Program: this chapter would include information on topics such as a preventive maintenance program, visual inspections and measurement, weld examinations, structural and pressure tests, leakage tests, component and material tests, shielding tests, thermal tests.

The Standard Review Plan could include a series of appendices to address specific package types such as radiography packages, Type B waste packages, unirradiated fuel packages, low enriched uranium oxide packages, transuranic waste packages, low enriched uranium hexafluoride packages, high enriched uranium or plutonium packages, and Type B special form packages.

3. Conclusions

Adoption of an international standard for the review and certification of transportation packages and for the reporting of performance data would be very beneficial to Competent Authorities and shippers. Consistent formats and acceptance criteria would lead to better utilization of resources and improve overall package safety. Such an internationally accepted standard should be developed by means of a Standard Review Plan that would include chapters on the package description, structural integrity, thermal protection, containment characteristics, shielding, criticality safety and maintenance programs.

Acknowledgement
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EFFECTIVENESS OF THE IAEA TRANSPORT REGULATIONS – *Implementation Issues for Nuclear Fuel Cycle Materials*

W.L. Wilkinson

World Nuclear Transport Institute (WNTI)
6th Floor, 7 Old Park Lane, London,
United Kingdom

Abstract.

The IAEA "Regulations for the Safe Transport of Radioactive Material" (TS-R-1) developed principles to ensure the safety of transport of radioactive materials, which were then included in regulations covering different forms of transport, thus ensuring a uniformity of regulation. TS-R-1 provides for harmonisation of transitional arrangements which allow existing packages to continue for a reasonable time, time schedules for implementation, validation of package designs, harmonising differing national regulations, labelling of packages, test sequencing, criticality safety analyses, radiation protection programmes. Overall, the experience of operating with TS-R-1 has been positive, and this is expected to improve as more experience is accumulated.

1. Introduction

Nuclear power has been providing clean, affordable electricity in many parts of the world for nearly half a century. Nuclear power now generates electricity in 32 countries and supplies over 16% of the world's electricity demand. It will continue to play a major role in meeting the world's increasing need for electricity and reducing carbon dioxide emissions without putting undue stress on the environment. The national and international transport of nuclear fuel cycle materials is essential to support this activity.

The IAEA "Regulations for the Safe Transport of Radioactive Material" (TS-R-1) developed principles to ensure the safety of the transport of radioactive materials. These regulations are then embodied in the international modal regulations; namely, the International Maritime Dangerous Goods (IMDG) Code for sea transport, the International Civil Aviation Organisation (ICAO) Technical Instructions for air transport, and the regional modal regulations, ADR and RID, for road and rail transport in Europe. They also are reflected in the regulations of national authorities. This system provides a uniform basis for regulation, and has ensured the safety of radioactive material transport for many years. The transport of radioactive materials is becoming increasingly international. As a result, the importance of maintaining consistency of interpretation and application of international regulations is also increasing. It is essential to ensuring that transport is safe, efficient and reliable that there is stability in regulations, and that the regulations are clearly understood, interpreted and applied consistently in several jurisdictions, and introduced with harmonised implementation dates.

Consistency and predictability of implementation not only assist in ensuring safety through compliance with the regulations, but also facilitate international movements. Although it is important to preserve the prerogatives and responsibilities of the national and international jurisdictions to implement the IAEA transport safety principles as deemed appropriate to particular circumstances and requirements, differences in interpretation and implementation can lead to duplication of effort, delays in obtaining approvals and inefficiencies both in the industrial organisations involved in radioactive transport and in national authorities.

To date, industrial transport organisations have generally had good experiences in working with the new IAEA Transport Safety Regulations (TS-R-1). Valuable lessons are being taught by operating within the TS-R-1 regime.

2. Experience with IAEA "Regulations for the Safe Transport of Radioactive Material"

2.1. Issues arising from the introduction of the 1996 edition of the IAEA transport regulations

2.1.1. Classification and labelling of packages

TS-R-1 Regulations require that packages are marked with a UN number and a proper shipping name. Implementing these requirements for international transport when some packages have different certificates in different countries can cause complications. For example, one competent authority may approve a package design as a Type B(U), and another may approve it as Type B(M), and it can therefore be necessary to assign different UN numbers. This causes problems at international borders where markings would need to be duplicated or changed.

2.1.2. Radiation protection programmes

TS-R-1 requires transport organisations to implement radiation protection programmes (RPPs) to control radiation dose exposure. Analysis of existing data on dose uptake for the transport of nuclear fuel cycle materials carried out by the World Nuclear Transport Institute (WNTI) has shown that it is unlikely that any worker or member of the public will receive annual radiation doses in excess of 1mSv, which is less than one third of the annual dose which most people receive from natural sources. Below this level, no individual dose monitoring will be required. Attention is being given to the preparation of RPPs by organisations in the transport chain. No significant problems have emerged, but transport organisations whose main business is not concerned with nuclear material transport need help and advice which the nuclear industry is providing where necessary.

2.2. Issues arising from the transition between two sets of regulations

2.2.1. Transitional arrangements

The transitional arrangements (grandfathering) provided by TS-R-1 to allow those existing packages which are properly maintained and meet their original design intent to continue to be used for a reasonable period after the new regulations come into force appear to be working satisfactorily. Stability in package approvals is important to ensuring safe, efficient and reliable transport.

2.2.2. Time schedules for introduction of new regulations

Implementation of the TS-R-1 Regulations for sea, air, road and rail transport by the modal organisations did not take place simultaneously and, for some time, both the old and the new regulations were in operation. Efforts by the IAEA and the modal organisations to harmonise implementation dates have been generally welcomed.

2.3. Issues arising from the uniform implementation of the regulations

2.3.1. Validation of package designs

A multilateral package design approval issued in one national jurisdiction is subject to validation in other jurisdictions where the package might also be used. Consistent interpretation of regulatory requirements, and close co-operation between industry and national competent authorities, and between competent authorities in different jurisdictions can help to clarify understandings and approaches, and potentially simplify and expedite the validation process.

2.3.2. Sequencing of tests

It is a basic principle that safety principally resides in the package. The IAEA Regulations specify rigorous tests to demonstrate the ability of packages to withstand accident conditions of transport. For example, the mechanical drop tests in the IAEA Regulations specify that the order in which the specimen is subjected to the drops shall be such that, on completion, it shall have suffered such damage as will lead to the maximum damage in the thermal test which follows.

A standardised understanding of what constitutes the most damaging orientations of the specimen package under test, or a specified sequence of tests, can assist in expediting validation of package approvals from one jurisdiction to another.

2.3.3. Criticality safety analyses

National authorities carry out independent reviews of the criticality safety of packages containing fissile material to ensure that critical excursions cannot occur. A single design may require the preparation of multiple criticality analyses to obtain base approval and foreign validations. Co-operation between and among industry and competent authorities can assist in assuring greater uniformity in criticality safety standards and also allow the development of generic safety cases where this is feasible.

2.3.4. Uniform implementation of regulation

The IAEA Regulations have been very successful in ensuring the safety of radioactive material transport, and it is important that they continue to provide the common basis for regional, national and modal regulations. The nuclear transport industry is fully committed to meeting its obligations within the international transport safety regulatory regime, and is working to ensure it meets all TS-R-1 and related requirements. The safe, efficient and reliable international transport of radioactive materials is enhanced to the extent that the regulations are implemented in a uniform way in all countries.

3. The way forward

The experience of the nuclear transport industry with operating within TS-R-1 has been positive, and this is expected to improve as accumulating experience and continued dialogue between stakeholders allow for improved understandings of requirements. Those issues which have arisen have related principally to differences in interpretation of the regulations by the modal organisations and competent authorities coupled with different time schedules for implementation. Such differences take on added importance in the context of the increased frequency of IAEA regulation review. Accordingly, a holistic strategy to ensure that regulations are implemented in a consistent and predictable fashion can go a long way to enhancing safe, efficient and reliable transport of radioactive materials.

To improve and facilitate this uniformity, the industry is seeking opportunities to increase dialogue with key intergovernmental organisations, including modal organisations and national competent authorities collectively, to encourage further co-operation and co-ordination to reduce differences in the interpretation and implementation of regulations. This is important not only from the point of view of safety, but also to avoid unnecessary duplication of effort for all concerned, and to reduce time-scales for approvals which can seriously disrupt international transport operation.

TRANSPORT REGULATIONS OF RADIOACTIVE MATERIALS IN ALBANIA

K. Dollani, J. Mbrica, L.Qafmolla

Institute of Nuclear Physics,
Tirana, Albania

Abstract.

The submitted paper aims to represent the efforts of the national competent authorities for providing a safe transport of radioactive materials in the country. Based on the IAEA publications and national experience, last year a draft regulations was prepared by Albanian specialists in co-operation with foreign experts. The main articles of the draft and the actual practice of the transport are described in the paper. This draft is foreseen to be approved by the National Radiation Protection Commission in the first half of this year.

1. Introduction

Albanian authorities had paid a special attention to the questions related with the safe transport of radioactive materials since the first issuing of the governmental ordinance on safe handling of the radiation sources [1]. There were defined special rules for the transport in accordance with provisions of the IAEA Safety Series Publication No.6 and categorization of the packages was based on the dose rate at their surface as well at 1 m distance. The responsibilities of the different parts involved in the process of the transport were described along with safety measures of this kind of transport. Special duties were foreseen also for the customs authorities related with the import of radioactive materials, which at that time was centralized by the Institute of Nuclear Physics for all country.

New Albanian Radiological Protection Act [2] adopted after ICRP Publication 60, has vested the National Radiation Protection Commission (NRPC) with the rights to approve the regulations for the different aspects of radiation safety, including the safe transport of radioactive materials inside the territory of Albania.

Two years ago a special group was formed for preparations of a draft regulations for the transport. Last year the draft was prepared and consultancy with foreign expert was provided through IAEA. Regulations consider new development in the safe transport process, described in the Regulations for the Safe Transport of Radioactive Materials, issued by the IAEA as Publication TS-R-1 [3].

2. Safe transport regulations

The new safe transport regulations are composed of fourteen articles, which describe in detail the provision related with this kind of the transport. Article 1 requires the obligation of the licensing of the legal persons engaged in the transport of radioactive materials by NRPC. The transport of the radioactive materials is carried out after approval and issuing of the special permission by NRPC.

The definitions related with the transport are described in Article 2, such as A_1 and A_2 values, carrier, consignor and consignee, low specific activity material, special form radioactive material, surface contaminated object, transport index etc. Article 3 describes radioactive materials, for which the transport regulations do not apply. Such materials are consumer products, natural ores containing radionuclides with activity concentration, which do not exceed 10 times the values of exempted limits.

Classification of the transport packages is done in accordance with IAEA documents and namely as excepted packages, industrial packages (LSA and SCO), type A packages and type B(U) and B(M) packages. This classification is related to the qualities and quantities of radioactive materials that shall be transported and to the requirements that they ought to fulfil for preventing or mitigation the consequences of normal or accident conditions of the transport that can be occurred during the shipment.

Article 5 describes the values of non fixed contamination on the external surface of the packages, which shall kept as low as practicable and shall not exceed 4 Bq/cm^2 for beta, gamma and low toxicity emitters and 0,4 Bq/cm^2 for all other alpha emitters. The contamination assessment shall include the package, the vehicle, the adjacent loading and unloading area. If necessary the replacement of the package is performed.

The radiation level limits, which are applied to packages and to vehicles, are described in Article 6. The radiation level for industrial, type A and type B packages shall not exceed 2 mSv/h at any point of external surface of the packages. The accumulation of the packages in a single vehicle shall be such that the radiation level under routine condition of the transport shall not exceed 2 mSv/h at any point and 0,1 mSv/h at 2 m from the external surface of the vehicle.

Each packages, other than the exempted ones, in accordance with Article 7, shall be assigned to one of the three following categories: I-White, II-Yellow and III-Yellow, taking into account both the surface radiation levels and the transport index. The values of the maximum radiation level on the external surface of the packages and of the transport index for mentioned categories are the same with the value recommended by IAEA documents.

Article 8 describes the rules for labelling the packages and the vehicle for the transport of the radioactive materials. Trefoil symbol and other recommended ones, such the orange placard indicating the UN number for the radioactive material transport shall be used for labelling purposes.

The supervision of the process of the loading of the radioactive materials, the transport itself and the down loading by a qualified person on radiation protection matter as an obligatory requirement is described in Article 9.

Article 10 urges the prohibition the transport of the radioactive materials along with other dangerous materials or foods, with undeveloped photographic films and other light sensitive materials.

The transport documentation for accompanying the shipment of radioactive materials is described in the Article 11. This documentation follows the recommendations of IAEA such as the proper shipping name, the name and symbol of each radionuclide, the activity of the radioactive material in the package, the category of the packages, the transport index, the identification mark of competent authority approval certificate applicable to the shipment etc.

The last articles are related with certificate requirements, the customs offices obligations for arrangement of radioactive materials in a special protected area and the necessary steps for clearance purposes.

All provisions described in the Radiological Protection Act as well in the regulations on the safe handling of radioactive materials are valid for activities carried out during the process of radioactive material transport.

In case of accident during the transport of radioactive materials are applicable the provisions of the Emergency National Plan.

There are some appendices of the regulations: the values of A_1 and A_2 for different radionuclides, the exempted total activities and activity concentrations, category packages labels, the placard etc.

3. Transport actual practice and its improvement

The transport actual practice of the radioactive materials in the country is regulated based in the mentioned old regulations. Nevertheless some new provisions are inserted in the daily practice of the national authorities aiming the improvement of the transport process toward its safety and security. At the moment there are two licensed carriers in the country, including the Institute of Nuclear Physics, for carrying out the transport of the radioactive materials.

The national competent authorities issue the special requirements, related with transport of radioactive materials, which ought to be fulfilled by the carriers as well by the legal persons, through contracts with transport companies, providing a safe transport process inside the country. For each transport, the consignor ought to notify by writing the authorities for the quantities of radioactive materials, the carrier and other details related with the transport process.

For imported radioactive materials, a special permission issued by NRPC is needed by legal person for goods clearance purpose along with his commitment for respecting the contract for transport process.

All mentioned measures are intend for further improving the radioactive materials transport process. It is hoped that after approval of the regulations by NRPC and through their implementation into the practice, to have in the country a more controlled, safe and secure situation in the transport of radioactive materials, always in accordance with new requirements and practice of the international bodies and organizations.

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ANALYSIS FOR THE EXEMPTIONS FROM SOME MODAL REGULATORY REQUIREMENTS FOR CERTAIN CONSIGNMENTS OF RADIOACTIVE MATERIALS

N. Capadona*, J. López Vietri*, R. Novo, E. Piumetti***

* Department of Radiation and Nuclear Safety,
Transport of Radioactive Material Unit, Nuclear Regulatory Authority,
** Institutional Relations, Nuclear Regulatory Authority
Argentina

Abstract.

Within the framework of the legal structure to regulate the transport of the radioactive material in Argentina, this paper analyses the need and convenience to exempt certain consignments of radioactive materials from some modal regulatory requirements without any impact on the level of safety.

1. Regulation of the transport of radioactive material by road in Argentina

As is true in other countries, in Argentina there is extensive use of radioactive material in medicine, agriculture, industry, investigation and electricity generation, which implies its transportation on public roads. The Argentine Nuclear Regulatory Authority (*Autoridad Regulatoria Nuclear, ARN*) is the government organisation that is in charge of the regulation and control of the transport of radioactive materials in what has to do with radiological and nuclear safety, safeguards and physical protection [1]. The objective is to ensure an adequate protection to persons, property and the environment from the inherent risks associated to radioactive material, as well as to ensure that it be not deviated from its pacific use.

The specific Regulatory Standard to be applied is AR 10.16.1 Transport of Radioactive Material [2] (*Transporte de materiales radiactivos*), which coincides in everything stated in the 1996 Edition (Revised) of the IAEA "Regulations for the Safe Transport of Radioactive Material" (TS-R-1) [3], document which is used by nearly all the international community.

Considering the many motives that justifies international prestige of IAEA's Transport Regulations, one which must be underlined is the following: the basis for the protection against ionising radiation is the limitation of the radioactive contents of a packaging as a function of its performance to face different situations of transport. This implies that the level of safety is focused on the performance of the package and the requirements are minimal regarding the vehicle or the driver. This concept responds to that known as intrinsic or by design safety.

To say it in other words, the basis for the AR10.16.1 Regulatory Standard is to limit the radioactive contents in the case of packages of intermediate resistance capable of withstand the usual mistreatment during transport, in such a way as to have under control the potential radiological consequences of an eventual accident. On the other hand it requires that the package that transports radioactive material which exceeds those limits, must withstand very severe transport accident conditions without losing its radiation shielding and containment systems function.

In relation to normal transport conditions, Regulatory Standard AR.10.16.1 establishes maximum values for the radiation levels surrounding the package and vehicle and for radioactive surface contamination. It also establishes requirements for the marking, labelling and placarding of packages, containers and vehicles, and determines the specific obligations of the consignor with regard to the preparation of the transport documentation, the information to be given to the carriers and the notification to the competent authorities in the cases where it is indicated. To complete the summary it must be underlined that it establishes the fulfilment with the internationally consented fundamental principals of radiological protection, quality assurance and response to emergency conditions.

The requirements of IAEA's Transport Regulations, as was stated before, coincide absolutely with those of the Regulatory Standard AR 10.16.1, and were adopted without exception by the national and international legislation for the transport of dangerous goods by all modes of transport, i.e. road, rail, maritime, fluvial and air [4] [5].

This is the case of the General Regulations for the Transport of Dangerous Goods by Road in Argentina [6] (*Reglamento general para el transporte de mercancías peligorsas por carretera*), whose application, fiscalization and control lies within the National Secretary of Transport and the National Commission of Transport Regulation. This regulation is expressed in the framework of the National Law on Traffic and Road Safety, Act. No. 24.449 [7] (*Ley Nacional del Tránsito y Seguridad Vial)*, its Regulatory Decree No. 779/95 and Resolution No. 195/97.

It seems important to remark that the requirements established by the General Regulations for the Transport of Dangerous Goods by Road in Argentina are based on the Recommendations on the Transport of Dangerous Goods of the United Nations [8].

2. Analysis for the exemptions from some modal requirements for the transport of certain consignments of radioactive material.

As well as adopting all the requirements of Regulatory Standard AR 10.16.1 for the radioactive materials, the General Regulations for the Transport of Dangerous Goods by Road of the National Secretary of Transport includes others which focus on controlling general safety aspects other than radioactive and nuclear safety, and which are common to the transport of all dangerous goods, like those referred to the licensing of transport companies and drivers involved in the bulk transport of these goods.

For example, on a daily basis, a huge amount of goods which belong to the list of dangerous substances that figure in the General Regulations for the Transport of Dangerous Goods by Road of the National Secretary of Transport, are transported to supply homes. That is the case of domestic insecticides and pesticides, chemical substances that form part of most of the cleaning products, pressurised liquid gases, etc. Nevertheless, these shipments are safe even without fulfilling the specific requirements of any regulation for the transport of dangerous goods. This is so because every regulation establishes exemption levels so that it may be applied rationally. The General Regulations for the Transport of Dangerous Goods by Road of the National Secretary of Transport does not have any exemptions for radioactive material, and that is just the question that this analysis hopes to broach.

There exists certain types of shipments that because of their nature and magnitude present such a low radiological risk that the requirements established by the General Regulations for the Transport of Dangerous Goods by Road in addition to those of the Regulatory Standard AR 10.16.1, do not contribute to improve significantly the level of safety in relation to the substantial increase of resources needed to satisfy them.

That is the case of the consignments of radioactive material that:

a) have no fissile material involved, and
b) are made up of only one radionuclide whose total activity does not exceed one tenth of the A_1 or A_2 values given in Table I or Paragraphs 402 and 403 of the Regulatory Standard AR 10.16.1, depending if one is dealing with radioactive material in special form or not respectively, or
c) when they are made up of a mixture of known radionuclides and the total activity does not exceed a tenth of the value of A_1 or A_2, derived according to paragraphs 404 and 405 of the Regulatory Standard AR 10.16.1, depending if one is dealing with radioactive material in special form or not respectively, or
d) when the total mass does not exceed 10 kg, when it is only one radionuclide or when it is a mixture of radionuclides for which each A_2 has no limit.

The consignments that present these characteristics and that are transported according to the Regulatory Standard AR 10.16.1 present the following scenarios, whose characteristics were derived from basic principles established by the IAEA Advisory Material TS-G.1.1[9]:

i) Under normal conditions of transport the requirements of the Regulatory Standard AR 10.16.1 are sufficient so that the radiation doses to workers and public are within the consented principles of radiation protection which are applied by all the international community.

ii) In the case of an accident, and assuming the total collapse of the package, the most exposed individual in a realistic scenario, would receive a radiation dose equal to the one if this same individual would receive if he were to be submitted to two abdominal radiological studies, or from another point of view, a dose ten times below that allowed in a year by a worker in the nuclear field.

These situations permit to infer that any requirement imposed to these consignments, in addition to those established by the Regulatory Standard AR 10.16.1, such as those referring to a specific licensing for vehicles and drivers for the transport of dangerous goods, not only do not result in a significant increase in the safety level, but are also an inconvenience. As was mentioned before, the increase in safety is insignificant when compared to the increase in the necessary resources for the transport and specifically to the drastic reduction of the number of available vehicles and drivers.

This results in a strong negative impact on the costs and time involved in the transport of a substantial number of consignments of small radiation sources used in medicine, industry and research. In particular, this situation is worse in the case of the distribution of radioisotopes for medical use to the interior of the country, specially in those places were regular commercial flights do not exist. In such cases, the need to take into account the radioactive decay of the radioisotopes (in some cases only hours) and the scarce availability of specifically licensed vehicles for the transport of dangerous goods may make the provision of vital material difficult or impossible.

3. Conclusion

For consignments such as described in section 2 of this paper, discussions with the National Secretary of Transport are being carried out in order to exempt them from complying with those requirements of the General Regulations for the Transport of Dangerous Goods by Road in addition to fulfilling the requirements of the Regulatory Standard AR 10.16.1.

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REGULATORY CONTROL AND TRANSPORT OF RADIOACTIVE MATERIALS – BANGLADESH PERSPECTIVE

M.M. Rahman

Nuclear Safety and Radiation Control Division
Bangladesh Atomic Energy Commission
4 Kazi Nazrul Islam Avenue, Ramna, Dhaka-1000
Bangladesh

Abstract.

As an economically challenged country, Bangladesh, still has limited amount of transport of radioactive materials and their wastes which are, of course, increasing steadily. Bangladesh Atomic Energy Commission (BAEC), by Nuclear Safety and Radiation Control (NSRC) Act (1993), has been conferred all necessary powers for regulatory control of all kinds of transportation of radioactive material, nuclear material or any prescribed substance and their waste. Accordingly, on that legal basis, adequate provisions have been incorporated in the NSRC rules (1997) to comply with IAEA transport regulations. As national guides for transportation of radioactive materials and their wastes are still underway, BAEC has adopted applicable IAEA standards, codes and guides set forth in this regard. Certain methodologies have been established for controlling the transport of radioactive materials in the country depending on the nature and practice of organizations using and transporting them. Mainly, category III-YELLOW packages of radioactive materials are transported in Bangladesh. Types of packages of radioactive materials associated with different conditions of transport are few. Close monitoring of regulations for safe transport of radioactive materials is being accomplished through inspection, supervision, training as well as providing licenses for this purpose. So far no reportable incident has occurred in the country in respect of transportation of radioactive materials. BAEC has established full control over all kinds of transport of radioactive materials and their wastes.

1. Introduction

As an economically challenged country, Bangladesh has comparatively less use of radioactive materials. The uses are limited to non-destructive testing, well logging, nucleonic gauges, and radioisotopes for medical purposes and food irradiation. However, the use is presently increasing steadily. IAEA regulations for safe transport of radioactive materials have been adopted through legislation in our nuclear safety and radiation control (NSRC) rules (1997). The NSRC rules state the manner for regulatory control and specifies schedule by which license has to be obtained for transport of radioactive materials. Conventional guidelines for safe transportation of dangerous goods are also being followed. Bangladesh Atomic Energy Commission (BAEC) is acting the role of competent authority for controlling the safe transport of radioactive materials. Different methodologies are used for their transport depending on the categories of users and practices carried out with the radioisotopes and radioactive materials. Packages conforming to category II-YELLOW and category III-YELLOW of radioactive materials having wide variety of activities and contents are generally transported in Bangladesh, mainly, for medical and industrial uses. Types of packages are limited.

2. Legal Basis

In Bangladesh, there are two legal instruments to regulate nuclear and radiological practices including transport of radioactive materials and radioisotopes. These are stated below:

1. Nuclear Safety and Radiation Control (NSRC) Act-1993 (Act No. XXI of 1993)
2. Nuclear Safety and Radiation Control Rules-1997 (SRO No. 205- Law/97).

2.1. Radiation Safety and Radiation Control Act

It took considerable time to establish legal basis for the control of uses of nuclear energy and radiological practices in the country. After long and concerted efforts, the Nuclear Safety and Radiation Control Act (NSRC) Act (NO. 21 of 1993) was promulgated on July 22, 1993 " to provide for ensuring nuclear safety and radiation control" in the country. The act confers all necessary powers to BAEC to regulate uses of atomic energy, radiological practices and the management of radioactive wastes.

2.2. Nuclear Safety and Radiation Control Rules

Pursuant to section 16(1) of the NSRC Act, BAEC formulated draft rules in 1995. The rules, after review of concerned Ministries and Establishments and necessary vetting from Ministry of Law, Justice and Parliamentary Affairs were notified in the Bangladesh Gazette on September 18, 1997. The rules are quite comprehensive for the control of radiation sources and radioactive materials in the country.

2.3. Competent Authority

The Bangladesh Atomic Energy Commission (vide Section 3 of the Act), is the Competent Authority for all regulatory control. This provision has been further illustrated in the rules.

2.4. Nuclear Safety and radiation Control Division

The Nuclear Safety and Radiation Control Division (NSRCD) (vide rule 4), is responsible to BAEC for facilitating the implementation of the provisions of the rules.

3. Rules for safe transport of radioactive materials in Bangladesh

NSRC rules has incorporated certain provisions for control and regulate the safe transport of radioactive materials. General requirements are stated for licensing of all practices including transportation in section 10 of the rules. Specific requirements and information to BAEC prior to any transportation are stated in section 86 of the rules. All other applicable transport rules and regulations shall have to be complied with as enforced by the government from time to time. In schedule IX of the rules, references have been made of the applicable standards, codes and guides for transportation of radioactive materials. Penalty clauses have also been incorporated for any breach to comply with the act and rules.

Transportation of Radioactive materials and waste management

The general requirement of NSRC rules of section 86 states that the licensee shall comply with the requirements and applicable standards of IAEA in this regard and shall duly provide required pre-shipment and transport information of any consignment of radioactive materials.

General requirement: The licensee shall comply with the requirements of IAEA safety series No. 6 as amended in 1990 including other applicable standards stated in schedule – IX of NSRC rules (1997) and subsequent amendments of IAEA transport regulations in 1996 (ST-I) and in 2000 (ST-R-I) for the safe transportation of radioactive materials and radioactive wastes.

Information to Commission: The licensee shall provide the Commission that is BAEC, with the required information as specified in the license before the transportation of any consignment of radioactive material, nuclear material or any prescribed substance and their waste at least 30(thirty) days prior to the scheduled date of transportation of the same.

Other applicable rules: The licensee and the vehicle shall comply with all other applicable rules and regulations enforced by the government from time to time.

4. License

The user or any other party on its behalf e.g. C&F (Clearing & Forwarding) agent responsible for transfer of radioactive materials shall have to obtain proper license following the conditions of general requirement and fulfillment of a prescribed form for this particular license.

4.1. General requirement

The general requirements state that the practice shall be justified, application be made in a prescribed form and requisite fee be paid. Further, adequate safety and radiation protection, financial resource, qualified and trained human resource shall be provided and above all, compliance with applicable requirements of the rules shall be met.

4.2. Classification of license

According to the schedule of classification of NSRC rules, Class D license is allocated to transport radioactive material, nuclear material, prescribed substances and their waste. The salient features that are required to be considered for issuance of license are, among others, radiation protection programme, QA programme, emergency response programme, radiation detection and safety related equipment, experience and training of RCO (Radiation Control Officer), description of packages, regulatory authorities approval certificate and administrative control.

5. Methodology for transport of radioactive materials

National guides for transport of radioactive materials are yet to be developed and are currently underway. At present IAEA safety regulations have been adopted in the NSRC rules and are being followed in the country. Several methodologies are being followed for state owned facilities and practices. Again, for supply and transport of radioactive materials state owned facilities are divided into two groups, namely facilities within BAEC and other facilities outside BAEC. Private organizations are treated as separate category. Radioactive sources and radioisotopes are centrally controlled and routinely imported by BAEC from abroad and transported for direct use in different facilities within BAEC. C&F agents are engaged for this transport by maintaining the schedule given by the suppliers. Radioisotopes produced in the laboratory of BAEC are transported to institute of nuclear medicine and different nuclear medicine centers within Dhaka by its own arrangement from radioisotope production division. Specially designed transport vehicle is used for this purpose. For distant transport to different other nuclear medicine centers outside of Dhaka licensed C&F agents play that role. State owned organizations/institutes collect radioactive materials through their respective administrative channels. For import and transport of radioactive materials private organizations, upon consultation with BAEC take all necessary radiation protection programme for safe handling and transportation. All private organizations dealing with radioactive materials have designated RCOs. Every organization, be it a state owned or private, shall have to obtain permit/ license for import and transport of any radioactive materials from regulatory authority. BAEC as regulatory authority has adopted IAEA transport regulations in its NSRC rules. Prior information are required to provide to BAEC regarding any consignment of radioactive materials at least 30(thirty) days before the schedule date of transportation. If it is deemed necessary, BAEC regulators appear to take the control of the consignment to give clearance for transport. Those organizations that lack in trained manpower and necessary radiation protection and detection equipment take helps from BAEC for safe transportation of their radioactive materials.

6. Transport of packages of radioactive materials – experience in Bangladesh

Uses of radioactive materials are still limited in Bangladesh. There are very small-scale productions of radioisotopes here. To fulfill demand most of the radioactive materials are imported from abroad and then transported to different practices and facilities in the country. No package is designed, fabricated and usually tested. The regulatory authority upon receiving the copy of shipping documents in advance verifies the information. Upon arrival the authority, for regulatory control, checks the packages for its marking, labeling, etc. to ensure proper category of the package and activity and contents in it. Parameters like transport index, maximum radiation level on external surface, corresponding UN number with proper shipping name, type of package are ascertained for satisfactory compliance of the requirements and limits of transport regulations for radioactive materials. Documents show that, mostly category III-YELLOW packages have been transported to Bangladesh. Packages of category II-YELLOW are few. Type A packages are generally chosen for transport of radioactive materials in nuclear medicine. For industrial practices type B packages are used in parallel to type A packages as well. Number of large activity sources for radiotherapy and irradiators are small in quantity and transported in special containers. The containers are then taken back by the suppliers as per contract between the users and the suppliers. Strict safety and security measures are taken for transport of such large containers.

7. Conclusion

BAEC as competent authority has established overall control over the import and transport of all kinds of radioactive materials in the country. Safety and radiation protections are being taken as much as possible to comply with relevant IAEA regulations. Internal methodologies developed and established for transport of radioactive materials is closely monitored for any shortcomings and no compromise is made regarding safety of the transport. Records show that, mainly category III-YELLOW packages are transported in Bangladesh. Types of packages associated with different conditions of transport are few. So far no reportable incidents has occurred during transport. Development of guides for transport of radioactive materials and radioactive wastes in the country are currently underway. NSRC act and rules are quite comprehensive for regulating transportation of the radioactive materials and radioactive wastes.

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UPGRADING BELARUS NATIONAL REGULATIONS FOR TRANSPORT OF RADIOACTIVE MATERIALS

E.R. Bariev, G.F. Novikov, A.A. Sudas, L.F. Rozdyalouskaya

Ministry of Emergency Situations,
220050 Minsk,
Republic of Belarus

Abstract.

Since September 2001 the regulations concerning safe transport of radioactive materials in Belarus have been introduced by the Ministry of Emergencies which structural sub-divisions. Promatomnadzor and Emergency Preparedness Department are responsible for the supervision of technical safety of nuclear facilities and safe transportation of dangerous goods. This paper summarizes the current status of the regulations and outlines some strategic elements that the Ministry of Emergencies could continue to pursue in coming years.

1. Introduction

As a country with no nuclear power plants and no radionuclide production Belarus has much less concern about safety transport of radioactive materials than many other European countries. The establishment of appropriate control of transport of radioactive materials at the borders of Belarus is considered as the issue of the highest priority. The reason is ensuring safety of entered (import) vehicles/packages and preventing unauthorized movements of radioactive materials between the Eastern and Western countries. Belarus is developing national legislation for the activities in the area with due regard to its international obligations and taking into consideration the experience accumulated in the world.

2. Regulatory base for control of movements of nuclear and radioactive materials through the customs borders of the Republic of Belarus

Belarus use radioactive materials in medicine and various sectors of national economy. The radioactive substances are imported mainly from Russian Federation, Great Britain and other countries. Besides, transfer of radioactive materials from/to the customs territory of the Republic of Belarus includes transit movements and transporting disused radioactive materials back to a foreign manufacture/supplier (if this meets terms of delivery of new radioactive sources). Transferring such things from/to the customs territory of the Republic of Belarus is possible on condition that legal entity pursuing export/import activities submits a single permit for such a movement while performing customs clearance.

The permits are issued by the Department Promatomnadzor of the Ministry for Emergencies in accordance with the *"Procedure for issuing authorisations on the movement (importation, exportation, transit) of ionising radiation sources, nuclear substances and materials, technical systems, installations and items structurally containing radioactive materials across the customs border of the Republic of Belarus*». The Procedure is put in force by Order of the Minister of Emergencies No 81 on December 1, 1999. The "Instruction for issuance of permits for the reception and the transference of radioactive sources», issued 02 June 2000 requires that an application for a permit consists of the following documents:

(a) application letter on the blank of the applicant;
(b) agreement (contract) for the shipment;
(c) licenses of a consignee and a carrier for execution of appropriate activities;
(d) sanitary passport for execution of activity involving radioactive sources issued by the Ministry of Health;
(e) consignor certificate confirming that the vehicle used has been fitted up in line with the relevant requirements for particular mode of radioactive material;
(f) confirmation that the consignor has been notified and agrees with the date of the load delivering;
(g) confirmation that competent authorities of States of transit have authorized a movement of radioactive material through their territories;
(h) confirmation that the State of origin will permit re-entry of the radioactive materials into it's territory to consignor, if the transportation is not completed in conformity with the stated requirements;
(i) confirmation that the transport route in the territory of the Republic of Belarus has been approved by the State Automobile Inspectorate of the Ministry of Internal Affairs of the Republic of Belarus;
(j) certificate of appropriate driver qualification;
(k) written emergency response manual issued by the manufacture/supplier/consignor of radioactive materials.

The Department Promatomnadzor of the Ministry for Emergencies reviews about 50 applications annually.

The Law of the Republic of Belarus «On Exports Control» defines "the legal bases for activities of state bodies, legal and natural persons of the Republic of Belarus in the field of export control and regulates relations arising in connection with the movement of objects subject to export control across the customs border of the Republic of Belarus and their subsequent use». According to Article 7 of the Law, the objects subject to export control (specific goods) include such items «as goods, technologies and services connected with nuclear fuel cycle and production of nuclear materials which can be used for production of nuclear weapons and nuclear explosive systems» as well as «dual purpose commodities».

By way of the Law implementing the Council of Ministers adopted Decree No 27 of 10.01.1998 «On the improvement of the state control trafficking of specific goods (works, services) through the customs borders of the Republic of Belarus». The Decree brings into force two regulations, concerning:

- "Procedure for licensing of export (import) of specific goods (works, services)", and
- "Procedure of official registration of obligations for the use exported (imported) specific goods (works, services) for declared purposes and organisation of control over the fulfilment of such obligations".

The Decree empowers the Ministry of Foreign Affairs to issue licenses for export of specific goods (works, services,) as well as to co-ordinate activities of all agencies and institutions involved in the export control work.

The Ministry of Emergencies in conjunction with other agencies concerned shall organise control of domestic movements and physical protection of nuclear materials which fall under the IAEA Safeguards.

The customs services are responsible for detection of unauthorised imports and exports of nuclear and radioactive materials on the customs border of the Republic of Belarus and report each case to other responsible authorities.

3. Control of movement and transportation of radioactive materials within the country

Currently the domestic movements include:

- delivering medical radioactive substances and sealed radioactive sources to their users (mostly for gamma-therapy and industrial radiography purposes),
- transporting radioactive waste from the users to the centralized disposal/storage facility "Ekores",
- transfer of radioactive materials from one Belarus institution to another for temporary use or owing to a new business orientation of the materials owner,
- transporting radioactive wastes generated by cleanup activities in the contaminated Chernobyl zone to authorized sites for treatment and disposal.

The general safety requirements for ensuring safety transportation in respect of the above mentioned activities are specified by the Law «On the Carriage of Dangerous Goods» which defines:

(a) the legal status of entities carrying out activities in the field of carriage of dangerous goods;
(b) the procedures of state regulation and management in the field of carriage of dangerous goods;
(c) the requirements for ensuring safety of dangerous goods;
(d) the order of organisation and realization of carriage of dangerous goods;
(e) the necessity of investigation of the reasons and record-keeping of accidents occurring in transportation of dangerous goods.

On base of Governmental Resolution No 510 of 02.08/1996 "On measures for realization of the European Agreement concerning the international carriage of dangerous goods by road" (ADR) the special "Procedure for the interaction of all state authorities involved in control of ensuring safety transport of dangerous goods" was approved by Ministry of Emergencies, Ministry of Internal Affairs, Ministry of Health Care, Ministry of Labour and Ministry of Environment. Co-ordination, licensing and state technical supervision of this kind of activity is carried out by the Department Promatomnadzor of the Ministry of Emergencies.

The activities involving transfer and transport of radioactive substances is regulated on the base of recently issued Basic Sanitary Rules for Ensuring Radiation safety of Radiation Sources (OSP-2002) and three old documents of the former Soviet Union:

- Basic Rules for Ensuring Safety and Physical Protection in Transportation of Fissionable Nuclear Materials (OPBE -94),
- Safety Rules for Transportation of Radioactive Substances (PBTRV-73), and
- Sanitary Rules for Management of Radioactive Waste (SPORO-85).

In concert the rules establish all the necessary requirements for ensuring physical protection, package surveys and safe transport of packages containing radioactive sources. The documents are still in compliance with the domestic safety approaches but the efforts should be taken for review/development of the normative/methodological procedural basis in accordance with the IAEA Safety Standards Series No. ST-1.

4. Responsibilities in Case of Transport Emergency

Matters related to response in case of transport emergencies involving packages with nuclear and radioactive materials are within the comprehensive state system for prevention and mitigation of natural and tecnogenic emergencies. There are several recent Governmental

Resolutions directed at upgrading the system and creating material reserves for it's effective functioning:

- On the State System for Prevention and Liquidation of Emergency Situations, No.495, of 10.04.2001,
- On the Order of preparation of the managers, responsible officers and workers of the Republican Bodies, Unified Institutions, local executive bodies, organizations, social institutions and the population in the field of protection against emergency situations of natural and tecnogecnic character, No.1281 f 23 04.2001,
- On the Establishment of the Republican System of Reserves of Material for Liquidation of Emergency Situations, No.1800, of 20.11.1998,
- On the approval of the List of the Republican State Authorities and other state organizations, subordinated to the Government of the Republic of Belarus, in which branch sub-systems of the State System for Prevention and Liquidation of Emergency Situations are established, No.181 of 02.04.2002.

The internal system procedure defines that Ministry of Emergencies is the main contact point for the notification of any accident involving transport of radioactive material in the territory of the Republic of Belarus. The drivers shall be provided with emergency response manual, in which addresses/phones for notification in case of the emergency should be indicated. The consignor/ consignee organizations shall have emergency crew staffed with the trained qualified persons who take actions in according with the emergency response plans prepared in advance

If the emergency response crew does not have sufficient resources, the necessary actions are organized by the regional Emergency Preparedness Commission within framework of State System on Preparedness and Liquidation of Emergency Situations. Within the System the Ministry of Emergencies is responsible for the assessment of the radiological situation, radiation control and providing additional appropriate emergency procedures.

Ministry of Internal Affairs is responsible for notification of all the bodies involved in the liquidation of consequences of the accident, restoration of traffic public peace and security of possessions. The Ministry divisions take part in rescue operations and give preliminary medical care to the suffering people.

The Ministry of Health Care is responsible for medical care and execution of the sanitary actions.

The Ministry of Environment contributes to assessment of the environment damage and contamination and supervision of actions directed at the environment rehabilitation.

The investigation of the causes and effects of the emergency situation is conducted under the command of one of the above stated Ministries depending on the nature and magnitude of the damage and hazard caused by the accident. The accounting of the accidents involving transportation of radioactive materials is the responsibility of the Department of Promatomnadzor of the Ministry of Emergencies.

5. Conclusion.

The created framework for regulation of safety transport of radioactive materials in Belarus works effectively to prevent illicit traffic of radioactive materials through the borders of the country and provide necessary level of safety for these materials transportation. Nevertheless it is considered of benefit to review the relevant normative documents in order they become more in line with the IAEA Safety Standards Series No. ST-1.

EXPERIENCE IN THE IMPLEMENTATION OF THE IAEA TRANSPORT REGULATIONS IN CUBA

J.R. Quevedo García; I. Sarabia Molina; Y. López Forteza

National Centre of Nuclear Safety
Havana, Cuba

Abstract

The Cuban Competent Authority responsible for approvals and authorizations in respect to the transport of radioactive material has paid special attention to obtaining assurance that all transport requirements are being met in practice by the users. With this purpose, a consequent policy has been applied based on the establishment of supplementary requirements to those imposed by the IAEA Transport Regulations. The paper provides detailed discussion about the implementation of the IAEA Transport Regulations in the Cuban Regulatory Framework.

1. Introduction

Although IAEA Transport Regulations authorize several cases in which transport can be made without Competent Authority involvement or package design approval, a key function of the Competent Authority is the conduct of a systematic programme responsible for issuing documents that approve the transport of radioactive material. Obviously, the way in which the Competent Authority will conduct such a programme may be different taking account of local situations, technical resources, the scale of transport operations and other factors that will determine priorities.

Cuban first Transport Regulations were promulgated in 1987 [1]. Differences among this document and the IAEA Transport Regulations were basically referred to requirement of national shipment approvals for all radioactive materials. In 2000, Regulations were reviewed [2] to adopt the 1996 edition of the IAEA Transport Regulation (ST-1) and the above requirement was also included. The Cuban Regulatory Framework in the field of transport of radioactive materials is discussed in this paper.

2. Supplementary requirements

In Cuba, responsibilities for regulating both, the safe transport of radioactive material (Competent Authority) and the safe use of the radioactive materials (Regulatory Authority) are allocated to one unique governmental authority. This fact from one hand prevents the existence of conflicting requirements and from the other facilitates and simplifies the establishment of a coherent regulatory framework.

Taking into account not only the numbers and types of packages being transported but also the foreseen development of the national industry, the Competent/Regulatory Authority created a legal environment in which it can function effectively. Such legal environment was based on the issue of authorizations or approval for shipment of radioactive material as a way of optimizing its own available resources:

— frequent transport operations are to be considered as a practice or as part of a practice and the Regulatory Authority will be in charge of verifying the compliance with the Transport regulations and,

— infrequent transport operations should be authorized and the Competent Authority will verify if the requirement for transport of radioactive material are being met.

On this basis, the Cuban Competent Authority established a group of supplementary requirements to be applied when transporting radioactive material, in order to assure the safety of transport personnel, the general public, property and the environment. Most of these supplementary requirements are established in the Regulations for authorization of practices involving radioactive sources [3]. They can be summarised as follows:

Requirements to transport operations of mobile sources

Authorizations for practices involving transport of mobile sources shall include transport operations. Applications for authorization in these cases shall comprise: the operational procedures for maintenance of packaging and for loading, carriage and unloading of packages; the measures to be taken in case of accident during the transport; the program for training of the personnel, the programme for area monitoring, as well as the records to be kept. Authorizations to be granted should include those conditions/requirements that authorized user must meet. During regular inspections, specific aspects related to the safe transport of sources can be periodically reviewed.

(a.) Requirement to frequent transport operations

The frequent transport operation carried out by a user is considered as a practice that shall be authorized and regular inspections should be conducted. Documentation to be submitted for authorization includes a safety assessment that shall be conducted by the user.

(b.) Shipment approval as requirement for delivering radioactive material

Delivery of radioactive material by Customs Authorities in ports and airports should be carried out only under presentation of the corresponding shipment approval; delivery and reception of radioactive materials to be transferred among users requires also the presentation of the mentioned authorization. The requirement seems to be useful for the control of the traffic of radioactive materials at the borders, as well as to prevent the use of radioactive material without Regulatory Authority involvement.

Some other operational requirements are commonly imposed by the Authority as result of the assessment of the applications for authorization. They are established as part of the conditions/requirements of the authorization document. The most important of them are the following:

— Participation of inspectors of the Competent Authority, jointly with police forces, in the transport of the sources of major risk.

Transport of the sources of major risk (sources for industrial irradiators and for gammatherapy units) is carried out only with the participation of a police escort in charge of reducing the possibility of occurrence of traffic accidents. As rule, experienced inspectors from the Competent Authority also participate in these transport operations. Inspectors are empowered to stop the transport operations if it is considered necessary from the radiation safety point of view.

— Participation of a radiation protection officer in the transport of mobile sources.

Granted authorizations establish that transport operations of mobile sources most be escorted by a personnel responsible for the radiological protection during such operations. This personnel is responsible for the adoption of the initial measures to be taken in the case of accident according to the approved emergency plan

Further use of the Cuban Regulatory Framework, organized as described above, was discussed in 2000, when elaborating the new Transport Regulations. Taking in mind that levels used when defining radioactive material in ST-1 are coincident with the exemption levels in SS 115, for the coherent of the regulatory framework it seems reasonable that the Regulatory/Competent Authority authorizes transport, and thus movement of the radioactive material which use is to be controlled by notification/registration/licensing. Convenience of keeping in the regulations the requirement of shipment approval for all radioactive material was agreed.

3. Discussion of results

Transport operations in Cuba are basically dealing with consignors of mobile sources and minor consignors. Transport of mobile sources represents almost 10% transport operations in the country and they are grouped into a dozen of users holding the corresponding authorization according to Regulations for authorization of practices. These authorizations are commonly issued for a two year period, and they while no representing any obstacle for the user, facilitates through periodical inspections the assurance that all transport requirement are being met

Minors consignors are basically represented by three institutions specialized respectively in the purchase of sealed sources for industrial applications, sealed sources for medical applications and unsealed radioactive sources used in medical applications. These three institutions handle more than 99% of the total activity used in the country. According to the Regulations for authorizations of practices, license was issued for the frequent transport operations of unsealed sources.

Transports of sealed sources as well as any other infrequent transport of radioactive material are subjected to authorization according to the national Transport Regulations. Transport of radioactive wastes from users to central processing and storage plant has been organized up to the present as special arrangement. Shipment approvals for radioactive material are promptly issued so that they do not represent any obstacle for the user. Authorizations are issued for a reasonable period of time and the consignor shall notify to the Competent Authority when transport had been successfully performed.

50 shipment approvals approximately are issued annually as average in Cuba. Most of these authorizations correspond to the transport of radioactive material from ports and airports after their import.

Granted authorizations (authorization for practices and shipment approvals) require the notification to the Regulatory/Competent Authority of any uncommon event for routine transport. From 1994 to the present it has been reported in Cuba only two event of a package's lost (in both the cases package was recovered) and more recently an event of internal contamination of a package containing unsealed sources. In all the cases the Competent Authority had evaluated the situation concerned and the learned lesson had been informed to users and utilized to revise the conditions/requirements of the authorizations in order to avoid recurrence.

Transport Regulations are complemented by a Regulatory Guide on the procedures to be carried out by users in order to apply for shipment approval and for approval of shipment under special arrangement.

Model conditions/requirements for shipment approval were developed to be used as a guideline by evaluators during the authorization process. Model forms for shipment approval and for approval of shipment under special arrangement were also developed

4. Conclusions

In implementing the IAEA Transport Regulations in Cuba, the Competent Authority established a group of supplementary requirements based in the authorization of all transport operations. Developed authorization system can be considered as one of the ways in which compliance assurance with the IAEA Transport Regulations can be organized when transport operations in the country includes only consignors of mobile sources and minor consignors and when available resources are limited.

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TRANSPORT OF RADIOACTIVE MATERIAL IN THE CZECH REPUBLIC
An overview and the legislation and regulatory framework

V. Duchacek

Department of Nuclear Materials, State Office for Nuclear Safety,
Senovazne namesti 9, 110 00 Praha 1
Czech Republic

Abstract.

The range of the radioactive material transport in the Czech Republic is given by geographical location and by the number of nuclear installations and facilities handling radionuclide radiation sources. The paper shows types of radioactive material shipments, transport volumes and modes of transport. The safety of radioactive material transport in the Czech Republic is illustrated by low number of transport incidents and by the absence of any radiological consequences. The legislation and regulatory framework for the shipment of radioactive material and for design approval of packagings for shipment and storage of nuclear materials and radioactive substances is described.

1. Introduction

The Czech Republic, which is situated approximately in the geographical center of Europe; it is landlocked country, which has an area of 78 866 km^2 and has a population of 10.3 million. The nuclear power industry, which is at present time (January 2003) represented by the operation of the Nuclear Power Plant (NPP) Dukovany ensures about 22 % of the electricity production. Together with Nuclear Power Plant (NPP) Temelin, which has already been completed and is tested and in the trial operation now, the contribution of nuclear sources to the total power production will raise to 48 % in near future.

There are several nuclear facilities related to the nuclear fuel cycle in the Czech Republic (see Fig. 1):

- uranium mining and milling facilities in state owned company DIAMO at Straz pod Ralskem and Dolni Rozinka sites,
- commercial nuclear power plant at Dukovany and Temelin sites owned by the Czech Power Board (CEZ),
- research reactors in Prague (VR-1, Department of Nuclear Reactors, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University) and Rez (LR-0, LVR-15, Nuclear Research Institute Rez),
- spent fuel facilities for both power and research reactors,
- low- and intermediate level waste disposal facilities at Dukovany (radioactive waste arising from the operation of NPP Dukovany and Temelin), Litomerice (institutional waste) and Jachymov (uranium mining and milling waste) sites.

Apart from nuclear facilities, there are nearly 7000 workplaces with over 8000 radiation generators and approximately 6000 facilities handling sealed sources and over 300 facilities handling unsealed radionuclide radiation sources. These facilities handling radionuclide radiation sources are industrial irradiators, centres of non-destructive testing, hospitals, research centers, universities, etc.

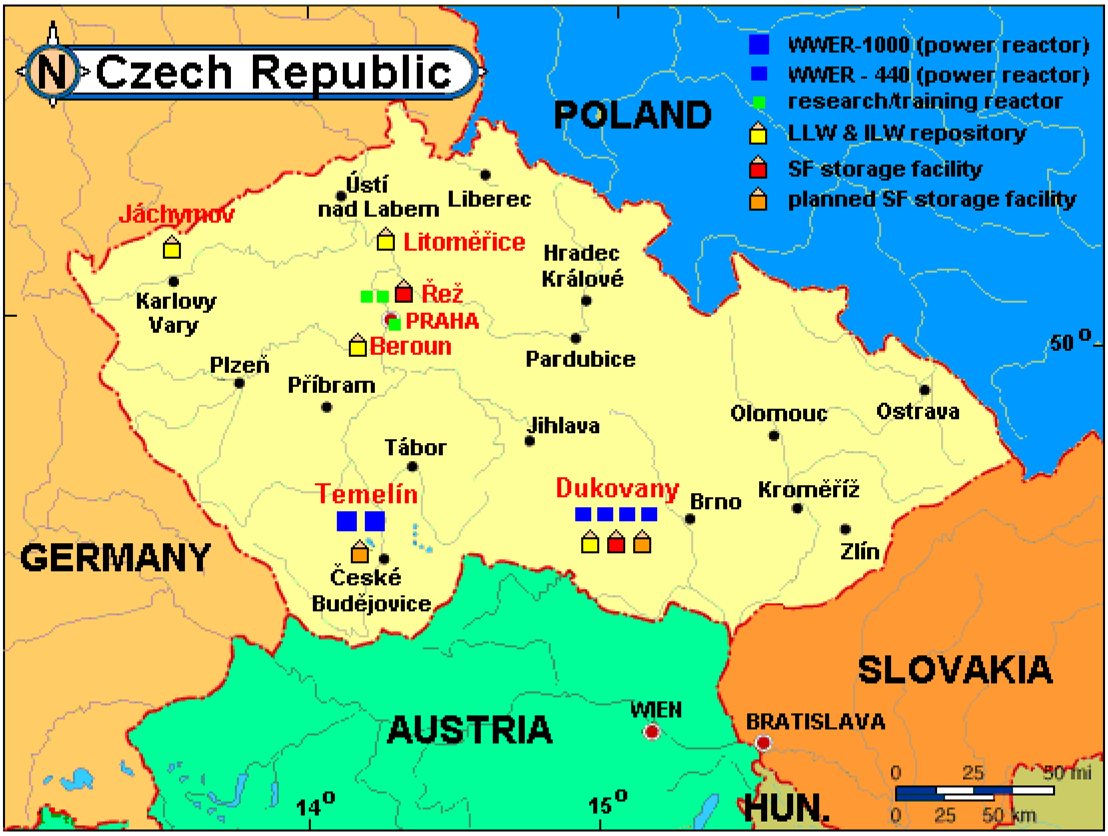

FIG. 1 Map of basic nuclear installations at the territory of the Czech Republic.

2. Type of radioactive material shipments, transport volumes and modes of transport

Fresh nuclear fuel was supplied to the Czech Republic from Russian Federation and United States of America. NPP Dukovany continues with the import of the fresh fuel from the Russian Federation (Mashinostrojitelnyj Zavod Elektrostal), while for NPP Temelin it has been decided to rely on supplies from the USA (Westinghouse Electric Corporation). Russian suppliers have provided the fuel supply not only for NPP Dukovany, but also for all three operated research and training reactors. All such shipments have been realized by combination of the air and road or rail modes, since 2001 also by see and rail modes of transport. The year's delivery of the fresh fuel represents about 10 shipments.

Spent nuclear fuel from NPP Dukovany has been stored in the Interim Spent Fuel Storage Dukovany, so it has been transported, four times per year, by rail within the NPP site boundary only. NPP Temelin plans analogous solution of the spent nuclear fuel storage.

Operational waste of approximately 1500 drums (i.e. 200L) per year from the NPP Dukovany has been disposed of in the Repository Dukovany. The transport of this waste has been realized within the NPP site boundary several times per month. Last year the NPP Temelin started shipping the operational waste to Repository Dukovany by road. Overall amount of the operational waste will represent approximately 900 drums per year in full NPP operation. NPP Temelin plans approximately six such shipments per year. The drums can be shipped also by rail.

The export of the uranium concentrate from the Czech Republic to the Canada, France and Russian Federation for enrichment process has been realized maximally 10 times per year. Each shipment represents from 50 to 100 metric tons of uranium concentrate.

The import of non-fissile radioactive materials in the Czech Republic, mostly for industrial users, hospitals, research and universities, has been provided mainly by road, or by combination of the air and road modes. University, research, industrial and hospital wastes (i.e. institutional wastes) have been sent to several facilities (e.g. the Nuclear Research Institute Rez near Prague) for conditioning. The volume of conditioned wastes produced each year has been between 100 and 300 drums (i.e. 200L). The conditioned institutional wastes have been then shipped to the waste disposal facility. The overall amount of transport of non-fissile radioactive material in the Czech Republic ranges about 100 TBq per year in terms of total activity. The total number of shipments reaches the number 10 000, including about 700 ones handled in the Type A packaging and circa 100 shipments using the Type B packaging.

3. The legislation and regulatory framework for the shipment of radioactive material

The Act No.18/1997 Coll. (Atomic Act) [1] addresses the shipment of nuclear material and assigned radioactive material (radioactive material with activity higher than 3000 A_1, or 3000 A_2 or 1000 TBq and other shipments, see Fig. 2) by implementing regulation No. 317/2002 Coll., on type-approval and shipment [2]. This regulation is based on the international agreements of ADR, RID and ICAO-TI/IATA-DGR for transportation by road, rail and air respectively. Currently, the existing regulations are based on the IAEA Safety Standards Series, Regulations for the Safe Transport of Radioactive Material, 1996 Edition (Revised), Requirements, No. TS-R-1 (ST-1, Revised), IAEA, Vienna, 2000. Some aspects of the shipment are covered by the other regulations [3 – 8]. The requirements for the transport of other radioactive material are defined in mode specific legislation [9 – 12], which are also based on the international agreements above mentioned. The Czech Republic accepted the Vienna Convention on Civil Liability for Nuclear Damage and the Joint Protocol relating to the application of the Vienna and Paris Conventions, the Convention on the Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency.

State Office for Nuclear Safety (SONS) is responsible for administration and supervision in the fields of uses of nuclear energy and ionizing radiation and of radiation protection in the Czech Republic. It is an independent governmental regulatory body with its own budget. The SONS is the competent authority for the shipment of radioactive material. The responsibilities of the SONS in this field include, but are not limited to, the following issues:

- Approving designs for packagings for shipment and storage of radioactive material
- Licensing of shipments of nuclear material and assigned radioactive material
- Inspecting of shipments (circa 30% of approved shipments are inspected)
- Reviewing and approving documentation related to nuclear safety, radiation protection physical protection and emergency rules for shipment of radioactive material
- Cooperation and collaboration with other governmental regulatory bodies
- Providing relevant information regarding shipments of nuclear material and radioactive material to the public and to the Government of the Czech Republic
- Providing domestic and transboundary emergency assistance, if necessary.

The legislation and regulatory framework for the shipment of radioactive material in the Czech Republic is illustrated in Figure 2.

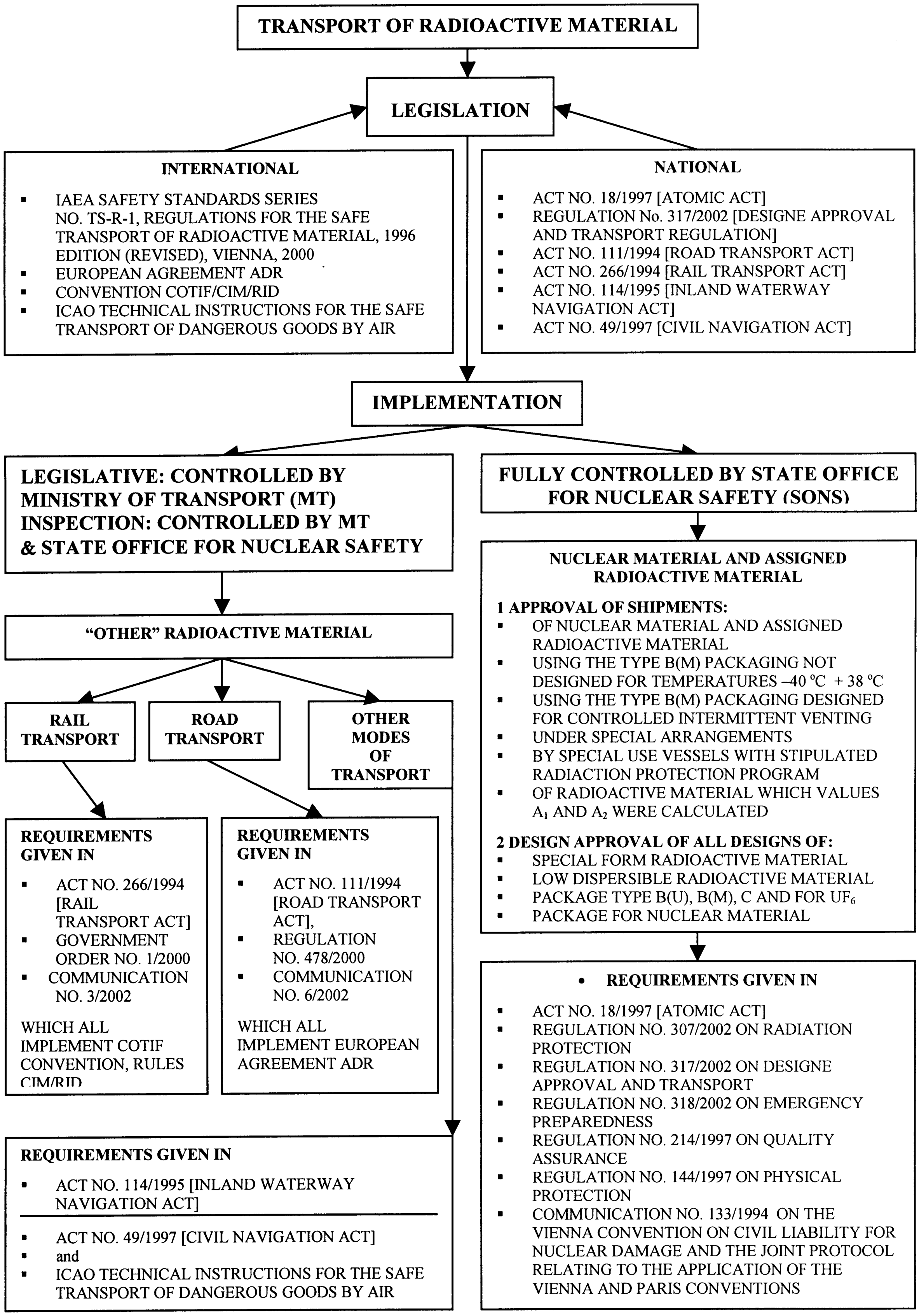

FIG. 2 Scheme of Legislation and Competent Authorities in the Transport of Radioactive Materials in the Czech Republic.

4. Conclusions

In last ten years, there is only two reports concerning a transport event involving radioactive material in the Czech Republic:

- In the year 1997 one company realized a shipment of a package whose content (nuclear material) was wrongly described (due to an administrative error). The error had no influence on the nuclear safety, radiation protection of persons and physical protection of the nuclear material involved.
- In the year 2000 the department of nuclear medicine of a hospital in the north part of Bohemia reported a missing delivery containing radioactive material, which was dispatched from a railway station in Prague. The investigation by Police of the Czech Republic concluded that it was stolen in the course of railway transport on the way. Considering the nature of shipped radioactive material (yttrium-90, 1.4 GBq) there was no life threat to the population or individual persons.

On the other hand, the SONS has registered about 30 cases per year, that measuring instruments at entrances to steelworks, or at border crossings detected radioactivity in vehicles (railway carriages, trucks) transporting iron scrap. There have been also circa 20 cases of detection of contamination in garbage-collecting trucks at entrances to waste incinerator facilities per year in the Czech Republic. However, these events have been classified rather as a "illicit trafficking" (usually unintended) than as a transport events.

Following of the above-mentioned it is clear that the legislation and regulatory framework is sufficient for safe transport of radioactive material in the Czech Republic.

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[3] Regulation No.144/1997 Coll., on Physical Protection of Nuclear Material and Nuclear Facilities and their Classification.

[4] Regulation No.146/1997 Coll., Specifying Activities Directly Affecting Nuclear Safety and Activities Especially Important from Radiation Protection Viewpoint, Requirements on Qualification and Professional Training, on Method to be used for Verification of Special Professional Competency and for Issue Authorisations to Selected Personnel and the Form of Documentation to be Approved for the Licensing of Expert Training of Selected Personnel.

[5] Regulation No.214/1997 Coll., on Quality Assurance in Activities Related to the Utilization of Nuclear Energy and in Radiation Practices, and Laying Down Criteria for the Assignment and Categorization of Classified Equipment into Safety Classes.

[6] Regulation No.307/2002 Coll. on Radiation Protection.

[7] Regulation No.318/2002 Coll., on Details of Emergency Preparedness of Nuclear Facilities and Workplaces with Ionising Radiation Sources, and on Requirements on the Content of On-Site Emergency Plans and Emergency Rules.

[8] Communication of Ministry of Foreign Affairs No. 133/1994 Coll., on The Vienna Convention on Civil Liability for Nuclear Damage and the Joint Protocol relating to the application of the Vienna and Paris Conventions.

[9] Law. No. 111/1994 Coll., on Road Transport and implementing regulations.

[10] Law No. 266/1994 Coll., on Rail Transport and implementing regulations.

[11] Law No. 114/1995 Coll., on Inland Waterway Navigation and implementing regulations.

[12] Law No. 49/1997 Coll., on Civil Navigation and implementing regulations.

THE EGYPTIAN LEGISLATION FOR SAFE TRANSPORTATION OF RADIOACTIVE MATERIALS

F.A. Rahman, N. Riad

NSNCRC, AEA, Egypt

Abstract.

According to the Egyptian legislation related the safe transport of radioactive materials**,** a licence is required for the transport, import and or export these materials. The licence is granted, upon a written application to NCNSRC-AEA. All the procedures and conditions for granting the NCNSRC-AEA licence to handle/ transport radioactive materials/wastes have been developed according to the international and Egyptian legislation. The procedures for transit of ships carrying radioactive materials in Suez Canal are also constructed. The NCNSRC-AEA experts are entitled to accept or to refuse the transit of ships carrying radioactive materials in the Suez Canal, in the Egyptian regional waters, in the sea harbours or in the exclusive economic zones of Egypt according to the national and international regulations.

1. Introduction

During the last decades, radioactive materials and radiation sources have been widely used in various fields. Nowadays, large quantities are produced by several specialized centers all over the world. The number of consignments of radioactive materials being transported within countries and between countries is likely to increase with the development of nuclear power and the use of other nuclear techniques.

Accidents can happen in all modes of transport, and it is likely that a significant number of accidents will involve packages of radioactive materials. International and national regulations for safe transport of radioactive materials were developed to provide protection of public, transport workers, and property from radiation, contamination and criticality hazards during the transport of radioactive materials.

The Egyptian legislation for transport of radioactive materials is based on all the regulations of the International Atomic Energy Agency (IAEA) for safe transport of radioactive materials [1,2] taking into account the following international regulations for the different modes of transport:

- the International Regulations concerning the Carriage of Dangerous Goods by Rail ; RID [3], and by Road; ADR[4];
- the Conventions related to the safe transport; SOLAS (1974)[5], the joint protocol related to both conventions Vienna and the Paris (1988)[6], the early notification of nuclear accidents & assistance in the case of a nuclear accident or radiological emergency (1986)[7], and finally the united nations convention on the law of the sea (1982)[8];
- the International Maritime Organization Dangerous Goods ; IMDG Code[9];
- United Nation Recommendation on the Transport of Dangerous Goods (1995)[10];
- the International Civil Aviation Organization (ICAO) technical instruction [11].

The National Center for Nuclear Safety and Radiation Control- Atomic Energy Authority (NCNSRC- AEA) is the independent governmental regulatory body for controlling all activities concerning the transport of both radioactive materials and radioactive wastes. The

NCNSRC-AEA is also designated - in the sense of the IAEA regulations as - the national competent authority in all matters concerning the safe transport of these materials [1, 2].

The IAEA regulations for the safe transport of radioactive materials were not formally included in the legislation in Egypt, but they clearly recognized since they form the basis of the Egyptian safety requirements.

Even that Egypt has not signed the Convention on the Physical Protection of Nuclear Material [12], the requirements for the level of physical protection in Egypt are consistent with that Convention. The regulatory body, NCNSRC -AEA ensures that the requirements on physical protection are exactly followed since -according to the Egyptian constitution- the international law is more obliged than the national law in Egypt [13].

The passage of radioactive cargoes in Suez Canal represents an additional transport activity in Egypt. Radioactive cargoes travelling through Suez Canal include fresh and spent reactor fuel as well as uranium hexa-fluoride. The nuclear ships also, pass through Suez Canal several times each year. Generally, no serious accident with radiological consequences have been reported during the period from 1963 (date of the first ship carries radioactive materials passed through Suez Canal) until now except the accident of the vessel M/V GERENT [24, 25].

2. The requirements for handling radioactive materials/waste in the Egyptian legislation

According to the Egyptian radiation protection legislation [i.e. Law No. 4 for year 1994 (Law of the Environment)[14], and the Prim Minister's Decree No. 338 for year 1995[15] promulgating (the Executive Regulations for Law of Environment No. 4 for year 1994)], a licence is needed for the handling of radioactive materials. According to that Law, a licence is required for handling the radioactive materials including collecting, transporting, storing, treating, or using the radioactive materials.

For the possession and use of radioactive material for medical purposes, the licence is granted, upon a written application either to NCNSRC-AEA, or to the Minister of Health. However, the Law of Environment stipulated that the handling of hazardous substances should be prohibited without a permit from the competent authority (i.e. NCNSRC- AEA) [16]. Law No.4 strictly stipulates to get the NCNSRC-AEA licence before importing any radioactive wastes or allowing its entrance or its passage through the Egyptian territories, territorial sea or the exclusive economic zones of Egypt [17].

The Egyptian Environment Law provides that the licence shall include all conditions and instructions considered necessary for securing nuclear safety. Such conditions and instructions may be modified later, if needed. In the licensing procedure, the Ministry of Trade - or any other national authority - shall get a specified licence from NCNSRC- AEA, if needs to import any radioactive package or shipment of nuclear fuel.

2.1. Procedures for granting the NSNCRC-AEA licence

For granting a licence for the safe handling/transport of radioactive material/waste, a written request shall be applied to NCNSRC-AEA, containing the following information and conditions:

- Name of the body or individual that will handle/transport of radioactive material/waste, and all information concerning insurance, etc.
- A complete description of the substances and waste to be handled/transported.
- A clear indication of the available mode of transport (either by land, railway, sea, air, or by internal waterways) and a clarification of routings.

- A commitment from the licensee to maintain the registers, that include the mode of transport with providing this data upon request. The commitment also includes a non-destruction of these registers for a period of five years.
- A commitment to undertake all procedures that ensure the proper package of radioactive material/waste during the collection, transportation and storage phases.
- A detailed description of an Emergency Plan for confronting all unforeseen circumstances that guarantee the protection of human beings and the environment [18].

2.2. Conditions for transport of radioactive materials/wastes

It shall be prohibited to transport any radioactive material/waste in a way other than that mode of transport mentioned in the granted licnece, such that the transport trucks - used in the extension routes - shall comply with the following conditions:

- Transport trucks shall be fitted with all necessary safety equipment and shall be in good working condition.
- The capacity of transport trucks and their rotation schedule shall be adequate for radioactive material/waste volume.
- Trucks shall be driven by specially trained drivers, able to take independent action, particularly in emergencies.
- Clearly evident signs shall be placed on these trucks, indicating the extent of danger of their cargo and the best action to be taken in emergencies.
- Routing of trucks carrying radioactive materials/wastes shall be determined and the Civil Defense bodies shall be immediately notified if any changes therein, in order to enable them to act quickly and appropriately in emergencies.
- It is forbidden to transport the trucks currying radioactive materials/wastes through residential and other populated areas or through city center during daytime.
- Trucks transporting radioactive materials/wastes shall always be washed and cleaned after each use according to the instructions set down by both the Ministry of Health and the NCNSRC-AEA [19].

2.3. Transit of ships transporting radioactive materials/wastes

To allow the passage or transit of ships carrying radioactive materials/wastes in the regional waters, in the sea ports or in the exclusive economic zone of ARE, the following procedures shall be followed:

- A transit permits from the competent administrative department either in the Ministry of Maritime Transport or in the Suez Canal Authority (SCA), provided that the Egyptian Environmental Executive Agency EEAA, is notified accordingly.
- In case of granting the transit authorization, all necessary and stipulated precautions stated in international conventions shall be taken, provided that the ship has a Guarantee Certificate as prescribed by Law.[20]
- The competent administrative department either in the Ministry of Maritime Transport or in the Suez Canal Authority, shall notify the NCNSRC-AEA by the date of arrival of the ship carrying the radioactive material. Also they send a copy of all document related to the package for the compliance assurance according to the international regulations [23].
- Prior to the ship carrying radioactive material arrival date, the NCNSRC experts shall inspect all radioactive material packages outside the regional waters of Egypt. The NCNSRC inspector experts are entitled to accept or refuse the ship carrying the radioactive material transit. In case of acceptance, the transit permit is granted.

3. The role of the Egyptian Atomic Energy Authority (AEA) in the safety of radioactive material transport

In Egypt, no nuclear power reactors have yet been built, but there are two research reactors used for experimental and sample irradiation research and isotope production. There is also, in operation, an approximately 370.000 Ci Cobalt Irradiation Facility used for sterilization of food and medical products. Radioisotopes and radioactive sources are used through the country for medical and industrial applications. Some radioisotopes and radioactive sources are produced in the AEA and some are imported. So they are transported through the country by different modes of transport.

3.1. Radioactive material transport inside the AEA site

Before transporting the irradiated samples or radioactive materials, a certificate shall be issued from NCNSRC-AEA including all data important and essential for safe transport inside the AEA Site. The issuing of that certificate should be an origin and a copy. The copy is kept with the transported radioactive material, while the origin is preserved at the NCNSRC-AEA center as a record.

3.2. Radioactive material transport outside the AEA site

The transported radioactive materials outside the site of the AEA includes:

- Radioactive materials transport from the Reactor Department to the isotopes production laboratories and then to the medical centers and research facilities out side the AEA.
- Radioactive materials transport from Cairo Airport to the medical centers and research facilities out side the AEA.
- The transport of high activity radioactive materials from naval ports to the licensee competent.
- The transport of radioactive wastes from different sites within the country to the AEA.

It is worthy noting that the transport of all types of radioactive sources (sealed or open) and other radioactive materials is the responsibility of the NSCRC-AEA. This responsibility deals with establishing the regulations, organizing and supervising the transport of radioactive materials inside the country, across its territories and its regional waters. But the Ministry of Health is responsible only for importing and not transporting the sealed sources that used outside the AEA site.[(21)]

4. The safe transport of radioactive material through Suez Canal

4.1. The Canal and the zone

The Suez Canal is situated in the north-east of Egypt. It extends from Port Said to Port Tawfik (near Suez) connecting the Mediterranean Sea to Suez Gulf of Red Sea. The Suez Canal is 192-km long, passes through a zone of considerable business, agricultural, and industrial activities. The zone consists of three populated provinces; Port Said, Ismaiellia, and Suez. This Egyptian waterway is an important international trade rout. Through the Sues Canal, the radioactive materials including fresh fuel elements and spent fuel and about 1000 metric tones of uranium hexa-fluoride are transported every year. The vessel traffic is controlled by (SCVTCS) system, which is a very accurate system for ensuring safety of transit in the canal. This system consists of:

- Three-station radar net located at Port Said, Bitter Lakes, and Port Tawfik.
- A wireless, Loran c, position fixing net located at Port Said, 10th of Ramadan City, and Raas Sedre.

- Digital computer networks that aim at collecting accurate and comprehensive data about the traffic situation and displaying them on screens in the control room.
- Several wireless communications networks all along the canal that keeps continuos contact between one site and another.

4.2. The Suez Canal Authority (SCA) rule of navigation

To regulate the safe passage of the radioactive materials ships through Suez Canal, the Suez Canal Authority (SCA) rules of navigation[22] stipulated that the following documents shall be submitted to the NSNCRC for compliance assurance[23] and prior to ship carrying radioactive material arrival by at least forty eight hours:

- Documents proving that the ship carrying radioactive materials has complied with conditions and prescriptions contained in laws and rules enforced in the exporting country, and with the conditions and prescriptions recommended by both the IMO Code [9] and the IAEA regulations [1, 2].
- Compensation warranty document covering all direct or indirect damage that may be caused to the environment by the presence of the radioactive materials.
- Document similar to the declarations of the AEA concerning the shipment with all information required by the IAEA regulations[1, 2]. Each declaration concerns with one of the following three basic groups:

  Group A: contains all fissile materials, including uranium-233, uranium-235, plutonium-239, plutonium-241 which under certain conditions are capable of undergoing fission, and spent reactor fuel elements.

  Group B: includes all artificially high activity radioactive sources.

  Group C: includes non-fissile materials (low-specific activity materials LSA, surface contaminated objects, SCO), Uranium ores and concentrates, natural uranium and thorium, radioisotopes for medical, agricultural, scientific or industrial use.

4.3. The NSNCRC-AEA permission for the transport of the ships carrying radioactive materials

To obtain The NSNCRC-AEA permission for the transporting ships carrying radioactive materials through Suez Canal some requirements and procedures shall be followed. These requirements and procedures, which depend on the group type of the radioactive materials, are:

A - For Group A radioactive materials, a prior approval from NSNCRC-AEA before the shipment shall be needed. For Group B and C radioactive materials, such prior approval is not required.

B - The agent of the vessel carrying radioactive materials must notify the NSNCRC-AEA by the time of the Ships Carrying Radioactive Materials arrival at least 48 hours in advance. This notice shall also include all the documents concerning the radioactive material cargo.

C - These documents shall include: The declaration mentioned in the previous section 4.2. according to the radioactive material group type. A copy of the warrantee document [22], the origin is kept at Suez Canal Authority. For Group A; the warrantee document is the insurance policy issued by an approved protection and insurance organization. Such insurance policy must cover all kinds of damage due to the passage of the ship in Suez Canal. For Groups B and C, the warrantee document shall be a certificate issued by an official recognized authority in charge of the protection and compensation of the ship owners against damage. The compensation warrantee document of whatever kind (insurance/ certificate) must explicitly state that the victims shall receive compensation. This compensation shall cover all direct and indirect damage that may occur resulting from the radioactive material load during the ship passage through Suez Canal including the entrance of both Port Saied and Port Tawfik and their vicinities. The Egyptian Courts are the solely and exclusively competent to decide thereof in claims of damage compensation and all that may be connected with the accident or its direct or indirect consequences.

D - Special sign shall be hoisted by the ships carrying radioactive material on arriving the territorial waters. This sign is either the four red lights or the flag "F" of the international code between two balls [22].

4.4. The NSNCRC-AEA experts inspection

On the arrival of the ship carrying radioactive material, the experts of the NSNCRC-AEA go on board of the ship to inspect and to examine the radioactive materials load. The master of the ship shall handle to them the official stowage plan of radioactive material load -signed and stamped by the ship owner- for sake of the calculation of the Transport Index (TI) and/or the Criticality Safety Index (CSI) according to IAEA regulations [1, 2].

According to the calculations of TI/CSI and to the inspection of the radioactive materials load, the expert shall issue a certificate to Suez Canal Authority. The certificate includes permission that such ship can safely pass the Suez Canal. The certificate may include one or more of the following conditions:

a - Authorizing the ship to enter the port and transit the canal.
b - Handling of other goods inside and outside the ship during its transit.
c - Transporting the radioactive materials load to another ship or to the shore.
d - Authorizing the ship to make repair in the port and to take supplies.

The NSNSRC-AEA expert -according to his inspection and calculations for the radioactive materials load- may decide to accompany the ship from the moment it enters the territorial waters of Egypt until its leave.

4.5. The accident of the M/V GARENT vessel in Suez Canal (1981)

On ninth of December 1981, a collision between the Panamian ship "M/V Garnet" and the Liberian ship "Molafinsher" had been occurred near the wave breaker of Port Said. As a result of that collision, the ship M/V Garnet had sunk. According to the shipping data and the permission of the ship passage through the Suez Canal issued by the AEA, the ship "M/V Garnet" was carrying two Sr^{90} radiation sources with activity of 0.5 mCi each [24].

In August 1985, the AEA had been informed that the actions of floating the ship had been started and the radiation protection help were needed to restore the two containers containing the radioactive material. The containers were situated in the lower chamber since 1981. Water marine herbs and other marine samples were collected from the lower chamber. The samples were analyzed in the laboratories of Radiation Protection Department of the Nuclear Research Center at Inshas. The results showed no evidence for the presence of radiation levels in those samples, reflecting no environmental radiation contamination [24].

After restoring the two sources, it was found that they were contained in a wooden box (20x20x40 cm.) and they were in a very bad condition as a result of being under water for a long time. The containers were labeled with a metallic plate containing all the data concerning the sources. Radiation measurements were carried out and shoed the presence of the two sources inside their containers and the conformation of non-external contamination. The containers were cleaned and placarded and labeled according to the national and international regulations for the safe transport for radioactive materials, and returned back to its original country [24].

5. Conclusions

1. The Egyptian legislation for transport of radioactive materials are based on all the regulations of the IAEA for safe transport of radioactive materials taking into considerations the international laws, conventions, protocols, codes, and technical instructions in this concern.
2. According to the IAEA regulations, the NCNSRC-AEA is the independent governmental regulatory body and the competent authority for controlling all activities concerning the transport of radioactive materials inside the country, across its territories and its regional waters.
3. According to the Egyptian radiation protection legislation (law No. 4 (1994), Prime Minister Decree No 338 (1995)), the NCNSRC-AEA licnece is needed for handling the radioactive materials. Such handling include all collection, transport, store, treatment or using the radioactive materials.
4. Law No.4 strictly stipulates to get the NCNSRC-AEA lincence before importing any radioactive wastes or allowing its entrance or its passing through the Egyptian territories, territorial sea or the exclusive economic zones of Egypt.
5. All the procedures and conditions for granting the NCNSRC-AEA licence to handle/ transport radioactive materials/wastes have been developed according to the international and Egyptian legislation.
6. The procedures for transit of ships carrying radioactive materials in Suez Canal are also constructed. The NCNSRC-AEA experts are entitled to accept or to refuse the transit of ships carrying radioactive materials in the Suez Canal, in the Egyptian regional waters, in the sea harbors or in the exclusive economic zones of Egypt according to the national and international regulations.
7. All the documents of the ship carrying radioactive materials shall be submitted to the NSNCRC for compliance assurance prior to ship arrival by at least forty eight hours to regulate safe passage of such ship through Suez Canal.
8. The documents required for compliance assurance are:
   - a certificate proving that the ship carrying radioactive materials has to comply with the conditions and prescriptions enforced by laws and rules in the exporting country, with the conditions and prescriptions recommended by the IMO code and the IAEA regulations.
   - a shipment declarations concerning all the information required by the NCNSRC-AEA to classify the radioactive materials load among one of the three basic groups; Group A, contains all fissile materials, Group B includes all artificially high activity radioactive sources and Group C includes non-fissile materials.
   - a Compensation warranty document covering all direct or indirect damage that may be caused by the presence of the radioactive materials in Suez Canal.
9. On the arrival of the ship carrying radioactive material, the experts of the NSNCRC-AEA go on board of the ship to inspect and examine the radioactive material load. According to the calculations of TI/CSI and to the inspection of the radioactive load, the expert shall issue a certificate to Suez Canal Authority. The certificate includes permission that the ship carrying the radioactive materials can safely pass the Suez Canal.
10. The Accident of the ship M/V GARENT that had sunk in Suez Canal 1981 was revealed with no environmental radiation contamination.

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SAFETY SUPERVISION PROVISIONS FOR THE TRANSPORT OF RADIOACTIVE MATERIAL IN FRANCE

P. Saint Raymond, J. Aguilar, E. Jacob, E. Seyer

Direction Générale de la Sûreté Nucléaire et de la Radioprotection
Paris, France

Abstract.

This paper gives an overview of the Safety supervision provisions for the transport of radioactive material in France. The introduction sets the responsibility of the French regulator as regards transport of radioactive material since the major change, which occurred in France in 1997. Then the main lines of the regulation in force are presented, related to the various mode of transportation in use, together with the process for assessing the safety documents and the inspection and field supervision system. Following that is the presentation of the emergency response organisation in case of an accident. Finally the important aspect of the communication with the public about the issue of transport and related events even with minor impact is described. The conclusion gives the ASN prospects to continue striving for maintaining the transport safety at the highest level.

1. Introduction

In the context of supervision of the safe transportation of radioactive and fissile materials, the French Nuclear Safety Authority (ASN) is responsible for:

– defining technical regulations and monitoring their application,
– accomplishing authorisation procedures (approval of packages and organisations),
– organising and implementing inspection procedures,
– proposing and organising the information of the public.

In addition, the ASN can act in the context of emergency plans defined by the authorities to contend with an accident.

The ministers responsible for nuclear safety set up, by a decision of December 1, 1998, an Advisory Committee for the transportation of nuclear materials, on similar lines to those previously existing.

Depending on the importance of the issue, expert assessment by its technical support organisation, the Institute for radiation protection and nuclear safety (IRSN), at the ASN's request, could be supplemented by an Advisory Committee examination.

2. Regulations

Unlike the technical safety regulations for plants, which are specific to each State, an international basis has been defined by the International Atomic Energy Agency (IAEA) for transportation safety.

This basis has been used for the definition of the modal safety regulations currently in force: the ADR agreement on road haulage, the RID agreement on transport by rail, the ADNR regulations for inland waterway transport, the IMDG code and the technical instructions of the ICAO for sea and air transport respectively, all of which have been entirely integrated in French law. In this context, the ASN has frequent contacts with the Government departments dealing with the different modes of transport (Directorate for Inland Transport, Directorate for Maritime Affairs and Seafarers, Directorate for Civil Aviation) and has a representative at the Interministerial Committee on the transport of dangerous goods (CITMD).

Transport safety is based on three main factors:

– first and foremost, on the engineered toughness of the packages,
– on transport reliability and certain specially equipped vehicles,
– on efficient emergency action in the event of an accident.

Regulations are based on IAEA recommendations, which specify package performance criteria. The safety functions to be assured are containment, radiation protection, prevention of thermal hazards and criticality.

The degree of safety of the packages is adapted to the potential noxiousness of the material transported. For each type of package (excepted packages, industrial type packages, type A packages, type B packages, type C packages), the regulations define the associated safety requirements, together with test standards to be reached. In its latest recommendations in 1996, the IAEA introduced a new type of package (type C), designed for air transport of large quantities of radioactive material. These recommendations came into force in France on July 1, 2001.

These regulations cannot be other than international, considering the number of transboundary movements involved. The ASN will consequently endeavour to involve itself with decisions as far upstream as possible in the drafting of these regulations, in cooperation with the IRSN, and notably at the IAEA Transport Safety Standards Committee (TRANSSC), where the ASN has a qualified expert.

3. Assessment of safety documents

The ASN proceeds to a critical analysis of the safety documents proposed by the applicants to obtain an approval certificate for their package design.

Certain package designs require the approval of the competent authority before they can be authorised for transport in France:

– radioactive materials in special forms,
– slightly dispersible radioactive materials,
– type B and C packages and all fissile material packages,
– special arrangement shipments (the package fails to comply with all the requisite criteria, but compensatory transport condition measures have been taken to ensure that transport safety will not be below that of a transport operation involving an approved package).

By delegation from the Ministers and after technical examination of the documents by the IRSN, the ASN gives its approval to the package designs complying with the regulations and validates certificates issued by authorities in other countries for inland transport in France.

These certificates are usually issued for a period of a few years. At the present time, about 100 applications for approval are submitted annually by the manufacturers to the ASN (new package design, extension of the term of validity, validation of a certificate issued by a foreign authority, special arrangement, extension of a certificate to cover contents other than those initially defined in the safety documents).

Generally speaking, certificates are issued for package designs and not package by package. However, manufacturing, operating and maintenance conditions are consistently specified.

These certificates are often issued outside the context of specific transport operations, for which no prior warning of the ASN is generally required, but which may be subjected to security checks (physical protection of materials under the control of the Senior Official for Defence at the Ministry for Industry).

4. Inspection and field supervision

The ASN has implemented inspection provisions involving the regional directorates for industry, research and the environment (DRIREs) at local level, in similar fashion to the procedures already adopted for Basic Nuclear Installations.

These organisational arrangements allow inspections to be carried out at the works of designers, manufacturers, users, carriers, consignors and their subcontractors and enable package quality to be monitored between two authorisation extensions. In this connection, a manufacturing supervision assignment was entrusted to the ASN division in charge of nuclear steam supply system supervision (BCCN) at the beginning of 1998 for B type packages. Training sessions for "transport" inspectors were renewed in 2001. They will be periodically provided to maintain inspector qualification.

On both the regulatory and practical planes, it is important to ensure good cohesion with other supervisory authorities responsible, notably, for the inspection of transport vehicles, for work and safety inspection in the transport sector or for the protection of nuclear materials. These authorities may have to prohibit transport operations further to observation of regulatory non-conformances.

5. Emergency response provisions

Nuclear safety is not only directed towards accident prevention, but also towards limitation of consequences. To this end, in conformity with the defence in depth principle, the necessary provisions must be made to bring even an improbable accident situation under control. These "ultimate" lines of defence comprise specific organisational structures and emergency plans, involving both the consignor and the authorities.

The details of emergency assistance in the event of an accident are defined in special emergency response plans for radioactive material transport accidents, in accordance with decree 88-622 of May 6, 1988, implementing law 87-565 of July 22, 1987. These actions are supervised by the Directorate for civil defence and security at the Ministry of the Interior, which the ASN assists.

6. Information of the public

As provided for in decree 93-1272 of December 1, 1993, and confirmed by decree 2002-255 of February 22, 2002, the ASN is responsible for proposing and organising the information of the general public on nuclear safety. So, in the field of transportation, the ASN will rely on the methods and tools which, in the nuclear plant supervision field, enabled it to introduce regular, constructive exchanges with the general public and the media, marked by constant concern for clarity and exactness. Such provisions include notably:

- the "Transport" section of the review "Contrôle", which gives details of recent authorisations and incidents,
- the publication of information on the Magnuc viewdata server and the ASN Internet site,
- exchanges with the media: conferences, communications, public reports,
- the introduction of transport issues in the commission for local information (CLI) debates,
- the development of communication tools, such as the INES scale.

In particular it should be emphasised that any event rated INES level 1 and above occurring in France give rise to a press release and, if it concerns a transboundary movement, is also reported to the international nuclear event web-based system (NEWS) monitored by the IAEA.

However, it should be noted that particular transport operations may benefit from a certain level of confidentiality on nuclear material security grounds.

Issue 146 of the "Contrôle" review, published in may 2002, is devoted to radioactive material transportation and includes 18 contributions from the different stakeholders (regulators, operators, IAEA and environmental association).

7. Conclusion

The ASN continues to reinforce the supervision it has exercised since 1997 over radioactive material transportation by:

- pursuing inspections on the premises of the designers, manufacturers, users, carriers, consignors of radioactive material packaging,
- reviewing internal transport regulations at nuclear sites,
- testing the emergency response provisions it would implement in the event of an accident involving radioactive material transportation,
- updating communication tools enabling information of the public as to the seriousness of an accident involving radioactive material transportation.

These actions have reinforced the safety culture of the transport operators, many of whom have undertaken a thorough revision of their activity.

2001 was marked by the entry into force of requirements included in the most recent IAEA recommendations and confirmation of application of the INES scale to transport incidents after the trial period. 2002 was marked by the entry into force of radiation protection programme and , for the first time, by an event, rated by the Swedish Authority at the level 3 of INES, during a transport from Sweden to USA through the Roissy airport and by an event, rated at level 1, of contamination of an internal road between the two terminals of this airport. Each year, around 50 events are rated at level 0 and around 15 at level 1 in France, which must be compared to around 600 000 packages transported.

However, it is important not to overlook the substantive technical work underlying the issue of package approval certificates: safety reviews of existing package models and the approval of new models incorporating innovative design features contribute to the overall upgrading of transport safety.

Finally, in order to obtain an external assessment of its transport supervision system, France has requested the IAEA, on the 11 September 2002, for a TRANSAS mission, which, after a preparatory stage during the spring 2003, will be conducted in the year 2004.

CONTENTS SPECIFICATION CRITERIA FOR PACKAGE DESIGN APPROVALS IN GERMANY

F.-M. Börst, F. Nitsche

Federal Office for Radiation Protection
Salzgitter, Germany

Abstract.

Requirements for a package design for the transport of radioactive and fissile material are established in the Regulations for the Safe Transport of Radioactive Material - 1996 Edition (TS-R-1). Beginning with the first edition in 1961 the Regulations for the Safe Transport of Radioactive Material were developed consequently to a high standard to protect persons, property and the environment from the effects of radiation during the transport of radioactive material by placing the primary reliance on the package design. One important part of the package design approval procedure is to show that all dose rate limits and other requirements relating to radiation shielding are fulfilled when the maximum radioactive contents is considered. The applicant has to find covering parameters for the contents description which will be fixed in the package design approval certificate as maximum permissible parameters. This paper describes the contents description for spent fuel elements and vitrified high level radioactive waste (HAW) from the reprocessing which are acceptable to the Federal Office for Radiation Protection (BfS) as the competent authority for package design approval. Such parameters for spent fuel elements are i.e. enrichment, burn-up, cooling time, or the description by source strengths for gamma and neutron emitters. It is also shown which specific evidences, i.e. for weak areas of the shielding, are requested by BfS.

1. Introduction

Type B packages are used for the transport of spent fuel elements and vitrified high level radioactive waste (HAW). They require a package design approval by the competent authority of the country of origin and due to the fissile contents a validation (multilateral approval) by the appropriate competent authorities if transported internationally.

According to the German dangerous goods transport law in connection with national dangerous goods transport regulation for the different transport modes the BfS is the competent authority for these package design approvals. All aspects dealing with the radiation shielding and criticality safety are examined by BfS. The evaluation of the mechanical and thermal behavior, the leaktightness and the quality assurance of a package design is performed by the Federal Institute of Material Research and Testing (BAM).

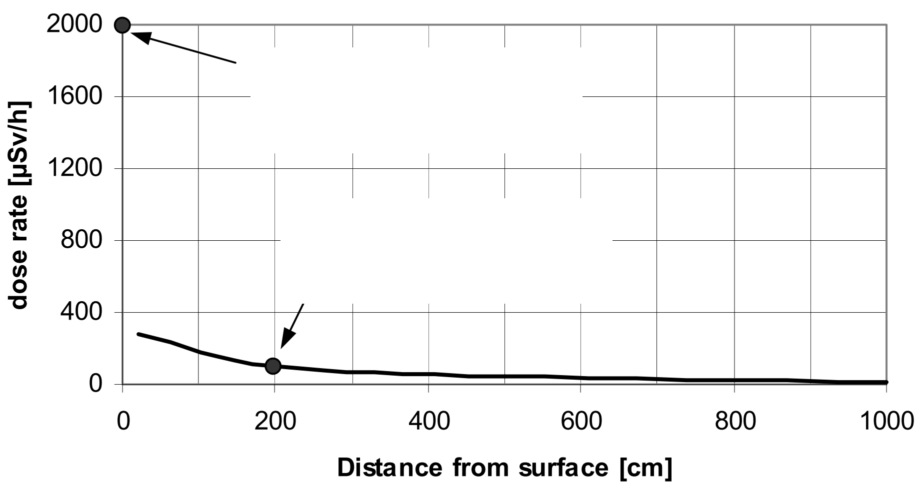
The requirements for package and packaging, respectively, are established in the modal transport regulations for dangerous goods, class 7 in compliance with the Regulations for the Safe Transport of Radioactive Material - 1996 Edition (TS-R-1) [1].

2. Dose rate limits

Any package or vehicle used for radioactive material transport has to meet the applicable dose rate limits as required by TS-R-1 in chapter 5 and 6. From this the dose rate limits to be considered in a package design approval procedure are listed in Table 1. The italic marked limits are not explicetly required for a package design approval by the regulations but often they are the limiting values for the use of the package (see Figure 1). All German package designs used for the transport of spent fuel elements and HAW are based on the dose rate limit of 0,1 mSv/h in 2 m from the surface of the conveyance. This fact has the advantage that no additional shielding provided by the conveyance must be used which can have a major influence on other paramaters, i.e. heat flux limitations according to permissible package surface temperature, and which needs additional operational control of the conveyance.

Table 1: Dose Rate Limits

„Limit"		Paragraph of TS-R-1	Remark
Routine conditions of transport			
0,1 mSv/h	1 m from the package surface	530	derived from TI = 10
2 mSv/h	at any point on the external package surface	531	non-exclusive use
10 mSv/h	at any point on the external package surface	532	exclusive use (modal specific conditions of paras. 572(a), 574 and 578 have to be considered)
2 mSv/h	*at any point on the external surface of the conveyance*	*566*	
0,1 mSv/h	*2 m from the external surface of the conveyance*	*566*	
Additional requirements for rail and road transport			
2 mSv/h	at any point on the external package surface	572	
10 mSv/h	at any point on the external package surface	572	only when additional conditions (enclosure, fixing, no loading/unloading during shipment)
2 mSv/h	*at any point on the outer surface of the vehicle*	*572*	*includes upper and lower surface*
0,1 mSv/h	*at any point 2 m from the vertical planes*	*572*	*planes represented by the outer lateral surfaces of the vehicle*
Additional requirement for transport by vessels			
> 2 mSv/h	*at the package surface*	*574*	*transport only under special arrangement*
Additional requirement for air transport			
> 2 mSv/h	*at the package surface*	*578*	*transport only under special arrangement*
Normal conditions of transport			
increase in the radiation level < 20%	at any point of the external package surface	646	after „type A tests"
Accident conditions of transport			
10 mSv/h	1 m from the package surface	656	with maximum radioactive contents after „type B tests"



In case of para. 656 of TS-R-1 it is explicitly required to meet the dose rate limit of 10 mSv/h in 1 m distance from the package surface after accident conditions with the package containing the maximum radioactive contents. BfS requires the applicant to proof by comprehensive package design shielding analysis that all dose rate limits are fulfilled when the maximum radioactive contents has been considered. This is in full compliance with paras. 415, 418 and 833 (l) and (m) of TS-R-1 where a detailed description of the authorized contents including any contents restriction and the declaration of the activities of the involved isotopes is required.

This procedure for contents specification is also useful regarding practical application aspects of the regulations, e.g.:

- It must be shown that all applicable requirements are fulfilled before each shipment (see para 502 of TS-R-1). This can be done best if the proof has considered the maximum contents.
- Neither a longer cooling time of a loaded cask or unloading (radiation protection! - see para. 104 of TS-R-1) nor additional dose rate calculation become necessary before shipment.
- Criteria for the inspection of the authorized contents by concerned local state authorities are available before loading the cask.

3. Contents description and specific evidences for the dose rate assessment

In addition to the required description of geometry, chemical and physical form of the radioactive contents the following contents descriptions due to the radioactive properties - often as combination - have been applied to meet the appropriate dose rate limitation of the package design:

- the specification of fixed parameters for minimum and maximum enrichment, maximum burn-up, specific power of the last irradiation cycle and minimum cooling time,
- the specification of source strengths, energy dependent for the gamma dose rate and spectral type dependent for the neutron dose rate,
- the specification of activities and/or masses of nuclides/actinides relevant for compliance with the dose rate limits outside the cask.

Examples of the first two possibilities with detailed descriptions can be found in [2]. Some aspects of their applications were discussed in [3]. The selection of the appropriate kind of specification must be done by the applicant. When the radioactive contents to be transported, and this also for the near future, is known in a way that covering parameters can be found it is suggested by BfS to use the first method of contents specification because the examination effort and time as well as the possibility to make errors in the practical implementation can be minimized. When no covering parameters can be found, the BfS have made good experiences with the other description possibilities listed above. But in these cases the examination by the competent approval authority necessitates more calculational effort and therefor more time especially when each single spent fuel element or HAW canister inside the cask is described in this way.

When examined by BfS that all applicable requirements relating to the dose rate limits of the regulations are met, these parameters will be fixed in the package design approval certificate as maximum permissible parameters.

Due to the design feature of a cask for spent fuel elements or HAW it is possible that weak areas in the radiation shielding can exist. It is a task of the applicant to localize such areas for the design, if there are any, and to give evidences that all applicable dose rate limits are met for these areas too. From the BfS experiences specific evidences are necessary for (see also Figure 2):

- corner areas between cask body and lid/bottom
- trunnions and the surrounding area
- end fitting zones for spent fuel elements

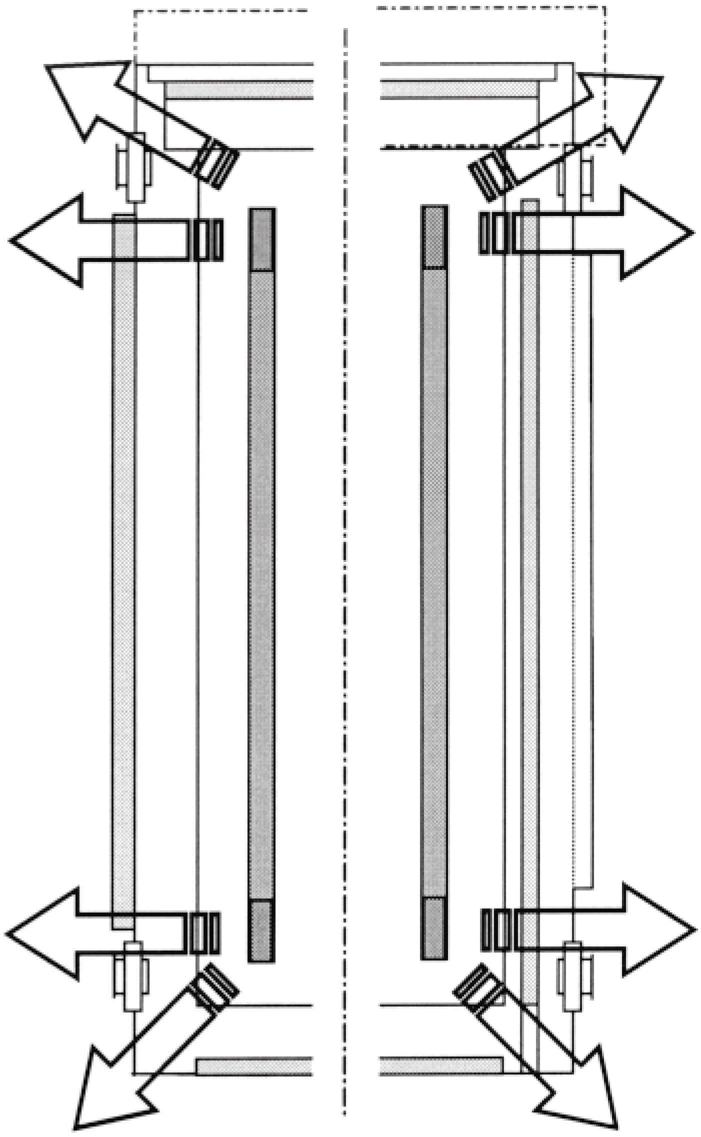


Figure 2: Schematic view of areas for which specific evidences are required.

4. Conclusions

Good experiences have been made since the contents descriptions as discussed have been used within German package design approval certificates. The need for revising a certificate due to practical needs of the applicants could be reduced. The described contents specifications provide a certain degree of flexibility to the cask user to cover a range of various spent fuel elements and practical needs according to future developments. Although the contents description seems to be difficult when useing source strengths their practical application e.g. by the local state authorities responsible for inspections shows good experience.

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SAFETY IN THE TRANSPORT OF RADIOACTIVE MATERIAL - INDIAN SCENARIO

S.P. Agarwal, A.N. Nandakumar, K.C. Upadhyay, A.R. Sundararajan

Radiological Safety Division, Atomic Energy Regulatory Board
Niyamak Bhavan, Mumbai-400 094,
India

Abstract

The Competent Authority for the enforcement of regulations on safe transport of radioactive material in India is Atomic Energy Regulatory Board (AERB). Transport of radioactive material in India is governed by the AERB code [1] which is based on the IAEA regulations on the safe transport of radioactive material, Safety Series No. 6, 1985 [2]. The code is being revised to take into account the revision made in the IAEA transport regulations i.e. TS-R-1 (ST-1, revised), 2000[3]. For a majority of the shipments, the consignor is the supplier of radioactive material to various users in medicine, industry and research.. Radiation safety in the transport of these packages in ensured through A well defined regulatory frame work and radiation protection procedures. The consignor is required to ensure that the packages used meet the prescribed standards. Transport documents, in addition to the consignor's declaration, include instructions to the carrier and transport emergency card (TREMCARD). TREMCARD describes the potential hazards involved in the shipment, primary emergency response action plans and emergency contact numbers. A well-defined emergency response system is in place in India to handle emergencies, which may occur during transport of radioactive material. The paper highlights the volume of transport of radioactive material, package approval procedure and various aspects including emergency response system adopted in India to ensure the safe transport of radioactive material.

1. AERB code versus IAEA regulations

The code in general adopts all the requirements of IAEA regulations. However, country specific conditions to the regulations are added as follows:

1. Ambient temperature has been taken as 42^0C in place of 38^0C.
2. Gross weight of the package exceeding 30 kg needs marking on the package.
3. Type A packages need to be registered with the Competent Authority.

2. Volume of transport of radioactive material

About 80 000 packages containing radioactive material are transported in India. A Majority of the transport is generated due to supply of radioactive material by the Board of Radiation and Isotope Technology (BRIT), Mumbai. This includes transport and export of decayed/disused sources, movement of sources from one working site to another, transport of LSA material and transport related to nuclear fuel cycle. Distribution of different types of packages used is shown in the Table 1 below. Type B(U)/B(M) packages mainly include industrial radiography exposure devices, gamma irradiator transport containers, gamma cells, teletherapy source transport containers and spent fuel.

Table 1

Type of package	Distribution %
Excepted packages	55%
Industrial packages	2%
TYPE A packages	40%
TYPE (B(U)/B(M) packages	3%

3. Package approval procedures

As per the current regulatory procedure, the designer/consignor is required to submit an application in the prescribed format to AERB demonstrating compliance with the requirements of the regulations. The documents to be submitted include design drawing, specifications, and construction details of the package and quality assurance procedure. An expert committee constituted by AERB evaluates the package design. The expert committee critically reviews the design with respect to its compliance with the requirements of the regulations and submits its recommendations to an apex committee, viz., Safety Review Committee for the Applications of Radiation (SARCAR), which finally recommends issuance of approval certificate for the package. Type A packages are registered with the AERB whereas for TYPE B(U)/B(M) packages, type approval certificate is issued. The process involves critical examination to ensure that all the design features are in line with the requirement of the regulations. Test requirements are met either by established theoretical methods or by using validated computer codes such as PAMCRASH. In some of the cases, conducting actual tests on a scaled down experimental models does the computer code validation. However, light weight packages are subjected to the actual tests for evaluation.

4. Commonly used mode of transport in India

Air and road modes are the commonly used modes for transport of radioactive material in India. Sea mode is not used for domestic transport due the large transport time and inconvenience involved. However, for export of heavy packages or large volume of LSA material, sea mode is used. Air freighting of all classes of dangerous goods require permission from the Director General of Civil Aviation (DGCA), New Delhi. The DGCA issues a permit to the carrier/consignor based on the recommendation of AERB.

5. Operational controls including quality assurance

The consignor is required to exercise control over the shipment during its movement from one place to another. He is required to give instructions to the carrier for loading, transshipments and unloading and security of the consignment during transport. Consignor's declaration, instructions to the carrier in writing, emergency procedures and TREMCARD are included in the transport documents. A quality assurance (QA) programme has to be established by the consignor which includes a comprehensive check list to ensure that all the regulatory procures are scrupulously followed while preparing, marking, labelling and transporting the package. The consignor is not relieved of his responsibility till the shipment reaches its destination safely.

6. Emergency response system and transport incidents

Despite the measures taken to ensure that probability of occurrence of an accident is very low, it is a standard practice, as a prudent measure, to have an emergency response mechanism in place. The response system, in India consists of a centralized Emergency Communication Room (ECR) which is manned all the time. A specific document which details the response plans to handle emergencies during transport of radioactive material has been prepared. The document contains response action plans for each type of shipment covered in the standards with different UN numbers. Regulatory procedures require that transport documents include a transport emergency card (TREMCARD) bearing the contact details of ECR and first aid action plan. A network of 15 emergency response facilities (ECF) has been created all over the country. All the response facilities are equipped with appropriate instruments and trained manpower. ECR will contact the ERF nearest to the site of accident so that response action can be implemented within A short time of the receipt of information at ECR. There have been a few incidents involving radioactive consignments in India. For example:

- head on collision between a vehicle and one carrying radioactive consignment;
- toppling of vehicle carrying radioactive consignment;
- Fall of a package while being lifted by overhead crane;
- damage to the packages due to large number of transshipments during transport;
- pilferage at the cargo office;
- loss of package during transport;
- package forwarded without proper closure.

None of the above type of incidents has resulted in any significant exposures to workers or members of the public.

7. Dose assessment programme

Most of the packages containing radioactive material originate from Mumbai. The persons who are engaged in the preparation of the package are occupationally exposed to radiation. Among the members of public, the group who encounters the largest number of packages is the cargo handlers. A study was undertaken to measure the radiation dose received by the cargo handlers at Mumbai airport by providing personnel monitoring badge to each cargo handler. It was found that no worker would receive an annual dose exceeding 1 mSv. A study carried out in India under AN IAEA coordinated research programme revealed that the total dose that could be received by the pedestrian, passengers and public residing on the route taken by radioactive shipment would not add significantly to the exposures received form natural background radiation.

8. Conclusion

The regulatory procedures for the safe transport of radioactive material in India are in line with the IAEA regulations. The consignors adopt some additional measures such as registration of TYPE A packages and stringent operational controls. The few incidents that occurred during transport of radioactive material did not result in any significant exposure. An emergency response system is in place to handle any emergency occurring during transport of radioactive material. The regulatory procedures are periodically reviewed and updated based on the experience gained for ensuring the radiation safety during transport of radioactive material.

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EXPERIENCE IN THE APPLICATION AND IMPLEMENTATION OF EUROPEAN AND INTERNATIONAL REGULATIONS ON THE TRANSPORT OF RADIOACTIVE MATERIAL IN IRELAND

J.T. Duffy, J. O'Grady, C.P. Hone, S.G Fennell, A.T. McGarry

Radiological Protection Institute of Ireland,
Regulatory Service, 3 Clonskeagh Square, Clonskeagh Road,
Dublin 14, Ireland.

Abstract.

The implementation in Ireland of European and International regulations relating to the licensing and transport of radioactive material is discussed. The licensing system, inspection programme and specific requirements therein concerning transport are outlined. Finally, the Institute's role in staff training and information sharing for the benefit of both regulator and licensee is presented.

1. Regulatory infrastructure

Radiological Protection Act, 1991

The primary legislation governing safety for the custody, use or transportation of ionizing radiation in Ireland is the Radiological Protection Act, 1991[1]. This Act provided for the establishment in 1992 of the Radiological Protection Institute of Ireland, whose role among others things is to advise the Government on measures for the protection of individuals from radiological hazards. The Institute was previously under the aegis of the Department of Public Enterprise but as of the last quarter of 2002, now reports to the Department of the Environment and Local Government. Under the Act the Institute functions as the competent authority for the control of sources of ionizing radiation in Ireland including the transport of radioactive material. The Act was amended in 2002 by the Radiological Protection (Amendment) Act, 2002 [2] which, inter alia, makes it an offence to breach a licence condition.

Radiological Protection Act, 1991 (Ionizing Radiation) Order

The Radiological Protection Act, 1991 (Ionizing Radiation) Order, S.I. No. 125 of 2000 [3] implements in Irish Law the provisions of Council Directive 96/29/Euratom laying down the basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation [4]. The Order requires that all practices including the custody, production, processing, handling, holding, storage, use, manufacture, importing into and exporting from the European Union, transportation, recycling, reuse or other disposal of radioactive substances and nuclear devices be licensed by the Institute unless the conditions for exemption are met.

Carriage of Dangerous Goods by Road Act, 1998

This Act [5] enables effect to be given to the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) [6] and Council Directive 94/55/EC of 21 November 1994 [7] on the approximation of the laws of the Member States with regard to the transport of dangerous goods by road and Council Directive 95/50/EC of 6 October 1995 [8] on uniform procedures for checks on the transport of dangerous goods by road. The Institute is one of four appointing authorities listed in section 6(1) of the above Act that may appoint inspectors for the purposes of the Act and is the competent authority for Class 7 dangerous goods. The other competent authorities deal with different classes of dangerous goods, such as chemicals, explosives etc.

The Carriage of Dangerous Goods by Road Regulations, 2001

The Carriage of Dangerous Goods by Road Regulations, 2001, S.I. No. 492 of 2001 [9] came into operation on the 1 April 2002 and gave effect to Council Directive 94/55/EC of 21 November 1994 [7] and are made under the Carriage of Dangerous Goods by Road Act, 1998. These regulations also implement the ADR. They apply to the carriage, both in packages and in bulk form, of dangerous goods by road, including the loading and unloading of dangerous goods in relation to their carriage.

The Regulations impose duties on the consignor and the carrier of dangerous goods and on the driver of the vehicle carrying the goods. They contain requirements for the vehicles, tanks, tank containers, receptacles and packages containing dangerous goods during their carriage. The Regulations require that drivers and others involved in the carriage of dangerous goods by road (including their loading and unloading) are adequately trained, and that drivers hold certificates for the relevant ADR classes of dangerous goods being carried and for the mode of carriage appropriate for the load. They also contain provisions on an EC harmonised approach to their enforcement by carrying out road checks.

The competent authority for these regulations is the National Authority for Occupational Safety and Health. The Institute is one of the authorised bodies appointed by the Authority for the purpose of enforcing the regulations and is the competent authority in respect of matters relating to the carriage by road of radioactive materials (ADR Class 7). This includes the approval of specialisation courses for the training of drivers of vehicles carrying radioactive material and the examination of these drivers in accordance with Marginals 10315 and 71315 of the ADR and regulations 27 and 29 of the Carriage of Dangerous Goods by Road Regulations, 2001.

Dangerous Goods Safety Adviser, Regulations, 2001

Any undertaking involved in the transport of dangerous goods by road or rail, subject to some limited exemptions, is required to appoint a Dangerous Goods Safety Adviser by virtue of the European Communities (Safety Advisers for the transport of Dangerous Goods by Road and Rail) Regulations, 2001, S.I. No. 6 of 2001 which came into force on the 17 January 2001 [10]. Radioactive material is currently not transported by rail in Ireland.

These regulations implement Council Directive 96/35/EC [11] on the appointment and vocational qualification by examination of safety advisers for the transport of dangerous goods by road and rail and the associated Council Directive 2000/18 [12] on minimum examination requirements for safety advisers for the transport of dangerous goods by road and rail. The competent authority in the State for the purpose of the regulations in relation to the transport of dangerous goods by road is the National Authority for Occupational Safety and Health and by rail is the Minister for Transport.

Licensing system – requirements for transport of radioactive material

Under the Radiological Protection Act, 1991 (Ionizing Radiation) Order, S.I. No. 125 of 2000 an application to the Institute for a licence must be made at least one month before taking possession of a source and must be accompanied by the relevant documentation as outlined below. The Regulatory Service of the Institute is responsible for licensing, inspection, enforcement and incident investigation.

The Institute issues licenses covering a broad range of applications, but only about 100 licensees (representing 7% of the total) are involved in transporting radioactive material. These include for example, those involved in the distribution of radioactive material, industrial radiography, irradiation facilities, users of nuclear moisture density gauges, hospitals with nuclear medicine departments, hospitals with radiotherapy departments and some universities / institutes of technology. Under the present licensing system the scope of a licence is practice specific and only covers transport if the licensee is routinely engaged in transporting radioactive material.

General Licence Conditions

The licence for a practice including the custody, use and transportation of radioactive material includes a range of conditions that relate to general administrative items, acquisition of sources, personnel dosimetry, operational controls, maintenance and quality control, transportation, exportation, disposal and record keeping.

Applications for a new licence and / or licence renewal must include radiation safety procedures and a risk assessment as appropriate. The risk assessment is designed to identify the hazards, the severity of the risks and the control measures needed to reduce the risks from exposure to ionizing radiation.

These documents must address all issues associated with the practice including where relevant, the safe transport of radioactive material. The Institute's Regulatory Service has compiled guidance notes for use by licensees to assist them in the completion of radiation safety procedures [13] and a risk assessment [14].

The requirement under Article 19 of the Radiological Protection Act, 1991 (Ionizing Radiation) Order S.I. No. 125 of 2000 for a licensee to appoint a Radiation Protection Adviser (RPA) has not yet been formally enforced. However, the Institute is currently setting up a register of Radiation Protection Advisers. The requirement to appoint an RPA is expected to lead to improved safety standards as the licensee will then seek advice directly from an RPA on matters pertaining to the safe transport of radioactive material to, within and from Ireland.

Article 37 of the Radiological Protection Act, 1991 (Ionizing Radiation) Order S.I. No. 125 of 2000 on Intervention and Emergency Preparedness specifies that in the case of a licensable practice, the undertaking carrying on the practice shall, when directed in writing by the Institute, prepare an appropriate intervention plan to deal with a radiological emergency which could give rise to significant hazards to members of the public. Where a risk assessment shows that a radiological accident involving the transport of radioactive material is a possibility, the licensee is required to prepare an emergency response and preparedness plan for workers and members of the public who may be affected. Draft guidance notes for licensees on emergency planning and preparedness for radiological accidents have been prepared [15]. The most up-to-date and relevant IAEA TECDOC's and Safety Standard Series publications are referenced in the guidance notes. The requirement to prepare an emergency plan has not yet been enforced, however, it is expected that by the end of 2003, certain licensees involved in the transportation of radioactive material will be required to prepare a plan.

Licence conditions for the transportation of radioactive material

The Institute's licence conditions for the transportation of radioactive material are based on the IAEA Regulations [16] and associated advisory material [17] and also, where road transport is concerned, on the ADR Regulations. The licence conditions on transportation include the following:

- The licensed radioactive source shall be shielded, packaged and transported in accordance with the IAEA Regulations for the safe transport of radioactive material [16].
- The Radiological Protection Institute of Ireland licence and the 'Notes for Drivers and Others involved in Road Transport of Radioactive Materials' [18] shall be made available by the licensee to all relevant personnel involved in the transportation of radioactive sources. These Guidance Notes provide basic information to the Driver on requirements before the start of transport, during and after transport and breakdowns and accidents while carrying radioactive material.
- Radioactive sources must normally be transported directly from one location to another and may only be undertaken in the licensee's vehicle unless otherwise authorised by the Regulatory Service.
- Secure and Safe parking shall be provided for any vehicle left unattended while the vehicle contains a licensed item. These vehicles shall also be fitted with a suitable alarm system that shall be set whenever the vehicles are left unattended.
- An industrial radiographer must accompany industrial radiography sources during their transportation.

Additional conditions for the acquisition and transportation of cobalt-60 for irradiation facilities apply.

- In the case of a replenishment of the irradiator with new cobalt-60 sealed radioactive sources the licensee shall obtain and forward a Consignor's Certificate, a Leak Test Certificate, a Competent Authority Certificate and a Special Form Certificate in advance of the proposed replenishment.
- The licensee shall notify the Regulatory Service of the transport arrangements well in advance of the proposed shipment date.

An Import licence is required if sealed sources are imported from outside the European Union and an Export licence is required if sealed sources are exported to a country outside of the European Union. Prior authorisation is required in both cases.

The Council Regulation 1493 of 1993 on the shipment of sealed radioactive sources between Member States of the European Union [19] is also referenced in the licence and the relevant trans-frontier shipment forms are regularly used. Institute guidelines are also available for the transport and exportation of Type B(U) packages such as those used to transport sources used in research and industrial irradiation facilities [20].

2. Inspection programme

An inspection programme covering different licence bands (industrial, medical, education/research, distribution and others) is drawn up at the beginning of each year. This programme is designed to ensure that those licensees, where the greatest radiological risks exist are inspected most frequently. Inspections are safety-focused and where practical, sources are inspected while in use, following the recommendation of the IAEA Peer Review Mission in November 2000 [21]. Standard inspection audit forms are used as a guide for the inspector and a summary report letter is issued following an inspection outlining the actions to be undertaken within a specified period. The programme is operated in accordance with the Customer Service Charter [22] and the Quality Management System of the Regulatory Service [23].

3. Training, education and information sharing on issues related to the transport of radioactive material

Although the number of licensees involved in the transport of radioactive material in Ireland is small and the number of packages transported to, within and from Ireland is only approximately 4800 per year, the licensing system is designed to ensure that doses to employees and members of the public are as low as reasonably achievable. In 2001 approximately 70% of the packages transported were Type A, approximately 29% were excepted packages and 0.1% were Type B.

As indicated, guidance notes are provided for licensees to assist them in complying with licence conditions and national and international regulations. Relevant staff of the Regulatory Service have attended training courses at the National Radiological Protection Board in the UK in relation to transport emergencies and the Institute is represented on national, European and international committees relating to radiological protection. The Institute has a formal Memorandum of Understanding [24] with the National Authority for Occupational Safety and Health and the Department of Enterprise Trade and Employment on matters relating to the transport of dangerous goods.

The Institute has representation on the European Commission Standing Working Group on the Safe Transport of Radioactive Material for many years. Since June 2002, the Institute has acted as the contact point for the IAEA Illicit Trafficking Database Office for matters relating to the unauthorised transfer, theft etc., of radioactive material. From early 2002 the Institute has nominated staff members to attend meetings of the IAEA Safety Standards Committees including the Transport Safety Standards Committee.

4. Conclusion

The regulatory infrastructure and licensing system as implemented in Ireland ensure that the transport of radioactive material both within Ireland, and to other countries, is carried out in accordance with the relevant international standards.

The competent authorities in Ireland are committed to implementing European and international Regulations to ensure that doses to employees and members of the public are as low as reasonably achievable and that property and the environment are protected from the effects of radiation during its transport.

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REQUIREMENTS FOR THE SHIPMENT OF RADIOACTIVE SUBSTANCES AND RADIOACTIVE WASTE IN LITHUANIA

K. Zemkajus

Radiation Protection Centre of Lithuania
Lithuania

Abstract

The first steps to regulate radiation protection of population and environment were taken after Lithuania regained its independence. Legislation was developed; governmental institutions responsible for supervision and control of implementation of the requirements of legal documents, were established; necessary legislation, setting requirements for conducting practices with sources of ionizing radiation, including requirements for shipment of radioactive substances and radioactive waste, were established. All above mentioned actions taken served as a basis for implementation of the requirements of the International Atomic Energy Agency and of the European Union regarding the shipments of radioactive substances in Lithuania.

1. The regulatory system

Radioactive substances and radioactive waste in Lithuania can be carried by air, waterways, rail or road. Transport and other relevant operations must comply with:

- Law on Transport of Dangerous Goods by Road, by Rail, by waterways of the Republic of Lithuania;
- Law on Environmental Protection of the Republic of Lithuania;
- Law on Radiation Protection of the Republic of Lithuania;
- Law on Radioactive Waste Management of the Republic of Lithuania;
- Law Concerning Control of Import, Transit and Export of Strategic Goods and Technologies of the Republic of Lithuania;
- Resolution of the Government of the Republic of Lithuania on the Procedure of Implementation of Import, Transit and Export Licensing and Control of Strategic Goods and Technologies;
- Resolution of the Government of the Republic of Lithuania on the Approval of Regulations Governing Licensing of Practises Involving Sources of Ionizing Radiation;
- Order of the Minister of the Environment of the Republic of Lithuania No 397 of 13 December 1999 on the Procedure for the Import into, Export out of, Transit and Shipment within the Country of Radioactive Substances and Radioactive Waste, and the Return of Used Sealed Sources.

In order to implement the provisions of Council Directive 94/55/EC on the approximation of the laws of Member States with regard to the transport of dangerous goods by road and Directive 95/50/EC of 6 October 1995 on uniform procedures for checks on the transport of dangerous goods by road, the Government by it’s Resolution adopted the Resolution of Control of Dangerous Goods by Road, by Rail and Inland Waterways. The Minister of Transport and Communication approved the Qualification Requirements for Drivers of Road Transport, Carrying Shipments of Dangerous Goods. Lithuania has signed following International Agreements and Conventions, regarding the Carriage of Dangerous Goods:

- Annex 18 to the Convention on International Civil Aviation of the International Civil Aviation Organisation (ICAO) and DOC 9284-AN/905 "Technical Instructions for the Safe Transport of Dangerous Goods";
- Convention concerning International Carriage by Rail (COTIF);
- Regulations concerning the International Carriage of Dangerous Goods by Rail (RID);

- European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR);
- Annex 2 "Regulations concerning the Carriage of Dangerous Goods" to the Agreement on the International Carriage of Goods of the Organisation for Railways Co-operation;
- International Maritime Dangerous Goods Code (IMDG) of the International Maritime Organisation (IMO).

In order to implement the provisions of Council Regulation (Euratoam) No 1493/93 of 8 June 1993 on Shipments of Radioactive Substances between Member States and Council Directive 92/3 Euratom of 3 February 1992 on the Supervision and Control of Shipments of the radioactive waste between Member States and into and out the Community has been approved the Procedure for the Import into, Export out of, Transit and Shipment within the Country of Radioactive Substances and Radioactive Waste, and the Return of Spent Sealed Sources.

The import into and export out of, transit and shipment within the Republic of Lithuania of radioactive substances, as well as the export out of, transit ant shipment within the Republic of Lithuania of radioactive waste is subject to an appropriate authorisation granted by the Government of the Republic of Lithuania or the Ministry of Environment, as well as a license issued by Radiation Protection Centre of the Ministry of Health for engaging in operations (activities) related to sources of ionising radiation. Transportation of radioactive materials within Lithuania is controlled by licence by Radiation Protection Centre of Lithuania that obliges the licensee to adhere to the International Atomic Energy Agency Regulations for the safe Transport of Radioactive Materials. The import into, export out of and transit of radioactive substances that have been entered into the lists of controlled strategic goods and technologies (including nuclear fuel for the Ignalina Nuclear Power Plant) is subject to a license issued by the Government of the Republic of Lithuania.

Health care, scientific and educational establishments and undertakings as well as public administration institutions and executive bodies shall be granted authorisations for the shipment of radioactive substances by the Ministry of the Environment. In all other cases, authorisations shall be issued by the Government of the Republic of Lithuania. In order to obtain authorisation for the import of sealed sources into Lithuania, the applicant must either submit documents which would reasonably ensure that such sources will be returned to the supplier of the sources after their use or a written consent granted by the State Atomic Energy Safety Inspectorate which enables to entomb such sources in Lithuania. Used sealed sources can be returned to Lithuania provided they are returned to the legal person who produced them and who has been authorised to accept and keep them. The application must be approved by the Radiation Protection Centre of the Ministry of Health and the State Atomic Energy Safety Inspectorate (in the case of shipment of nuclear materials or sources containing nuclear materials). The application must be accompanied by: a document characterising the radioactive substance involved in the shipment (a certificate, passport or certificate of examination), description of the intended use and a copy of a license for engaging in operations (activities) related to sources of ionising radiation.

The Ministry of the Environment shall examine the application for authorisation and shall take decision to grant authorisation for the import into, export out of, transit or shipment within the country of radioactive substances or for the export out of, transit and shipment within the country of radioactive waste or, alternatively, it shall draw up a reasoned refusal to issue such authorisation. Authorisation shall be refused due to failure to comply with the legislation of the Republic of Lithuania, international conventions and agreements ratified by the Republic of Lithuania, and the policy and security of the State; due to failure to comply with this Procedure, Regulations for the Safe Transport of Radioactive Material and standards of radiation protection, and where the documents submitted do not comply with the established requirements or contain misleading data.

The shipment of radioactive substances by post is prohibited.

Currently 8 legal persons for shipment of radioactive substances are licensed in Lithuania. Several institutions are allowed to transport portable units containing radioactive sources to the workplaces.

2. Scale of transport of radioactive substances

During last years the use of radioactive substances and shipments has decreased. The main is the shipment of nuclear fuel that is used at the Ignalina NPP. More considerable amounts of radioactive substances are shipped for medical purposes. Total activity of unsealed sources imported into Lithuania reaches several TBq, while for sealed sources – insignificant. Most part of shipments contains the transport of spent sealed sources, radioactive waste to the radioactive waste interim storage facility located at Ignalina NPP.

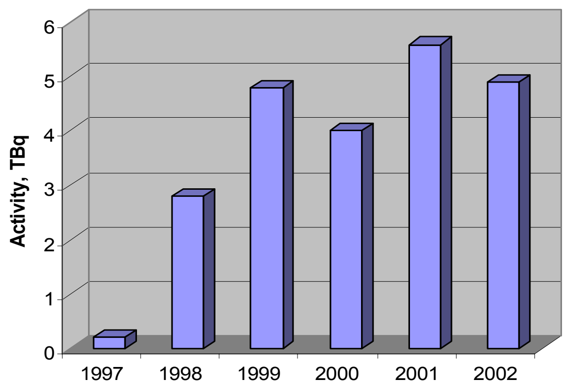

Figure No. 1: Net Activity of Radioactive Substances (TBq) transported in Lithuania.

Table 1: Unsealed sources transported in Lithuania for health care institutions in 2002.

Radionuclide	^{3}H	^{14}C	$^{32}P+^{33}P$	^{35}S	^{99m}Tc	$^{125}I+^{131}I$	Other
Activity, MBq	1323	178	4033	129	3600000	291284	432

Table 2: Net activity of sealed sources transported into Lithuania in 2002.

Radionuclide	^{192}Ir	$^{90}Sr+^{90}Y$, ^{57}Co, ^{60}Co	^{85}Kr, ^{241}Am
Activity, TBq	80	720	0,3

Data on sealed sources imported into Lithuania in 2002 is given in Table 2. Amounts of shipments of sealed radioactive sources, used in industrial applications decreased during last years.

3. Conclusions

Data given allow to estimate the status of shipments of radioactive substances and radioactive waste in Lithuania. Main radioactive substances transported are radiopharmaceuticals used in medical applications and fresh nuclear fuel for Ignalina NPP. Necessary legislation, setting requirements for safe shipment of radioactive substances and radioactive waste, is established. The scale of shipments is not large, but the tendency of it’s increase is observed in Lithuania.

SOME ASPECTS IN ENSURING SAFE TRANSPORT OF RADIOACTIVE MATERIALS

V. K. Parami, L.B. Cayabo, C.M. Nohay, E.G. Racho

Nuclear Regulations, Licensing and Safeguards Division
Philippine Nuclear Research Institute, Diliman, Quezon City
Philippines

Abstract

This paper presents some regulatory practices and experiences of the Philippine Nuclear Research Institute (PNRI) in ensuring safe transport of radioactive materials. The regulation and licensing the use of radioactive materials started in 1958. In 1966, the Philippine Atomic Energy Commission (PAEC), now the PNRI implemented its first safe transport regulations that were mainly based on the publications of the International Atomic Energy Agency (IAEA). The number of packages containing radioactive materials transported into and within the country has increased with the increase in number of licensees. During the period 2000-2002, the total number of licensees is 293, 311, and 311, respectively. The PNRI issues certificates of release and transport. Based on the data of certificates, the topmost sealed source shipments from abroad, mostly in Type A package, are ^{192}Ir and ^{125}I for brachytherapy. For unsealed sources, also mostly in Type A package, the topmost radioactive materials are ^{99m}Tc (generators), ^{131}I, ^{201}Tl mainly for medical diagnosis. From the data on certificates of transport, the total number of packages inspected for the period 2000-2002 is 464, 577, and 747, respectively. Likewise, the packages are mostly Type A containing radioactive material for medical use. The experiences in the enforcement of the transport regulations and the implication of issuing certificates of release and transport are discussed and recommendations are presented.

1. Introduction

In 1965, a National Committee approved the "Rules and Regulations on the Safe Transport of Radioactive Materials in the Philippines". The Committee was composed of representatives from government agencies such as the civil aeronautics, national railway, customs, post, land transportation, the public service and PAEC. This was the first set of transport regulations that took effect on May 24, 1966. It was mainly based on the IAEA 1964 Revised Edition of the Regulations for the Safe Transport of Radioactive Materials. [1] In 1983, the PAEC adopted, by an administrative order, IAEA Transport Regulations Safety Series No. 6, 1973 Revised Edition, as amended. In March 2000, the PNRI, also by an administrative order, adopted IAEA ST-1 (1996 Edition), "Regulations on the Safe Transport of Radioactive Material" to govern whenever practicable, the safe transport of radioactive material in the Philippines by air, land, or water.[2, 3] The adoption of the two (2) IAEA revisions of the safe transport regulations has not resulted yet into a revision of the first Philippine transport regulations.

The PNRI regulates the use of radioactive materials in the country since 1958. Persons who intend to import, manufacture, distribute, acquire, own, possess, use or export radioactive materials above exempt quantities are required to obtain a license. The basic safety requirements for a license are appropriate and approved design of facilities and equipment, qualified personnel, and adequate radiation safety program. At present, there are three hundred eleven (311) licensees. Fig. 1 shows the distribution according to geographic location.

All licensees who frequently transport radioactive materials are required safe transport procedures as part of the radiation safety program as well as comply with the applicable provisions of the IAEA safe transport regulations. In addition, licensees are required to obtain certificate of release and certificate of transport for incoming shipments of radioactive materials from abroad and for shipments within the country, respectively. PNRI conducts regular compliance monitoring of licensees. Some of the most frequent violations are presented and discussed. Some concerns with the issuance of certificates of release and transport are also discussed and recommendations are given.

2. Regulatory aspects

2.1 Regulatory requirements

All licensees are required to comply with applicable provisions of the Code of PNRI Regulations. To highlight the requirements relative to ensure safe transport, these are the following:

- All licensees are required to designate an individual as radiological health and safety officer. To qualify, the individual must have training on radiation safety that includes a topic on safe transport of radioactive materials.
- All licensees who will be transporting radioactive materials are required to include safe transport procedures in their radiation safety program.
- All licensees who will be designing and fabricating Type A packages are required to comply with the applicable requirements of IAEA safe transport regulations.
- All licensees are required to submit certificates for Special Form Radioactive Materials and Type B Packages.
- All licensees are required to keep records of packages received, inspected and transported.

2.2 Certificates of release and transport

- Certificate of release is issued by PNRI for shipments of radioactive materials from abroad. This certification is issued in order that shipments will be released from the Bureau of Customs at international ports of entry. It contains the name and address of the licensee and the list of radioactive materials authorized in the license. The Bureau of Customs will only release the shipment from their custody upon presentation of this certificate. The data contained in the certificate of release for the period 2000-2002 have been collected and analyzed. Tables 1 and 2 present the number of shipments, type and content of packages for the period 2000-2002. Most of the packages are Type A containing radioactive materials for medical use.

- Certificate of transport is issued for inspected packages. This certificate covers incoming and outgoing packages, and packages transported within the country. The inspection includes condition of packaging, the type of package based on the contents, entries on package label i.e. name of radionuclide, activity, transport index, T. I. and category of package. T. I. is verified by actual monitoring at the surface and 1 meter away from the package. Fig. 2 shows the number and types of packages inspected by PNRI for the period 2000-2002. Type A packages containing radioactive material (sealed and unsealed) for medical use are the most frequently transported into and within the country. Outgoing packages usually contain depleted or unused sealed sources that are returned to principal suppliers abroad. These data however, do not include packages that are not covered with certificate of transport.

2.3 Compliance monitoring

All licensed facilities and radioactive materials are inspected almost annually to verify compliance with the applicable provisions of the Code of PNRI Regulations, license conditions and commitments in license applications. With respect to transport requirements, the main bases are the applicable provisions of IAEA ST-1, 1996 edition. The most frequent inspection findings are non-compliance on specific license conditions on certificates of release and transport.

2.4 Training

Aside from the training requirements of licensee personnel, cargo handlers of major airline companies are regularly trained e.g. on safe air transport of dangerous goods inclusive of radioactive material. Training of Customs personnel is also provided by the PNRI on per request basis.

FIG. 1: Geographical distribution of licensees, 2002

Region	No. of Licensees
I	2
III	26
IV	43
V	2
VI	9
VII	14
VIII	4
IX	3
X	5
XI	11
XII	3
CARAGA	1

Cordillera Autonomous Region (CAR) - 4
National Capital Region (NCR) - 184

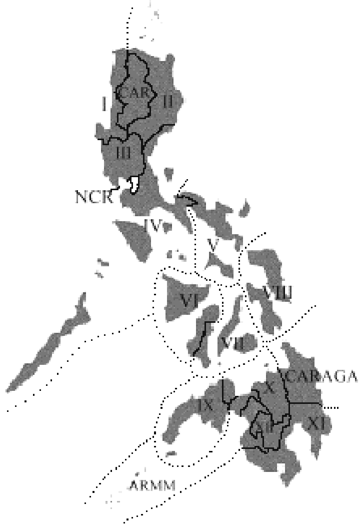

Table 1: Shipments of Sealed Sources Covered with Certificate of Release

Type A Package	Number of Shipments (Units)			Range of Activity
	FY 2000	FY 2001	FY 2002	
Medical				
^{137}Cs	-	1 (2)	-	1.94 GBq
^{192}Ir	11 (11)	8 (8)	10 (10)	370.00 – 472.00 GBq
^{125}I (seeds)	-	-	42 (3718)	10.36 – 23.46 MBq
^{90}Sr	1(2)	2(2)	-	33.30 MBq
Industrial Radiography				
^{75}Se	1(1)	2(2)	-	0.59 – 1.29 TBq
^{137}Cs	1(1)	2(2)	-	335.00- 616.00 GBq
Industry				
^{137}Cs; ^{241}Am:Be	3(3)	7(7)	-	0.37 – 1.48 GBq
^{85}Kr	4(4)	1(1)	1(1)	444.00 – 555.00 GBq
^{252}Cf	1(1)	-	-	0.40 GBq
^{90}Sr	2(2)	-	2(13)	0.7 – 1.85 GBq
^{60}Co	-	-	2(2)	73.00 – 307.00 MBq
^{147}Pm	1(1)	-	1(2)	25.90 GBq
^{137}Cs	-	1(1)	2(3)	0.37 GBq
Type B Package				
Medical				
^{60}Co teletherapy source	1(1)	2(2)	-	222.00 – 370.00 TBq
Industrial Radiography				
^{192}Ir	11(34)	20(48)	13(24)	1.85 – 7.40 GBq
^{60}Co	-	5(5)	-	250.00 GBq

FIG 2: Packages of radioactive materials covered with certificate of transport, 2000-2002

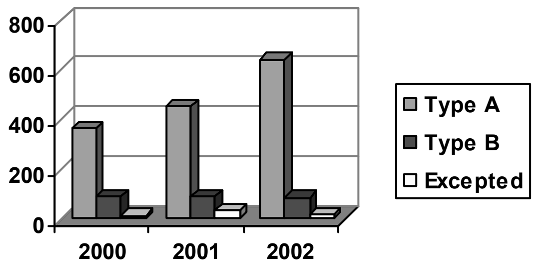

Table 2:Shipments of Unsealed Sources Covered with Certificate of Release

Type A Package			
Year	FY 2000	FY 2001	FY 2002
No. of shipment	314	364	349
	Total Activity		
Medical			
^{99m}Tc Generator	9.76 TBq	10.76 TBq	12.78 TBq
^{131}I	3.55 TBq	5.10 TBq	6.10 TBq
^{201}Tl	151.40 GBq	154.00 GBq	250.00 GBq
^{67}Ga	1.90 GBq	212.00 GBq	4.14 GBq
^{111}In	2.45 GBq	1.26 GBq	1.27 GBq
^{125}I (RIA)	2.45 GBq	1.26 GBq	1.27 GBq
^{14}C (RIA)	177.60 MBq	962.00 MBq	710.40 MBq
Research			
^{32}P	2.40 GBq	1.314 GBq	1.10 GBq
^{3}H	186.85 MBq	148.00 GBq	222.00 MBq
^{35}S	9.25 MBq	37.00 MBq	37.00 MBq
^{14}C	75.85 MBq	38.55 MBq	74.00 MBq

3. Discussion and recommendations

While arrangements for regulation, control, compliance monitoring and training exist to ensure safety in transporting radioactive material, there is always room for enhancement and strengthening. The National Committee has never been re-convened with the adoption of IAEA safe transport regulations. Thus, provisions in the regulations addressed to modal agencies i.e. air, water and land, may not be adequately implemented. There is need therefore to establish close co-ordination with these agencies in order to completely implement the provisions of the transport regulations. In the case of the issuance of certificate of release, this covers only international ports located in Metro Manila. With the international concern on illicit trafficking of radioactive material, there is urgent need to expand the practice to include all international ports in the country. This will also require expansion of training of Customs personnel as well as modal agency personnel responsible for dangerous goods. The certificate of transport, on the other hand, is viewed as the responsibility of the consignor or licensee hence it is recommended that this practice be reviewed. More attention should be given on licensee's compliance with the provisions on packaging, labelling, placarding of vehicles, and proper declaration of shipments of radioactive material. Most of the packages transported are Type A containing radioactive material for medical use. For unsealed sources, frequently transported are ^{99m}Tc generators and ^{99}Tc pertechnetate, ^{131}I, and ^{201}Tl. For sealed sources, these are ^{192}Ir for brachytherapy and for industrial radiography. Since most of the medical licensees are located in the National Capital Region, this includes Metro Manila, it follows that transportation of radioactive materials especially by land, occur in Metro Manila. So far, there has been no report of accident or incident during transport of packages of radioactive material. If emergency should occur during transport, it is more likely that it will involve Type A packages containing radioactive material for medical use. With this knowledge, preparedness and response could be appropriately planned.

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STATUS AND PERSPECTIVES OF SAFETY MANAGEMENT AT TRANSPORT OF RADIOACTIVE MATERIALS IN RUSSIA

G.A. Novikov[a], A.M. Agapov[a] , V.V. Ananiev[a] , V.N. Ershov[b] , M.O. Shvedov[a]

[a] Department of Safety, Ecology and Emergency Situations of Minatom of Russia, Moscow
[b] Emergency Response Center of Minatom of Russia, St.-Petersburg,
Russian Federation

Abstract

For 50 years experience of mass transportation of radioactive materials (RM) in Russia there were not registered not only serious radiation affects on the population and personnel owing to such shipments but there were not almost transport accidents as well. The total number of transport infringements at RM shipments for these years is estimated only by units. In the paper the basic provisions of management system of RM transport safety that determine the high level of RM transport safety in practice are briefly considered in the historical plan and in perspectives.

1. Introduction

The first registered shipment of RM in Russia was held 100 years ago in 1903. The mass transportation of RM in Russia (former USSR) are carried out about 50 years. The list of transported RM in the country includes all kinds of a nuclear fuel cycle RM (from ore, physical and chemical concentrates, hexaflouride up to the fresh and spent nuclear fuel and radioactive waste), and also numerous kinds of RM and RM products, widely used in other branches of industry, medicine, agriculture etc.

The main part of RM used in all branches of economy are made inside the country and the main part of RM shipments is made as internal transportation. Nevertheless the volume of the international shipments of various kinds of RM in Russia is significant including the volume of transit transportation through the territory of Russia.

For all years of mass transportation of RM in Russia (former USSR) there were not registered not only serious radiation affects on the population or personnel owing to such shipments, but practically there were no serious transport accidents in a course of such transportations. Even the total number of transport infringements, which, obviously, are inevitable on transport, at the transport of RM for these years is estimated only by units.

Such results in safety field are certainly a consequence of management system of safety at transportations, including safety regulation, organizational structure and other elements that have been used and are using now. Below in the present paper the main provisions of this system are briefly considered, as in the historical plan, and in the perspectives.

2. Organizational and technical requirements of safety

Historically it was inevitable at the nuclear industry within its creation and early development period of time to hold the closed regime that predetermined appropriate closed regime of transportation of the main amount of RM as a whole and practically 100 % of amount of nuclear materials not only in a nuclear weapon complex, but also in a nuclear fuel cycle. The observance of confidentiality regime of nuclear branch demanded practical exception of infringements at transportation of the appropriate materials. On the other hand as against in comparing the nuclear enterprises the transport highways are roads of common usage that also demanded maintenance of the special regime of safety.

The uniform decision of these tasks could not be provided by so-called constructional safety, that is, safety at the expense of a design of packaging with RM. The emphasis was made on use of organizational measures at transportation, which would reduce to a minimum probability of transport infringements with RM at transportation. In the terms of IAEA RM transport regulations it is possible to say, that practically for all shipments the special arrangements were used.

During the time in process of development of the international constructional requirements for packaging with RM and issuing of the appropriate IAEA RM transport regulations these requirements took root in Russia (former USSR) as the state standards (in 1977 for packaging with not fissile RM [1], that was revised in 1988 [2]) and in 1983 for fissile nuclear materials as national rules [3]. These standards and rules were developed on the basis of appropriate IAEA RM transport regulations.

Now in Russia the new national rules are prepared for issuing [4] that completely in technical (constructional) part corresponds to new IAEA RM transport regulations (IAEA document ST-1/TS-R-1 the edition 1996/2000 years [5]). These new national rules envelop all kinds of RM (fissile and not fissile RM).

Nevertheless, for transportations of many kinds of RM, first of all for most potentially dangerous RM, such as spent nuclear fuel, plutonium and others, alongside with the requirements to a design of packaging there were preserved the rigid requirements of organizational character for conditions of transportation of these materials that have been established in the special normative Russian documents on organization of transportations of the appropriate kinds of RM.

Besides the performance of many requirements of organizational character for safety these requirements are determined also by necessity of maintenance of physical protection of RM at the transportation. The appropriate requirements are established in the special Russian documents on the physical protection.

Naturally, the providing of special organizational arrangements at transportation causes the significant financial expenses. Now they could seem excessive if take into account that in comparison with the old period (approximately 30 years ago) the Russian national RM transport rules acting now demand the performance of all modern constructional requirements of safety to packaging design that in turn also causes the large expenses as well.

On the other hand now there are new tasks on maintenance of antiterrorist protection (security measurements) for RM consignments and one condition for performance of such tasks is preservation of a special regime of transportation. Although the real threats (except of pronouncement in mass media) of acts of the nuclear and radiological terrorism in Russia were not registered, nevertheless the problem takes place due to general current situation in the world and appropriate measures are arranged [6].

Thus, the questions on an opportunity of mitigation of the organizational requirements or on the contrary preservation of special regime of transportations for the most dangerous RM consignments even only from the technical point of view on safety are not put today. If to take into account social and political conditions for acceptance of those or other decisions, such questions are complicated even more.

3. Maintenance of assurance (guarantees) of safety

The decision of a question on an opportunity of a mitigation of special regime of transportation for the many dangerous RM consignments from the technical point of view substantially depends on assurance (guarantees) of technical safety, which is determined by reliability and sufficiency of the technical requirements of safety to RM consignments (packages) and presence of guarantees of compliance of such requirements, that is compliance assurance of rules in practice.

Concerning reliability of the existing requirements to packages in Russia, as, obviously, and all over the world, there are various points of view. However, the fact of the agreement of the new Russian rules of RM transport safety [4], that completely corresponds to new IAEA RM transport regulation [5], by the overwhelming majority of the federal executive bodies of the authority in Russia testifies that reliability of these requirements as a whole is recognized for transport conditions of our country. We hope, that survey job, that is organized by IAEA within the framework of the coordination research programs, on collection and analysis of the data on behaviour of transport packages under very severe accidental load conditions [7], should once again confirms the reliability and sufficiency of the technical requirements of IAEA regulations.

Concerning guarantees of performance of the requirements of rules in practice it must be noted that the safety management system, acting in Russia for RM transportation, provides the following basic tools:

- requirement of presence and control of quality assurance system for all organizations participating in RM transportation, including the designers, manufacturers, consignors, consignees, carries. Such quality assurance systems should meet to the requirements of appropriate national norms and rules, documents of IAEA and ISO;
- mandatory licensing of activity of organizations, participating in RM transportations;
- certification of appropriate RM, transport packages and shipments on conformity to the requirements of national and international rules;
- certification of vehicles used for RM shipments;
- state system for warning and elimination of accident at transport of RM (providing the emergency response cards, accident elimination plans, emergency response team etc.);
- supervision of performance of jobs in the field of RM transportations from the part of special state supervision bodies in the field of nuclear and radiation safety;
- the general control of a safety, performance of rules and coordination of activity of state bodies connected to transportation, from the part of a state competent body on safety of RM transportations.

These tools and appropriate procedures correspond to the world practice. However, the majority of them have begun intensively to take root into practice of management of safety for RM transportations in Russia rather recently, basically on the ground of the appropriate provisions of federal laws (FL) that have been issued in 1995-1996 years in nuclear area - FL "About use of an atomic energy" and FL "About radiation safety of the population". Therefore supporters of preservation of the special regime of RM transportation consider the experience of management of these tools as insufficient for a mitigation of such regime for transportation of many kinds of RM.

It is really possible to agree with such considerations. Besides the time for maintenance of effective interaction of a federal body of management of safety (Minatom of Russia), federal bodies of regulation of safety (Gosatomnadzor of Russia, Ministry of Health of Russia, Ministry of Internal Affairs of Russia, FSB of Russia) and bodies ensuring transportation (MPS of Russia and Mintrans of Russia) in light of the new federal laws in nuclear area and general laws influencing activity in nuclear area is required. The appropriate instructions on maintenance effective interaction in the field of RM transportation are given to these bodies on the part of Government of Russian Federation [6].

4. Conclusion

The management system of safety at transportation of RM in Russia has ensured a high level of safety of such transportation within 50 years. Despite of introduction in last 20 years of all international requirements in a part of technical safety of RM consignments meeting to IAEA RM transport regulation, possibilities for refusal of special organizational measures in a course of transportation of many kinds of RM in Russia (for example for rise of economical effectiveness), first of all, most potentially dangerous, demands accumulation of experience and all-round analysis. Obviously, the coming years the mitigation of special transportation regime of s such RM can not be recommended, including in view of new tasks of antiterrorist (security) protection of RM consignments at transportation.

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TRANSPORT REGULATIONS FOR RADIOACTIVE AND NUCLEAR MATERIALS IN SLOVENIA

L. Vrankar, J. Cešarek

Slovenian Nuclear Safety Administration,
Železna cesta 16, 1001 Ljubljana
Slovenia

Abstract

In Slovenia, transport of radioactive and nuclear materials is regulated by the Act on carriage of dangerous goods including all international conventions and agreements concerning transport of dangerous goods. This paper will also cover some practical experience, past events, co-operation among national regulatory bodies and bilateral and multilateral programmes. The paper also gives an overview of responsibilities for approval and inspection of radioactive and nuclear material shipments in Slovenia.

1. Introduction

In Slovenia, safe transport of radioactive and nuclear materials is assured in compliance with the Act on carriage of dangerous goods and the Act on protection against ionising radiation and nuclear safety. Slovenia also tries to conform domestic regulations with European [1,2] and International standards. The purpose of this paper is to give an overview of these regulations in Slovenia, including the responsibilities. Some practical experience of the last decade will be also presented.

2. Legal framework for transport of radioactive and nuclear materials in Slovenia

In order to comply with ratified international conventions and treaties, and to comply with international standards, Slovenia has been recently making significant efforts to modernise legislation and its enforcement in the area of transport of **n**uclear and other **r**adioactive **m**aterials - NRM. These efforts coincide with modernisation of the existing legislation adopted from former the Yugoslavia and with harmonisation of legislation with that in the European Union.

In Slovenia, transport of NRM is regulated by the following acts:

- Act on carriage of dangerous goods including:
- The European Agreement concerning international transport of dangerous goods by road;
- The Convention concerning International Carriage by Rail (COTIF), a constituent part of which is the Rules on International Transportation of Dangerous Goods by Rail (RID);
- International Convention on Safety of Human Life at Sea, 1974:
- Protocol Amending the International Convention on Safety of Human Life at Sea, 1974 and
- Convention on International Civil Aviation;
- The Convention on Physical Protection of Nuclear Materials;
- The Common Convention on the Safe Management of Used Fuel and on the Safe Management of Radioactive Waste;
- Act on protection against ionising radiation and nuclear safety;
- Decision of publication of Annex A and Annex B of the European Agreement concerning international transport of dangerous goods by road.

Transport of NRM must be performed within this legal framework. This means that for specific transport the requirements of transport regulations of dangerous goods, Class 7 have to be met.

The approval for transport of NRM is issued by the minister responsible for the environment in agreement with the minister responsible for health, while the approval for transportation of radio-pharmaceuticals is issued by the minister responsible for health.

Supervision of the transport of dangerous goods on the roads is exercised by the Police. Supervision of the transport of dangerous goods by sea and in inland waterway traffic is exercised by the Maritime Transport Administration of the Republic of Slovenia. Supervision of the transport of dangerous goods in railway and air traffic is exercised by the Ministry of transport. Customs Administration of the Republic of Slovenia is responsible for import and export of dangerous goods into and from the customs territory of the Republic of Slovenia.

Slovenia has also translated Annex A and Annex B of the European Agreement concerning international transport of dangerous goods by road.

It is necessary to mentioned that only approvals for those types of packages, that comply with ADR are issued. In most cases this means shipments under "special arrangement", transport of nuclear material, etc.

3. Experience, past events and co-operation among national regulatory bodies in this area

Some experience with transport of NRM in Slovenia [3] was connected with: activities of the Krško NPP, operation of TRIGA research reactor; production of isotopes at the Jožef Stefan Institute; use of radioactive isotopes in medicine, research, education and industry. Transport of NRM is performed mostly due to the needs of clinics (7), the research institute and industry (app. 100 registered users).

The new Act also incorporates requirements of the Recommendations of International Atomic Energy Agency - IAEA (Safety Standards Series No. 6, No. ST-1, Regulations for the Safe Transport of Radioactive Material which was substituted by No. TS-R-1, 1996 Edition, Revised).

Similar to the world practice, there are the following types of packages, which prevail during transport in Slovenia: excepted packages, type A and B(U) packages. Slovenian and foreign companies also carry out transit to Croatia and Hungary.

Practical case: the Krško NPP asked for issuing the permit for temporary export of the radioactive waste (types: compacted waste and other waste) which will be incinerated at Swedish enterprise Studsvik RadWaste. Radioactive waste, which was not sorted, was packed into standard drums (industrial packages). The main radioactive nuclide were Co-60, Co-58, Cs-137 and Cs-134. The total mass of radioactive waste, packed into 250 standard drums, was approximately 21 tons. The average activity of the drums was 8.2 MBq, the total activity of the consignment app. 2 TBq. The export was performed in the year 2002.

4. Bilateral and multilateral support programmes [4]

On 25 September 1998, the General conference of the IAEA adopted the resolution GC(42)/RES/13 on the Safety of Transport of Radioactive Material. The General Conference recognised in adopting that resolution that compliance with regulations that take account of the IAEA's Regulations for the Safe Transport of Radioactive Material is providing a high level of safety during the transport of radioactive material. The General Conference requested the IAEA Secretariat to provide for the application of the Transport Regulations by providing a service for carrying out, at the request of any State, an appraisal of the implementation of the Transport Regulations by that State. In response to this direction, the IAEA has created and offered to all States the Transport Safety Appraisal Service.

The Government of Slovenia was the first who requested such an appraisal and, more specifically, a review of Slovenian draft legislation on transport of NRM. The IAEA expert team (hereinafter called TranSAS team) carried out the appraisal and review on 21-24 June 1999 at the headquarter of the Slovenian Nuclear Safety Administration in Ljubljana. The appraisal was carried out in accordance with TranSAS procedures and on the basis of a questionnaire devised for the purpose of assisting TranSAS team.

The mission ended with a presentation of the TranSAS team's findings and recommendations at a meeting held in Ljubljana on 5 July 1999. The report included the following:

- The ready availability of the Slovenian translation of the 1996 edition of the IAEA's Transport Regulations and of the relevant Slovenian regulations will facilitate preparations for compliance with the latest edition of the international regulations for the transport of dangerous goods by the various modes of transport when they become effective;
- Radioactive material transport emergency capabilities have been incorporated into the overall emergency preparedness structure, which in turn ensures that good emergency response capabilities are available if they are needed for radioactive material transport emergencies.

5. Physical protection during transport of NRM

Physical protection during transport of NRM is also important. Special emphasis is given mainly on shipments of nuclear material. In these particular events, held in Slovenia approximately once a year, "design basis threat" is assessed on a case-by-case basis. Physical protection during a transport route is provided by the Ministry of the Interior. No intends, mishaps or disturbances, caused by possible intruders (including protestors) have been observed in the last decade. One of major challenges for all involved subjects was a shipment of spent nuclear fuel. At that time, a special security plan was prepared, considering among other things, target identification, threat analysis and protection strategies.

6. Transport of nuclear material

6.1 Fresh nuclear fuel (import)

In the last years, fresh nuclear fuel for the Krško NPP has been shipped by a vessel[1] (USA - Port of Koper), at the port the fuel is unloaded and loaded on some dedicated lorries. The number of fresh nuclear fuel elements varies a little from year to year, being 30 on average. The packages of type AF, CSI and TI are well below 1, with II-Yellow labelling.

FIG. 1 shows the route from the Port of Koper to the Krško NPP. Various types of roads are used - highways, motorways and local roads. Physical protection is provided by the Ministry of the Interior on a case-by-case basis. After the final unloading at the Krško NPP site, empty packages are shipped back to the consignor by the same means.

Previous legislation required several licences to be obtained by the organiser (consignee). The main approval was "Trade/trafficking and transport approval" which was issued by the Slovenian Nuclear Safety Administration - in consent with several other ministries. Current legislation has changed the licensing process a lot. The following approvals are needed:

- for import of fresh nuclear fuel,
- package design (re-)validation,
- an authorisation to carry out a practice involving radiation (issued for any transport of nuclear materials).

FIG. 1. Transport rute of fresh nuclear fuel

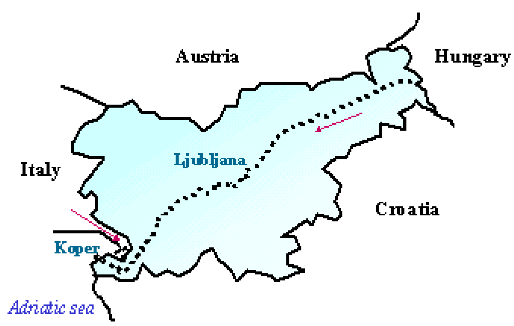

FIG. 2. Transport route of spent nuclear fuel

1 before, other types of transport were used (air)

6.2 Spent nuclear fuel (export)

In July 1999, a large action which involved several European countries was successfully accomplished. They returned their spent nuclear fuel to the US Department of Energy (DOE). Non-proliferation of nuclear material played then an important role.

Slovenia co-operated with Italian and Romanian sides, which were involved at the same time - and transport (transit) was performed across the Slovenian territory (FIG. 2). The fuel was shipped in type B(U)F packages. Low and highly enriched uranium (total activity exceeded 1000 TBq) was shipped as "exclusive use", labelled with Yellow-III. In the Port of Koper, all containers were unloaded from lorries and loaded into a dedicated vessel, being subsequently shipped to the USA.

The SNSA issued several licences for domestic consignment; for Italian and Romanian consignment. "Transit approval" with exact data on fuel - nuclear material, packaging, route(s), carriers, consignor, consignees, conveyances, dates, etc. was necessary.

7. Summary

As described above, the transport of NRM in Slovenia is regulated by dangerous goods transport regulations of Class 7 in compliance with the IAEA Transport Regulations as well as with dangerous goods transport regulations of the International Modal.

Not only the IAEA, European Union and the world but also Slovenia gives a higher priority to safe transport of NRM. Our work is led through several ways - legal area, international and enhancing national co-operation including education, and enforcement actions.

The Slovenian Nuclear Safety Administration has reinforced its awareness of the above-mentioned themes and plays one of the main roles.

Slovenia is still a developing country and will need certain aid from the IAEA, other institutions and developed countries, since this issue is *a never ending story*, representing an ongoing process and exchange of information. In particular, there will be a certain lack of means and equipment for use at south-east borders to detect possible smuggling of NRM. There is also a need to continue and increase training efforts for staff involved in e.g. emergency response.

International missions, e.g. TranSAS, carried out by the IAEA, are an important pillar for every country to obtain a broader view – it is clearly recognised that any thorough examination through a state system of safe transport of NRM (all aspects) will bring praises for accomplished areas and recommendations and good practices on the other hand, for those "grey" areas, which need some improvement and enhancement.

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THE SAFE TRANSPORT OF RADIOACTIVE MATERIAL IN TANZANIA

A.A. Yange
National Radiation Commission, P. O. Box 743, ARUSHA.
Tanzania

Abstract.

The aim of this paper is to give an overview of the status of transport of radioactive materials in Tanzania. Issues on legislation and training of radiation workers on the radiation hazards and precautions to be observed in order to restrict radiation exposure are presented. This paper also gives a list of radioactive materials, and their applications, imported in Tanzania.

1. Introduction

In Tanzania, ionizing radiation in the form of medical X-rays was introduced for use as early as 1938. Although from then there was no radiation protection law until 1983, the applications of ionizing radiation in various field increased rapidly. In recognition of the potential hazards, the Parliament of the United Republic of Tanzania enacted the Protection from Radiation Act No. 5 of 1983 that established the National Radiation Commission (NRC) as a competent authority [1]. The Government's objective in introducing the legislation was to establish a national framework of an authoritative reference in the radiation protection of workers, members of the public and the environment from the effect of ionizing radiation, while at the same time promoting its increased peaceful uses for the benefit of mankind. Under this Act there are three sets of regulations made specifically for: (a) The Protection from Radiation (Code of Practice) Regulations 1990, (b) The Protection from Radiation (Control of Radiation Contaminated Foodstuffs) Regulations 1998 and (c) Radioactive Waste Management (for the Protection of Human health and Environment) Regulations, 1999.

Currently, there are 300 radiation Centers employing nuclear techniques throughout Tanzania. 25 out of these Centers are using radioactive materials in medicine, industry, agriculture, research and teaching. These nuclear applications have made it necessary for various sources of radioactive materials to be transported across the country and on transit to the neighboring countries.

2. The protection from radiation (code of practice) regulations, 1990

The Protection from Radiation (Code of Practice) Regulations of 1990 became effective on January, 1991 and is a subsidiary regulation [2]. According to the Code of Practice all users, importers and exporters of radioactive materials are requested to secure a license from the NRC before a practice is allowed. Under this Code of Practice there are eight types of licenses issued by the Commission. These are:

(a) A license and registration certificate authorizing the holder to possess or use radiation devices.
(b) A license authorizing the bearer to possess or use radioactive materials.
(c) A license authorizing the bearer to import/export radiation devices or radioactive materials.
(d) A license authorizing disposal of radioactive materials.
(e) A radiation premises license.
(f) A license authorizing modification of licensed premises, materials and devices.
(g) A license to sell, lease or deal with radiation devices or radioactive materials.
(h) A license to administer ionizing radiation to persons.

Table 1: A list of imported radioactive materials in Tanzania from September 1987 to December 2002.

NAME OF CENTRE	ISOTOPE	ACTIVITY	APPLICATION
Ocean Road Cancer Institute	Co-60	173.53 TBq	Radiotherapy
	Co-60	85.47 TBq	Radiotherapy
	Cs-137	61.79TBq	Brach therapy
	I-125	unknown	Nuclear medicine
	I-131	3GBq	Nuclear medicine
	Tc-99	18 GBq	Nuclear medicine
Tanzania Cigarette Company	Sr-90	925 MBq	Density gauge
	Sr-90	925 MBq	Density gauge
	Sr-90	925 MBq	Density gauge
M/s Anmercosa Services Ltd.	Cs-137	0.37 MBq	Density gauge
	Cs-137	5,550 GBq	Density gauge
	Am-241	185 GBq	Density gauge
	Am-241	185 GBq	Density gauge
TAZAMA Pipelines	Cs-137	55.5 GBq	Density gauge
	Cs-137	55.5 GBq	Density gauge
Impresa Fortunato Federici	Cs-137	1.85 GBq	Density gauge
	Am-241	1.48 GBq	Density gauge
Tanzania Petroleum Development	Am-241	592 GBq	NDT
Corporation	Am-241	18.5 GBq	NDT
	Cs-137	629 GBq	NDT
ALUCO, Aluminum Africa Ltd	Sr-90	185 MBq	Thickness gauge
STEELCO, Aluminum Africa Ltd.	Am-241	18.5 GBq	Thickness gauge
	Am-241	37 GBq	Thickness gauge
MM Integrated Steel Mills	Am-241	11.1 GBq	NDT
Tanzania Breweries Ltd., Mwanza	Am-241	3.7 GBq	Level gauge
	Am-241	3.7 GBq	Level gauge
	Am-241	3.7 GBq	Level gauge
Nyanza Bottling Company Limited	Am-241	1.67 GBq	Level gauge
	Am-241	1.67 GBq	Level gauge
Dept. of Microbiology, MUCHS	H-3	unknown	Tracer
Dept. of Biochemisty, MUCHS P-32	18.5 μBq	Tracer	
Tanzania Industrial Research and	Co-60	444 GBq	NDT
Development Organization.	Ir-192	4.107 GBq	NDT
Tsetse Research Institute.	Cs-137	218,300 GBq	Insect sterile
	Co-60	976,800 GBq	Insect Sterile
National Institute for Medical Research	C-14	unknown	Tracer
National Artificial Insemination Center	I-125	0.925 MBq	Tracers
	I-125	0.37 MBq	Tracer
Ifakara Health Research and Developmt.	P-32	unknown	Tracer
Lake Tanganyika Biodiversity Product.	H-3	unknown	Tracer
Sokoine University of Agriculture (SUA)	I-125	185 KBq	Tracer
Africa Mashariki Gold Mines.	Cs-137	74 MBq	Soil density
Williamson Diamonds Limited.	Cs-137	1.85 GBq	Soil density
	Cs-137	7.4 GBq	Soil density
	Cs-137	7.4 GBq	Soil density
National Radiation Commission	Cs-137	740 GB	Calibration
	Co-60	3.7 GBq	Calibration
Mgololo Paper Mills	Am-241	unknown	Density gauge
Kahama Mining Corporation	Cs-137	3.7 GBq	Soil density
	Cs-137	3.7 GBq	Soil density
	Cs-137	1.85 GBq	Soil density
	Cs-137	0.74 GBq	Soil density
	Cs-137	0.74 GBq	Soil density
	Cs-137	0.37 GBq	Soil density

Pursuant to Part V of the Code of Practice, all transporters of radioactive materials are required to secure a transportation license from the NRC before a consignment is cleared from the customs. However, in practice this is not done because samples of application form and license certificate for this kind of authorization are not given in the Schedule I of the Code of Practice. Despite the fact that at present the transportation license is not practicable, the safety of radioactive materials during transport is taken care in the import/export license upon an application being made to the NRC in the prescribed form and payment of prescribed fees. According to the International Atomic Energy Agency (IAEA) Regulations [3], the transport of radioactive materials requires to meet the following conditions:

(a) Package categories e.g. Category I, Category II and Category III.
(b) Package types e.g. Type A and Type B.
(c) Emergency procedure in the case of accident.
(d) Labelling of a vehicle in which radioactive materials are transported with radiation symbols.
(e) Inspection by the competent authority before transport of a consignment.

Since the transportation license is not issued therefore, the transport requirements specified above are not met during transport of radioactive materials. For instance, there is no inspection done by the NRC at the entry point when radioactive materials are cleared and transported to the final destination, radioactive materials are being transported in the same vehicle with the people, vehicles are not labelled with radiation symbols during transport of radioactive materials, there is no written emergency plan in the transporting vehicle, etc.

3. Applications of radioactive materials in Tanzania

As Tanzania develops it is bound to the increased use of radioactive materials, which necessitated the transportation of these materials to the final users. Table 1 is a list of radioactive materials imported from September 1987 to December 2002.

4. Training

The National Radiation Commission conducts training courses, seminars and workshops on radiation protection to radiation users and custom officers at least once a year. Already for the past five years, the Commission conducted several training courses and seminars specifically for the Custom Officers from the Kilimanjaro International Airport (KIA), Dar-Es-Salaam International Airport (DIA), Dar-Es-Salaam Handling Company (DAHACO); and radiation workers from Hospitals (Medical Radiographers) and industry (Industrial Radiographers). Such seminars are also given to members of the parliament of the United Republic of Tanzania occasionally. Also, the NRC concerns in a great deals with public awareness on the hazards associated with ionizing radiations. On this basis the NRC disseminates radiation protection information in form of brochures, pamphlets, television and radio programs.

4. Conclusion

The status of transport of radioactive materials in Tanzania has been presented. There is a need for the NRC to improve the main Act and its subsidiary Regulations (Code of Practice) to ensure a specific set of detailed regulations related to the transport of radioactive materials are clearly spelt out. The Government is now amending the current Act and hopefully by 1st July, 2003 a new Act will be ready because the amendment is already in the parliament of the United Republic of Tanzania to be approved.

Regarding the training course, seminars and workshops that the NRC organizes yearly, more efforts are needed to ensure that they are continued. The NRC, therefore, has to continue seeking both technical and financial assistance from the IAEA in order to improve this area with a view to imparting more knowledge especially on public awareness.

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IAEA-CN-101/82

RADIOACTIVE MATERIAL TRANSPORTATION IN TURKEY

S. Türkes, I. Uslu

Radiation Health and Safety Department, Turkish Atomic Energy Authority (TAEA),
06530 Lodumlu, Ankara,
Turkey

Abstract

Turkey has thousands of radiation sources and there is an intensive traffic in the region. The number of imported radiation sources for nuclear medicine purposes within a year exceeds 60 000. The number of diagnostic radiology equipment is about 7000, industrial radiography equipment is 353 and therapy equipment is around 120. There are 3 PET machines, 2 Pet cyclotrons, 2 isotope production units, 2 sterilization facilities etc. Besides, in Turkey there is an intensive import of scrap materials as well as export (there are totally around 12 panel detectors, of which 6 are located at customs and 6 are owned by scrap steel operators); 59 online stations are in 24-hrs operation. Some of the radiation protection systems used in Turkey are produced by the Turkish Atomic Energy Authority (TAEK) in accordance with the EC standards. The regulatory actions for the issue of the transport of radioactive materials are summarized briefly together with their design approvals of packaging and storage of nuclear materials and radioactive substances. Underlined are the great importance given to nuclear and radioactive material security and radiation safety due to the presence of thousands of radiation sources in the country and intensive traffic in the region.

1. Introduction: organizational structure of TAEK

In Turkey, the Ministry of Health issued the first act related with ionizing radiations in 1937. After that, the Turkish Atomic Energy Commission (TAEC) was established in 1956 one year before the establishment of the IAEA. Turkey became an IAEA Member State in 1957. In 1982, TAEC was re-established as the TAEK (act numbered 2690) [1]. The act defines the structure of the TAEK, the duties, responsibilities and jurisdiction of each unit. According to the Act, TAEK is the judicial organization for preparing the regulatory framework concerning radiation protection and nuclear safety. The Nuclear Safety Department and Radiological Health and Safety Department perform the regulatory tasks pertaining to the nuclear and radiation safety, including waste management (Revised version of the Radiation Safety Regulations [3], based on the BSS and Euratom EC Directive, was issued in March 2000 (Official Journal 23999)).

According to TAEK legislation, the structure of TAEK is shown in Figure 1. The Radiological Health and Safety Department (RHSD) has six divisions and some particular standing committees.
Divisions are:

- Diagnostic Radiology Licensing Division,
- Radiotherapy Licensing Division,
- Nuclear Medicine Licensing Division,
- Nuclear Gauges Licensing Division,
- Industrial Radiography Licensing Division,
- Environmental Radiation Monitoring Division.

The Scientific Standing Committees are:

- Radiation Sources and Waste Safety Committee,
- Radiological Accident Management Committee,
- Legislation Committee
- Training Committee

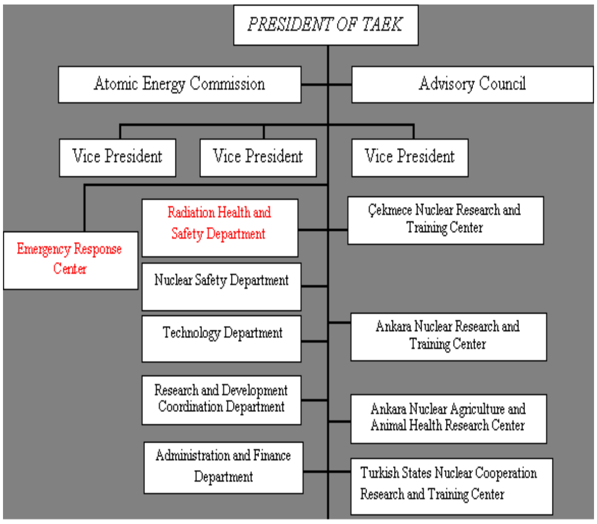

Figure 1: Organizational chart of TAEK

2. TAEK legislations

The functions and the scope of duties of the Department are based on the Radiation Safety Legislation [1-3]. Beside the Act mentioned above [1], TAEK issued two decrees [2] as the relevant National Authority for regulating activities involving the licensing procedures of nuclear installations and radiation safety. The revised version of the Radiation Safety Regulations Based on BSS 115 of IAEA and 94/43 and 96/29 EURATOM Directives was issued in March 2000 [3]. The main purpose of the legislation is to ensure the radiation safety for people and environment against ionizing radiation and the latest regulation covers the issues relating to all facilities requiring radiation safety, all countermeasures required for the protection of persons and environment from the harmful effects of radiation sources, and all issues relating to the actions to be taken [1-3].

3. Inventory

The number of sources or installations in use and the number of facilities are given in Table.1. As far as the extents of radiation practices are concerned, full range of practices exists using sealed and unsealed sources in medicine, industry, agriculture, research, etc. The practices include the diagnostic radiography and fluoroscopy, radiation therapy, nuclear medicine, industrial radiography, industrial and research irradiation facilities, nuclear gauges, unsealed radioactive sources, etc. A national inventory of radiation sources and users is maintained by the Radiological Health and Safety Department of TAEK. TAEK uses the electronic database system (Client/Server Architecture, ORDBMS, and UNIX) to keep the inventory of radiation sources. It is more usable for the TAEK needs than the RAIS.

4. Regulation for the safe transport of radioactive materials

"Safe Transport of Radioactive Materials" regulations were accepted in 1997 and since then they are still in use [4]. They are recently revised in corresponding with ST-1 criteria but not published yet. In this study on new regulations, some new concepts, which are already in use in practice but not included in the current regulations, are added or modified under the guidance of ST-1. For example, Type-C packages, which are not used in Turkey, are included in new regulations and the details about the process in the custom are expressed in details. The new regulations will be in active in near future.

Table 1: The sources and installations

Numbers of diagnostic x-ray equipment						
Conventional diagnostic radiology	***Mammography***	***Bone densitometry***	***Interventional radiology systems***	***CT scanners***	***C-arm***	***Microfilm***
3149	**433**	**251**	**181**	**685**	**66**	**121**

Radiotherapy

Numbers of therapy equipment							
Teletherapy units				***Brachytherapy afterloading units***			
Low-energy x-ray	***^{60}Co***	***Linear accelerator***	***Stereotactic (using gamma sources)***	***Intravascular brachytherapy systems***	***Manual***	***Remote***	
						LDR	***HDR***
12	**56**	**33**	**1**	**11**	**6**	**1**	**17**

Nuclear Medicine
NM laboratories: 134 RIA laboratories: 166

Numbers of diagnostic equipment					
Nuclear medicine in vivo units					
Gamma cameras		***PET scanners***	***Rectilinear scanners***	***Static gamma detectors***
Planar	***Tomographic (SPECT)***			
10	**220**	**3**	**2**	**25**

Industrial Applications

Graphy units				***Others***		
^{192}Ir	***^{60}Co***	***^{75}Se***	***X-ray***	***Package control***	***Analysis (X-ray)***	***Analysis (^{55}Fe, ^{109}Cd)***
117	**7**	**5**	**224**	**573**	**130**	**33**

Nuclear Gauges

Density	***Moisture***	***Thickness***	***Level***	***Well logging***	***Portable Density& Moisture***
375	**50**	**320**	**1058**	**92**	**235**

Radioisotope Production Facilities

$^{99}Mo/Tc$ generator Production	***11 MeV Cyclotron***
2	**2**

Irradiation Facilities

Industrial Irradiation Facilities
2

Lightning rods; **10.462 (users) (^{241}Am)**
Smoke detectors; ***(Collected and stores as waste)***
^{239}Pu: 56 - ^{241}Am: 146
Research and Education
18 laboratories
124 sealed and unsealed sources(^{32}P, ^{14}C, ^{3}H, ^{35}S)

Total number of hospitals/centers/departments;
Diagnostic Radiology:**3594;** Nuclear Medicine:1**34**
Radiotherapy: **43**
Total number of companies;
Industrial radiography: **598;** Nuclear gauges: **553**

Research and Training Reactors

- 1 MW TR-1 completed in 1962 by the American Machine & Foundry Company and operated for 15 years from May 27, 1962 until shut down in September 1977.
- In the 1970's, 5 MW TR-2 reactor was installed in the building and in the pool of the first reactor. TR-2 reactor had been operated since 1984 until shutdown in 1995.

The aim of this regulation is during the transportation of radioactive substances by land, sea or air, the workers, public and the environment should be protected from radiation [4]. This regulation includes issues concerning the storage, loading and unloading of radioactive substances during transportation by land, sea or air [4]. The content of this regulation is given below:

PART I Aim, concept, support, terms, abbreviations.

PART II	Transportation Index (TI) determination classification, marking, labelling, number plating, packing, transportation, temporal storage.
PART III	Contamination and leaking packages, contaminated packet surfaces.
PART IV	Responsibilities of sender and receiver.
PART V	Other matters: dose limits, other matters indicated by the institution authorities, transportation of other substances, radioactive substances with dangerous properties, additional conditions for land and railway transportation, additional conditions for sea transportation, additional conditions for air transportation, additional conditions for postage transportation, special sending condition certification.
PART VI	Last laws, validity, application.

The number of imported radiation sources for nuclear medicine purposes within a year exceeds 60000. Quantity and activity of radioisotopes which are imported between 01.01.2002 and 31.12.2002 for this purpose are given Table 2:

Isotope	*Quantity*	*Activity (mCi)*
C-14	57,466	216.5644
CONT.	5	0.0000
Co-57	353	6.2761
Cr-51	29	41.0000
Ga-67	1,044	6,453.7188
Gd-153	4	20.0000
H-3	27	35.8705
I-123	13	106.0000
I-125	21,342	650.6525
I-131	8,584	237,266.3580
In-111	116	435.8922
P-32	16	25.2500
RF-KM	20	0.0000
RIAKM	34	0.0000
Re-186	16	379.4056
S-35	4	1.5810
Sm-153	2	151.0000
Sr-89	2	8.0000
Sr-90	1	4.0000
Tc-99m	3,460	2,110,713.1726
Tl-201	3,235	38,378.3677
Xe-133	5	52.5000
Y-90	36	372.0000
TOTAL	**95,814**	**2,395,317.6094**

Table 2: Radioisotopes imported between 1.1.2002 and 31.12.2002 for nuclear medical purposes.

5. Methods

According to TAEK legislation it is an obligation to get license from TAEK for all kind of radiation related activities. These activities are observed by the RHSD. On side control activities are carried out by experts of the RHSD and CNRTC Health Physics Department. However, TAEK license is not a working permission. The license application is just an obligatory stage before the work permission that will be issued by other related authorities (organizations). The companies with the TAEK licenses have to get a permission for each import, export and transport activities. The requirements for the permission include the serial number of the radiation source (either equipment or radioactive source), Producer Company, the end user, quality certificates of the radiation sources. All preparations including loading, transportation, unloading, temporal storage until the packets are in the hands of the receiver, all responsibilities are beared by the sender. The information and certificates indicated below are forwarded to the institution or authorities 15 days before by the sender. The certificates must also contain information on loading, unloading and the area of temporal storage.

i. Certificate of packed presentation,
ii. Association/institution's approved certificate
iii. A picture showing the shape of the packets,
iv. Types of radioactive substance, physical and chemical properties, quantity of radioactive material or if decomposing substance is present, then the mass value is measured in gram,
v. Transportation and route,
vi. For air transportation purposes, the sender has to show a declarative certificate of the radioactive substances.
vii. Plans must be made towards preventing any uncertain accidents.

After the authorities of have institution has carefully studied the information and certificates above, according to the rules and regulations of safety radiation laws the permission is either granted or not.

When the container is arrived to its destination, a special form for safe arrival should be prepared and sent back to the TAEK.

If some additional processes, like changing parts, moving the items to new locations, are necessary, the staff of the firm who has the same license previously should be responsible for their actions under the supervision of the TAEK. The report of mounting or source replacement is prepared by the TAEK experts. If there is a new source replacement, the container for older source is tested and a report is issued in terms of its safety condition. After this stage, the firm has to apply for a permission to transport the old source. The firm should also get permission for deporting the source. For an application to this type of permissions, the initial permission date of the import, the licence number obtained from the TAEK, the serial number of the source and transport container, and the company and the country where the source is intended to be sent are required for the records.

The used radioactive sources to be deported are held in storage section in the plant or CNRTC unit until when the deportation takes place. The storage unit that the source has to be held is decided by the TAEK experts. However, the safety of the item is under the responsibility of the owner the owner of the plant or their security authorities.

TAEK should be informed when the used source arrives to the custom for its deportation. After the proper tests according to the custom regulations, a proper label is attached to the package. In 15 days after the package is sent to abroad two forms, '"sent form for abroad" and "receive form" from the producer company should be sent to the TAEK.

The records after each process are carefully documented and filed in the database of the TAEK.

Since 1997, the "Regulation for the Safe Transport of Radioactive Materials" [4] is used to organize our license related activities. On the other hand, some issues which are not addressed in this regulation must be referred to the rules and the regulations of the IAEA International Transportation Regulations and other universal transportation regulations for guidance.

6. Conclusion

In Turkey, we generally encounter Type-A packages. In the matter of Radioactive Material's transport since the radioactive materials used in many applications of nuclear medicine (Mo-99/Tc-99m (generator)), I-131(capsule), Tl-201, Ga-67) are transported in Type-A Packages. For the applications of radiotherapy, Co-60 sources transported in Type-B and Ir-192, I-125, Sr-90, P-32 transported in Type-A Packages are some examples in the traffic of radioactive material's transport. Due to increasing amount of use of radiactive materials in medicine, industrial and research areas and also increasing number of visiting submarines and ships which are powered by nuclear material, there is now a higher risk in nuclear and radiological hazards in the phase of transporting and storing these radioactive materials. Thus, in the TAEA, a 'Crisis Center' has been organized to act immediatelly for preventing the individuals, public and environmental assets against radiation effects and contamination. This center is also responsible for directing all necessary actions and taking all necessary precautions for this matter. For any emergency situation, one can reach to TAEA via direct phone line called 'ALO TAEK 172' and report the incidants or accidants that can cause hazardous results.

Turkey gives great importance to the nuclear and radioactive material security and radiation safety due to the presence of thousands of radiation sources in the country and intensive traffic in the region.

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4. Regulations for the Safe Transport of Radioactive Materials, Official Journal No. 23106, 10 September 1997 **(under revision).**

(The revised version of the Radiation Safety Regulations is based on BSS 115 of IAEA, and 97/43 and 96/29 EURATOM Directives.)

TRANSPORTATION PACKAGE DESIGN CERTIFICATION PROCESS AT THE U.S. NUCLEAR REGULATORY COMMISSION

N. Osgood

U.S. Nuclear Regulatory Commission
Office Of Nuclear Materials Safety and Safeguards
Washington, DC
United States of America

Abstract*

The Spent Fuel Project Office of the U.S. Nuclear Regulatory Commission (NRC) certifies designs for Type B and fissile material transport packages. The Spent Fuel Project Office also conducts technical reviews for foreign-approved designs for import and export shipments. In an effort to improve efficiency and effectiveness, the Spent Fuel Project Office developed Standard Review Plans for transportation package design review and established internal policies and protocols to formalize the review process. The Standard Review Plans were developed to summarize the regulatory requirements for package approval, describe the procedures by which the staff determines that these requirements have been satisfied, and document the practices developed by the staff in previous reviews of package applications. The Standard Review Plans are used in conjunction with a Standard Format and Content Guide and other regulatory guidance documents developed by the NRC. Use of these documents is intended to assure high quality applications for package approval and to result in a technical review that is timely and consistent with regulatory requirements. A formalized review process was also developed that included work prioritization, scheduling, and review process templates. The development by IAEA of a standard format for applications for package approval and a review guide for competent authority approved designs and shipments based on Regulations for the Safe Transport of Radioactive Material, TS-R-1, could be used to assist package designers and shippers involved with international transport of radioactive materials. The author also comments on participation in the IAEA TranSAS Mission to the United Kingdom with respect to the package design certification process.

1. Introduction

The United States has several agencies that share responsibility for the safety of radioactive material in transport. The primary agencies that implement the IAEA Regulations for the Safe Transport of Radioactive Material (TS-R-1) are the Department of Transportation (DOT) and the Nuclear Regulatory Commission (NRC). The NRC is an independent Federal agency established by Congress to ensure adequate protection of the public health and safety, the common defense and security, and the environment, in the use of nuclear materials in the U.S. The NRC scope of responsibility includes regulation of commercial nuclear power reactors; non-power research, test and training reactors; fuel cycle facilities; medical, academic and industrial uses of nuclear materials; and the transport, storage and disposal of nuclear materials and waste.

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* The views expressed in this paper do not necessarily reflect those of the U.S. Nuclear Regulatory Commission.

The Spent Fuel Project Office serves as the agency lead in radioactive material transport and spent fuel storage activities. The office licenses and inspects spent fuel storage facilities - both those located at the sites of operating or decommissioned reactors and at locations other than reactor sites. The office also certifies Type B and fissile material transport package designs and spent fuel storage cask designs. A related major responsibility of the Spent Fuel Project Office is to develop and maintain regulations that apply to these activities. The NRC regulations that apply to packaging and transportation are in the Code of Federal Regulations, Title 10, Part 71. Part 71 includes package performance requirements for Type B and fissile material transport packages that are in general consistent with TS-R-1. Responsibilities of the office also include review and approval of quality assurance programs for transportation and storage activities, and inspection of the fabrication and use of NRC-certified packages.

2. Transport package design certification process

In the mid to late 1990's, as commercial reactor spent fuel pools began to fill up, there was a large increase in the number of commercial reactor plants that were turning to on-site dry cask storage for spent fuel. A number of cask designers were also developing casks or canister-based systems that could be used for both storage and transport. The significant increase in the design review work for the Spent Fuel Project Office prompted a review and revamping of the certification process within the NRC. The key elements of the improvement program included development of Standard Review Plans, a system of work prioritization, and use of review schedules and review process templates.

2.1. Standard review plans (SRP)

The NRC has had SRPs for the licensing of commercial power reactors for many years. The standard review plans for transport package design certification are relatively new for the NRC. The Spent Fuel Project Office developed four SRPs - two for transport and two for spent fuel storage. The SRPs are available full text through the NRC website and are listed here:

—SRP for Transportation Packages for Radioactive Material (NUREG-1609), May 1999

—SRP for Transportation Packages for Spent Nuclear Fuel (NUREG-1617), March 2000

—SRP for Dry Cask Storage Systems (NUREG-1536), January 1997

—SRP for Spent Fuel Dry Storage Facilities (NUREG-1567), March 2000

For transport packages, each SRP summarizes regulatory requirements for package approval. It describes the procedures that the NRC staff use to determine that the requirements have been satisfied, and it documents the practices developed by the staff in their previous package reviews. It is useful in a number of other ways, for example, it helps staff ensure that technical reviews are consistent and thorough. It is also useful to applicants to understand the information and criteria that the staff use to make their regulatory determination. The SRPs are intended to be living documents that will be updated and revised as regulations or practices change. To assist in keeping the SRPs up to date, interim staff guidance documents are used to identify emergent issues and develop staff positions in a timely manner.

NRC has issued other Regulatory Guides for the broad spectrum of NRC-regulated activities. Regulatory Guides addressing various aspects of packaging and transport are grouped into Division 7, Transportation. The SRPs are used in conjunction with NRC Regulatory Guide 7.9, Standard Format and Content of Part 71 Applications for Approval of Packaging for Radioactive Material. The Standard Format and Content guide was developed to aid in the preparation of applications and to facilitate the staff review of these applications. This Regulatory Guide and others in Division 7 are currently being updated to be compatible with the major rule change currently underway that will harmonize U.S. domestic regulations with the 1996 Edition of TS-R-1.

2.2. Review schedules and templates

The review of both transport package and spent fuel storage designs is integrated in the Spent Fuel Project Office. To optimize the review process a system of work prioritization is used. The first priority is, of course, maintaining safety. The second priority is the operational needs for nuclear facilities, for example, operating reactors, or a specific scheduled shipment to support operations. The third priority is work that supports decommissioning activities, and fourth is all other work. In general it is up to each applicant to identify the specific needs that the staff use to make their judgements regarding work priority.

At any time there are on average 40 to 50 cases in various stages of the review process. For transportation packages this includes new designs, amendments to existing certificates, certificate renewals, and review of foreign-approved designs.

When a request is received it is immediately docketed and assigned to a project manager. The project manager develops a schedule, based on the priority of the work and the complexity of the request. We use standard review duration templates to assist in developing the schedule. The project manager will identify technical review disciplines needed to complete the review. Separate reviewers are typically assigned for structural, thermal, nuclear, and materials reviews. The technical reviews are performed concurrently.

The review templates identify the major steps in the review process and outline standard time durations for completion. The first step is to ensure that the application is essentially complete, is sufficient for a detailed technical review, is in the standard format, and is, in general, consistent with the guidance in the Standard Review Plan. When the technical review is complete, we may issue a formal written request for additional information. This identifies the technical information needed by the staff to make their regulatory determination. Information provided by the applicant in response to this request is normally submitted in the form of revised and supplemental pages to the application.

Package approval results in the issuance of an NRC Certificate of Compliance and a staff Safety Evaluation Report. The Safety Evaluation Report describes the basis for the staff's determination that the package design meets the regulatory requirements in Part 71.

2.3. Public insight into the package design certification process

The NRC as an agency is committed to providing opportunity for the public to participate in and observe our regulatory program and activities. For transportation activities, the public has opportunities for comment during rulemaking activities. It should be clarified that by public, we mean not only individual persons, but members of the regulated industry, groups or organizations representing the industry, and public interest and environmental groups.

Public participation in the transportation rulemaking currently being undertaken in the U.S. includes an enhanced public participation process, with meaningful opportunities for the public to influence our regulatory program. In addition, our program allows public observation of our implementation of the package approval process. Essentially all interactions between the applicant for a package design approval and the NRC staff are open for public observation. This includes correspondence, which is available through the NRC electronic reading room, meetings, which may be attended by individual members of the public, and the submission of an application for package approval. Importantly, the documentation of our review, including the Certificate of Compliance and the staff Safety Evaluation Report, is also available for public review.

Information that is sought to be withheld from the public must meet certain criteria. The criteria are described in NRC regulations. Information that might be considered for withholding includes detailed engineering drawings or details regarding unique materials or processes used in the package design or fabrication. The applicant must provide a justification and rationale to withhold these limited and specified pieces of technical information.

3. NRC review of foreign approved designs

The NRC review process for foreign-approved designs is somewhat different than that for domestic approvals. First, the review is, in general, performed against the IAEA standards and not our domestic regulations. However, the guidance in the Standard Review Plans is generally applicable, since the NRC package performance requirements are generally consistent with IAEA standards. Second, the NRC role in the review is different. We are not the certifying agency, and therefore our review is documented in a letter to DOT, which is designated as the U.S. Competent Authority. The NRC does not issue the competent authority certificate, nor do we validate the foreign certificate. Third, the type of review is different. Since another competent authority has already performed an independent technical review, our review may be less detailed than for an NRC-approved design. For example, we may or may not perform independent confirmatory calculations for a foreign-approved design.

In spite of these differences, the review protocol for a foreign-approved design is similar to NRC-approved designs. The work is still scheduled with our other review work. We also perform a preliminary review to ensure that the application is complete, is internally consistent, and is sufficiently detailed to perform a technical review. If the application is not substantially complete, we will close the review and inform DOT in writing regarding deficiencies identified in our administrative review. It should be noted that in these cases we are not necessarily judging that the design is inadequate, but that we do not have sufficient information to make a regulatory determination.

With respect to our review of foreign-approved designs, our administrative and technical reviews are often complicated by the fact that IAEA does not have a recommended or a suggested format for applications for package design approvals. In addition, some type of IAEA review guide might be a valuable tool that could assist competent authorities worldwide in assuring that applications address the appropriate performance requirements.

4. Author’s comments on the IAEA TranSAS mission to the U.K.

The author’s participation in the IAEA Transportation Safety Appraisal Service to the United Kingdom in June 2002 provided a unique insight into the package review and certification process used in another country. In comparing the U.S. and U.K. programs, the author concluded that the review processes were similar; however, each program seemed to have different strengths and weaknesses. With respect to the strengths of the U.K. program, the individuals performing transport activities were dedicated, focused, and experienced in their expert fields. The close interaction of this group was clearly beneficial in assuring a consistent and comprehensive technical review for all designs - from physical testing of packages to fabrication and operation. In comparison, the Spent Fuel Project Office staff is quite large, since our major workload is review of spent fuel storage casks and facilities. As a result, the NRC process has a greater degree of formality and structure. However, it was clear that both systems work well and support the goal of safety in the international transport of radioactive material.

REGULATORY BASED TRAINING FOR RADIOACTIVE MATERIAL TRANSPORT IN THE UNITED STATES

D. Pstrak

U.S. Nuclear Regulatory Commission
Office of Nuclear Materials Safety and Safeguards
Washington, DC
United States of America

Abstract*

There are many different factors that a consignor must take into consideration when preparing a package of radioactive material for transport. Based on the type of material involved, decisions need to be made concerning the proper use of the transportation regulations for that material. Failure to adequately address a regulation could result in a lost, delayed, or unsuccessful shipment, or a government-imposed enforcement action. A very effective tool for ensuring that a consignor is properly versed on all of the appropriate regulatory requirements is a systematic training program.

1. Regulatory agencies in the United States

In the United States, the U. S. Department of Transportation (DOT) and the U. S. Nuclear Regulatory Commission (NRC) jointly share responsibility for regulating the safety of transportation of radioactive material. As set forth in National Laws, the DOT establishes and maintains the regulations for packaging and transporting all hazardous materials, including radioactive material and the NRC has responsibility for safety in the possession, use and transfer of byproduct, source, and special nuclear material. In order to avoid duplicative and perhaps conflicting regulations, both agencies signed a Memorandum of Understanding in 1979 that delineates their respective responsibilities regarding transportation of radioactive material. Since the DOT sets forth the regulations for packaging and transporting all hazardous materials, including radioactive material, it is appropriate that they also develop and maintain the training requirements for hazardous materials. Consequently, in 1992, the DOT published a rule incorporating hazardous material training and testing requirements into 49 Code of Federal Regulations (CFR) - Transportation.

2. Areas of required training

Three major areas were established for hazardous material employee training, often referred to as hazmat training. These include General Awareness/Familiarization Training, Function Specific Training, and Safety Training. It is important to note that while the training requirements in the regulations are generic for all hazardous materials, the training that is required for a particular class of material is specific to that material. In other words, while the discussion that follows covers the broad topic of hazardous material training, it also applies to radioactive materials (hazard class 7).

General Awareness/Familiarization Training is required to ensure that a hazmat employee is able to recognize and identify hazardous materials based on the communication standards of 49 CFR 172, including shipping papers, package marking, package labelling, vehicle placarding, and emergency response information. For example, should an employee of a consignor or carrier of radioactive material assign a Radioactive Yellow - II label to a package, he/she should be able to recognize that a second label is also required to be placed on the opposite side of the package. Likewise, should an employee of a consignor or carrier see one Radioactive placard on one side of a vehicle, he/she should expect to see three additional placards applied to the other sides of the vehicle. In other words, the

* The views expressed in this paper do not necessarily reflect those of the U.S. Nuclear Regulatory Commission.

workers are generally aware of what the communication requirements are, and are familiar enough with the transportation regulations to find out specifically how to meet the requirements.

Function Specific Training is focused on the tasks or activities that a hazmat employee actually performs. For example, should a hazmat employee's job involve loading a package prior to transport, the training for that individual should include, among other things, topics related to loading requirements, weight limits, lid closure devices, etc. Should certain hazmat employee functions not be performed by a particular individual, then training and testing of that individual is not required. Many hazmat employers require a "job-task analysis" for every aspect of preparing a package for transport. Thus, individual jobs are described in detail, and a systematic training program developed to ensure that the hazmat employee's training is adequate for him/her to complete the task. While not required by law, these analyses are an effective method for identifying the specific training that a hazmat employee must accomplish in order to properly and efficiently apply the transportation regulations to their actual job.

Safety Training ensures that the hazmat employee has sufficient knowledge in emergency response information from 49 CFR 172 subpart G, self-protection measures, and accident protection methods and procedures. Generally, safety training is for those hazmat employees who actually handle or transport packages of hazardous materials and who might be exposed to the hazards during transport. With that in mind, training should include protection measures for those hazardous materials the hazmat employee actually encounters in the work place. Employees who do not actually handle packages of hazardous material during their course of work do not need to be trained in this aspect of the regulations.

Training in these three areas is not immediately required for a new hazmat employee or for a hazmat employee who changes job functions, provided the hazmat employee performs those functions under the direct supervision of a trained and knowledgeable hazmat employer. However, training must be accomplished within 90 days of employment or change in job function. Training in these three areas is required once every three years. Many facilities have elected to provide hazmat employee training annually so that their hazmat employees are reminded of the existing transportation requirements and any new requirements can also be incorporated into the training.

It is the hazmat employer's responsibility to ensure that each hazmat employee is trained and tested, as appropriate, in the three required areas. Training can be provided either by the hazmat employer or a contractor. The testing can include hands-on tasks or written exams. In either case, the hazmat employer may choose the testing method. Lastly, a record of current training, inclusive of the preceding three years, shall be created and maintained by the hazmat employer for each hazmat employee. The record must be retained by the hazmat employer for as long as the hazmat employee is employed and for 90 days thereafter. The record must include the hazmat employee's name, the date of the most recent training completed, a description or copy of the training materials that were used, and the name and address of the trainer.

3. Applicability of training

Historically, the hazmat employee training requirements became effective on October 1, 1993. Since then, DOT has incorporated some minor revisions to improve the requirements and to clarify the frequency in which the training must be provided. Currently, hazmat employers are required to ensure that each hazmat employee is properly trained and tested once every three years.

If an accident occurs involving a hazardous material, one area that will definitely be investigated is hazmat employee training. Records can be reviewed, training material analyzed, and procedures read in order to determine if part of the cause of the accident is related to training. The DOT regulations even contain a structured set of monetary penalties that can be imposed on a hazmat employer for failing to follow the required regulations for hazmat employee training. Examples of these penalties include failing to provide training to hazmat employees and failure to maintain training records for those who have completed training.

The NRC's regulations include requirements for quality assurance (QA) programs for personnel that engage in activities involving the transportation of radioactive materials in Type B and fissile material packages. While not specified, the expectation is that personnel who perform QA activities have received sufficient training that supports the activity they are actually performing. NRC QA requirements apply to the design, purchase, fabrication, handling, shipping, storing, cleaning, assembly, inspection, testing, operation, maintenance, repair, and modification of components of Type B and fissile material packages that are important to safety. Additionally, in accordance with NRC regulations (10 CFR 71.5), each licensee who transports licensed radioactive material outside the site of usage or where transport is on a public highway, or who delivers licensed material to a carrier for transport, must comply with the applicable regulations of the DOT. This provision also applies to the hazmat employee training requirements of the DOT. NRC inspectors review the shipping practices of licensees and enforce compliance with the DOT regulations.

The hazmat employee training requirements also apply to carriers who transport hazardous materials by rail, highway, sea, and air. The specific training provided to workers in each of these modes is specific to that particular mode. Thus, from the time a package of hazardous material is prepared for transport to the time it is delivered to its destination, it is in the hands of personnel who have attended and passed various training requirements that ensure the safe transport of that material.

During the development of the 2003 revisions to the International Atomic Energy Agency Transport Regulations, the United States proposed an amendment to add training requirements directed at all parties involved in package preparation, shipment, and carriage of radioactive materials. These amendments were accepted and will add training requirements that are closely aligned with those contained in the UN "Orange Book". The requirements are directed at ensuring that all workers involved in the transport of radioactive material receive training in the Transport Regulations commensurate with their responsibilities. Additional details are provided on the types of responsibilities that are included and three levels of training are specified: general awareness/familiarization; function-specific; and, safety. Details are provided on the content to be included in each level of training. This training must be provided or verified upon employment and must be supplemented periodically with retraining as deemed appropriate by the Competent Authority.

4. Summary

The regulations that apply to the packaging and transportation of radioactive material in the United States are issued and enforced by the DOT and NRC. DOT's regulations include training requirements that apply to employees at nuclear facilities who perform various functions related to preparing a package of radioactive material for transport. The purpose of the training requirement is to ensure that the employees are familiar with the numerous transportation requirements for that material, thereby ensuring the safe transport from the point of origin to point of delivery. Should something go wrong with the package during transport, both the training program and records can be inspected to ensure that the employees involved were properly and adequately trained. The systematic training requirements of the DOT have existed for nearly 10 years in the United States. Thus, many consignors of radioactive material have received training and refresher training in various aspects of the transportation regulations. Recurrent training helps to ensure that the regulations are properly applied thereby increasing the confidence and competence of the consignors and carriers. Training clearly leads to success.

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COGEMA LOGISTICS' EXPERIENCE WITH THE NEW MODAL REGULATIONS

P. Malesys, M. Lesage

COGEMA LOGISTICS,
Montigny-le-Bretonneux, France

Abstract.

The new modal regulations have had to be fully implemented since 1 January 2002. The 1996 Edition of the Regulations for the Safe Transport of Radioactive Material, as set forth by the International Atomic Energy Agency (IAEA), provide the framework for the new modal regulations. COGEMA LOGISTICS closely followed the development of the new IAEA Regulations and worked intensively to ensure it meets the new requirements within the due date. This allowed mastering efficiently their implementation, in spite of important changes. Nevertheless, this was not at no cost, since some requirements have been enhanced such as those for the transport of uranium hexafluoride or for the transport of fissile material by air. Unexpected difficulties also came from what we had considered as minor changes, such as the new principle for the allocation of UN numbers and proper shipping names. Further difficulties arose from the modal regulations and their provisions which are not dedicated to radioactive material. That means that in the future we will have to pay attention not only to the revision of the IAEA Regulations, but also to the revision of the modal regulations. COGEMA LOGISTICS' experience of implementing the new modal regulations has been positive so far. However, sufficient time is needed to ensure common implementation of new requirements and, in the case of industry, to provide for any necessary changes, including staff training, new design and/or approvals, and updates of operating procedures. Consequently, COGEMA LOGISTICS expresses the wish for a stable and predictable set of regulations.

1. Introduction

International transport of radioactive material is regulated by international and regional modal regulations which apply to all dangerous goods. As regards radioactive material, the requirements in the modal regulations are based on the "Regulations for the Safe Transport of Radioactive Material" set forth by the International Atomic Energy Agency (IAEA). The last edition of the IAEA Regulations was published in 1996 [No TS-R-1 (ST-1, Revised)], then incorporated into the modal regulations, and finally implemented, with various transitional periods. As a result, since 1 January 2002, it has been mandatory, for all modes, to perform transports in accordance with the 1996 Edition of the IAEA transport regulations.

In the mean time, all these international and regional regulations have also been reformatted to adopt the unified format of the United Nations (UN) "Recommendations on the transport of dangerous goods – Model Regulations", often referred to as the Orange Book.

This paper presents COGEMA LOGISTICS' experience with the application of this new set of regulations to design of packages, to transport operations, and to administrative matters.

2. From the 1985 Edition to the 1996 Edition of the IAEA Regulations

Between the 1985 and the 1996 Editions of the IAEA Transport Regulations for the Safe Transport of Radioactive Material, main differences deal with:

- the revision of the values for
- the activity concentrations for exempt material,
- the activity limits for an exempt consignment,

- the exceptions from the requirements for packages containing fissile packages, and
- A_1 and A_2 values,

- new requirement for implementing Radiological Protection Programmes (RPP),
- new requirements for marking the packagings with UN number and proper shipping name,
- enhanced requirements for the transport by air of
  - large quantities of radioactive material (Type C packages), and
  - fissile material,
- enhanced requirements for the transport of uranium hexafluoride (UF_6).

3. Activity limits and material restrictions

Up to now the activity limit for exemption of the regulations was a single and well-known value: 70 kBq / kg. The new regulations introduce two sets of values: one activity concentration to exempt material, and one activity limit to exempt consignment. Furthermore, these values are radionuclide-specific. One particular difficulty comes from the mixture of radionuclides: the formula to calculate the equivalent values for a mixture of radionuclides may not be well known of those who do transport under the regulatory limits and were not very familiar with the regulations.

The exceptions from the requirements for packages containing fissile material are now also somehow more complex. Beside the existing limits applicable to each package, new requirements apply to the consignments.

The regulations also introduced modifications in the A_1 and A_2 values. This does not cause significant problems apart from the extra-attention which has to be given. Indeed, in some cases the type of package to be used with the new requirements may differ from the type of package formerly used.

In response to these new requirements, COGEMA LOGISTICS, using in-house specialits, set up an extensive program of education and training to all the staff involved in the transport operations

4. Radiation protection programmes

The 1996 Edition of the IAEA Regulations for the Safe Transport of Radioactive Material set the need to establish Radiation Protection Programme (RPP) for the transport of radioactive material. This is a significative new requirement. Even if the regulations recognise that “the nature and extent of the measures to be employed in the programme shall be related to the magnitude and likelihood of radiation exposures”, it remains that the requirement applies to all transports.

COGEMA LOGISTICS developed and implements RPPs for its own activities. Actions were also taken to assure that all the organisations involved in a transport are fully aware of this requirement and of their subsequent duties. It appears rapidly that small companies, or companies which realise most of their business outside the nuclear market, were not inclined to devote resources to develop such RPPs. To alleviate this difficulty, while keeping the possibility to use a large spectrum of sub-contractors, COGEMA LOGISTICS decided to propose its assistance and to prepare model RPPs for families of sub-contractors. It also appeared as more efficient, in the case of special and non-routine transports, to develop a single RPP which covers all the organisations involved in the transport. Either for its own RPPs, or for those prepared as model for other organisations, COGEMA LOGISTICS took advantage of its long experience with assessment of effective doses, but also with management of transport, training and quality assurance. Deep consideration was also given to different guidances developed within the IAEA, within the European Commission by national safety institutes and by the industry in the framework of WNTI.

5. Transport of large quantities of radioactive material by air

When transported by air, large quantities of radioactive material must now be shipped in a new type of packages: Type C packages. This new requirement has been applicable since 1 July 2001, that is to say without transitional period.

In that area, COGEMA LOGISTICS had undertaken, about 15 years ago, preliminary studies to design packages to transport plutonium oxide powder, in accordance with the US regulations, which are somehow more stringent than the Type C requirements. Again, about five years ago, when the requirements for Type C packages were established and stabilised, COGEMA LOGISTICS considered the design of a package to transport fresh mixed oxide uranium – plutonium (MOX) fuel assemblies by air. The preliminary studies allowed demonstrating the feasibility of such a Type C package. Was a need to appear, COGEMA LOGISTICS would be ready to go towards licensing of a type C package.

6. Transport of fissile material by air

Packages containing fissile material and transported by air are now submitted to enhanced tests (equivalent to tests applicable to Type C packages). The wording of the regulations appears for some people as confusing. This was generally acknowledged and a new wording will be introduced in the future revision of the IAEA Regulations. Nevertheless, COGEMA LOGISTICS which had participated in the revision process for the 1996 Edition of the IAEA Regulations, has been in a position to master the appropriate understanding of the topic.

On that basis, COGEMA LOGISTICS applied for approvals for packages containing fissile material to be transported by air. No major problems were met with the competent authorities about the interpretation of the regulations. The only issue during the assessment by the competent authorities was the level of conservatism, which has to be considered in the assumptions of the criticality assessment, and particularly about the worst case regarding the distribution of the materials.

7. Packages containing uranium hexafluoride

Considering the chemical hazards of uranium hexafluoride, the new IAEA Regulations include specific requirements for packages containing uranium hexafluoride.

Multilateral approval for packages containing natural uranium hexafluoride has been required, for all modes of transport, since 1 January 2002. This topic was extensively discussed within the HEXT (uranium HEXafluoride Transport) group of the World Nuclear Transport Institute (WNTI). Several industrial organisations, members of WNTI, including COGEMA LOGISTICS, decided to join their resources and developed an appropriate technical solution (Valve Protect Assembly – VPA – to protect the valve during the drop test) for 48 Y cylinders. Multilateral approvals were granted for a five-year period in North America (USA and Canada) and Russia, and until 31 December 2003 in Europe (France, Belgium, United-Kingdom, the Netherlands, Germany and Spain). It is noteworthy that unexpected delays and administrative difficulties were encountered, as the implementation of the new regulations was postponed in the United-Kingdom.

In a view of a unilateral approval, middle-term actions are in progress, within the same group of industrial companies: a thermal protection is under development and will allow coping with the thermal test requirements.

8. Marking of the packagings

The new regulations impose that the packagings must be marked with the UN number and proper shipping name. This new requirement may appear as a minor change, nevertheless, when time has come for enforcement, difficulties have arisen. In fact difficulties are not only due to the marking by itself, but come from the way UN numbers and proper shipping name are allocated according to the type of packages. Some examples of problems that can be met are given below :

- a package for low enriched uranium can be approved as IF (Industrial package containing fissile material) in one country and validated as AF (Type A package containing fissile material) in another one,
- a package for spent fuel or high level waste can be approved as B(U)F (Type B(U) package containing fissile material) in one country and approved as B(M)F (Type B(M) package containing fissile material) in another one,

- a package can be approved in one country, and it may be necessary to transport the consignment under special arrangement in another one,
- a package containing uranium hexafluoride can be considered as such, but also as an Industrial Package or a package containing fissile material.

This situation has created one of the most important issues at the beginning of the implementation of the regulations. It is a typical example of such issues with a low safety impact, but which represents quite a burden on the industry. Indeed, the solutions must be found case by case and can range from a double marking, to a change of marking at the borders between two countries, or on board of the ships, to the grant of appropriate provisions in special arrangements. This problem was largely recognised and should be dealt with in future revisions of the IAEA Regulations.

9. Modal regulations aspects

9.1. New format

The new editions of the modal regulations are now published with a unique format : the format of the UN Orange Book. Harmonization can only represent an improvement provided that the users of the regulations get familiar with the new format. This is of particular importance regarding these regulations, as they are not exactly user-friendly for operators involved in the transport of radioactive material: the natural entrance in the reformatted regulations is the UN number. From this number, the applicable requirements can easily be tracked. For dangerous goods other than radioactive material, the UN number is directly associated with the material itself. For radioactive material, the UN number is associated with the type of package. And the applicable requirements, including those applicable to the package, are defined from the UN number. Therefore, a high level of skill is necessary, otherwise there is a significant risk to find neither the entrance, nor the exit, of the maze.

9.2. Tanks

The new regulations include new requirements for tanks but provisions applicable to tanks manufactured before the date of entry into force of the new regulations are not explicitly provided. Consequently, specific agreements with the competent authorities must be sought after.

9.3. Subsidiary risks

In the former regulations, provisions allowed to transport, in a Type A or a Type B package, radioactive material with subsidiary risk. These provisions are no longer available. The consequence is the need to fully comply with the requirements of two classes of dangerous goods (and in some instances both sets of requirements cannot be met simultaneously), even for low quantities, or, once again, to apply for a special agreement with the competent authorities.

10. Conclusion

The overall experience of COGEMA LOGISTICS with the implementation of the new modal regulations has been positive. Key elements for a successful transition include:

- anticipation of the changes thanks to a close follow-up of the regulations review process,
- time and resources devoted to analyse and deal with new requirements as well as specific issues,
- extensive program of education and training for all the staff involved in the transport operations.

However, sufficient time is needed to ensure common implementation of new requirements and to provide for any necessary changes, including staff training, new design and/or new approvals and potential changes to operating procedures. Consequently, COGEMA LOGISTICS expresses the wish for a stable and predictable regulatory framework.

RADIOACTIVE TRANSPORT CLEANLINESS PLAN AT THE ATOMIC ENERGY COMMISSION (CEA) IN FRANCE

J. C. Caries [a], G. Bruhl [b]

[a]Commissariat à l'Energie Atomique,
DEN/CAD, 13108, Saint Paul lez Durance,
[b]Commissariat à l'Energie Atomique,
DSNQ/MSN, 91191, Gif-sur-Yvette,
France

Abstract:

Transports of radioactive material are vital in achieving the current research programs undertaken by the CEA in its different nuclear facilities, located in several nuclear Centres throughout the country. Since transports are very frequent (1200 movements per year and more than 16000 packages) and require using public networks to ensure continuous transport between Centres or towards other locations involved in the nuclear industry, it is a key issue to keep the associated packages free from radioactive contamination, with regard to the risk to the general public and the environment. With this objective in mind, which is a major challenge for the CEA, a specific plan for action, called "Radioactive transport cleanliness plan" has been implemented in the frame of an overall plan entitled "Radiological cleanliness plan at the CEA".

1. Introduction

The different aspects of this specific « Radioactive transport cleanliness plan » will be summarized here below. The main issues resulting from this plan concern the following areas:

- Strengthening the prevention means by improving knowledge,
- Improvement of systematic inspection procedures,
- More stringent operation procedures,
- Reinforcement of the dismantling program for the package inventory no longer in use.

Other special features have been identified, such as the improvement of the interfaces between the involved units, the need to harmonize the radiological monitoring procedures with the different partners, a better implementation of ALARA programs in order to reduce radiation exposures, sharing experience feedback, ….

For each of these identified features, a series of recommendations has been established and included in a « Guide for good practices ». In addition, this guide identifies the teams in charge of the implementation of each of the proposed good practices and describes a standard radiological monitoring procedure for transport operations.

2. Objectives of the main issues

2.1. Strengthening the prevention means by improving knowledge

Improvement of knowledge has been especially implemented in the two following domains:

2.1.1. Organization of training sessions dedicated on transport means

For all its personnel involved in transport operations, the CEA has defined different training sessions dedicated on the different aspects of radioactive transport (e.g. regulation aspects, operational aspects). In the next 5 years, these training courses will concern about 500 to 700 employers, which represent approximately 4 % of the whole population of the CEA. Two types of training sessions are proposed:

General training session. This training session covers the different domains concerned by the transport of radioactive material by road. It includes a one-day theoretical program focused on the ADR requirements, licensing and package approval procedures, and a 2-day practical program focused on the operational aspects of the transports (preparation of the packaging, execution of the transport). The later are more specifically treated in the form of practical workshops. This training session is organized by the Department of the CEA called « National Institute for Nuclear Sciences and Techniques ». About 300 to 400 people are concerned by this general training, necessary to sign shipments documents, according to the ADR requirements. For this session, an operational support document called "Vade Mecum" will be written in the coming months.

Dedicated training sessions. Besides the previous general training session, dedicated training sessions are developed, consisting generally on single-day courses focused either on aircraft regulation, evaluation of the safety of the packages, knowledge on shipment aspects, labeling and marking requirements, radiological control procedures, intervention after incident or accident situation.

For each of these sessions, relevant support documents are available.

2.1.2. Experience feedback sharing

Experience feedback is very important in transport as it is in any nuclear activity. For that purpose, several items have been more especially explored throughout the CEA "Radioactive transport cleanliness plan". These items are presented here after.

The overall challenge of this experience feedback program is to reduce the number of significant incidents affecting the transports, to limit the radiation exposures of the operators concerned, and finally to be more efficient in the different tasks linked to the transports. In order to reach these objectives, exchanges with other nuclear operators have been made and mutual experience feedback taken into account as far as possible.

(a) Experience feedback throughout the elaboration of generic procedures. Several domains have been explored, namely:

- *Implementation of an "on-site transport regulation system"*
  According to the request of the competent Authority, CEA has implemented an "on-site transport regulation system", whose objective is to govern the design, the maintenance programs, the requirement for use as well as the procedure of approval of packages intended for on-site transport purposes.

- *Definition of a generic methodology for safety assessment of existing packages*
  A generic methodology for the improvement of the periodic safety review of existing packaging inventory has been developed, in order to increase the lifetime of a number of packages in use. This methodology has to comply with the regulatory requirements in force and accepted by the competent Authority.

- *Definition of operational control procedures*
  In the frame of the CEA "Radioactive transport cleanliness plan", a set of operational control procedures has been established, which includes the following concerns: verification of the correct stowage, leaktight measurements, compliance with the surface contamination limits.

(b) Exchange experiences on good practices. In collaboration with the different partners involved (designers, users, regulators, consigners) different practices have been compared in order to elaborate the following guides for good practices:

- ♦ *Control method for the measurement of radiation emissions*

  A radiological control method has been elaborated, which takes into account the feedback of several French nuclear operators (CEA, COGEMA, EDF, TRANSNUCLEAIRE, …). This control method addresses to the measurement of external radiation emissions (gamma + neutrons) as well as to fixed and non-fixed surface contamination.

- ♦ *Decontamination procedure*

  An adapted decontamination procedure has been addressed in order to reduce the level of surface contamination of the packages in use. This procedure constitute an alternative to the guide of recommendations for the design of new packaging, whose aim [with regard to this objective] is also to limit the deposit of radioactive contamination on the external/internal surfaces of the packages.

(c) Experience feedback issued from incident or accident situations. In line with the previous actions, experience feedback from international and national transport events have been analyzed, and classified according to the following sources of incidents or accidents:

- radiological aspects (presence of abnormal contamination, irradiation)
- mechanical aspects (non respect of loading or stowing requirements)
- procedure aspects (non respect of regulatory rules), etc.

For each category of potential source of incidents or accidents, a specific plan of actions has been addressed and included in the general "CEA radioactive transport cleanliness plan".

2.2. Improvement of systematic inspection procedures

An overall inspection program has been implemented in order to verify if the organization on the different operational levels of decision of the CEA (mainly within each facility and on the head directory of each nuclear centre) is in accordance with the general principles approved by the regulatory Authority.

Preliminary: In line with the objectives of the "Radioactive transport cleanliness plan" and in order to coordinate the transport business in the different Centres, CEA internal procedure specifies that only Departments or Nuclear facilities having got an agreement, are authorized to achieve their own shipments. This agreement is delivered on the basis of different criteria: knowledge on regulatory and operational aspects, ability of technical staff, organization in accordance with assurance quality requirements, …

The other nuclear facilities must realize their shipments under the responsibility of a specific Transport Office (see next clause), which has been created in each Centre for that purpose.

2.2.1. Role of the Transport Office

The Transport Office of each CEA nuclear Centre is in charge of systematically controlling the transportation on CEA internal roads and on public roads.

To achieve this operational control, a check list, including the following parameters has been established: type and activities of radioactive materials involved, suitability of the packaging for the material shipped, authorizations, exposure and contamination of packaging and vehicles, safety documents, loading and stowing, shipment bill of lading, respect of the specific regulations for nuclear materials concerning physical safety).

2.2.2. Role of the Nuclear Safety Department

In each CEA Centre, a Nuclear Safety Department, independent from the operational units, and the Radiation Protection Section mentioned here after (see clause 2.3), is in charge of the final control. This control consists in the verification of the adequate organization, authorizations, approvals, safety files, accompanying documents.

This specific Department supports also the Director of the Centre in delivering on-site packages approvals and associated transportation autorizations.

2.3. Implementation of more stringent operation procedures

The guide for good practices includes a clause, which describes a general and complete procedure for the control of radioactive material transportation. This procedure takes especially into account:

- the use of international quality standards (ISO) for exposure and contamination measurements,
- the description and localization of check points.
- the need to implement better traceability of all the results, which are of importance in case of abnormality and incident.
- the reference to only use certified radiation protection instruments, where possible.

The unit of charge of these controls is a dedicated Department of Health Physics (called Radiation Protection Section), which acts for the operational units in charge of the organization of the transports.

2.4. Reinforcement of the dismantling program of the packaging inventory no longer in use

In order to reduce the number of packages stored within nuclear facilities or on specific storage areas, the CEA has decided to undertake the dismantling of most of the package inventory no longer in use.

The achievement of this program contributes to reduce the source term in different nuclear installations, which corresponds to a good practice regarding the current safety requirements.

About 3000 packages are concerned by this dismantling because of the great diversity of the materials transported during the last 56 years of CEA activities.

2.5. Safety Transport Adviser

It is important to note that the CEA Head Safety Transport Adviser and the Site Safety Transport Adviser of each Centre are greatly involved in the improvement of these practices.

3. Conclusion

At the present stage, the “Guide for good practices” is experimented by several units especially in charge of radioactive transport in order to integrate experience feedback. It will be distributed, later on, to all of the operational units, for application. To cope with this strategy, this guide will also be used in support of the different training sessions described here above.

Simultaneously, a very large communication campaign took place in 2002 and continues in 2003 on the several radiological cleanliness themes of the CEA policy. High involvement was observed. This work will continue to be achieved within the next two years and afterwards to preserve the acquired knowledge of this radiological culture.

SAFE TRANSPORT, USE AND DISPOSAL OF NUCLEAR MEDICINE SOURCES IN INDIA - *Controls and Administrative Procedures*

K.R.K. Singh, S.P. Agarwal, K.C. Upadhyay. M. Inamdar

Radiological Safety Division, Atomic Energy Regulatory Board,
Niyamak Bhavan, Anushaktinagar, Mumbai – 400 094,
India

Abstract.

Large number of applications of radioactive material (RAM) in medicine, industry, agriculture and research necessitates its transport from one place to another. In view of the radiation hazard associated with the transport of RAM, these are required to be transported in accordance with the national regulations. In India, Atomic Energy Regulatory Board (AERB), the Competent Authority, enforce the regulations for the safe transport of RAM through a *Code*. The code is based on the IAEA regulations for "Safe Transport of Radioactive Material" with modifications to suit the conditions of transport specific to India. In India, a considerable supply of the radioisotopes, particularly short-lived, used in nuclear medicine, is of foreign origin and the quantum of such imports is increasing annually. In this paper, the current administrative procedures and controls followed for safe transport, use and disposal of RAM used in nuclear medicine in India are discussed in detail.

1. Introduction

With the rapid increase in the use of radioactive material (RAM) in different fields, the quantum of transport of RAM from one place to another is also increasing. Even though there is a potential for radiation hazard in the transport of RAM, such hazard is controlled to an acceptable level by following the regulations for safe transport of radioactive material [1]. The "Regulations for Safe Transport of Radioactive Material" of the International Atomic Energy Agency (IAEA) is the backbone of the regulations in many countries. These regulations aim at providing an acceptable level of control of the radiation hazards to persons, property and the environment that are associated with the transport of radioactive material. In India, safety in transport of RAM is governed by AERB, the Competent Authority. Safety is ensured by implementing the provisions of the AERB Safety Code and Guides [2][1], which are based on the IAEA regulations [3] with amendments to suit the Indian ambient conditions of transport.

2. Different modes of transport

The RAM needs to be transported from manufacturer to user, from one user to another, and from user to disposal site, including loading, unloading and storage-in-transit. These types of transport are performed by air transport, road transport and rail transport. It can be noted that no particular mode of transport is considered preferable to others. The consignor taking into consideration convenience as well as cost of transport involved can choose any mode of transport. However, for nuclear medicine sources air is the preferred mode of transport since it can transport in the shortest possible time, which is very much essential for short-lived sources used in nuclear medicine.

[1] This code is under revision now in the light of the IAEA's current regulations for safe transport of RAM.

2.1. *Procedure for transport of RAM by air*

- Import, export and domestic transport of short-lived RAM involve air transport.
- Any carriage of RAM by air through, into, or over India requires prior permission from the Director General of Civil Aviation (DGCA), New Delhi.
- For any indigenous procurement or import of RAM, the user needs to obtain No Objection Certificate (NOC) from AERB.
- The NOC for import/export is also meant to facilitate the necessary clearance from Customs.
- With the copy of the NOC issued by AERB, the user has to approach DGCA with the details of consignment (like, type of package, Transport Index, category, the proposed nature of application of the RAM), name of consignor, name of consignee, ports of embarkation/disembarkation in the format prescribed by the DGCA.
- DGCA issues the permission for airfreighting to the applicant only on the basis of the No Objection Certificate (NOC) for import/export/movement in the country issued by AERB.

2.2. *Procedure for transport of RAM by road*

Generally, nuclear medicine sources being short-lived, are transported by air. Many work places are not connected directly by air. Therefore, the RAM needs to be transported by road from the nearest airport to the work place. For the safety of RAM during road transport the following procedure is followed.

- The user is required to comply with the transport regulations during transport of RAM from the nearest airport to work place.
- For those shipments, which fall short of regulatory requirements and are qualified for transport under *Special Arrangement* with additional compensatory safety measures, require prior approval from the Competent Authority, i.e. Chairman, AERB.
- After ensuring that it is safe for transport, the consignor is required to include transport documents such as Consignor's *Declaration* (a declaration by the consignor about the proper classification, packing, marking and labelling of the consignment in accordance with the applicable regulations for transport of radioactive material), *TREMCARD* (Transport Emergency Card, which gives instructions regarding emergency management procedures, relevant address, telephone no. Fax no. for quick communication), *Instructions to the Carrier* (which are DO's and DON'Ts for the carrier engaged for carriage of RAM), *Instructions in Writing* (which gives information about the different types of packaging deployed, procedures for emergency handling and particulars regarding set of protective devices to be carried).

2.3. *Procedure for transport of RAM by rail*

With effect from 15.7.2001, Indian Railways has started accepting RAM for transport by rail by including provisions of RAM in chapter VII of their *Red Tariff* No. 20. With the necessary clearance from AERB, any user can book the radioactive consignment containing those RAM (71 radioactive items) listed by Indian Railways in their *Red Tariff* at notified stations by declaring it as dangerous goods, following rigorously their prescribed procedure during booking, loading/unloading, transit and delivery of the consignment, and forward it to notified stations as destinations.

3. Use of radioisotopes in nuclear medicine

In India, there are 179 approved nuclear medicine centres, which use radiopharmaceuticals for diagnostic well as therapeutic applications and palliative treatments. The regulatory approvals of such centres include plans of laboratory and treatment room, commissioning of equipments and facilities. The regulations [4] require that the applicant shall obtain approval of the Competent authority for introducing any new radio pharmaceuticals into use for diagnostic as well therapeutic applications and the appointment of a trained, qualified and approved nuclear medicine physician(s) and technologist(s). Further, it is an mandatory requirement to have a Radiation Safety Officer(RSO) in any nuclear medicine facility carrying out in-vivo/in-vitro diagnostic investigations(other than Radio Immuno Assay) and radio-nuclide therapy in India.

A sizable supply of the radioisotopes used in nuclear medicine centres in India is imported. Table I & II give the radioisotopes, range of activity, and approximate no. of shipments per year for imported and domestic supply respectively. ^{153}Sm has been recently inducted into use for palliative treatments after the clinical trials have been approved by AERB .

Table I: Shipments of radioisotopes imported to India for Nuclear Medicine use

Radioisotopes	Range of Activity (MBq)	No. of Shipments per Year
^{133}Ba	3.7-9.25	10
^{51}Cr	18.5-18500	210
^{169}Er	74-1110	250
^{57}Co	18.5-740	60
^{59}Fe	37-185	50
^{67}Ga	74-5550	2650
^{111}In	37-3700	1200
^{123}I	148-1110	50
^{131}I	7.4-18500	3000
^{99}Mo	444-29900	3200
^{32}P	370-14800	320
^{186}Re	185-1850	290
^{75}Se	370	60
^{89}Sr	37-1850	215
^{99m}Tc	7400-37000	120
^{201}Tl	37-19980	3500
^{133}Xe	444-3700	500
^{90}Y	185-3700	620

Table II: Shipments of radioisotopes of domestic supply for nuclear medicine use.

Radioisotopes	Range of Activity (MBq)	No. of Shipments per Year
^{131}I	1.85-22200	2610
^{99}Mo	3700-11100	3700
^{32}P	370	1000
^{153}Sm	1850-7400	45

4. Safe disposal of nuclear medicine sources

In India, the safe disposal of any radioactive waste is governed by Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987, issued under Atomic Energy Act, 1962(33 of 1962). These rules for the safe disposal of disused sources are enforced by AERB. As per the definitions under these rules, 'disposal' means release of any material to the environment in a manner leading to loss of control over the future disposition of the radionuclides contained therein and includes emplacement of waste material in a repository; 'radioactive waste' means any waste material containing radionuclides in quantities or concentrations as prescribed by the Competent Authority by notification in the Official Gazette. Any radioactive waste generator in India needs to be authorized by Chairman, AERB for its disposal. The authorized waste generator has to ensure that the waste materials are disposed of in accordance with the provisions of the rules, and in accordance with the terms and conditions laid down in the authorization issued by the Competent Authority. Records of waste disposal are to be maintained and periodic status reports are to be submitted to the Competent Authority by the authorized waste generator. The Competent Authority may cancel an authorization issued under the rules or suspend it for such period as it thinks fit, if in its opinion, the authorized person has failed to comply with any of the conditions of the authorization or with any provisions of the Act or the rules after giving the authorized person an opportunity to show cause and after recording reasons.

Except few sealed long lived sources, which are used for quality assurance programme, most of the unsealed radioisotopes used in nuclear medicine centres in India are disposed off locally. The radioactive wastes are discharged into a sanitary sewerage system or disposed off by burial into soak pits prepared in an exclusive burial ground approved by AERB; and ensured by all the authorized waste generators that disposals are within the limits prescribed by the Competent Authority.

5. Conclusion

The trend by which nuclear medicine centres are coming up in the country (65 in 1980, 101 in 1990, 141 in1999 and 179 in 2002) suggests that it is bound to increase the quantum of transport of sources for use in nuclear medicine. At the same time, the safety of transport, application and disposal of the sources can not be compromised with their heavy demand, urgent requirements and huge waste management by passing all the requisite controls and administrative procedures. In order to ensure safety in every stage of transport, application and disposal of the sources both the requisite technical as well administrative procedures are to be strictly followed. A well-balanced regime of technical and administrative controls ensures the maximum benefit with minimum hazard to humankind by the use of radioisotopes.

Acknowledgement

The authors are very thankful to Dr. A.N. Nandakumar of this Division for all his suggestive comments about this paper.

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IMPLEMENTATION OF TRANSPORT OF RADIOACTIVE MATERIAL IN INDONESIA

N. Noor

Nuclear Energy Control Board (BAPETEN)
Indonesia

Abstract

Over the last two decades, the utilisation of radioactive material and radiation sources for various purposes has significantly increased in Indonesia. This paper presents a brief description of the responsibility of the Nuclear Energy Control Board (BAPETEN). The most important rule and regulations on transport of radioactive material are outlined. The present status of transport of radioactive material in Indonesia is discussed. Some problems faced in the implementation of transport of radioactive material are presented.

1. Introduction

Over the last two decades, the utilisation of radioactive material and radiation sources for various purposes has significantly increased in Indonesia. Applications cover a very wide range of activities in industry (radiography, logging, gauging, analysis, etc.), medicine (radiotherapy, tele- and brachytheraphy, nuclear medicine) and research. An executing or promoting body (BATAN) operates several nuclear facilities: three research reactors (250 kW_{th}, 2 MW_{th}, 30 MW_{th}), radioisotope production and some other installations spread in Jakarta, Bandung and Yogyakarta. Operation of these facilities needs transport of radioactive material. The number of shipments of radioactive material totals 300-1000 each year, only few of them being Type B packages shipments. Legally, transport of radioactive material is one of the most important fields in nuclear safety in Indonesia. It is regu1ated by the legislation system: the Nuclear Energy Act Number 10, 1997 and Government Regulation Number 26, 2002. According to government regulation, a license is required for production, possession, transport, use, import and export and sale of radioactive material. The license is issued by the Nuclear Energy Control Board (BAPETEN) as a regulatory authority in Indonesia. Section 2 of this paper presents a brief description of the responsibility and authority of BAPETEN. Section 3 provides the most important rules and regulations on transport of radioactive material. Section 4 discusses the present status of transport of radioactive material in Indonesia. Section 5 presents some problems which occurred in the implementation of transport of radioactive material and finally, Section 6 closes this paper with a summary.

2. Responsibility and authority of BAPETEN

In Indonesia, the Nuclear Energy Control Board (BAPETEN) is the government regulatory body for controlling all activities concerning the use of radiation and radioactive material. It is designated as the national competent authority in matters concerning the safe transport of radioactive material. BAPETEN establishes regulations, conducts the licensing process and performs regulatory inspection. Activities are as follows:

(a) Establishing regulations on nuclear safety. Hierarchically, BAPETEN drafts and promotes any nuclear energy related Act to be approved by Parliament and signed by the President; drafts and promotes any nuclear energy related Government Regulation and Presidential Decree to be signed by the President; and establishes by Decree of Chairman of BAPETEN technical documents such as on guidance and procedure.

(b) Carrying-out the licensing for the utilisation of nuclear energy. There are some types of licenses issued by BAPETEN, i.e. siting, construction, operation, and decommissioning of nuclear and radiation facilities; license for importing and transporting radioactive and nuclear materials, license for radiation safety officer, license for reactor operator and supervisor.

(c) Conducting inspections periodically or at any time to ensure that the nuclear facility is operated safely according to the legal provisions and license conditions. In this task, BAPETEN performs nuclear safety and radiological inspection, quality assurance (QA) inspection, emergency preparedness evaluation, and safeguards.

3. Regulation on transport of radioactive material

To ensure the protection of human health and the environment, transport of radioactive material shall be managed within an appropriate legal framework. This framework has been established through laws, regulations, decrees or guides etc.

3.1. Nuclear energy act

According to Article 16 of the Nuclear Energy Act No.10, 1997, practices involving the transport of radioactive materials shall ensure the safety of worker, public and the environment. The Act accommodates only one article for the transport of radioactive material. Therefore the act has not governed yet detailed requirements.

3.2. Government regulation

In the case of transport of radioactive materials the implementation of Nuclear Energy Act 10, 1997, is regulated by Government Regulation (GR) Number 26 of the year 2002, on the Safety of Transport of Radioactive Material. The Government Regulation provides: general requirements, administrative requirements involving the license management, requirements on packaging, radiation programme, training programme, quality assurance requirements, characterization of package, exempted package, emergency response planning, enforcement.

3.3. Decree of chairman of BAPETEN

The Government Regulations are further implemented in the forms of Decree of Chairman (DC) of BAPETEN. The DC No.04/Ka.BAPETEN/V-99 on the safe transport of radioactive material was adapted from IAEA Safety Series No.6, 1985 Edition. Current1y a draft of a revised DC is being prepared. This document is adapted from the IAEA Safety Standard Series No. ST-1, No. ST-2, Revised, Safety Series No.87, No.l12 and No 113.

4. Present status of transport of radioactive material in Indonesia

In Indonesia, with a limited number of research facilities and use of radiation and radioactive materials, the use of resources must be optimised in BAPETEN. Directorate Licensing has the responsibility for all assessment and approval work involving the safe movement of radioactive material by all modes of transport within Indonesia. BAPETEN does not operate out any test facility. This is regarded as the responsibility of the applicant. The activities of BAPETEN concerning the transport of radioactive material are briefly addressed below.

4.1. Shipment approval

The transport of radioactive material can commence after approval from BAPETEN. Approval is applied in writing to BAPETEN not later than one week before the planned date of the transport. Information included in the application for approval of the transport is such as: (a) the address of consignor and consignee; (b) the license of the user (nuclear energy license); (c) certificate of the package, its category, transport index, emergency plan, etc.; (d) radiation type, dose-rate on the surface, contamination and total activity.

4.2. Certificate of package design (validation)

Until now, neither Type B packages ,nor packages for fissile material have been manufactured in Indonesia yet. On the other hand, BATAN or users have ordered spent fuel or radioactive material from foreign country, therefore BAPETEN has to assess the certificate package design. In the case of approval of foreign competent authority approval, certificates, assessment method and comparison with other design, particularly from the originating competent authority, are considered. At the end of the assessment process a certificate is issued, which is generally valid for a period of three years. In this certificate, reference is made to the drawings to which the packaging is manufactured, and the contents.

4.3. Emergency preparedness

When the potential hazard involved is considered to be high, such as in the case of the transport of spent fuel, the licensees are required to prepare emergency plans. These plans must be submitted to BAPETEN for approval.

4.4. Inspection and enforcement

BAPETEN is also responsible for inspection. The major emphasis of the programme is usually directed toward consignor such as the producer or distributor of radioactive material, the radiography supplier and the waste disposal collector.

5. Problems in implementation of transport of radioactive material in Indonesia.

Even though BAPETEN is quite a new regulatory body, established fully around June 1999, it is found that important problems arising from transport of radioactive material are as follows:

a Aircraft (domestic aircraft) unavailability in carrying radioactive material, because of limited knowledge covering radiation risk and the technical means to prevent undue exposure and to implement the ALARA principle.

b Indonesia is an archipelago country. Most of the industrial projects are far from the capital city, for instance inter-city transport in Papua, Kalimantan, etc. which only can be reached with a small aircraft with 6 or 8 passengers or by 'boat' through the river or sea, without special compartment for carrying radioactive material packages.

c Land transportation over a distance of 15 - 20 km in industrial radiography, with rapid change of location, without special vehicles to carry radioactive material.

d In some cases, BAPETEN encountered 'matter of fact' conditions, where radioactive material had been already imported into Indonesia without import license from BAPETEN. These cases are mostly related to large industrial projects belonging to other governmental institutions where officials are not familiar with regulations specifically applied to radioactive materials. To cope with this problem, BAPETEN has established close co-operation with several relevant authorities (Ministry of Manpower, Customs Office, etc.).

6. Summary

In a country like Indonesia, without nuclear power plants and with a limited number of research facilities and use of radioactive material, the use of resources must be optimized. After Government Regulation No.26 on the Safety of Transport of Radioactive Material has been launched in June 2002, the Indonesian Regulations have always been in line with the IAEA Regulations. In the near future, there will be no longer any difference between domestic and international transport in Indonesia, from the safety standpoint. This will make the transport of radioactive material easier, both within regions of Indonesia and external to Indonesia. Therefore training must be provided for aircraft companies and officers involved.

SAFETY OF TRANSPORT PACKAGES OF RADIOACTIVE MATERIALS ENSURED BY THE CURRENT REGULATIONS

C. Itoh[a], T. Kitamura[b]

[a]Central Research Institute of Electric Power Industry (CRIEPI),
Abiko-shi, Chiba,
[b]Japanese Nucler Cycle Development Institute (JNC),
Tokai-mura, Ibaraki,
Japan

Abstract

This is a summary of nuclear tests conducted in Japan, including (1) fireproof and pressure tests of an enriched UF_6 transport package, (2) drop, thermal, and pressure tests of a natural UF_6 transport package, (3) drop, thermal, submerge tests of a spent fuel transport package, and (4) drop, thermal, and submerge tests of a returned high level vitrified waste transport package. These tests proved that the transport packages meet IAEA's transport requirements with sufficient margins for the safety. In Japan, various safety demonstrations tests have been carried out for the security of radioactive materials during transport. Reflecting the results, no accident on leakage of radioactive materials has occurred.

1. Enriched UF_6 transport package

1.1. Fireproof test [1]

To ensure the fireproof property of the enriched UF_6 transport package as well as the safety margin, a fireproof test was conducted at an environmental temperature of 800° over 30 minutes specified by the transport regulation. The test used the same transport packaging and a protective cover as the actual component and employed steel shot to simulate heat capacity of contents instead of using the enriched UF_6. Temperatures measured at the test show the following results.

(1) The highest temperature of the valve body after four hours was 125 °C or less, which was lower than a melting point of solder (design standard temperature: 183 °C) which joins the valve to the body.

(2) After four hours, the highest temperature measured at areas except nearest portions in 0 ° direction at an external surface of the cylinder was 104 °C or less, which was much lower than 120 °C expected on designing to occur liquid pressure rupture.

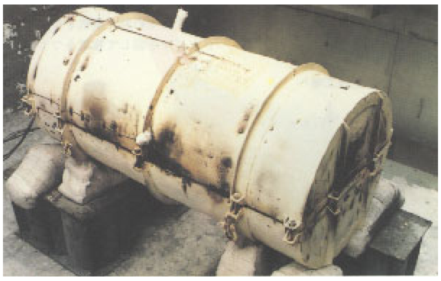


Fig.1 Enriched UF_6 transport package after fireproof test

This concludes that the packaging meets the fireproof test requirements specified by the transport regulation for the enriched UF_6 transport package with sufficient safety margin. In addition, a temperature rise of the content (enriched UF_6) at the actual package is expected to be reduced compared with this test result because of latent heat of the enriched UF_6 (heat necessary for dissolution). Therefore, the fireproof property of the actual component will be further enhanced.

1.2. Pressure test [2]

For clarification of a pressure-proof performance of the enriched UF_6 transport package and its ultimate property to the external pressure, the following test was conducted applying water pressure from outside of the packaging. This test was without the protective cover expected not to affect the pressure-proof property.

(1) Pressurization at 150 kPa(correspond to a depth of water of 15m) for 8 hours. This is a test required for B type, C type, and fissionable transport packages.
(2) Pressurization at 2 MPa(correspond to a depth of water of 200m) for 1 hour. This is a test required for B type and C type packages containing radioactivity over $10^5 A_2$.
(3) Ultimate pressure-proof test. To apply pressure until occurring collapse to check the safety margin of the container.

These tests reveal results as follows:

(1) The package remained within an elastic range until a water pressure of 2 MPa.
(2) At an external water pressure of about 6 MPa (correspond to depth of water of 600 m), the container collapsed to generate large deformation. Resultant maximum deformation in a radial direction at the packaging center was 670 mm.
(3) A soap bubble test which can check the confinement of a package by presence of bubbles, however, showed that the confinement of the packaging was sound after the test.

This concludes the enriched UF_6 transport package has sufficient pressure-proof property.

2. Natural UF_6 transport package

2.1. Drop test [3]

In order to verify the safety margin of natural UF_6 transport package for drop incident, an integrity test was conducted at conditions where the package assembled on a flat container was dropped onto the rigid floor at the horizontal state from the height of 12 meters at which the ultimate strain is induced at the body of the package according to the pre-drop analysis. The packaging was filled with steel shots to simulate the maximum load of UF_6 (12,500 kg). The tests reveal results as follows.

(1) Maximum deformation of 112 mm was observed at the area collided with a stand due to intrusion of the stand, but deformation at the central section between libs and an end section of the packaging was minor.
(2) A uniform acceleration occurred at the packaging and its maximum value was about 100 G.
(3) No residual strain was observed at a upper part of the body, a valve mounting area on the head, and an area near a stop plug.
(4) No bubble was observed at the soap test performed to evaluate the sealing effect of the container, ensuring its sealing performance.

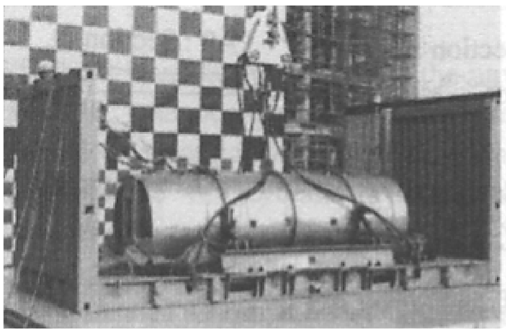


Fig. 2 Natural UF_6 transport package after drop test

This concludes that the natural UF_6 transport package assembled on the flat container if dropped from the height of 12 meters remains sound keeping its integrity.

2.2. Thermal test and analysis [4]

A thermal test was conducted in a furnace at 800° for 30 minutes to check conformity to the transport regulation. The test used the same transport packaging as the actual component filled with steel shots as a content instead of UF_6 to simulate heat capacity. Furthermore, to analyze the test, an analyzing method was first verified for its validity and then was applied to the thermal analysis of real natural UF_6 transport package with a fireproof protective cover attached.

The fireproof test reveals that the temperature at the valve position is lower than the melting point to keep the sealing effect. Analysis resulted in:

(1) Filling rate of UF_6 in the packaging 30 minutes after fire was 86 % not to cause the liquid pressure rupture (to occur at the filling rate 96%.).

(2) The maximum pressure in the packaging was 1.1 MPa lower than the ultimate pressure (2.7 MPa) without possibility of pressure rupture of the container.

(3) The temperature at the valve position was 144° not to melt solder (melting point: 203°) maintaining the seal effect.

This concludes the transport package can meet the transport regulation.

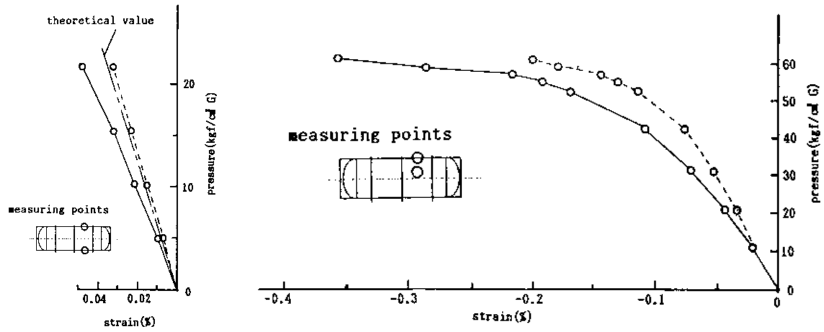
2.3. Pressure test [2]

Purpose and method of the test are the same as those for the enriched UF_6 pressure test described before to ensure the ultimate property of the transport package to the external pressure. The test shows results as follows.

(1) The container remains within the elastic region until a water pressure of 2.0 MPa keeping the sound sealing effect.

(2) At the external water pressure of about 6.1 MPa, the container collapsed to greatly deform. Resultant maximum deformation in the radial direction at the center of the container was 670 mm.

(3) After the test, the confinement remains sound.



a) Max. Pressure 2.0Mpa b) Max. Pressure 6.1Mpa

Fig.3 Relation between applied pressure and strains

This concludes that the UF_6 transport package has a sufficient pressure-proof property.

3. Spent fuel transport package [5, 6]

To demonstrate the validity to the transport regulation, the drop tests I, II, thermal test, and immersion test specified in the transport regulation were conducted for the typical target of a large transport package NFT-14P model carrying the spent fuel from nuclear power plants in Japan to the domestic reprocessing plant storage pool.

The transport package can contain 14 sets of PWR spent fuels (44,000 MWD/tU or less, cooled 630 days or more). Figure 4 shows an entire view of the package. A test body was made at the full size under the same specification as the real product except additional fitting necessary for the test. Stress caused by the drop test remains within the tensile strength and the leak rate at the seal area does not change before and after the test, ensuring integrity of the test package.

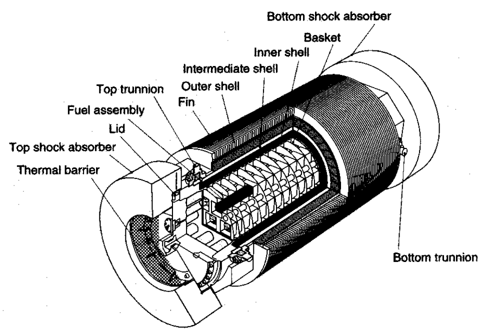


Fig.4 Outline of NFT-14P Package

The maximum temperature measured at various areas at the thermal test was lower than allowable operating temperature of materials employed. In addition, the leak rate at the seal area does not change before and after the test. This shows that the test packaging has a sufficient integrity at a temperature of 800° for 30 minutes. In the immersion test, stress generated at the body was much lower than the tensile strength keeping the integrity for the confinement after the test.

4. Returned high level vitrified waste transport package [7, 8]

To ensure the validity of the high level waste caused by reprocessing process to the transport regulation, the drop tests I, II, fireproof test, and submerge test specified in IAEA transport regulation were carried out. The test used a full size test body, as a test packaging, which is designed and fabricated taking features of transport packages in COGEMA and BNFL (scheduled) employed during an actual transport of the high level waste from France and the United Kingdom.

Stress caused at the drop test remains within the tensile strength and the leak rate at the seal area does not change before and after the test, keeping the integrity of the test packaging.

The maximum temperature measured at various areas at the thermal test was lower than allowable operating temperature of materials employed. In addition, the leak rate at the seal area does not change before and after the test. This shows that the test packaging has a sufficient integrity at a temperature of 800° for 30 minutes.

In the immersion test, stress generated at the body was much lower than the tensile strength keeping the integrity for the confinement after the test.

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CERTIFICATION OF PACKAGES FOR TRANSPORTATION OF FRESH NUCLEAR FUEL IN THE CONTEXT OF NEW SAFETY REQUIREMENTS FOR AIR TRANSPORTATION OF NUCLEAR MATERIALS.

V.I. Shapovalov, V.Z. Matveev, L.V. Barabenkova, V.I. Duday, A.I. Morenko, V.M. Nikulin, A.A. Ryabov, V.A. Yakushev

Russian Federal Nuclear Center,
All-Russian Research Institute of Experimental Physics (RFNC-VNIIEF), Sarov
Russian Federation

Abstract

Experience gained in the area of certification of packages for fresh nuclear fuel transportation in the context of new safety requirements based on IAEA-96 regulations (ST-1) on air transportation of nuclear materials (requirements for c-type packages) is outlined. Major results are described of more than two-years of RFNC-VNIIEF experience on certification of containers for fresh nuclear fuel (FNF) transport in compliance with safety requirements of the IAEA-96 regulations to nuclear material air carriage (requirements to C-type containers).

1. Introduction

A new version of the IAEA "Regulations for the Safe Transport of Radioactive Materials" IAEA-96 (ST-1) is effective since 2001. As compared with the regulations IAEA-85/90, it incorporates significant modifications pertinent to the safe transport of radioactive materials. With regard to severe consequences of potential aircraft crashes, the revised regulations first encompass a new type of container for air transportation of radioactive materials. This is the C-type container. New tightened requirements for testing of such containers have been introduced to verify safe air transportation of C-type containers. Pursuant to IAEA-96 regulations, these requirements shall be applicable to all types of containers for air transportation of nuclear materials. In compliance with new requirements on safety, containers for nuclear fissile materials air transportation should, regardless of their type, be additionally validated based on evaluated or actual condition of containers upon the following series of abnormal impacts:

First series:

- container drop from 9m;
- dynamic failure upon falling of a 500kg body from 9m onto container;
- puncture/rupture test during container drop onto a pin (during pin drop onto container) from 3m;
- effects of external thermal field with mean volumetric temperature of 800°C within at least 60 min onto container.

The condition of container in this series should be evaluated with allowance for damages accumulated consistent with a listed sequence of abnormal impacts.

Second series:

- container colliding with a target at V≥90km/sec.

Experimental or computational validation of container safety after the first series of abnormal impacts does not cause any serious difficulties to the developers and could be either performed at available certified experimental facilities or evaluated numerically by generally recognised techniques used for safety validation in previous IAEA-85/90 regulations. In turn, safety validation of nuclear fissile materials containers after collision with the target at V≥90km/sec does encounter hard trouble as such tests simulating air crash are new and complicated in character and require a unique experimental and computational base. In essence, neither developers nor fresh nuclear fuel producers have now these facilities available. However, RFNC-VNIIEF experts have justified a possibility of performing the afore going tests at a unique RFNC-VNIIEF testbed (only the United States have a similar testbed with likewise parameters).

2. The RFNC-VNIIEF testbed

The RFNC-VNIIEF testbed, fitted with all necessary instrumentation, allows to carry out impact tests of large-size structures up to 25t in weight and constitutes a rocket track with a vertical target positioned at the track end. In order to maximize compliance with rigidity requirements of IAEA-96 regulations, the target is made in the form of a concrete block faced with a 100mm steel sheet from the impact side and with a rear wall leaned against extended earth bank. In conformity with comments to Regulations ST-2 the total target weight exceeds the weight of the heaviest tested container by 100 times. This testbed, supported with all the necessary instrumentation, makes it possible to carry out target impact tests for large dimension constructions with masses amounting to 25 t.

In addition, RFNC-VNIIEF has the latest software attested and certified by GOST (State Standard) P System, and high-skilled personnel capable to perform physical simulation and numerical studies of container behavior under dynamic loading and high-speed deformation in the process of container-target interaction at V≥90km/sec.

3. Tests carried out

Keeping in mind all the aspects mentioned above, the nuclear fuel manufacturing plants approached RFNC-VNIIEF with a request to conduct joint activities on validating safety of air transportation of existing serially manufactured casks designed for transportation of the power and research reactors fuel bundles/assemblies (FA) for compliance with the new Regulations IAEA-96.

TK-C4 container–target impact tests, to evaluate the possibility of the former to be used for air transport of WWER-440 FA, have been first carried out at the RFNC-VNIIEF rocket track in conformity with new requirements of IAEA-96 Regulations. Set out below are the problems solved during testing:

- experimental verification of container strength during axial impact with the target at V≥90km/sec (axial direction of container hitting the target has been chosen on the assumption of creating maximum TC and FA deformations to obtain the worst container condition in compliance with nuclear safety requirements);
- acquisition of experimental data for calibrating VNIIEF computational strength methods as applied to TC designs;
- upgrading of testing techniques and hardware as applied to certification tasks.

For these purposes a four sectional TK-C4 container has been tested. A dynamic FA model ultimately close in its design to standard FA and having the fuel pellets being replaced by inactive imitator was embedded into one section. The remaining three sections contained overall and weight FA models.

The TK-C4 container was accelerated up to a pre-set speed by a double-track rocket platform based on solid-propellant jet engine. Once the platform reached the pre-set speed it was slowed down whereas the tested container kept free travel for another 30m because of the pulse received and absence of rigid coupling with the platform up to its derailment from the runners and then hit the target.

A standard chronography system and cable sensors were used for measuring the speed of the rocket platform and test container. The moment of the container–target impact was recorded by the foil-type pre-contact detector. Peak container and dynamic FA model overloads at the moment of collision with the target were recorded by crusher gages developed in VNIIEF.

Testing results of the TK-C4 container, dynamic FA model and target flaw detection allowed to draw a conclusion that, after hitting the target at V≥90km/sec, the TK-C4 container was deformed. However, these deformations did not entail any damage of the body of the container and fuel leakage. A video film on carrying out these tests and testing results is available.

Positive outcomes of container testing show potential possibility of validating conformity of serial TK-C4 containers to new requirements of the IAEA-96 regulations on safe air transportation of nuclear materials. In order to get all necessary proofs of container safety, RFNC-VNIIEF has carried out an extra series of numerical and experimental studies which cover physical and mechanical characterization of basic container and FA structural materials; development and calibration of container computer model; calculation of container condition and nuclear safety upon its exposure to abnormal effects provided for by the IAEA-96 regulations.

Thus, a performed set of research efforts has proven an actual possibility of numerical and experimental validation of safe air transportation of the TK-C4 container. In accordance with such validation, a certificate for container manufacturing and its further usage for transportation of VVER-440 FA by any types of transport, air carriage inclusive, pursuant to IAEA-96 regulations has been granted and is being now prepared by the respective RFNC-VNIIEF office.

Outlines (methodical approaches) and certification procedure for safety validation of existing containers and those of C-type being under development have been shaped and formulated relying on experience accumulated during TK-C4 container certification. These basics are set forth in the draft special regulations on validating safety of containers with fresh nuclear fuel (FNF) during air transportation worked out in furtherance of “Fundamental Rules on Safety and Physical Protection During Nuclear Materials Transportation" (OPBZ-83), the IAEA-96 regulations and comments ST-2. The first edition of the regulations has been prepared and submitted for review to the institutions concerned. The second edition is being prepared.

RFNC-VNIIEF, in compliance with the principles laid down in the regulations, executes certification on validating safety of serially manufactured transport casks TK-C5 (for VVER-1000 FA), TK-C14, TK-C15, TK-C16 (for research reactor FA) during air transportation.

Tentative numerical assessments of container response to increased abnormal effects as provided by the new IAEA-96 regulations have been performed aiming at evaluating potential possibility for certification of such containers.

The assessments demonstrate that the TK-C5 container (along with TK-C4) has sufficient safety margin, and to validate its correspondence to the IAEA-96 requirements on C-type containers it is sufficient to carry out container–obstacle impact tests at V≥90km/sec without any improvement in container design. Besides, the angle of shock during the impact which would cause maximum damage to the container has been calculated.

The above assessments have also shown that structural mechanical tests of TK-C14, TK-C15, TK-C16 containers would result in their crippling manifested in smelting and fissile material leakage in the process of thermal testing and release of radioactive contents from container during impact tests. In this respect, in order to keep container integrity under any mechanical loadings while testing containers for compliance with the IAEA-96 requirements placed to C-type containers, it is deemed reasonable to place them inside the protective casing.

Pursuant to recommendations TK-C5, TK-C14, TK-C15, TK-C16 containers have been prepared for testing at the RFNC-VNIIEF testing site.

4. Results

Major results of more than two-years of RFNC-VNIIEF experience with certification of containers for fresh nuclear fuel (FNF) transport in compliance with safety requirements of the IAEA-96 regulations to air carriage of nuclear material (requirements to C-type containers) are outlined as follows:

1. RFNC-VNIIEF has adopted and attested the computational and experimental base for certification on validating safety of C-type and other types of containers with fresh nuclear fuel (FNF) during air transportation.
2. A methodology has been developed for validation and verification of safety of containers with fresh nuclear fuel (FNF) during air transportation according to requirements of the IAEA-96 regulations (requirements for C-type containers). This methodology effectively combines computational and experimental techniques and ensures lowest certification costs. This methodology has found its reflection in regulations on validating safety of containers with fresh nuclear fuel (FNF) during air transportation.
3. An extensive complex of computational and experimental works has been carried out for validating safety of serially manufactured containers for transportation of fresh nuclear fuel (FNF) for power and research reactors. This work allows to certify and validate the available stock of containers for conformity with the IAEA-96 safety requirements for air-carried containers.

IMPROVEMENT OF COMPLIANCE WITH REQUIREMENTS CONCERNING CONTAMINATION LEVELS SINCE 1998 IN SWITZERLAND

J. van Aarle, B. Knecht, A. Zurkinden

Swiss Federal Nuclear Safety Inspectorate,
Section for Transport and Waste Management,
CH-5232 Villigen - HSK,
Switzerland

Abstract

In 1998, it became known that contaminations exceeding the limits of IAEA SS6/TS-R-1 were frequently observed on transports of spent fuel from Switzerland to reprocessing plants in France and in the United Kingdom. Transports of unloaded flasks were also affected. A number of measures were imposed by the Competent Authorities of the countries concerned. In Switzerland, technical, radiological and organizational measures were implemented. Between August 1999 and October 2002, 40 transports of spent fuel and vitrified high level waste were carried out within, from and to Switzerland. No contamination above the regulatory limits were observed, showing the effect of the measures taken and also the increased attention paid by the operators to the issue of contamination.

1. Introduction

Since the early 1970's, spent fuel is regularly transported from Swiss nuclear power plants (NPP's) to the reprocessing facilities of COGEMA in France and BNFL in the United Kingdom (UK). In April 1998, the Competent Authority, the Swiss Federal Nuclear Safety Inspectorate (HSK) was informed by the French Competent Authority that contaminations on the outer side of packages and on the inner surfaces of the railway waggons, respectively, had been detected frequently at the changing station at Valognes. In some cases, the regulatory limits were exceeded by up to three orders of magnitude. Not only were transports between French NPP's and COGEMA affected, but also transports between Germany and France and between Switzerland and France. It became also clear that contaminations also occurred on transports from and to BNFL. As a result of these findings, the Swiss Federal Office of Energy (BFE) called a halt to all transports of spent fuel from Swiss NPP's.

After evaluation of the proposals of the operators and consultation with the Competent Authorities of France, the UK and Germany, HSK published a report containing technical, radiological, and organizational measures in March 1999 [1] aimed at ensuring future compliance with the contamination limits. After the required measures were implemented by the different parties involved (consignor, consignee, carrier, and transport organizer), BFE allowed the transports to resume and issued a first transport licence in August 1999.

The present paper gives a brief overview of the measures required by HSK and the experience with the transport of spent fuel in Switzerland between August 1999 and October 2002. During this period 37 transports of spent fuel, i.e. 19 to COGEMA, 11 to BNFL, and 7 to the Swiss Central Storage Facility (ZZL), were carried out. Additionally, three transports of vitrified high level waste from the French reprocessing plant at La Hague to ZZL took place. All these transports were carried out in compliance with the requirements concerning contamination levels. A summarization of all 40 transports is given in table I.

2. Technical measures

The investigation carried out led to the conclusion that the observed contaminations were mainly connected to the loading and unloading procedures in the fuel element water pool in the NPP's and the reprocessing facilities. It was therefore essential to better protect the outer surface of a package during loading and unloading.

Table I: Transports of spent fuel and vitrified high level waste from reprocessing (*) carried out between August 1999 and October 2002.

Consignor (NPP)	No. of Transports	Period	Consignee
KKB	4	December 1999 – May 2000	COGEMA
	2	March and October 2002	BNFL
	2*	February and October 2002	ZZL
KKG	9	August 1999 – February 2001	COGEMA
	4	February – October 2002	ZZL
	1*	November 2001	ZZL
KKL	4	June 2000 – April 2002	COGEMA
	3	July 2001 – July 2002	ZZL
KKM	2	November 2000	COGEMA
	9	May – December 2001	BNFL

2.1 Measures applicable to the delivery of empty packages to Swiss NPP's

It has been shown that contaminations which remain fixed during a number of transports can later be mobilized when conditions change [2]. In such cases a detected contamination must not necessarily stem from the last transport of the package. Moreover, decontamination of packages with cooling fins in the heat transfer zone is difficult. Swiss NPP operators therefore required a pressure water cleaning of every empty or unloaded package being delivered to Switzerland. In addition, HSK required dedicated packages during a campaign of transports, i.e. usually several consecutive transports from one Swiss NPP. Finally, on account of requirements for extended measurement programs, the number of control measurements of contamination and dose rate upon arrival and for the dispatch of spent fuel was significantly increased.

From HSK's point of view, the repeated pressure water cleaning has a lasting effect in preventing the occurrence of contamination. Additionally, the use of dedicated flasks during a campaign of transports prevents the package from being contaminated in another facility. The extended measurement programs on contamination and dose rate levels also lead to an improved control of the radiological situation of packages and conveyances used for these transports. These measures are therefore judged to be effective and will be continued.

Whenever an empty package for the transport of spent fuel arrived at the Swiss border either by rail or road transport, HSK required control measurements for contamination on the outer surfaces as well as on easy-to-access areas inside the conveyance. These measurements were mainly intended to demonstrate to the public and to the railway staff concerned that the packages entered Switzerland free of contamination. The same procedure was required for the reception of vitrified high level waste from reprocessing. Because all transports of spent fuel and vitrified high level waste carried out between August 1999 an October 2002 without any contamination beyond the regulatory limits, HSK decided to give up this requirement as of January 2003 in order to avoid unnecessary delays at the border.

2.2 Measures applicable to the loading of packages in Swiss NPP's

The analysis of the occurrence showed that the contaminations were largely caused by lack of protection during the loading process, when the transport package is placed into the fuel pool. Thus, the following measures which are connected to the loading procedure were required by HSK: nuclide analysis of the pool water before and after loading, contamination measurements on the inside of the skirt, additional covers of the package, and monitoring of pressure and flow of water in the gap between package and skirt.

The analysis of the pool water before and after loading shows in general an increase of the activity, primarily from corrosion products but no clear hints of contaminations being imported into the pool water by the packages could be found. However, cleaning of the pool water below a certain activity level before loading guarantees an optimal radiological situation. The activity measurement after loading provides information on the radiological situation when the package is being raised from the fuel pool. In view of the minor effort needed, these measurements are maintained.

The skirt used in Swiss NPP's protects mainly the heat transfer zone from getting into contact with the pool water. Contamination there can be displaced to the heat transfer zone. Therefore, contamination measurements on the inside of the skirt are carried out before and after loading. Furthermore, in order to achieve a nearly complete covering of the package during loading, the top and bottom parts of the package are protected by adhesive plastic-foil.

For the period in which the package is in the fuel pool, a flow of inactive water is maintained within the gap between the package and the skirt in order to ensure that possible leakages are directed towards the pool water and not towards the gap. The water flow can be interrupted, e.g. by a blockage in the water supply, which would result in a loss of water pressure in the gap and eventually, into a contamination of this gap. Therefore, HSK required that the flow rate and the pressure difference be continuously monitored.

The experience shows that the additional protections on the top and the bottom of the packages are very effective in order to avoid contamination as well as to facilitate decontamination of the loaded packages. Furthermore, HSK is of the opinion that the monitoring of the pressure difference and flow rate in the gap between package and skirt must be continued for packages which need to be protected by using a skirt. These requirements will also apply in future.

2.3 Measures applicable to the dispatch of loaded packages in Swiss NPP's

Concerning the dispatch of loaded packages, HSK required the following measures: steam cleaning of the packages after loading, an extended measurement program for contamination and dose rate on the package and the conveyance, and a control of the contamination on the package and the conveyance by an independent third party.

After loading, the package is raised out of the water pool, dried, cleaned and checked for contamination. As an improvement, HSK required an additional steam cleaning at the top and the bottom of the package using conventional devices. Activity measurements of the collected condensed water show regularly measurable activities even if no contamination was found before cleaning. This results show that the steam cleaning is necessary and must be continued.

Documents for the transport of packages for spent fuel or vitrified high level waste have been standardized to a great extend. Included in the documents are the protocols of an extended measurement program for contamination and dose rate on the package and the conveyance. The number of measurement points is about three times as high as it was before 1999. In order to achieve a better assessment of the radiological situation on the package and the conveyance, HSK required that the effective values measured (not only the compliance with the regulations) be documented.

HSK is of the opinion that the new transport documentation with the extended measurement program is suitable in order to detect contaminations on the package or the conveyance with high probability, and that this measure must also be implemented in the future.

The independent control of contamination on packages and conveyances had been required in the first place by the French railway company SNCF for all rail transports of spent fuel and vitrified high level waste performed in France. HSK also required independent controls for all cross-border road transports as well as for all domestic rail and road transports. HSK's opinion is that these independent controls contribute significantly to the building up of confidence in the safety of transport of spent fuel and vitrified high level waste . Therefore, this measure will also be implemented in the future.

3. Radiological measures

As an additional measure for the build up of confidence in the safety of transport of spent fuel and vitrified high level waste, HSK, in agreement with Swiss Federal Railways, required that the railway workers concerned with such transports be monitored for the radiation dose received during the handling of the railway wagons, since railway workers are in general not classified as radiation exposed workers. Hence, HSK required that all rail transports in Switzerland be accompanied by qualified radiation protection personnel in order to monitor and record the dose rate and the exposure period for each railway worker concerned.

The results from 26 rail transports carried out between August 1999 and October 2002 show that the maximum individual dose collected by the rail workers has been 2 μSv per transport. The data gathered confirm the expectation that no radiation hazards exist for the railway workers concerned with the handling of those transports. These measures can therefore be discontinued.

4. Organizational measures

The analysis of the reasons for the contamination of packages and conveyances has shown that for more than 10 years, contaminations have been observed regularly without any attempt to improve the situation. This was possible because there has not been any compulsory reporting in case of non compliances with the regulatory limits. In order to improve the situation, HSK decided that all non-compliances with limits of dose rates and contamination connected to the transport of radioactive material must be reported by the respective NPP. Additionally, HSK requested that this requirement be incorporated into the quality assurance system of Swiss NPP's. Finally, for transports of radioactive material for which a licence is needed under the atomic energy legislation, this licence must be applied for by all partners (consignor, consignee, carrier, and transport organizer) involved in the transport. The licence sets clear obligations to the different partners in order to ensure that all participating operators are aware of their responsibilities.

Good experiences with these measures have been made not only with the transport of spent fuel to the reprocessing plants in France and the UK but also with domestic transports of spent fuel and vitrified high level waste to ZZL. All of these transports were carried out in full compliance with the requirements concerning contamination and dose rate levels. These measures will also apply to future transports.

5. Conclusion

Between August 1999 and October 2002, Swiss NPP's performed 37 transports of spent fuel to the reprocessing plants in France and the UK as well as to ZZL. All these transports have been performed in compliance with contamination and dose rate limits. Additionally, three transports with vitrified high level waste from the French reprocessing plant to ZZL have also been carried out without any non-compliance.

These results are satisfactory and show that the measures required by HSK in March 1999 [1] have lasting effects on compliance with contamination and dose rate limits. Based on this appraisal of the situation documented in [3], HSK fixed the conditions for future transports.

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PACKAGE DESIGN – COMPLYING WITH IAEA REGULATORY TEST REQUIREMENTS

A.R. Cory

Technology and Engineering Services,
BNFL Spent Fuel Services
United Kingdom

Abstract

The design of a package for the transport or storage of radioactive materials is essentially a simple and logical process, but the nature of the content and the high public awareness of safety issues means the demonstration of design must be both rigorous and extensive. The regulation of the nuclear industry is second to none, and requirements are laid down in the IAEA Transport Regulations which have a major influence in package design and analysis requirements. In particular, the Transport Regulations require certain tests to be carried out to ensure the safety of the package. This paper discusses the tests undertaken in the design of a package for the transport of radioactive materials, and the influence of the design processes on the test requirements.

1. Introduction

The current Transport Regulations (IAEA Safety Standards Series: Regulations for the Safe Transport of Radioactive Materials, 1996 Edition (Revised) No. TS-R-1) specify certain tests which are required demonstrations of the ability of a package design to meet with the requirements of the Regulation. Regulatory Test Procedures are specified in Section VII 'Test Procedures'. The scope of this paper is confined to the requirements for Type B(U) and Type B(M) packages. The applicable tests are discussed, and how they interact with the package design.

2. Tests

The tests applicable to Types B(U) and B(M) packages are:

2.1. Tests for demonstrating ability to withstand normal conditions of transport:

2.1.1. Water spray test: to simulate the effect of heavy rainfall, and ensure no water ingress. This test is usually dismissed by reasoned argument for type B(U) and B(M) packages, where the need to keep water in under all circumstances has a far more rigorous demonstration.

2.1.2. Free drop test: This drop test, from a restricted height, simulates handling damage. Its real aim is small packages, where handling is under conditions of far less control than large B(U) or B(M) packages. However, it is sometimes demonstrated as part of an impact test programme, that a large package can survive the combined effects of a number of low-height drops (usually 0.3m for package weights greater than 15,000 kilogrammes. Normally such a package is protected with shock absorbing structures, which would be expected to show signs of having absorbed the impact energy of even such a small drop, but without significant effect on their performance at drops of 9 metre height.

2.1.3. Stacking test: Aimed at crates and boxes, it is usually adequate to dismiss the need for a stacking test for larger packages, where operating procedures and practical considerations would preclude such a possibility.

2.1.4. Penetration test: The drop of a steel bar onto the package. Not usually performed for type B(U) or B(M) packages, as it can be argued easily that the consideration of the punch test following the 9 metre drop in accident conditions is far more onerous.

2.2. Tests for demonstrating ability to withstand accident conditions of transport:

2.2.1. Drop tests: the prototype shall be dropped from a height of nine metres onto an ‘unyielding’ target. The target is typically constructed from a steel plate between four and 10 centimetres thick, floated onto a mass concrete base. The mass of the target should be at least 10 times the mass of the prototype to be tested. Larger packages are normally dropped in scale model form, otherwise the requirements for the target would be unmanageable. Damage incurred to the detailed drop test model is directly scaleable to the full-sized package. The prototype is dropped in an orientation to cause maximum damage.

Sometimes it is not possible to test all features with a single drop, and in this case a number of tests are carried out, possibly using more than one model. Following the 9-metre drop test, there is a requirement to simulate the effects of an impact onto a 15 centimetre diameter steel punch, from a suspended height between prototype and punch of one metre. Foe a model test at scale, the punch diameter is proportionately scaled, but the impact height remains at one metre. The punch is aimed at the area of the package where damage can be maximised. This may be a flange, valve or orifice cover, or an area weakened by the earlier 9 metre impact. The punch could also be aimed to damage thermal protection to the package, or dislodge a shock absorber so that the effects of the enveloping fire are more serious.

The function of the impact tests is to demonstrate that the package is not so severely damaged after impact as to be non-compliant with the assumptions of the design analysis. For example, containment should be demonstrably within the allowable release limits for post accident conditions, and any damage to the internal structure maintaining the criticality safety of the contents should not be outside the bounding assumptions made in the initial analysis. Alternatively, using measurements made on the prototype or model following testing, a retrospective analysis can be made to demonstrate the integrity of the package.

Another requirement of the drop test is to demonstrate that the radiological shielding of the package is not damaged beyond the limits set out by the design. An increase in dose is defined following the accidental drop, but normal practice is to show shielding is retained in place, in which case the ‘normal transport’ requirements are met even after the accident drop. This may not be the case where some shielding components are mechanically attached to the package, rather than intrinsic with the package structure. In this case, it is necessary to demonstrate the additional shielding is retained for the ‘normal transport’ low-impact drop (as defined in Paragraph 722 Table XIII), and also that, if the shielding would be damaged or lost in the 9-metre drop, that sufficient shielding is retained around the package to ensure the post-accident dose criteria are not exceeded.

2.2.2 Thermal tests: The prototype shall be tested to ensure the package can withstand the effects of a 30-minute, 800°C engulfing fire. The Regulations prescribe conditions for the fire test, in which the prototype is suspended over a pool of flammable liquid, such as kerosene. For large packages, the uncertainty of achieving sufficiently quiescent ambient conditions to ensure stable flame conditions, coupled with concerns surrounding the environmental damage done in burning thousands of litres of kerosene in a short space of time, means that an analytical solution is usually favoured.

Analytical techniques have reached a level of validation where they can be relied on to predict accurate temperatures in both steady-state and transient conditions. Thermal tests may be carried out on a component of a package, with a view to establishing properties or underpinning key assumptions in the design. A recent example concerned the demonstration of the behaviour of the steel-cased, pine-filled shock absorbers of the NTL11 cask in a fire. As the fire accident has to be assumed to follow the impact accident, damage to the shock absorber (exposing some of the wood fill) was considered as possibly altering the original design assumptions. Performing a full-scale fire test on the shock absorber, with heat sink attached to represent the cask, yielded valuable data on temperature transients to allow a validated revision of the initial thermal analysis.

2.2.3. Water Immersion Tests: An enhanced water immersion test is applicable to Type B(U) and B(M) packages. This is to consider the effects of an external pressure due to submersion of the package under a water depth of 200m. It is not normal practice to demonstrate this test physically, as calculation and analysis routines are sufficiently well developed to predict the effects of external pressure on shell stresses. In the case of packages where the shell also forms the radiological shielding, the pressure stresses generated are usually trivial. Where the package containment is relatively thin-walled, for example where an internal liner provides the radiological shielding, the stresses may be more significant, but are often much less than stresses caused by internal pressurisation.

3. Interaction of test requirements with design

The need to survive the regulatory tests must be considered in the design process, but it must be emphasised that the prime design considerations are for the package to perform its intended duty in complete safety. The tests specified in the Regulations will not necessarily prove the efficiency of the design, or cater for every aspect of operational safety. However, there are a number of emerging axioms which designers at BNFL have adopted:

- The ***key features*** of most packages can be located in an area where they can be effectively protected from fire and impact by shock-absorbing end covers. With a larger package, the scope for shock absorber design is reduced due to constraints of geometry and weight.
- ***Wood-filled shock absorbers*** offer good general energy absorption properties, for example in the 9-metre drop, but are vulnerable to punch penetration, and the effects of a fire can cause the wood fill to burn out. Generally they also have a beneficial thermal insulating effect, protecting lid and valve orifices from fire.
- ***Metal-rib shock absorbers*** offer more predictable impact performance, but offer little or no protection to the key cask features from the effects of punch or fire.
- ***Fins*** – packages with a significant decay heat of contents may be provided with an extended surface area to aid heat dissipation by natural convection, and hence maintain surface temperatures below regulatory limits, for example, 85°C. Sometimes the extended surface (fins) can be utilised to absorb some of the energy due to accidental impact, by deforming in a controlled manner. Normally the consequential deterioration in thermal performance is acceptable in the post-accident situation.
- ***Orifice protection plates*** – vulnerable features of the package are often given additional protection in the form of heavy plates fixed on the outside of the cask. Typically such

plates are used to protect valves and orifices from impact. Normally the valves are located towards the ends of the package, in the case of a cylindrical package, and it may be prudent to incorporate the heavy protection plates as part of a detachable shock absorber.

- ***Lid flange design*** – the lid, as the major penetration into the package, requires special consideration in the design of closure. In a large package, the lid and its mating flange on the cask body require to be of substantial section to withstand the forces which may be generated by impact, or internal pressurisation. Additionally, the effects of the exposure to the regulatory thermal transient can cause distortion of the flanges, affecting the sealing system which provides the primary containment. Such distortion is identified by a dynamic thermal stress analysis. Minimisation of flange distortion, or bowing, due to pressure or thermal effects can be addressed and minimised by the application of appropriate design principles.
- ***Seal design*** – seals may take many different forms, and be manufactured from either metals or elastomers. Typically a re-useable Type B package will use an elastomer seal. This material, commonly Viton, silicon or EPDM, will operate effectively within a certain range of pressure, temperature and geometric conditions. It is necessary to site the seals to protect them from the direct effects of the regulatory fire, and to ensure that the seal housing is not excessively damaged or distorted as a result of drop testing.
- ***Design of internals*** – the package may contain an internal structure, used, for example to retain fuel assemblies in a sub-critical array. Design of such a structure must principally consider the effect of the drop test on that array, when loaded, or partially loaded with the package contents. The design must provide adequate strength and stiffness to ensure the structure maintains the contents in a safely sub-critical manner when subjected to drop testing in the most damaging attitude. The design of the internals is also required to minimise the subsequent damage to the contents as a result of such an impact, which I itself can potentially cause a criticality hazard.
- ***Trunnions and attachments*** – Consideration must be given to the behaviour of fixed attachments during the drop test. Substantial attachments, if involved in the primary impact, may subject the cask shell to high local stresses, and could even lead to failure or significant deformation of the containment, or loss of shielding performance. Trunnions are often designed to collapse before high loads can be transmitted, for example, by making them hollow.

3. Summary

In summary, the obligations of the designer are numerous, and this paper serves only to illustrate a few of the more common considerations. It must be stressed that the designer does not strive merely to meet the requirements of the Regulatory Tests – but to produce a package that is safe under all conceivable conditions. Once this is achieved, the Tests will be passed, without further consideration. They do, however, provide invaluable guidance and a means of benchmarking the design process, while not substituting for the human qualities of experience and ingenuity, which certainly will continue to be a deciding factor in successful package design.

ENVIRONMENTAL ASSESSMENTS AND TRANSPORTATION RISK STUDIES SPONSORED BY THE U.S. NUCLEAR REGULATORY COMMISSION

J. Cook

U.S. Nuclear Regulatory Commission
Office of Nuclear Materials Safety and Safeguards
Washington, DC
United States of America

Abstract *

The purpose of this paper is to provide information on past and present transportation risk studies in the U.S. Nuclear Regulatory Commission's (NRC's) transportation safety program, and on the role those studies have played in assessing the effectiveness of transportation safety standards in providing radiation protection in transport. NRC has completed three transportation risk studies. A fourth study on transportation, the Package Performance Study, is presently underway. This paper focuses on spent nuclear fuel transport, and also discusses the importance NRC places on communication with the public on regarding transport risks.

1. Introduction

NRC's responsibilities in the transport of spent nuclear fuel include certification of transport packaging designs, approval of transport package Quality Assurance programs, issuance of general licenses authorizing licensees to offer material to carriers for transport, and establishment of physical protection requirements for spent fuel in transit. Pertinent NRC regulations are contained in 10 CFR Part 71, "Packaging and Transportation of Radioactive Material," and in 10 CFR 73.37, "Requirements for Irradiated Reactor Fuel in Transit."

NRC studies transportation risks to assess the adequacy of transportation safety regulations, and to provide information to help allay public concerns about radioactive material shipments. Risk informed regulation is an important NRC initiative to re-examine the foundations of the U.S. regulatory system. Improved probabilistic risk assessment (PRA) techniques combined with over 4 decades of accumulated experience have caused us to recognize that some regulations may be over prescriptive or very conservative. This is because in part, when many NRC regulations were initially formulated, the NRC did not yet have much practical experience and generally proceeded very cautiously, relying on very conservative engineering judgement and defence in depth. We have learned more and now recognize that some of regulatory requirements may not be necessary to provide adequate protection of public health and safety. Where that is the case, the principle of risk-informed regulation indicates that we should revise or eliminate the requirements. On the other hand, we must be prepared to strengthen our regulatory system where risk considerations reveal the need.

The goal of the risk informing process is to provide a more objective and understandable evaluation of licensee performance, with a focus on operational aspects that are of the highest safety significance. It also improves public access to information and reduces unnecessary regulatory burden. Risk-informed regulation has in the past been focused more on reactors,

*The views expressed in this paper do not necessarily reflect those of the U.S. Nuclear Regulatory Commission.

but it's gaining momentum as well in NRC's waste and material arenas, including transportation.

Previous NRC transportation risk studies

NRC has been using risk information in assessing the level of safety provided by our transportation safety regulations for some time. In September 1977, NRC issued a generic Environmental Impact Statement (EIS), titled "*Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes*," NUREG-0170, that covered the transport of all types of radioactive material by all transport modes (road, rail, air, and water). The RADTRAN I computer code was developed to estimate the annual population dose that might arise from radioactive material shipments and accidents. Based in part on the EIS, the NRC concluded in 1981 that "present regulations are adequate to protect the public against unreasonable risk from the transport of radioactive materials" and stated that "regulatory policy concerning transportation of radioactive materials be subject to close and continuing review." The report contains an assessment of spent fuel shipment risk using the 1975 level of shipments, and a projection of risks for 1985, based on the assumption of a reprocessing fuel cycle. Sandia National Laboratories in Albuquerque, New Mexico, conducted the risk assessment for NRC, and developed the RADTRAN I radioactive material transport risk code, to perform the related dose calculations. The U.S. Department of Transportation also relied on NUREG-0170 to assess the impact of radioactive material transportation under its "Hazardous Materials Regulations" (49 CFR Subchapter C, Parts 171-180).

In the mid-1980s, several spent fuel shipment campaigns were initiated to return spent fuel from the West Valley facility in western New York to the originating utilities. These campaigns drew considerable public interest, and questions focused on the difficulty in comparing NRC's spent fuel cask accident standards with actual accident conditions. These standards are expressed as a series of hypothetical tests and acceptance criteria which are contained in 10 CFR 71.73. The NRC addressed the level of safety provided by its regulations with respect to accident conditions in a study, which is frequently referred to as the "Modal Study," conducted for NRC by Lawrence Livermore National Laboratory ("Shipping Container Response to Severe Highway and Railway Accident Conditions," NUREG/CR-4829, Volumes I and II, February 1987).

The Modal Study examined the response of generic steel-lead-steel truck and rail spent fuel casks to collision and fire accident conditions, using finite element impact and thermal heat transport calculations. Probabilities and forces associated with severe transportation accidents were also assessed. Although the Modal Study did not perform dose consequence calculations, comparison of the probabilities and magnitudes of the accident source terms developed for that study to those developed for NUREG-0170 allowed the Modal Study to conclude that the risks per spent fuel shipment for shipments by both truck and rail were "at least 3 times lower that those documented in NUREG-0170." The NRC staff concluded from the Modal Study that NUREG-0170 clearly bounded spent fuel shipment risks, which reaffirmed the 1981 NRC decision that there was no need to reconsider the transportation regulations to improve safety.

In March of 2000, NRC published a report entitled "*Re-examination of Spent Fuel Shipment Risk Estimates,*" NUREG/CR-6672. This study was initiated because the NRC decided (1) a significant increase in the number of spent fuel transports is likely during the next few decades, (2) these transports will be made to facilities along routes and in casks not previously examined in risk studies, and (3) the risks associated with these transports can be better estimated using new data and improved methods of analysis. This study focused on risks of a modern spent fuel transport campaign from reactor sites to possible interim storage sites and/or permanent geologic repositories. Its purpose was to determine whether the original NUREG-0170 risk estimates bounded those for the anticipated shipment campaigns. Like NUREG-0170, this study calculates the risks for spent fuel shipments under both incident-free and accident conditions, but unlike that study, takes into account such factors as the design, enrichment, burn-up, and cooling time of fuel currently anticipated to be shipped; the capacity and designs of newer casks; and current population densities along road and rail routes. Its analysis relied on RADTRAN V, an updated version of the computer code developed in 1977.

In addition, for the first time in an NRC sponsored transportation risk study, the Re-examination Study explicitly treated variability of RADTRAN 5 input parameters. For the "more important" input parameters (e.g., route lengths, population densities, accident rates, durations of truck stops, and cask surface dose rates), distributions of parameter values were constructed that reflected the likely real-world range and frequency of occurrence of the value of each parameter. This introduction of probabilistic techniques reflects the NRC's interest is conducting best-estimate risk assessments.

Results from the re-examination continue to show that accident risk estimates are less than those in NUREG-0170. The best-estimate spent-fuel shipment risks from the re-examination appear to be less than the Modal Study based estimates, by as much as 2 orders of magnitude. This is also much less than the NUREG-0170 estimates.

Nevertheless, public concern over spent fuel shipments is high. As an example, when shipment of less than 10 individual spent fuel rods (less than one assembly) from Philadelphia Electric Company's Limerick nuclear power reactor to the General Electric facility in Vallecitos, California, was announced, questions from local government and media representatives about shipment safety and security began to arise, particularly in the San Francisco Bay area. NRC Headquarters and Region IV staff held a public meeting in Alameda County, California to address concerns about the shipment and facility operations. Days before the shipment departure, there was a last-minute re-routing of the shipment due to public concerns. Based on this experience, and as large-scale shipment campaigns approach, with much greater quantities of spent fuel to be shipped from NRC-licensed facilities to storage and disposal facilities, public interest is expected to increase substantially and NRC has dedicated significant efforts to support public outreach activities on spent fuel transportation.

2. Current NRC transportation package performance study

The foregoing studies are technically robust so as to provide a comprehensive and defensible basis for transportation safety regulations. As important as the technical safety basis is, it is also very important to be able to communicate the results of these studies to the public in a readily understandable manner. To this end, the NRC has developed a transportation communications plan. One example of this activity is a Brochure entitled "Safety of Spent Fuel Transportation," that briefly provides the "bottom line" results of the safety studies using graphics and pictures.

One of the more recent NRC initiatives in the transportation risk assessment area is the Package Performance Study (PPS). This study began in 1999 and should be complete within 5-6 years. This study will focus on spent nuclear fuel cask responses to severe transportation accidents. The objective of the "Package Performance Study" is to increase public confidence in the safety of spent fuel transportation and to confirm the predictive capability of the modelling and analysis used in cask design and testing. The PPS will also address remaining spent fuel transportation issues from the "Modal Study" and the "Re-examination of Spent Fuel Transportation Risk Estimates." The PPS will use a public-participation approach to solicit public and stakeholder interests in developing the study's scope and parameters for review. Further, whereas the preceding transportation studies have all been analytical in nature, the “Package Performance Study” will consider the use of physical testing to address issues, where appropriate. Risk insights obtained using current analysis techniques, physical testing, and through interaction with stakeholders and the public, will support NRC’s ongoing efforts to assure that its regulatory actions are risk-informed and effective. The staff is using an enhanced public participation process to both design and conduct the “Package Performance Study.”

Since spent fuel transportation occurs in the public domain, shipments have, and will continue, to raise considerable interest, particularly as the series of new large-scale shipments approaches. The NRC studied public interest issues associated with spent fuel shipments ("Case Histories of West Valley Spent Fuel Shipments," NUREG/CR-4847, January 1987), as a way to identify effective measures to help address public concerns before commencement of spent fuel shipment campaigns. That study found that the development and implementation of comprehensive public information (and educational) programs that explain the technical, operational, safety, and physical protection aspects of spent fuel transport in layman’s terms improve public confidence in spent fuel shipping campaigns.

3. Summary

The transportation risk studies described here provide a technical basis for determining that current regulations are sufficient to provide adequate protection of public health and safety during transport of radioactive material. This conclusion was first based on early assessments of effectiveness that relied principally on engineering judgement, and has been more recently reaffirmed by studies using probabilistic risk assessment techniques. The ongoing “Package Performance Study” plans include physical testing to further demonstrate transport safety, and provides a process for public involvement in the decision making process for further studies. The implementation of safety regulations that are effective in providing radiation protection in transport, and communication of the safety success of those regulations, is key to public acceptance of radioactive material transport.

COMPARISON OF SELECTED U.S. HIGHWAY AND RAILWAY SEVERE ACCIDENTS TO U.S. REGULATORY ACCIDENT CONDITIONS AND IAEA TRANSPORT STANDARDS

D.J. Ammerman[a], C. Lopez[a], A. Kapoor[b]

[a] Sandia National Laboratories[1], Albuquerque, NM,
[b] U.S. Department of Energy, Albuquerque, NM,
United States of America

Abstract

This paper discusses selected severe historical US highway and rail accidents and compares the mechanical and/or thermal environments associated with these accidents to the 10CFR71 Hypothetical Accident Conditions and the accident environments (both regulatory and extra-regulatory) investigated in "Shipping Container Response to Severe Highway and Railway Accident Conditions", which is commonly known as the Modal Study, and in "Re-examination of Spent Fuel Shipment Risk Estimates", NUREG/CR-6672. Since the hypothetical accident conditions of 10CFR71 are similar to the International Atomic Energy Agency's (IAEA) package tests for accident conditions of transport, the evaluation is also valid in demonstrating the adequacy of IAEA's transport safety standard. Careful examination of the reports on the severe accidents revealed the accidents were found to be bounded by the regulatory environment described in 10CFR71.

1. Background

Radioactive material packages are required to withstand the hypothetical accident conditions of 10CFR71.73 [1] and/or IAEA test standards [2] without releasing their contents. For large packages, the hypothetical accident conditions consist of a 9-meter free drop onto an essentially unyielding surface, a free drop of 1 meter onto a 15-cm diameter puncture spike, exposure to a 30-minute fully engulfing hydrocarbon fuel/air fire, and immersion in 15 meters of water. For the accidents considered in this report, the relevant environments are provided by the impact and thermal accidents.

The severity of the impact environment is caused by the requirement that the impacting surface be essentially unyielding. In real accidents, the kinetic energy is also absorbed by the conveyance and the impacting surface. To construct an essentially unyielding target for a spent fuel cask requires a block of concrete that weighs 10 times the weight of the cask (that is, about 250 tonnes for a truck cask and 1000 tonnes for a rail cask) that is topped with a 10-cm thick plate of steel. Most surfaces that are available for impact are much less rigid than this type of target, and will therefore absorb a substantial amount of the kinetic energy of the impact. This makes the regulatory 9-meter free drop onto an unyielding target equivalent in severity to much higher drops onto softer surfaces. For example, the Modal Study states that for a rail cask impacting a concrete roadway in a side-on orientation, a drop of more than 30 meters is required to produce the same amount of damage as the regulatory impact.

The severity of the thermal environment is caused by the requirement that the fire be fully engulfing. That is, enough fuel needs to be supplied to a pool configuration just below the transportation cask and have a source of ignition for that to happen. Or else, fuel needs to flow under the cask at the right rate and form a thin film of fuel together with an ignition source to be able to burn and engulf the cask. However, a permeable ground (dirt or gravel) will absorb the liquid fuel, which will limit the size, intensity, and duration of the fire. If a spent fuel truck cask were to be subjected to a regulatory fire, a pool size of 12 meters by 8 meters would be used. For the 30-minute fire duration in this pool, about 12,500 liters of jet fuel would be consumed. To fully engulf a rail cask, the pool size would be

[1] Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin company, for the United States Department of Energy under Contract DE-AC04-94AL85000.

12 meters by 9 meters and the amount of fuel consumed would be 13,800 liters. The regulatory fire temperature is 800°C, which results in an initial heat flux to the cask of about 75kW/m^2. The heat flux to the cask decreases as the outer surface temperature of the cask increases during the fire.

In general, it is difficult to justify any fire that could be more severe than a fully engulfing fire. In the case of a sudden spillage of liquid hydrocarbon fuel onto the ground (e.g., a big hole was punctured in the tank carrying the fuel), a fire would not be able to burn for long due to the fact that either the fuel would be absorbed by the ground and not be available for combustion, or if the surface is not permeable, the fuel will disperse, which limits the pooling effect and therefore the fire duration. In the case of a slow fuel leak from a tank carrying the liquid fuel, the fire is most likely to burn locally by the small puncture hole, which would not pose any significant fire environment to make a cask fail, even if it were near the fire. For all of these events, the tank carrying the liquid fuel would have to be punctured at a location that allows the fuel to drain.

Spent fuel transportation risk assessments take into consideration the accident environment and calculate the response of casks to these environments. Two examples of generic spent fuel risk assessments are the Modal Study [3] and NUREG/CR-6672 [4]. The Modal Study analyzed how steel-lead-steel truck and rail spent fuel casks responded to unusually severe collisions, and to long-duration, fully engulfing fires. NUREG/CR-6672 extended the methods of analysis developed by the Modal Study by examining four types of spent-fuel casks: a steel-lead-steel truck cask, a steel-lead-steel rail cask, a steel-depleted uranium-steel truck cask, and a monolithic steel rail cask. Additionally, a parallel processing computer was used to perform three-dimensional finite element impact calculations that directly examined the response of the cask closure to unusually severe high-speed (up to 53.6 m/s) impacts and the fire durations that would heat a cask and the rods in the cask to temperatures where the rods would fail by bursting.

2. Accident review

The U.S. Department of Energy, Office of Environmental Management sponsored a group of packaging and transportation experts from DOE and Sandia National Laboratories. The group reviewed and analyzed 12 severe highway and rail accidents that occurred in the United States from 1983 to 1996 in the report, "Comparison of Selected Highway and Rail Accidents to the 10CFR71 Hypothetical Accident Sequence and NRC Risk Assessment", September 2002 [5] [6]. The following is a brief summary of some selected severe accidents reviewed and analyzed based on the data available in the accident reports filed with federal, state, and local authorities.

2.1. Collapse of a suspended span of interstate route 95 highway bridge over the Mianus River, Greenwich, Connecticut on 28 June 1983 [7]

The 30.5-meter span of the bridge that failed carries the eastbound lanes of I-95 across the Mianus River. Two passenger cars and two tractor-semi-trailers drove off the failed bridge and plunged approximately 21 meters into the water. Figure 1 shows the collapsed bridge.

Figure 1: Cleanup of the collapsed span of the Mianus River Bridge

If one of the trucks that went off the bridge had been carrying a spent fuel cask, the impact from a fall of 21 meters would result in an impact velocity of 20.5 m/s (the horizontal component due to the truck's speed when it left the bridge is parallel to the impact surface, so it does not increase the severity of the impact). The impact orientation that is most likely is a corner impact. A corner impact of 20.5 m/s into water is much less severe than the regulatory impact of 13.4 m/s into an essentially unyielding target. Therefore, there would have been no significant damage to the cask and it would have remained leak-tight. The shallow water that exists in this location cannot damage the cask due to external pressure, and since the cask would remain leak-tight, there is no possibility for water ingress. Recovery of a spent fuel cask from this accident would take only a short period of time.

2.2. Collapse of the Cypress Street Viaduct of the Nimitz Freeway in Oakland, California as a result of the Loma Prieta Earthquake on 17 October 1989 [8]

The Cypress Street Viaduct, a portion of Interstate 880 in Oakland, California, was a two-level structure. The upper level carried southbound traffic and the lower level carried northbound traffic. The road surface on the lower level is about 7.6 m above the ground and the road surface of the upper level is about 11.6 m above the ground. During the earthquake, the upper level collapsed onto the lower level. The free-fall distance is 4.5 m. At no location along the viaduct did the lower level collapse to the ground. The total width of the upper level is about 16.5 m and the spans range from 20.7 m to 27.4 m. The roadway consists of concrete box girders with a mass of about 80,000 kg per lineal meter. The lower portion of the box is 14 cm of concrete and there are 8 vertical members, each 20.3 cm thick. Each box girder is supported by bents made up of two columns and a transverse beam. The reinforced concrete transverse beam was 2.4 m deep and 1.2 m wide. Each of these beams has a mass of about 572 tonnes. Figure 2 shows the configuration of one of the bents.

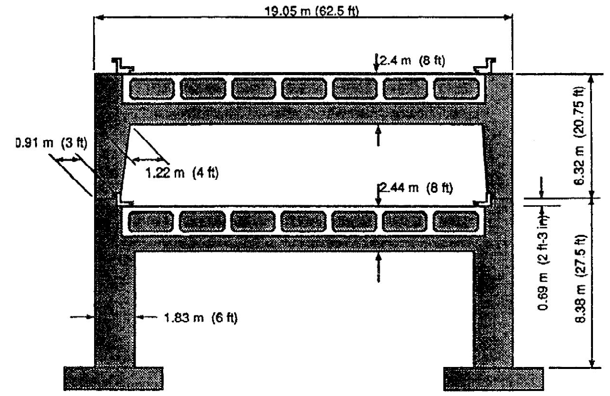

Figure 2: Typical bent of Cypress Street Viaduct

If a truck carrying a spent fuel cask had been on this structure at the time it collapsed there are several accident environments it could be exposed to. The worst case would be if the entire weight of the beam impacts the cask. The impact energy of the beam (weight times drop distance) is about the same as the impact energy for a 24-m drop (21.5 m/s). The results of NUREG/CR-6672 show that a truck cask will not fail its closure seal for impact velocities greater than 40.2 m/s. Therefore, if a spent fuel cask had been on the Cypress Street Viaduct when it collapsed, there would have been no release of radioactive material. For these reasons, the accident lies within the accident event-tree scenarios considered in NUREG/CR-6672, and within the envelope defined by the regulatory test sequence defined in 10CFR71.

2.3. Hazardous materials release following the derailment of Baltimore and Ohio Railroad Company Train No. SLFR, Miamisburg, Ohio, 8 July 1986 [9]

This derailment occurred while the 44-car train was traveling at 20 m/s across a plate bridge. Hazardous cargo consisted of yellow phosphorus and molten sulfur at 118°C. Major difficulties in handling the accident arose because the car containing phosphorus was damaged during derailment in a location that was difficult to access. Yellow phosphorus, unless covered with water or oil, ignites at 30°C when exposed to air. Damage to the tank car containing yellow phosphorus allowed phosphorus to leak onto the ground and surroundings, leading to phosphorus combustion and hazardous combustion products in the area.

Because the combustion of yellow phosphorus was limited to the immediate area of the tank car, there is no evidence that a spent fuel cask in the area of the damaged car would have been exposed to a fully engulfing 1000°C fire environment as described in NUREG/CR-6672. Because of hazardous cargo separation rules, any cask would have been one or more car lengths separated from other hazardous cargo. While the phosphorus fire continued for several days, part of the objective of the accident control effort was to allow combustion of the phosphorus in a controlled manner. To that end, the car was opened and repositioned to allow the phosphorus to complete combustion. Molten sulfur, while hazardous to humans at 118°C, is well below temperature design limits for spent fuel casks, and within the envelope defined by the 10CFR71 regulatory test sequence.

2.4. Derailment of Freight Train H-BALT1-31 Atchison, Topeka and Santa Fe Railway Company near Cajon Junction, California on 1 February 1996 [10]

This accident involved the high-speed derailment of a mixed-freight train caused by a failure of the train braking system on a steep downgrade. All four engines and 45 of the 49 freight cars, including 12 of 14 tank cars derailed in a relatively small area adjacent to a curve. The pileup of cars continued to burn for several days with local spot fires fueled by tank car leakage and cargo fires. After a brief initial attack, no efforts were made to suppress the fires. The fires were attacked instead by dragging individual cars from the wreckage with heavy equipment. One derailed tank car containing butyl acrylate remained intact, and after being dragged from the pile, was identified as a potential explosion hazard because the contents had apparently exceeded the 125°C limit of the chemical stabilizer. After determining that internal tank pressure was increasing, a hole was blown in this tank car with plastic explosives to provide pressure relief and drainage.

Examination of the accident report indicates that if a spent fuel cask were in the cargo manifest, the accident conditions would be enveloped within the long-term fire conditions assumed in NUREG/CR-6672. In NUREG/CR-6672 the response of four spent fuel cask designs to 1000°C long-duration (beyond regulatory test limits), fully engulfing fires is calculated. For the current accident, the conditions would not have fully engulfed a cask, since personnel access permitted removal of damaged cars while the fires continued to burn. The fact that the butyl acrylate tank car remained intact indicates that a much more substantial spent fuel cask would also have survived intact. The chemical stabilizer temperature of 125°C is well below seal and rod burst temperatures of a spent fuel cask, so cask fire exposure to similar conditions would not have led to a cask failure. With additional data on the equivalence of long-term exposure in small fires to short-term exposure in fully engulfing fires, the confidence in this conclusion could be further improved. Inclusion of additional detail of this type often removes conservatism from the study, and thus reduces the overall level of risk reported in NUREG/CR-6672.

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U.S. NUCLEAR REGULATORY COMMISSION'S PACKAGE PERFORMANCE STUDY FOR SPENT NUCLEAR FUEL TRANSPORTATION

R. Lewis [a], A. Murphy [a], C. Fairbanks [a], A. Snyder [a], J. Sprung [b], D. Ammerman [b], C. Lopez [b],

[a] U.S. Nuclear Regulatory Commission (NRC)
[b] Sandia National Laboratories
United States of America

Abstract*

The U.S. Nuclear Regulatory Commission (NRC) is currently planning to conduct confirmatory analyses and testing of the performance of Type B spent nuclear fuel (SNF) packages during severe accidents. Current plans call for full-scale rail impact and thermal tests, with pre-test predictions, of a truck cask design (~50 ton) and a rail cask design (~140 ton), in late 2004-2005. A public participatory process is being used to design and conduct this project, with a principle objective of increasing public confidence.

1. Introduction

The U.S. Nuclear Regulatory Commission (NRC) believes that current regulations and programs for transporting spent nuclear fuel (SNF) result in a high degree of safety. The agency bases this belief upon the regulations and requirements for SNF transport package design and testing, and the NRC staff's confidence in the shipping cask designs the NRC certifies. Ongoing confirmatory research regarding transportation safety further supports the agency's belief.

Under the current regulations, the NRC requires that SNF casks must be designed and constructed to survive a sequence of tests designed to simulate postulated accidents. These tests include a 30-foot drop onto an unyielding surface and a 30-minute fully engulfing fire. NRC regulations permit certification through testing, analysis, comparison to similar certified designs, or various combinations of these methods. Typically, the agency has certified SNF casks using a combination of analyses and testing of scale models or cask components. Previous NRC risk studies have estimated that the agency's certification standards encompass well over 99% of possible transportation accidents.

NRC certification of SNF casks has contributed to an excellent safety record for transporting spent fuel. Further, the characteristics of both fuel and cask systems continue to evolve, and the testing and analytical techniques used in certification applications continue to improve. However, the near-term possibility of a significant increase in the number of spent fuel shipments has focused NRC and public attention on the safety of SNF transportation. Despite the excellent record achieved to date and general improvements in cask design and analysis, some stakeholders have voiced concerns regarding transportation safety and the lack of full-scale testing of SNF casks.

The NRC believes the safety protection provided by the current transportation regulatory system is well established. NRC's primary role in transportation of spent fuel is certification

* The views expressed in this paper do not necessarily reflect those of the U.S. Nuclear Regulatory Commission.

of the casks used for transport. The NRC ensures that shipping casks are robust by regulating their design and construction, by independently confirming the ability of designs to meet the regulations and accident conditions through modelling and analyses, and by overseeing that licensees properly build, use, and maintain the casks. NRC's confidence in casks that it certifies is also supported by ongoing transportation safety research and by the outstanding safety record compiled using NRC-certified casks. Currently, NRC has certified several transportation cask designs that could be used to transport spent fuel, and additional designs are under review.

2. Package performance study (PPS)

The Package Performance Study (PPS) began in 1999 with a scoping phase, consisting of a series of public meetings to identify stakeholder issues with transportation risk studies and identify potential areas of further research. The scoping phase of PPS culminated in 2000 with issuance of the PPS issues and resolution options report (Issues Report) for comment, and an associated series of public meetings. NRC has since reissued the Issues Report, together with summaries of the public meetings and written comments received (NUREG/CR-6768). The Issues Report identified a number of areas for review in the PPS:

(1) use recent accident statistics/data to reconstruct train and train accident event trees;

(2) perform a high-speed impact test on a full-scale rail cask, to compare pre-test analyses to test results;

(3) perform a long-duration fire test to compare pre-test analyses to test results; and

(4) perform experiments on fuel pellets, rods, and assemblies to examine failure modes and fracturing properties, to support radioactive material release analyses.

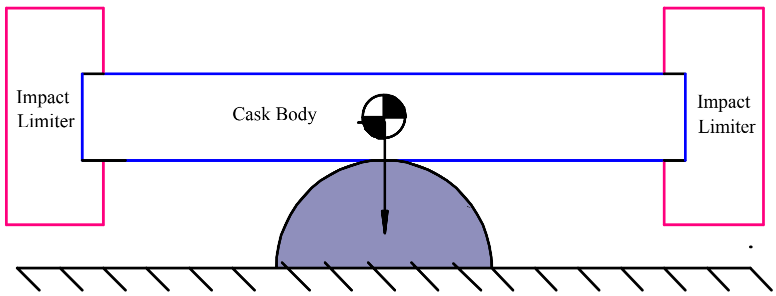
A PPS Test Protocols report was issued by NRC in early 2003 for comment. The protocols report is the first major PPS document since the Issues Report. The Test Protocols describe, at a conceptual level, the impact and fire tests that are currently planned for PPS, along with the goals for these tests. Several other PPS tasks, including the accident statistics/data work, investigations of fuel behaviour under impact and thermal stresses, historical accidents investigation, and uncertainty/sensitivity analyses for risk assessments, are planned as part of PPS, but they are not part of the Test Protocol as it focuses on testing. Publication of these test protocols does not imply any commitment on the part of the NRC to conduct any of these tests, or to conduct any test exactly as described in the report. NRC will be asking for public comment on the protocols report; the requests for comment are discussed at the end of this paper.

2.1. Collision test protocol

Within the context of the PPS, the NRC is proposing to conduct separate high-speed impact tests of a full-scale rail spent fuel cask and full-scale truck spent fuel cask using a drop impact as opposed to a horizontal impact test. The drop impact test was proposed after weighing such factors as test objectives, costs, local environmental and logistical concerns, and modeling issues. The staff will then compare the results of these tests to detailed pre-test damage predictions developed by computer models. (The computer model analyses conducted in the process of developing the preliminary design of the impact test are described in this report.) The staff proposes the following tasks for the collision test protocol:

- Subject a full-scale rail cask to an extreme impact onto a flat, unyielding surface (The staff proposes an unyielding surface because (1) the proposed impact test is intended to evaluate cask performance and an unyielding surface causes all of the cask kinetic energy to be absorbed by the cask, and (2) an unyielding surface simplifies the analysis by deforming only the cask and not the target.)

- Equip the lid end of the test cask with an impact limiter; the cask would contain one "fuel assembly" containing surrogate fuel, and sufficient dummy assemblies to fill the canister or cask.
- Structure the test to deliver the impact onto the lid end of the cask that is equipped with the impact limiter.
- Orient the cask so the impact is on the corner or edge of the lid.
- Test cask performance on impact with an unyielding surface at an impact speed of 60 to 90 mph (based on preliminary analysis of the computer model).
- Subject a full-scale truck cask to an extreme "back-breaker" impact[1] onto one of the internal flat sides of the cask, midway between the impact limiters onto a rigid semi-cylinder, as shown in the following illustration:



- Ensure that the cask contains one real fuel assembly and sufficient dummy assemblies to fill the cask.
- Test cask performance on impact with an unyielding surface at an impact speed of 60 to 90 mph (based on preliminary analysis of the computer model).

2.2. Proposed speed for rail impact test

The NRC staff with contractor support obtained preliminary impact analyses to support the development of the test protocols. These analyses spanned the range of impact speeds from 60 to 90 mph; this report presents the results of these analyses for impact speeds of 60 and 75 mph. The NRC staff reviewed these analyses and developed three criteria for proposing test parameters for the PPS impact and thermal tests. The NRC staff conducted a trial application of these criteria to determine the speed for the rail cask impact. The NRC staff optimized the benefits of the three criteria, i.e., (1) enhancing public confidence, (2) validating the computer models, and (3) ensuring realism in the probability of the occurrence of the test parameters. On the basis of that optimization, the NRC staff proposes the impact speed of 75 mph.

2.3. Fire test protocol

Within the context of the PPS, the NRC plans to conduct separate fire tests of a full-scale rail cask and a full-scale truck cask. For these thermal tests, PPS will use a fully engulfing, optically dense fire, which completely surrounds the test specimen and obscures visibility of the test specimen through the flames. In each test, the fire will burn for more than the half-hour duration of the thermal certification test. The NRC staff will compare the measured temperature history of the cask at various points to the detailed pre-test predictions developed

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[1] A back-breaker impact is one in which the cask strikes the target between the impact limiters in a sideways orientation. The impact target is similar to a bridge column or abutment.

by computer models. (Again, the computer model analyses conducted in the process of developing the preliminary design of the thermal test are described in this report.) The staff proposes the following tasks for the fire test protocol:

- Subject a full-scale rail cask to a fully engulfing, optically dense fire for a duration of more than a half hour.
- Subject a full-scale truck cask to a fully engulfing, optically dense fire for a duration of more than a half hour.

3. Public comments

The NRC published and distributed the protocols report in early 2003, for a 90-day comment period. In addition, the NRC conducted a series of public meetings to obtain comments on the report. The NRC is currently considering the comments received. The agency particularly sought comments and stakeholders' views on the following nine key issues

- How many casks and what types of cask designs should be used in the tests?
- At what scale should the cask impact tests be conducted (e.g., full-scale or a partial-scale)?
- Should the impact tests be conducted as drops from a tower, as proposed in this report, or along a horizontal track using a rocket sled?
- What should the impact speed and orientation be for the rail cask impact test?
- Is 60 to 90 mph a reasonable speed range for the rail cask impact test given that the frequency for a rail cask impacting a hard rock surface within this speed range is 10^{-6} to 10^{-8} per year?
- Is the 75 mph rail cask impact speed proposed by the NRC staff appropriate?
- What should the impact speed be for the back breaker truck cask impact test?
- What should be the duration and size of the cask fire tests?
- What should be the cask position relative to the fire?
- How many and what types of surrogate PWR or BWR fuel assemblies should be in the casks during the tests?
- Will the proposed tests be able to yield risk insights consistent with NRC's risk-informed regulatory initiatives?

After receiving and considering all stakeholder comments on the test protocols, the NRC staff will develop detailed test plans and procedures for each of the PPS testing programs. The NRC will make these detailed plans, procedures, and tests available to the public before finalizing and conducting the planned tests. Thus, the finalized detailed plans will reflect public comments on these test protocols, constraints imposed by NRC's programmatic priorities, and the available funding to support these tests.

'TOO MANY PLACARDS ?'
Do all vehicles carrying radioactive material require a placard?

P.J. Colgan

Australian Radiation Protection and Nuclear Safety Agency
Australia

Abstract.

The philosophic basis for regulating Dangerous Goods can broadly be stated as: *'Many chemicals and substances can be dangerous under certain conditions and in certain quantities if not handled or treated properly'* This then leads to the prescribing of a list of dangerous chemicals or substances called 'Dangerous Goods', and the setting of regulations pertaining to (amongst other things) their transport, as set out in the UN Orange Book. For Radioactive Material, the basic philosophy underlying their regulation can broadly be set out as *'All Radioactive Materials are dangerous and subject to regulation, unless specifically exempt'* . This then leads to the prescribing of a list of exempt quantities of radioactive material or products containing radioactive material. The IAEA Model Regulations for the Safe Transport of Radioactive Material (TS-R-1) sets the requirements for the safe transport of all radioactive material, based on this philosophy.

Radioactive Material is a subset of Dangerous Goods (Class 7) and to overcome this philosophical difference the UN Orange Book has to date referenced TS-R-1when referring to the transport of Class 7 material. While this is a convenient quick fix for the policy makers, at the operational level it causes difficulties. A case study of the consequences of the placarding requirements for shippers of Dangerous Goods compared to the placarding requirements for shippers of Radioactive Material, demonstrate the poor fit of these two philosophies. The resulting confusion at the operational level from these different philosophic bases could help explain the increase in the 'Denial of Shipment' reports being received concerning the transport of radioactive material.

1. Introduction

Australia is a Federation of six States, two Territories and the Commonwealth. Each jurisdiction has its own legislative framework, and this means that in regulating the transport of both dangerous goods and radioactive material there needs to be consistency and/or uniformity.

For the transport of dangerous goods, an Australian Dangerous Goods Code (the ADG Code)[1] was developed by an Advisory Committee to the National Road Transport Commission based on the UN Recommendations[2]. The various jurisdictions then introduced 'mirror' legislation to effectively control the transport of dangerous goods across Australia.

For the transport of radioactive material a 'Code of Practice for the Safe Transport of Radioactive Material (2001)'[3] (the Transport Code) was developed by the Radiation Health Committee of the Australian Radiation Protection and Nuclear Safety Agency, based largely on the IAEA Regulations[4] This code has been adopted by reference in most jurisdictions, or is in the process of being adopted.

2. Background

Australia is a large country, with a small population (approx 20 million) having an average GDP of US$20,000 per person. As a consequence, the transport infrastructure of Australia is based on various types and sizes of transport companies, with many small operators and sub-contractors transporting, amongst other things, dangerous goods and radioactive materials at the end of the transport chain. Australia is a free market, and the transporting of dangerous goods and radioactive material is open to any company or individual who satisfies the training and logistic requirements set under the various registration and licensing regimes in the various jurisdictions. The training requirements can be expensive for small operators, and the logistic arrangements with increases in vehicle safety, security during transfer or overnight storage, and additional administrative arrangements being costly and time consuming to administer. Because of the potential for damages and the possibility of expensive cleanup following an accident during the transport of dangerous goods, insurance premiums are often high. The owner and prime contractor transporting dangerous goods under a 'placard load' must ensure the vehicle is insured during transport. Insurance coverage is required to be A$2.5 million for bulk vehicles and A$1 million for package vehicles, and is needed for:

- Property damage, personal injury and other damage (excepting consequential economic loss) arising out of any fire, explosion, leakage or spillage of dangerous goods etc; and
- Costs incurred by or on behalf of a government authority in a clean-up resulting from the events.

3. Case Study

Australians expect access to a high level of medical care, medical assessment and medical treatment facilities, and this expectation extends to those living and working in rural and regional areas within Australia. As a consequence of this expectation there is sometimes a need to transport small amounts of medical radioisotopes to hospitals in regional areas. Mostly this can be achieved by air transport, but occasionally this needs to be undertaken by road vehicle.

In one such instance, medical radioisotopes were ordered from the manufacturer, and flown on the first leg of the journey to the regional area hospital. The driver of the road transport vehicle, familiar with the requirements for shipping dangerous goods but not actually registered to transport dangerous goods, was then engaged to deliver the medical radioisotopes from the airport to the hospital, a distance of some 200km. The transport was not under 'exclusive use', and for a 5kg package was not very profitable. The medical radioisotope shipment was to be included as part of a weekly run delivering supplies and spare parts to the regional area township. The package containing the medical radioisotopes was category II yellow, displaying the label shown in Figure 1:

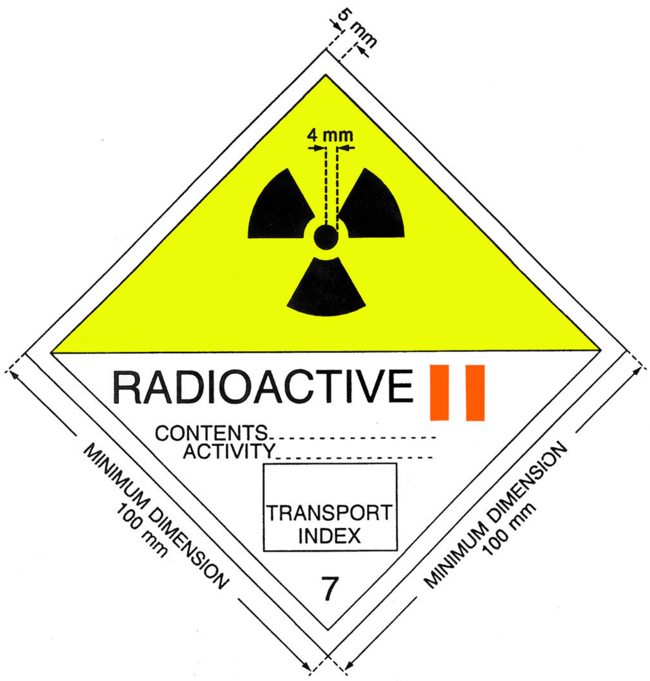

Figure 1

When transporting a radioactive material by road in Australia, paragraph 570 of the Transport Code requires:

> "570. Rail and road vehicles carrying packages, overpacks or freight containers labelled with any of the labels shown in Fig. 2, Fig. 3, Fig. 4 or Fig. 5, or carrying consignments under exclusive use, shall display the placard shown in Fig. 6 on each of:
>
> (a) The two external lateral walls in the case of a rail vehicle;
> (b) The two external lateral walls and the external rear wall in the case of a road vehicle."

As the shipment satisfied the criterion for para 570, a vehicle placard was necessary. The placard required to be displayed by the Transport Code is shown in Figure II. For the medical radioisotope being transported to the regional area hospital, the placard was required to be displayed on the back and sides of the vehicle carrying the single package of medical radioisotopes.

The driver was also aware of the requirements for transporting dangerous goods, which require a road vehicle transporting a 'placard load' of packaged dangerous goods to be placarded with the class label for the goods. A 'placard load' is defined under the ADG Code as being (amongst other things) either dangerous goods in 'bulk', or where the number of kilograms, or the number of litres, exceeds 1000. For a placard load, the placard is to be displayed on the front and rear of the vehicle.

The placard required by the ADG Code to be displayed for the transportation of a 'placard load' of radioactive material is **identical** to that required for the normal shipment of radioactive material under the Transport Code , i.e. that given in Figure 2.

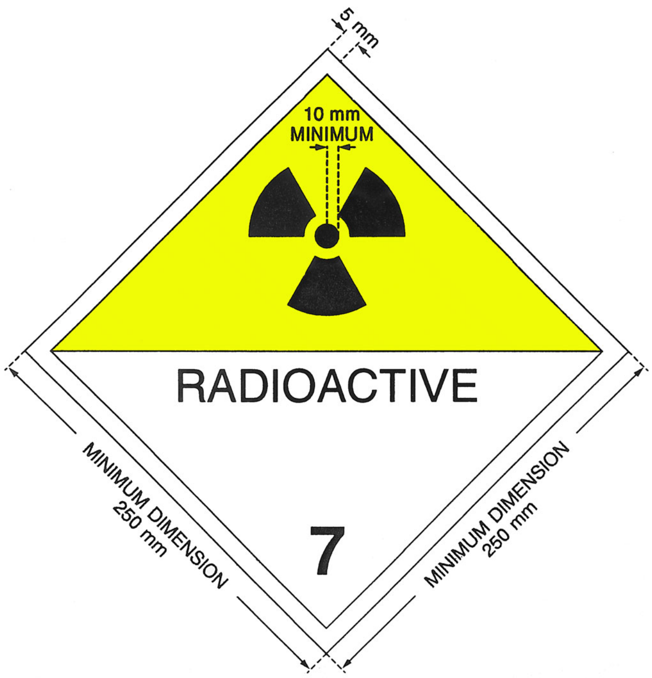

Figure 2: Placard required for transporting radioactive material,
and a 'placard load' of dangerous goods.

In addition, the driver was aware that the ADG Code required segregation distances to be observed between dangerous goods, and other items such as food, photographic film etc.

The Transport Code states:

> "506. *Consignments* shall be segregated from other dangerous goods during transport in compliance with the relevant transport regulations for dangerous goods of each of the countries through or into which the materials will be transported, and, where applicable, with the regulations of the cognisant transport organizations, as well as these Regulations."

Application of the segregation tables for a 'placard load' to small trucks carying radioactive materials effectively preclude the carrying of other dangerous goods (such as more than 40 litres of paint, 2kg of dishwasher detergent or 3 kg of fire-lighters) all of which are necessary in regional areas, and would normally be carried on a mixed load or 'consumer quantity' to a regional area.

The driver was faced with the following:

- The vehicle requires a placard under the (radioactive material) Transport Code. The placard is to be displayed at the rear and two sides of the vehicle.

- The placard is identical to that required under the ADG Code which requires the placard to be displayed at the front and rear of the vehicle. The driver does not have the registration or insurance for transporting a 'placard load' of dangerous goods.
- If the shipment requires a placard, then the segregation requirements of the ADG Code mean that the driver cannot transport other consumer quantities of dangerous goods such as paint, dishwasher detergent , fire-lighters or food.
- The package weighs less than 5kg, therefore making the transport (based on weight) not profitable in comparison to other goods typically required to be transported to regional areas.

Although the shipment was not a 'placard load' of dangerous goods, the displaying of a radiation placard that is identical to that required for shipping dangerous goods implies that the shipment is a 'placard load'. In addition the driver was concerned with issues over administrative paperwork and insurance coverage that transporting dangerous goods entails, the small profit margin and the inability to transport other (heavier and therefore more profitable) materials to the regional area due to segregation requirements. Using the 'too difficult/too complex' excuse, the driver declined to ship the medical radioisotopes, and other arrangements were made.

4. Discussion and conclusion

Radioactive Materials are a deemed to be a subset of Dangerous Goods (Class 7). While this may be appropriate for large shipments of radioactive material or shipments of high activity sources in type B(U), B(M) and type C containers, the above case study shows it may not be fully effective at the operational level for small sources. The requirement to display a 'placard' on vehicles transporting small amounts of radioactive material is totally different to the requirement to display a 'placard' when transporting a placard load of dangerous goods, yet the placards themselves are identical. For segregation, paragraph 506 of the Transport Code gives the head of power for the segregation requirements for transporting mixed loads of dangerous goods containing radioactive material to other regulations, which usually means a dangerous goods regulation. Inspection of these segregation requirements make little sense in their practical application, especially in combination with the confusion over the placarding requirements for transport vehicles.

The packaging and labelling requirements for transporting radioactive material have been based on a rigorous assessment of the hazards of radioactive material based on the Q system, which look at possible exposure pathways resulting in potential exposures based on postulated accidents and releases. Assuming the same amount of rigour has been applied to the potential consequences of an accident involving dangerous goods, then closer attention needs to be paid to the harmonisation of the models on which both regulations are based to ensure a common language is developed. It is hard to imagine that the consequences of a transport accident involving a Category II medical radioisotope would be similar to that for a 'placard load' of dangerous goods (1000 kg of Ammonium Nitrate Fertiliser say), yet both require the display of a placard on the transport vehicle.

Acknowledgements

The author gratefully acknowledges Mr Ian Gibbs of ANSTO, and Mr Alan Ritchie of the NSW EPA.

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IAEA-CN-101/97

EFFECTIVENESS OF THE IAEA REGULATIONS: ENABLING GLOBAL HEALTH CARE

P. Burchat, M.A. Charette, M. Krzaniak, E. Martell

MDS Nordion, 447 March Road,
Ottawa, Ontario, K2K 1X8,
Canada

Abstract

Radioisotopes and radiation technology are used around the world to advance global health. Prevention, diagnosis and treatment of disease require a secure supply of radioisotopes, and transportation is a vital link in ensuring this secure supply. International Atomic Energy Agency (IAEA) transport regulations have facilitated global health by providing a consistent framework for safe international transport. However, the complexity of regulations and inconsistent application have compromized the ability to supply essential radioisotopes around the world. IAEA, competent authorities and the industry need to work together to ensure that the needs of global health care are considered during the development and implementation of international transport regulations.

Introduction

In recent years, there has been growing demand for radiation and radiation technology to prevent, diagnose and treat disease. New developments in medical treatments using radioisotopes have increased the demand for supply. Increasing requirements for food safety have broadened the market for irradiation as well. The prognosis of increasing incidence of diseases such as cancer will continue to escalate the worldwide demand for quality health care. This will further intensify the demand for a secure supply of radioisotopes used for medical purposes.

Medical uses for radiation technology

There are many uses for radioisotopes and radiation technology in health care. From medical treatments for cancer and heart disease to food safety and the sterilization of a vast array of disposable medical products and consumer goods, radiation is used extensively to prevent, diagnose, and treat disease.

Diagnosing Disease

A nuclear medicine procedure provides physiological information about how a patient's body and organs are functioning. It provides disease detection before anatomical changes are apparent. Physicians are able to see, for example, whether the heart has been damaged following a heart attack. Nuclear medicine using radioisotopes for medical imaging scans accounts for nearly 20 million procedures each year around the world.

There are over 100 nuclear medicine procedures that are clinically important for cardiac scans, brain scans and cancer diagnosis. Nuclear medicine procedures are cost effective alternatives to more invasive diagnostic procedures, such as exploratory surgery. New applications and improved nuclear medicine technology have also increased the demand for radioisotopes.

Treating Disease

According to the World Health Organization, there are currently 10 million new cases of cancer diagnosed globally each year and it is expected that in the next twenty years that figure will increase to 15 million. The World Health Organization has also estimated that by 2020 nearly two-thirds of the worldwide cancer cases will occur in the developing world. Radiation is an integral part of cancer therapy[1]. Approximately 50% of all cancer patients are treated with radiation, and 15million treatments are delivered every year using cobalt radiation therapy[2]. Established techniques such as radiosurgery and brachytherapy are increasing in popularity worldwide.

New treatments such as radiolabeled monoclonal antibodies are increasingly important techniques for treating cancer of the lymphatic system. Advancements in combining molecular targeting and radioactivity have led to new technology to treat disease. The combination of a radioactive isotope and a biologic improves the penetration into the cancer tumour and increases therapeutic effectiveness. This highly localized radiation at the disease site decreases damage to surrounding healthy tissue. This can result in less toxicity and better quality of life for the patient than if they were treated with other approaches.

Sterilizing medical and consumer products

Gamma irradiation technology plays an important role in preventing disease. This technology virtually eliminates pathogens on healthcare and consumer products that may cause infection or disease. Because gamma rays can penetrate even very dense materials, products can be irradiated after they are packaged and boxed. This reduces the chance of the products becoming re-contaminated. Irradiation is ideal for sterilizing heat-sensitive products, such as plastics, since irradiation is a "cold" process that generates very little heat.

Hundreds of irradiators have been installed around the world. Every year more than 30 million cubic metres of heath care supplies - including surgeon's gloves, syringes and sutures, contact lens solutions and disposable diapers - are sterilized with gamma irradiation[3].

Preventing food-borne illness

Food-borne illness claims thousands of lives worldwide each year. The United Nations reports that contaminated food is "perhaps the most widespread health problem in the contemporary world and an important cause of reduced economic activity." The World Health Organization estimates that each year 30% of people in industrial countries suffer from food-borne diseases. In the United States alone, it is estimated that 76 million people become ill due to microbial contamination, and 5,000 people die[4].

Irradiation destroys bacteria, yeast and moulds that causes spoilage in fresh foods, such as fruit and vegetables. It destroys dangerous microorganisms such as Salmonella in poultry, *E. coli* 0157:H7 in meat and Listeria in prepared meats. Spices and grains are irradiated to destroy insects and their eggs or larvae. Irradiation also inhibits unwanted sprouting in foods such as potatoes, onions and garlic.

Over 40 countries have approved food irradiation for over 50 different foods such as shrimp, beef, chicken, spices and potatoes. The potential uses of food irradiation are numerous. There is increasing interest in food irradiation due to high food losses due to spoilage, infestation and contamination. The United Nation's Food and Agriculture Organization estimated that nearly 25% of all food production is lost to insects, bacteria and rodents after harvest. Food irradiation can play a key role in reducing this loss.[5]

Preventing Graft Versus Host Disease

Using irradiated blood in transfusions is recognized as the most effective way of preventing Graft Versus Host Disease (GVHD). GVHD most commonly occurs following bone marrow transplants; however, it is also recognized as a rare risk associated with blood transfusions - especially in patients with severely weakened immune systems, such as newborn infants and leukemia patients. GVHD occurs when blood from the donor makes antibodies that try to destroy the cells of the recipient, and is nearly always fatal.

Blood irradiators provide precise, cost-effective blood processing for hospitals, blood banks and clinics. The American Association of Blood Banks, the United States Food and Drug Administration, and other organizations all recommend using irradiated blood for patients with severely weakened immune systems and recipients of bone marrow transplants.

Ongoing research and new applications

Irradiation has proven to be an effective process for many different applications. For example, in Africa, irradiation is used on tse tse flies, which carries a parasite that causes sleeping sickness in humans and animals – an illness that can effect the blood and nervous systems and has an 80% mortality rate. According to the World Health Organization, sleeping sickness has affected over 500,000 people in sub-Saharan Africa and has cost millions of dollars in economic loss each year.[6]

Importance of global access

As demonstrated above, around the world each day, radiation technology is relied upon to prevent, diagnose and treat disease. Given the often short half-lives of many of these products, sophisticated global distribution systems are required to deliver products, often in less than 24 hours. Adding to the complexity is the fact that there are only a few companies based in Canada, South Africa, Belgium, Russia, France, Argentina and the United States who supply these radioisotopes to tens of thousands of users around the world.

Transport regulations

Development of New Regulations

The IAEA transport regulations include comprehensive and effective requirements that have helped to prevent the occurrence of any significant radiological incident. New experiences and new conditions require the regulations to be updated and improved on an ongoing basis. However, it is important that the future development and revision of the regulations not only consider the potential added safety in transport but also the effect that these requirements may have on global health. As compliance to the regulations has become more complex over the years, many international carriers have decided not to carry this material. Any additional regulatory cost and administrative burden may further reduce the list of available carriers. As a result critical medical supplies might soon be no longer available to many member states that require them to meet their health care needs.

Adoption and implementation of new requirements

Different timelines in different jurisdictions introduce unwarranted complexity. Modal organizations and member states have adopted the current regulations with different schedules. Even after adoption, IAEA requirements are not implemented consistently among member states. For example, the IAEA concept of unilateral approval is not uniformly applied. This creates additional complexity and introduces barriers to the shipment of medical isotopes.

Conclusion

IAEA transport regulations have facilitated global health by provide a consistent framework for safe international transport of medical isotopes. However, new requirements must not impede the effective transport of radioisotopes used for health care. In recent years, carriers have dropped out of the supply chain and further erosion may seriously compromise global health care that relies on the supply of medical isotopes. Uniform implementation is also critical to supply. Inconsistencies in application introduce barriers and unnecessary administrative burden that impedes the efficient global delivery of medical isotopes. IAEA, competent authorities and the industry need to work together to ensure that the needs of global health care are considered during the development and implementation of international transport regulations.

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IAEA-CN-90/98

TRANSPORT OF IRRADIATED NUCLEAR FUEL IN GERMANY
Legal basis, status and prospects

F. Nitsche, Ch. Fasten

Federal Office for Radiation Protection
Salzgitter, Germany

Abstract.

Transport of irradiated nuclear fuel from nuclear power plants in Germany is regulated by the Dangerous Goods Transport Regulations in compliance with the IAEA Transport Regulations and in addition by the regulations of the German Atomic Energy Act.

All irradiated nuclear fuel shipments as well as shipments of vitrified high level radiactive waste from France to Germany were stopped in May 1998 when it became known that contamination limits had been massively exceeded. Based on criteria of the competent authorities, intensive and comprehensive expert studies by GRS and Öko-Institut and approved procedures applied by the utilities to load and handle the casks in compliance with the results of these expert studies the resumption of shipments took place in March 2001. Experience with all shipments of 170 casks up to the end of 2002 has shown that the measures taken to meet the requirements for non-fixed contamination are effective and that in all cases the measured contamination levels were clearly below the permissible limits.

Based on the agreement between the German government and the nuclear power utilities the phase out of nuclear power has been legally implemented by the latest version of the Atomic Energy Act in 2002. In the context with this change in energy policy a new spent fuel management concept was developed. In particular the requirements to end the shipments of spent nuclear fuel to reprocessing facilities on 1 July 2005 and to build decentralised interim storage facilities at the nuclear power plant sites will result in a minimisation of the future number of shipments of spent nuclear fuel and vitrified high level radioactive waste in Germany.

1. Introduction

The safe transport of irradiated nuclear fuel from nuclear power plants in Germany is ensured by comliance with the dangerous goods transport regulations of class 7 which are fully consistent with the IAEA Transport Regulations and in parallel with the regulations of the Atomic Energy Act. The purpose of this paper is to give an overview of this legal basis and the appropriate regulations applicable to irradiated nuclear fuel transport in Germany. Some aspects of the status and the future development of spent fuel shipments will be described including experiences since resumption of those shipments in 2001 as well as consequences resulting from changes in energy policy.

2. Legal Basis

The transport of irradiated nuclear fuel in Germany is regulated by two legal areas:

- the area of the dangerous goods transport law and the dangerous goods transport regulations for which the Federal Ministry of Transport, Building and Housing (BMVBW) is responsible for, and
- the area of the Atomic Energy Act for which the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has the responsibility.

There is a link between these two areas in so far as the transport provisions of the Atomic Energy Act contain the requirement that the transport must comply with the dangerous goods transport regulations. In addition to this they contain other requirements regarding the reliability of transport organisations and persons, the qualification and training of persons involved in transport, the nuclear liability insurance, the physical protection and the public interest.

The IAEA Regulations for the Safe Transport of Radioactive Material TS-R-1 (ST-1 Revised) [1] have to be applied in Germany through the implementation of the dangerous goods transport regulations for class 7 of the International Modal Organisations. Therefore for spent fuel shipments from nuclear power plants taking place by road and rail the dangerous goods transport regulations for class 7 of the international modal regulations ADR (European Agreement Concerning the International Carriage of Dangerous Goods by Road) and RID (Agreement for the International Carriage of Dangerous Goods by Rail) have to be applied in Germany. They have been implemented for the two modes of transport by the following German Regulation: GGVSE, Gefahrgutverordnung Straße und Eisenbahn.

There are the following responsibilities according to these dangerous goods transport regulations:

- The Federal Office for Radiation Protection (BfS) is the competent authority for package design approvals for spent fuel casks and if applicable also for shipment approvals,
- The Federal States are responsilble for the inspection of spent fuel shipments by road, and
- The Federal Railway Office (Eisenbahnbundesamt) is the competent authority for the inspection of spent fuel shipments by rail.

Based on the Atomic Energy Act the shipment of irradiated nuclear fuel has to be approved according to para 4 of the Atomic Energy Act [2]. The BfS is the competent authority for such shipments approvals. An approval for irradiated nuclear fuel shipment from a nuclear power plant will be granted if the applicant can demonstrate to fulfil the approval requirements according to para 4 of the Atomic Energy Act comprising mainly [3]:

- Reliabilitiy of companies and persons involved in transport
- Qualification and training of persons involved in transport
- Compliance with dangerous goods transport regulations
- Nuclear liabilitiy insurance
- Physical protection measures
- Public interest, and
- On-site interim storage cababilities for spent fuel.

The Federal Railway Office is responsible for the inspection of the approved rail shipments in this field and the Federal states for all road shipments.

3. Status of irradiated nuclear fuel shipments

The irradiated nuclear fuel shipments are subject to the approval requirements of para 4 of the Atomic Energy Act. These shipments as well as the shipments of vitrified high level radioactive waste from France to Germany were stopped in May 1998 by the BMU when it became known that contamination limits had massively been exceeded. The main requirement for the resumption of these shipments therefore was to be demonstrated by the applicant that the limits for non-fixed surface contamination can be met. This demonstration is in particular necessary to fulfil the approval requirement of para 4 of the Atomic Energy Act regarding the compliance with the dangerous goods transport regulations. Only when such a demonstration was available and accepted and all the other approval requirements according to para 4 of the Atomic Energy Act were fulfilled a shipment approval could be granted by BfS to resume these shipments.

Based on the criteria catalogue of the BMU and on intensive and comprehensive studies and expertises by Gesellschaft für Anlagen- und Reaktorsicherheit (GRS), Köln, and Öko-Institut, Darmstadt, many measures were taken to meet the requirements for non-fixed surface contamination. They contain detailed procedures for the loading, handling, transport, transfer and unloading of casks to prevent contamination, to improve decontamination methods as well as contamination detection and contamination measurements, to get complete and uniform documentations and to ensure the duty of notification if contamination limits are exceeded. Those measures are laid down in the shipment approval issued by BfS depending on the concrete shipment application.

Experience has shown up to now that these measures are effective. The resumption of transport of vitrified high level radioactive waste from France to Germany took place at the end of March 2001 with full compliance with the contamination requirements. The first shipment of spent nuclear fuel to France (COGEMA) was performed on April 10, 2001 and to the UK (BNFL) on April 24, 2001. Since then 170 casks with spent fuel or vitrified waste have been shipped in Germany up to the end of 2002. In all cases non-fixed surface contamination was clearly below the permissible limits.

4. Prospects

Concerning the future development of irradiated nuclear fuel shipments within Germany and to the reprocessing facilities in France and the UK there is a new concept on the basis of the agreement between the German government and the nuclear power industry (from June 11, 2001) to limit the future use of the nuclear power plants in Germany. This agreement has been legally implemented by the latest revision of the Atomic Energy Act, which came into force on April 27, 2002. In context with this change in energy policy a new waste management concept was developed.

The essential requirements of this revised Atomic Energy Act affecting transport are:

1) The transport of spent nuclear fuel for reprocessing will end on July 1, 2005.
2) Interim storage facilities for spent nuclear fuel shall be built at the nuclear power plant sites (decentralized storage) and the spent nuclear fuel shall be stored there until a final repository for spent nuclear fuel is available about 2030.
3) The transport of spent fuel from a nuclear power plant to a centralised storage facilitiy is subject to the demonstration that on-site interim storage capabilities are not available.

By this concept the number of shipments of spent nuclear fuel and vitrified high level radioactive waste can be minimized in the future.

The interim storage approval procedures for all nuclear power plant sites in Germany (except Muelheim-Kaerlich and Stade as special cases) are under way [4]. From end of 1998 to 2000 eighteen new applications for on-site interim storage facilities have been filed (12 storage buildings, one storage tunnel and 5 interim storage areas) at 13 nuclear power plant sites in five federal states. One application for the interim storage facility at Stade has been withdrawn in August 2001 because the final shut down of Stade nuclear power plant is foreseen in 2003.

In 2001 three on-site interim storage areas at Neckarwestheim, Philippsburg and Biblis have been licensed by BfS and in 2002 the licenses for two interim storage facilities at Lingen and Grohnde have been issued by BfS. The licenses for the other interim storage facilities are expected until end of 2003. With an assumed construction period for the storage buildings of about two years the on-site interim storage facilities could then be available around 2005 [5].

5. Conclusions

The transport of radioactive material in Germany is regulated by the dangerous goods transport regulations of class 7 in compliance with the IAEA Transport Regulations and in parallel to these regulations by the regulations of the Atomic Energy Act .

Based on the demonstration of compliance with the dangerous goods transport regulations and the shipment approval requirements of the Atomic Energy Act shipments of spent nuclear fuel and vitrified high level radioactive waste could be resumed in March 2001. Experience with all shipments up to the end of 2002 has shown that the measures taken to meet the requirements for non-fixed surface contamination are effective so that in all cases the measured contamination levels were clearly below the permissible limits.

The agreement between the German government and the nuclear power industry to phase out the use of nuclear power was legally implemented by the latest version of the Atomic Energy Act, which came into force on April 27, 2002. In particular the requirements to end the shipments of spent nuclear fuel to reprocessing facilities on July 1, 2005 and to build decentralized interim storage facilities at the nuclear power plant sites will result in a minimization of the future number of shipments of spent nuclear fuel and vitrified high level radioactive waste in Germany.

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VALIDATION OF CERTIFICATES FOR TYPE B(U)F TRANSPORT AND STORAGE CASKS OF CASTOR TYPE

D. Hell, B. Beine

Gesellschaft für Nuklear-Behälter mbH
Hollestraße 7A, Essen,
Federal Republic of Germany

Abstract.

GNB has profound practical experiences with validations of Type B(U)F certificates for CASTOR casks around the world. There are big differences in the approach of the competent authorities concerning the amount of documents needed for a validation and in the approach to the evaluation of these documents which all have been already evaluated by the competent authority of the country of origin. This holds in general for ADR member states and other countries. Examples showing the scope of differences are given and propositions for a uniform approach are presented.

1. Introduction

Type B(U)F certificates for transport casks need a validation in all countries in which they are transported (besides the country of origin). There is (or should be) a general difference between ADR member states and other countries because the content of the ADR. A short description of the approach to a validation in countries outside the ADR and the differences of an approach in the ADR countries is presented in the following.

2. Validation of Certificates

A validation of a certificate can be done either by recognising the certificate of origin or by issuing a separate certificate. GNB got validations for type B(U)F packages in many countries inside and outside the area of ADR application.

Transport and Storage Cask Type B(U)F	Countries
CASTOR® HAW 20/28 CG	France, Switzerland
CASTOR® 440/84	Hungary, Czech, Slovak, Lithuania
CASTOR® IIb/9	France
CASTOR® S1	France, Great Britain
CASTOR® KRB-MOX	Sweden
CASTOR® MTR	France, Great Britain, Canada, Belgium, Netherlands, Sweden
CASTOR® THTR/AVR	Switzerland
GNS 16	USA, Denmark, Venezuela, Brazil, Slovenia, Portugal, Netherlands, Great Britain,
GNS 11	USA, France, Great Britain, Netherlands, Denmark, Belgium, Greece, Brazil, Venezuela

3. Validation in non ADR countries

All countries request the complete safety analysis report; mostly it is accepted in English language. Furthermore the certificate of origin and its English translation is needed (some countries request a translation into their official language). Then the big differences begin. In the US the whole safety analysis report is checked and evaluated as if nothing was checked in the country of origin; and a lot of questions and additional explanations may arise from this procedure. Other countries issue the validation with a short look only on the criticality analysis.

4. Validation in ADR countries

4.1. Theoretical procedure

Comparing the passages in the ADR for type B(U) packages - they need no validation - to those for type B(U)F packages - they need a validation - the only difference is that for type B(U)F packages a criticality analysis is needed in addition.

Because of this it is agreed by all competent authorities of the ADR member states that only the criticality analysis has to be checked for a validation of a foreign certificate.

Thus the criticality analysis properly translated together with the certificate of origin and its translation should be sufficient for a demand for validation.

4.2. Practical procedure

During the last years the difference to the theory became bigger and bigger.

Most ADR countries request the complete SAR in English. Also in Germany the tendency of requiring a complete SAR - and this most probably in German - becomes evident.

The depth of evaluation of the SAR varies from country to country. Some countries check only the criticality analysis; either by controlling the submitted calculations or by own calculations.

Other countries control the whole SAR in detail resulting for example in questions concerning details in material specifications or drawings.

In some cases it is required to generate additional technical reports to answer very specific questions of one competent authorities; other competent authorities would say these questions are without any concern for the safety of the package.

5. Propositions

All ADR member states should require the same amount of documents in English for a type B(U)F validation. The depth of the evaluation should be the same in all countries and limited strictly to the criticality analysis.

In all ADR countries being members of the EU no validation of certificates of EU countries should be necessary.

INTERNATIONAL RULE MAKING OF RADIOACTIVE MATERIAL SAFE TRANSPORT AND ITS INTRODUCTION INTO NATIONAL REGULATIONS

H. Tani

The Federation of Electric Power Companies, Tokyo,
Japan

Abstract

It is important that the transportation of radioactive material should be carried out safely. The same safety level should be maintained in each country and for each mode of transport, to ensure a smooth transfer of radioactive material travelling internationally or by land, sea and air. When transport regulations are different between countries involved or modes of transport, there is the possibility of confusion at the transfer point. It is very important for the international community to consider how to introduce common IAEA transport regulations into national regulations in each country. Under such conditions, it is open to question whether a revision interval of two years of the IAEA transport regulation is suitable.

1. International rule making for the safe transport of radioactive material

The transportation of radioactive material must be carried out safely, but at the same time, safety standard should be the same in each country for in each mode of transport. Because, transportation of radioactive material will be carried out internationally by land, sea and air, it is desirable that unified standards apply to the package in all countries and through all transportation modes for smooth transfer.

On the other hand, each transportation mode has an indigenous safety system, and the navigation requirements and loading needs on each transportation mode are different. As a result there are certain safety regulations that need to be added to each transportation mode for certain conditions. For example, conditions like segregation between radioactive material and other dangerous goods differ greatly between transportation modes.

As a result, the United Nations Economic and Social Council (ECOSOC) established the Committee of Experts on the Transport of Dangerous Goods and developed the "Model Regulations (the orange book)" on the transport of dangerous goods. These model regulations classify dangerous goods into 9 groups such as explosive, high-pressure gases, and they provide standards on packaging, labels, property stabilization method and so on, common to all transportation modes of land, sea and air. Class 7 of model regulations covers "radioactive material". Making the regulation on radioactive material effective has been entrusted to the IAEA, as it is a specialist international organization on the radioactive material. The IAEA Regulations for the Safe Transport of Radioactive Material (The IAEA Transport Regulations) are the result of this. It will be unified as one part of the United Nations model regulations when the IAEA Transport Regulations are completed.

When the United Nations model regulations have been completed, they will be sent to the International Maritime Organization (IMO) and the International Civil Aviation Organization (ICAO), and will serve as the basis for the international modal regulations that will be made by the IMO for sea transport and by the ICAO for air transport, after they have added conditions specific to each mode of transport. There is no international organization covering land transport, but in Europe, the United Nations Economic Commission for Europe (UNECE) makes regulations covering rail, road and inland waterway transport.

The International Maritime Dangerous Goods Code (The IMDG-code) made by the IMO has detailed obligatory regulations based upon Chapter VII (Carriage of dangerous goods) of the International Convention for the Safety of Life at Sea (SOLAS). The ICAO's Technical Instructions for the Safe Transport of Dangerous Goods also has detailed obligatory regulations based upon the Chicago Convention. The 1996 edition of the IAEA Transport regulations has been introduced into the 1999 edition of the United Nations Model Regulations, and is used as the basis of the current IMDG code and the current ICAO's Technical Instructions.

This work is very complicated, but is necessary, because the transportation of radioactive material is carried out internationally and through multi-mode for land, sea and air. It is yet to be resolved how to introduce the same IAEA transport regulations into the national regulations in each country at the same time. When a regulation in either country involved in the transportation, or a regulation of a mode of transport, is different, it produces confusion at transfer point. How to coordinate the rule-making schedule in each international organization, and how to unify the time of introducing in each country, will become a very important issue.

So far there has been little confusion over the few revision of the IAEA Transport Regulations. However, it will be necessary to examine this issue in detail in the future when the revision is done every 2 years. This will be discussed in detail later in this paper.

The Code for the Safe Carriage of Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes in Flasks on Board Ships (INF-code) is not included in the United Nations model regulations, and has been developed by the IMO. A ship applied this INF code will comply with the very high-level safety requirements. For instance, in the case of a class INF 3 ship, the ship is required to have, among other thing, a double hull system, very severe damage stability for collision or grounding damages, various fire safety measures, and an alternative electrical power supply source.

2. Imposition of the transport regulations

Neither the IAEA regulations nor the United Nations model regulations have legal force, and a member state does not bear any duty to automatically adopt this. In addition, so far each country was free to decide whether or not to adopt the IMDG code. However, the IMDG code will become mandatory on 1 January 2004 by amendments made to Chapter VII (Carriage of dangerous goods) of the SOLAS in May 2002. The INF code became mandatory on 1 January 2001 by the SOLAS amendments adopted in 1999.

As a result of this revision to SOLAS, introduction of the IMO-codes will be obligatory by member states, and considerable progress will be made in reinforcing safety. The INF-ship shall be inspected and surveyed by a registered state, and an international safety certificate will be issued based on SOLAS after an inspection and survey of the INF-ship that satisfies the requirements of the INF code. Therefore, the government of the state where the INF ship come into own port become very convenient for safety confirmation, because the state can confirm everything that is required for the international safety certificate.

However, each state needs a procedure to ratify or accept the convention in order to accept obligation imposed by the convention. A different convention is applied to each transport mode. All international organizations and all member states that are involved have been requested to adjust work schedules minutely and to unify introduction time in order to enforce regulations in all transportation modes simultaneously internationally.

This is not easy. Therefore, care must be taken over introducing international regulations simultaneously. Confusion will occurs when some country or some transportation mode cannot adopt new regulations.

3. Introduction of international regulations into national regulations

Japanese radioactive material safe transport regulations are based on four laws. In the case of marine and air transport, the Ship Safety Law and the Aviation Law covers all radioactive material such as nuclear fuel and RI, without distinction. The Ship Safety Law is to enforce a lot of conventions adopted in the IMO such as SOLAS. The Aviation Law is similar regarding ICAO-related conventions. Therefore, both laws provide a structure compatible with international rule system described above. Adjustment of other safety regulations on introduction is easy. In addition, the administrative office of both laws is the Ministry of Land, Infrastructure and Transport.

On the other hand, in the case of land transport, Japan does not need international adjustment, because, unlike Europe, Japan is not connected by land with a foreign country, and the IAEA regulations are introduced directly into national regulations. Land transport safety regulations are divided into regulations base upon the Nuclear Raw Material, Nuclear Fuel and Nuclear Reactor Control Law applied to nuclear fuel, and regulations based upon the Radiation Disease Prevention Law applied to RI for research, medical care and industry. In addition, each Ministry regulating a nuclear facility controls packaging process, and the Ministry of Land, Infrastructure and Transport regulates method of loading trucks and trains, and safety measures in service.

Furthermore, the safe transportation of radioactive material requires physical protection, emergency response and traffic control. Therefore, close contact with the police and the Coast Guard is necessary when formulating regulations. As previously mentioned, many government offices are connected in the task of introducing the international regulations into the national regulations.

In Japan, all relevant Ministries and Agencies are cooperating closely in revising the regulations in order to ensure that the transportation regulations of land, sea and air are compatible. For example, the IAEA1996 transport regulations and the IAEA and ICAO transport regulations were introduced into the national regulations for land, sea and air simultaneously, and have been enforced since 1 July 2001.

A lot of work will be required to implement and coordinate the changes if the IAEA regulations are to be revised every two years in future.

There are no special technical problems to introducing requirements of the INF code into the national regulations on the basis of SOLAS, because it was implemented since long time ago in Japan. The only new aspect is the issuing of international safety certificate to INF ships. These revised regulations have been enforced since 1 January 2001.

4. Review every two years of the IAEA Transport Regulations

The IAEA Transport Regulations will be reviewed every two years. Safety regulations should introduce new technology as appropriate, and it is necessary to keep a high level of safety as possible. A review every two years was better way from this point of view. However, revising the safety regulations is more than just a paper exercise. It is more important that the regulations be implemented effectively, in particular with regard to the international transportation of radioactive material and when various transportation modes of land, sea and air are used. As previously mentioned, when regulations of either involved country are not revised, or regulations of different transportation mode in one country are not revised, it produces potential confusion at transfer point, and could also lead to the prospect of a safety problem. Therefore, it is desirable to introduce as far as possible the same safety regulations simultaneously into all transportation modes in all countries. Many organizations and people are involved in developing safe international and national transport regulations for radioactive material. There is some unease about whether it is possible to achieve broad coordination between so many people with a two-yearly cycle. Regulations on dangerous goods transportation in the ECOSOC, IMO and ICAO are reviewed every two years, this is given as the reason why the IAEA Transport Regulations are reviewed every two years. However, this explanation is being questioned.

Many dangerous goods in addition to radioactive material (for example, explosive, high-pressure gas, inflammable liquid, poison) are included in the United Nations Model Regulations and the IMO and ICAO regulations. For these dangerous goods, a large number of materials is listed, and requirements such as packaging and labeling for each material are given. However, requirements for an individual material are comparatively simple.

Special approval from countries concerned is required in order to transport the material that is not listed in the above list. Many new chemical materials that are not listed appear every year in many countries and they require special approval by each government. It is necessary to frequently provide an international unification standard for new dangerous goods, and to add it to the list in order to reduce work on special approval of a government of every country. International confusion will occur if the list of new dangerous goods is not frequently updated.

On the other hand, basic physical and chemical nature of radioactive material are well known, and it is an extremely unlikely that there will be new material details that are not included in the list. In the regulations of transportation of radioactive material, safety requirements for an individual material are prescribed in detail.

The purpose of revising regulations on radioactive material is to improve current regulations. Such improvements are necessary on a regularly basis. However, we should take into account the fact that many packagings are used repeatedly, and consider how we should enforce regulation revision, and provide sufficient time to prepare for revision and enforcement.

It is normal that a time is allowed for adjustment from the present conditions to the revised regulations. During the interim period, two different requirements apply at same time. If another revision is introduced during the interim period, the regulations become very complicated, and it will be difficult to globally implement international unified regulations.

After a revision of regulations has been completed, the next revision should be considered after having evaluated the current revised regulations. If priority is given to revising schedule every two years, and consider the next revision without evaluating result of the current revision, it will cause confusion.

It is open to question what the revision interval of the IAEA Transport Regulation should be. I think that two years is a little bit too short.

When a review is done every two years, I think that it is necessary to divide it into two different areas. The first are those that do not need broad co-ordination, and second are those that do need broad co-ordination. The revision should be done intensively once every 4-6 years, to allow enough time for preparations in the case of those areas that need broad co-ordination.

As last word, I would like to repeat that revision of the safety regulations is not simply things that we have only to write on paper. It is more important to implement the revised regulations effectively.

THE TRANSPORT OF RADIOACTIVE MATERIAL IN NEW ZEALAND
A regulatory perspective

C.M. Ardouin, A.D. Cotterill

Ministry of Health, National Radiation Laboratory,
Christchurch,
New Zealand

Abstract

The National Radiation Laboratory (NRL), acting as New Zealand's regulatory authority and within a regulatory system that implements the International Atomic Energy Agency's (IAEA) transport regulations, has developed an approach to the transport of radioactive materials that takes account of New Zealand's relatively low population (less than 4 million) and its nuclear power free status. Within New Zealand there is, on a world scale, little radioactive material transported. NRL has taken a proactive role in communication, provision of advice and education. This paper discusses NRL's approach and raises issues pertinent to countries similar to New Zealand.

1. Introduction

New Zealand's Radiation Protection Act [1] and Radiation Protection Regulations [2] govern the use and transport of radioactive material. The IAEA Transport Regulations [3] are legally binding (with one minor modification relating to the positioning of vehicle placards) and through NRL, users of radioactive material are required to be licensed (renewed annually by application) and consents obtained to import and export radioactive materials.

New Zealand has the following distinguishing characteristics:

- A relatively small population.
- No nuclear power generation or associated industry.
- There are less than a thousand people licensed to use radioactive materials.
- Relatively little transportation of radioactive materials.
- Very few movements of Type B packages.
- Due to a lack of demand, there is limited expertise available in the transport industry.
- Little incentive for commercial carriers (this could be translated into an unwillingness by commercial carriers to offer a service).
- Transport is predominantly by road. Inter-island transport is by ferry or air.
- Transport can be through geographically remote areas.
- Transport drivers require a driving licence endorsement to carry dangerous goods. The Land Transport Safety Authority administers this.

There are a few reported incidents each year involving the transport of radioactive material. Recent incidents have included:

- Type A packages containing materials destined for medical use could not be readily located while in transit by a commercial carrier.
- Employees of a commercial carrier incorrectly believed a Type A package was leaking.
- Incorrectly labelled Type A packages and incomplete documentation.
- Long delays have occurred in the marine transport of radioactive sources by commercial carriers between the North and South Islands. This was as a result of economies of scale being applied in the use of space on ferries.

2. NRL's approach

(a) General

- NRL has been proactive in communicating requirements through policy statements [4], [5] and will provide advice on request.
- The scope of NRL produced 'codes of safe practice' (compliance with the applicable code is a licence condition) and associated guidance notes include the transport of radioactive material.
- Recently introduced 'core of knowledge courses' for non-medical users include training in transport requirements.
- Regular on-site compliance monitoring of licensees.
- A study day is to be organised for commercial carriers. The purpose of the study day is to provide training and a forum for commercial carriers to discuss issues.
- Consideration is being given to the setting up of a transport of radioactive material user's group.
- A consent to import radioactive material is required from NRL.

(b) Type B packages

Most package movements are of industrial radiography cameras:

- Industrial radiographers are subjected annually to on-site compliance monitoring visits.
- Recently introduced licensing requirements include compulsory attendance at an NRL specified training course and the provision of evidence of continuing education.

(c) Importation of Type B packages

- Prior to the import of notifiable shipments, e.g. Type B(U) irradiator sources, NRL monitors the transport arrangements and advises other government agencies.

(d) Type A packages

Most package movements are medical sources or industrial gauges:

- At regular intervals (2 to 4 years), licensees are subject to on-site compliance monitoring by NRL.
- Recent requirements for non-medical users include licence applicants demonstrating that their training has included all of the components contained in an NRL specified core of knowledge. Licensees are required to provide evidence of continuing education.

(e) Radiation incident response

- NRL co-ordinate a national radiation incident response plan.
- Health Protection Officers, from regional offices, provide a response at the scene. These officers have been trained by NRL and have access to basic instrumentation.
- NRL provide initial telephone advice and a back-up response if required. A duty emergency response officer will respond within 15 minutes of being alerted.
- At least one emergency response exercise is conducted annually.

3. Issues for consideration

- Should future revisions of the IAEA transport regulations address the transport of radioactive materials associated with the nuclear power industry in a separate document? It is believed that this would improve accessibility.
- Is a review needed of the placarding of vehicles when instruments that use radioactive material, such as industrial gauges, are transported by road? There are perceived security (advertising the presence of radioactive material) and health and safety (persons first on site to an accident may be deterred) issues.
- The IAEA could consider producing user-friendly guidance notes for different applications e.g. industrial gauging, industrial radiography etc.

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THE CHALLENGES OF HANDLING AN EVER INCREASING VOLUME OF RADIOPHARMACEUTICALS BY AIR - *A Case Study*

P.D. Horner, S.R. Yates

DHL Aviation (UK) Ltd,
United Kingdom

Abstract.

Transporting radiopharmaceuticals by air is more than just putting a box on an aircraft. Many other factors need to be taken into consideration, primarily the health and safety of the airline staff coming into contact with the shipments, the requirements of the shipper and the needs of the end user. With a thorough understanding of the radiopharmaceutical industry, airlines can work in partnership with manufactures to provide the levels of service required to sustain the industry. The consultation and involvement with employees in developing workable procedures is also critical to the success of the handling process.

1. Introduction

Along with an increased volume of shipments being transported by air, the Aviation industry has faced a gradual increase in legislation, both National and International, over the past number of years. This has lead to a more complex handling process, and requires consultation with several outside agencies.

Following a recent request from a major UK manufacturer of radiopharmaceuticals to increase the volume of shipments sent by air, and the number of destinations served, DHL Aviation (UK) Ltd discovered that there were many complexities that had to be overcome before the details of the contract could be agreed.

2. Compliance with national and international legislation

Before agreeing to handle the additional quantities, the following regulations had to be checked and the operational and financial impact assessed:

International Air Transport Association Dangerous Goods Regulations 44th Edition.
The Radioactive Material (Road Transport) Regulations 2002.
Health and Safety at Work Act 1974 (UK Statute Law).
Ionising Radiation Regulations 1999 (UK Statutory Instrument).
Radiation (Emergency Preparedness and Public Information) Regulations 2001 (REPPIR).

3. Increased support

Monitoring

Additional personal monitoring was purchased, changing from film badges to the more robust TLDs. Direct reading dosemeters were also purchased to assist with the auditing process.

Professional advice

Advice was sought from our Radiation Protection Advisor and the Manufacturer of the radiopharmaceuticals.

Risk assessment

A full risk assessment of the whole handling operation was carried out. This process is required by national legislation (and required to be fully documented). This identified many areas for changes to processes and equipment, in order to cope with the increased volumes, and highlighted the need for additional staff to enable more job rotation.

Liaison with authorities

The REPPIR Risk Assessment had to be resubmitted to the local Health and Safety Executive (HSE) office, due to the the planned increase of MO99 to 18TBq (more than stated in the previous submission).

Documentation and record keeping

All documentation, including Local Rules and Departmental Work Instructions, had to be amended to include the recommendations made by the RPA and the Manufacturer. It was decided to employ the National Radiological Protection Board (NRPB) to keep our dose records. This decision was taken to improve our administrative process, and provide greater visibility to the staff. The company has no Classified Workers (as defined under the Ionising Radiation Regulations).

4. Possible "show stoppers"

Allocation of a budget from the revenue?

The biggest problem was the cost to implement all the additional safety requirements before we could commence handling the freight. This caused difficulties releasing budgets, without any actual revenue received.

Start up costs for new locations

The same problem was encountered with the destination airports, but was exasperated because they would not benefit directly from any revenue for receiving shipments. Some of these airports had never previously received or handled radioactive freight, and had the additional burden of obtaining the necessary licences.

Increased complexity of existing arrangements

The complexity of the arrangements has lead to a increase in the requirements for supervision, training and provision of information.

5. Implementing controls

Process/Procedures

After compiling the revised procedures, the task of implementing them began. Trying to get handling staff to differentiate between "normal" freight and radioactive shipments was the biggest challenge. Once shipments were loaded into the aircraft containers, they became invisible. We had previously encountered problems marking all aircraft containers with the 250mm x 250mm radioactive placard, as the labels used were difficult to remove and soon became permanent fixtures. Our Network Standards Department in Brussels overcame this problem by sourcing labels with a special "easy peel" glue.

Human factors

Human factors always have an impact on new procedures, but are especially pertinent to an unseen hazard. This was overcome with increased supervision, regular audits, provision of direct reading dosemeters and additional training.

6. Comparisons between regular and radioactive shipments

Increased training

Staff require very little training to handle regular shipments (Manual Handling, DHL Procedures etc), whereas the staff handling the radioactive shipments require specialist training. We currently have 25 trained Radiation Protection Supervisors, and all staff involved with the acceptance of the shipments undertake 5 day IATA Dangerous Goods training.

Dwell times

The dwell time for certain regular shipments can be up to 7 days, dependant on the level of service purchased by the customer. Due to the short half life of many of the radiopharmaceuticals, any delay can render the contents useless, at great cost to the manufacturer and to the detriment of the end user/patient. With this in mind, the handling processes were designed to allow the shipper the latest possible delivery times, and the shortest possible handling window before being loaded into the aircraft for uplift.

Special handling

Our facility at East Midlands airport was purpose built in 2000, and contains a fully automated sort system within a 30,000 square metre warehouse. This means that the majority of regular shipments are sorted for destination automatically, requiring limited physical handling by staff. All radioactive shipments are handled manually, to reduce the risk of damage and exposure to untrained staff.

7. Conclusions

The whole process was far more complex and time consuming than at first anticipated. Target start dates have had to be revised, as the additional requirements have been satisfied and destination airports/handling facilities have been upgrading their facilities. Providing all the groundwork, planning and compliance with legal requirements is done in a structured manner, with safety being of paramount importance, the results can be quite rewarding.

Acknowledgements

Radiation Protection Advisory Service (RPAS)
NRPBoard
Environment Agency
Local Health and Safety Executive (HSE) Office (Northampton)

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TRANSPORT OF RADIOPHARMACEUTICALS UNDER ENHANCED SECURITY MEASURES

R.W. Brown

TCInternational, Albuquerque, NM
United States of America

Abstract

The radiopharmaceutical industry makes million of shipments each year of both finished products and the medical radionuclides used to manufacture these drug products. These shipments are made to an from almost every member state of the IAEA. Since the events of September 11, 2001 member states have taken steps to enhance security of all dangerous goods. These well intentioned steps have often resulted in delays causing significant radioactive decay of these short half-life radionuclides. The IAEA can take a leadership role in the international regulatory community by enhancing security measures without allowing delays of critical radioactive materials shipments.

PACKAGE CERTIFICATION AND VALIDATION OF CERTIFICATES FROM AN INDUSTRY PERSPECTIVE

L. Farrington

World Nuclear Transport Institute (WNTI)
6th Floor, 7 Old Park Lane, London,
United Kingdom

Abstract

This paper considers the many aspects of the package certification and validation process, from an Industry perspective, to identify ways to further enhance the efficiency of the regulatory function. The challenge is to achieve these enhancements without a conflict of interest or the perception of a conflict of interest whilst ensuring that the regulator remains clearly independent. The Competent Authorities (CAs), responsible for regulating the transport of radioactive materials around the world, have developed procedures for the overview of the package design and shipment approval process that includes Pre-Transport license application activities; package testing programmes; license application guidance and technical reviews of the applications. There is an impressive degree of competence, experience, and knowledge among the Competent Authorities in the provision of the regulatory function. There is a great deal of constructive interaction between team members, the different CAs and the CAs with Industry; considering the quantity of work. In providing its radioactive material transport regulatory programme over recent years, the CA has demonstrated a commendable openness and a strong desire to be transparent with regard to the vital regulatory activities. The manner in which the CAs support Industry is a demonstration of the commitment to an excellent safety culture in its transport regulations.

1. Introduction

The Competent Authorities (CAs), responsible for regulating the transport of radioactive materials around the world, have demonstrated a commendable openness and a strong desire to be transparent with regard to this vital regulatory activity. A fundamentally important component of the regulatory function is the overview of the package design and shipment approval process. The challenge here is to provide an efficient package certification and revalidation process in a timely manner. This requires close co-operation between CA and Industry; Competent Authority and Industry are constantly striving to streamline and enhance the efficiency of this activity. Some aspects of the package design and shipment approval process are considered below and, where possible, enhancements to procedures and processes are proposed.

2. Package certification and revalidation

The technical arm of the Competent Authority is directly responsible for review and assessment activities associated with the package design and shipment approval process. They are experienced and knowledgeable in their respective areas of responsibility and have well-developed procedures to address many parts of the process.

This paper considers the following specific aspects of the approval processes giving an Industry perspective:

- Pre-Transport License application activities
- Package testing programmes
- License application guidance
- Technical reviews of the applications.

2.1. Pre-transport license application activities

Often, in the past, the first contact of applicants with Competent Authorities was when they applied for an approval. It is now quite common practice for CAs and Industry to get in contact during the preliminary design stages in order to discuss the implementation of the relevant design principles and to establish both the approval procedure and the incumbent actions.

Most CAs and applicants have an established practice of early and active interaction with prospective applicants. This informal interaction, during the very early design review process and thereafter is beneficial in both assuring a quality application and in facilitating the final review process by addressing problems early in the design phase. Whilst all parties acknowledge the benefits of such early interaction, equally, all parties understand the effect that ad-hoc, un-programmed interactions have on scarce resources. Industry works with very demanding shipment schedules and relies on timely Approvals. Staffing levels and financial resources available to regulatory bodies are important to their ability to fulfil their responsibilities in the area of the approval of package design in a predictable and reasonable time schedule.

2.2. Package testing

The impact design of packages is based upon a series of drop tests, which are considered to be the most onerous. The drop tests, are performed to demonstrate that the containment of the package is not breached and that the package is protected from the effects of an impact such that the contents do not breach reactivity limits. The packages usually use drop testing as a fundamental part of their design justification.. Such drop testing utilises, for example, one-third, full size model sections or even full size models of the package.

In general the CA has an established practice of regularly observing physical testing of package designs. The CA reviews and influences proposed package-testing programmes. The discussions include potential use of scale models or prototype packages, attributes of the test facilities, and test details such as drop orientations.

In some cases supplementing drop tests with Finite Element (FE) calculations may be seen as a reliable method of demonstrating structural integrity. However it is also accepted that such analyses can become subjective due to a plethora of unknowns. This has lead to protracted discussions and the inevitable delays to the delivery programme. Some of this subjectivity can be removed during the testing programme as the results of one test are used to influence the conditions of subsequent tests, *with agreement from the regulator*. This can only be achieved if suitably qualified and experienced staff is made available from both Industry and the regulators during the testing programme.

2.3. Application guidance

It is the responsibility of the competent authority to determine that the designs of packages are assessed against all the relevant parts of the Regulations. Many Competent Authorities have issued Applicant’s Guides that are current and comprehensive in scope. The Applicant’s Guides are a practical and useful tool. They are publicly available and include relevant administrative as well as technical aspects with respect to the information that is necessary for the submittal of an application for approval. Consistent approaches and consistent interpretation across the guides can expedite the Approval and subsequent Validation process.

2.4. Technical review of the application

The technical review is a co-ordinated review of, amongst other things, the mechanical engineering, criticality and quality assurance aspects of an application. Most CAs have procedures, at various stages of development that provide an administrative guide for their assessors. From an Industry perspective the review process, whilst complete and thorough may be different from one Competent Authority to another. From an Industry perspective consistency in the review process is an essential efficiency component. Of particular note here is multilateral approval and validation and the importance of making a clear distinction between the two to avoid an excessive or protracted review process.

3. Conclusion

Safe, efficient and reliable transport within the international transport safety regulatory regime is enhanced by the Competent Authorities and Industry communicating and co-operating to the maximum extent throughout the regulation and review processes.

PROPOSED REGULATORY CHANGES TO CREATE A NEW CATEGORY FOR SOME MEDICAL RADIOACTIVE SHIPMENTS

I. Gibbs

Radiopharmaceuticals and Industrials
Australian Nuclear Science and Technology Organisation
PMB 1 Menai, NSW 2234, Australia

Abstract.

During recent times it has become apparent that the freight transport industry is in the process of major change, in particular 'dangerous goods' have been the subject of intense scrutiny. This has prompted a number of carriers to review their 'dangerous goods' policy; in some cases the decision has been made not to carry any dangerous goods, while other carriers have chosen not to accept radioactive shipments. This situation is a major cause of concern to ARI (ANSTO Radiopharmaceuticals and Industrials) because of the effect it has had on some 'urgent' shipments of medical isotopes. Such shipments need to be carried on the first available direct service, but to achieve this carriers will need to be better informed and provided with the option of carrying only 'medical radioactive' shipments. There is a need for the minimal hazard of some medical radioactive shipments to be put into perspective and recognised by regulators of the transport industry.

1. Introduction.

Nuclear Medicine is a branch of medicine that uses radiation to provide information about a person's anatomy and the functioning of specific organs. In most cases the information enables physicians to provide a quick, accurate diagnosis of conditions such as cancer, heart disease, thyroid disorders and bone fractures. In some cases radiation is used to treat these conditions. Nuclear Medicine enables doctors to produce a quick, accurate diagnosis of a wide range of conditions and diseases in a person of any age. This allows the appropriate treatment to begin as early as possible, which means it has a far greater chance of being fully effective.

The tests are painless, and most scans expose patients to only minimal amounts of radiation. Nuclear medicine provides an effective means of examining whether some tissues are functioning properly. Therapy using nuclear medicine is an effective, safe and relatively inexpensive way of controlling, and in some cases eliminating, conditions such as overactive thyroid, thyroid cancer and arthritis. Nuclear medicine is a vital part of health care, as it gives many people the opportunity of continuing to live full and healthy lives.

Small packages (non 'bulk' shipments) of medical radioactive material, by nature of their intended use (injection or ingestion into patients), comprise mainly very short half-life isotopes of low activity. Such products, particularly when contained in approved packaging (individually) represent a very low level of hazard or potential hazard (accident/incident). Even groups of these packages, when handled, stored and carried in accordance with the regulations, have a very low hazard potential.

Australian shippers of radioactive material are extremely fortunate that their relationship with forwarders, carriers and competent authorities is one of complete trust and understanding. These excellent relationships are the result of close cooperation, through fora such as the

ADGATC (Australian Dangerous Goods Air Transport Council), where local, national and international shipping problems are freely discussed and resolution sought.

The ADGATC format has given ANSTO the opportunity to provide additional information, in less scientific terms, to dangerous goods acceptance staff; improving their understanding of radioactivity by putting 'medical' and 'dose' into perspective. Many of these staff, when faced with a 'radioactive' shipping problem have no hesitation in contacting ANSTO for clarification of a particular issue or regulation. The fact that those staff understand the importance of the term 'urgent medical radioactive material' means that every effort is made to ensure that shipments are uplifted and delivered on time.

Unfortunately there appears to be a developing trend, amongst some overseas (Non Australian) airlines, to refuse the carriage of any dangerous goods, while other airlines choose not to carry (only) radioactive material. Unless this trend can be arrested, it will have dire consequences for the 'medical radioactive' industry, and therefore for health care generally, worldwide.

2. How and why do airlines choose not to carry radioactive material?

There are undoubtedly many and varied reasons why airlines choose not to carry radioactive material, and the process of arriving at these decisions may be extremely complex. Regardless of the reasons for a particular decision, that decision can only be based on the information available to the decision-maker. Unless that information is complete, factual and understandable, an inappropriate course of action may be taken. Very few transport company staff would have (even) a basic knowledge of radioactivity or any understanding of different isotopes and their uses, in which case the wrong conclusions may be reached and poor decisions made. Indeed, it is not unusual to find transport company staff who display a 'fear or dread' of completing the dangerous goods check on a shipment of radioactive material.

Nevertheless, transport companies may need to take action as a result of an incident or accident involving a radioactive shipment. In these instances, they must be provided with sufficient information and options to make an informed and rational decision; rather than just adopting the simple solution of refusing to accept all radioactive shipments. After all, incidents involving dangerous goods in passenger baggage do not result in a ban on all passenger baggage; instead the industry tries to better educate the customer.

The existing regulations do not offer airlines much in the way of choice, except by use of the IATA (International Air Transport Association) 'Operator Variations', in which case they may choose to limit Transport Index or place other conditions on carriage. There are virtually no options available and only very limited information on which to base those decisions; it is therefore much easier for airlines to make a blanket decision, and carry no radioactive shipments. Reasons frequently given are that the regulations are complex and onerous, and staff training is expensive. There is a need for fully explained alternatives.

3. Why airlines should be able to carry some radioactive material.

Competent Authorities require all airlines to provide dangerous goods training to cargo acceptance staff; this is to ensure that all 'declared' dangerous goods comply with packaging and documentation regulations. However, this training also enables staff to ask the correct questions that may identify undeclared dangerous goods. So regardless of whether airlines carry radioactive material, staff must still be trained to recognize all dangerous goods and know what to do if they find them. Most airlines will act as an agent for another carrier at some airports, in which case the customer airline may be carrying radioactive material, and therefore require trained staff to complete the dangerous goods checks on their behalf.

The fact that most airlines do not discount freight rates for dangerous goods should be sufficient commercial incentive alone; in addition to which, volume versus weight makes very profitable use of aircraft space when TACT (The Air Cargo Tariff) rates are applied. Most radioactive shipments take up very little space on an aircraft, but off-loads and delays are frequent, regardless of whether the shipment is for industrial or medical use (which again indicates a lack of understanding, particularly in relation to medical shipments). Transport organisations have a social and moral obligation to ensure that these shipments (which may be life saving) are given maximum priority.

The purpose of the IATA / ICAO (International Civil Aviation Organization) regulations is to create a worldwide standard of safety for the aviation industry. This should also apply to the standard of information that is used to make their decisions, but it is obvious that some organisations are better informed (or make more effort) than others.

4. How can airlines carry radioactive material?

Most airlines can and do carry radioactive material, in accordance with all regulations, in complete safety. Those airlines that have elected not to carry radioactive shipments need to be given an alternative that will persuade them to accommodate the transport of medical shipments on passenger aircraft. To achieve this, it may be necessary to change or add to some of the existing methods of classification.

Shippers are required to provide a considerable amount of information when completing the 'shippers declaration'. Of most importance to the carrier, the shipment will be allocated to one of three categories; (White 1, Yellow 11 or Yellow 111) which are based on the Transport Index and Surface Dose of the package. Unfortunately, this information only indicates the radiological hazards for storage and transport but provides no indication of the 'potential for hazard' or the intended use of the product. It is possible for two Type A packages to have exactly the same Transport Index and Surface Dose, yet the activity and 'potential hazard' of the two isotopes contained within could be extremely different, and in the event of an incident, may need to be treated in different ways.

This means that a small (low activity) medical isotope shipment, that is to be administered to a single patient, will be treated exactly the same as an industrial isotope. This is despite the fact that the medical product will have very low activity and a very short half-life while the industrial source could have a much higher activity, and a half-life of many years. The only apparent differences between these packages would be the weight (thickness of shielding) and (possibly) the dimensions of the package. What most transport organizations do not realize is that the 'potential hazard' of the medical product is insignificant when compared to that of the industrial source.

It may therefore be necessary to provide a special category, within the regulations, that identifies medical shipments. Such a category could be restricted to Type A packages of certain medical isotopes and (limited) activity that have been identified, by the regulators, as having a minimal 'potential hazard'. These shipments would still be packed, stored and carried in the same way as any other 'Type A' package, but with the added identification of minimal 'potential hazard' medical products. A shipping statement such as 'Type A {MED}' would immediately put the shipment into perspective, by indicating to the carrier the true nature of the shipment, and the extremely low 'potential hazard'. This would at least give carriers the option of an including an 'Operator Variation' in the 'IATA Dangerous Goods Regulations' that may state; 'Class 7, Type A (MED) only accepted for carriage'.

5. Summary

Transport organisations that presently carry radioactive shipments must be given all possible assistance to ensure that they continue to provide this vitally important service. For those organisations very little would change, except that they would be provided with additional information and an additional category of Type A (Med).

Organisations that have made a blanket decision not to carry any radioactive shipments should be persuaded otherwise; the 'potential hazard' for shipments of low activity medical products must be put into perspective. If this can be done, those organisations will at least have a fully detailed option that provides all of the information on which to base their decision. Perhaps a lesser 'potential hazard' option would be sufficient incentive for those organisations to resume the (limited) carriage of medical radioactives.

6. Conclusion

In parts of the world, where many airlines operate on the same routes and there are several flights a day to almost any major international destination, this is not yet an issue for shippers of radioactive material.

Despite having excellent relationships with national and international carriers in Australia, ANSTO frequently finds it difficult to supply international customers' needs because of the lack of scheduled direct flights. This often means that there will be several shipments booked on a single flight from Sydney, creating a transport index space problem for the carrier, which may result in an off load.

Shipping problems created by the shortage of direct schedules to particular destinations can be particularly frustrating, and very difficult to explain to customers when another carrier is operating but will not carry dangerous goods.

The reason for the proposed changes is to ensure that all transport organisations will carry (some) 'urgent medical radioactive material', thereby creating guaranteed space on any commercial passenger flight worldwide, and thereby helping to ensure that those who need nuclear medicine treatment can receive it.

THE IMPORTANCE OF RADIOPHARMACEUTICALS AND RADIONUCLIDES IN MEDICINE AND RESEARCH

R.W. Brown

TCInternational, Inc., Albuquerque, NM
United States of America

Abstract

Radiopharmaceuticals and medical radionuclides are used by physicians and biomedical researchers each day throughout the world. Radiopharmaceuticals provide physicians with a means of diagnosing a variety of diseases including cancer, AIDS, pulmonary emboli, coronary artery disease, and many others. Radiopharmaceuticals can also be used for therapeutic treatment of many types of cancer as well as other diseases. Medical radionuclides are used by biomedical researchers for the study of human disease, drug development, AIDS research, and many other areas. Transport of these radionuclides is critically important. Their unencumbered movement ensures availability of these products to all physicians and researchers. Uniform international standards for transport provide the framework for the free movement of these materials across member state borders.

1. Introduction

Radiopharmaceuticals are used in more than 40 million medical diagnostic and therapeutic procedures each year around the world [1]. Radionuclides are used by biomedical researchers in a variety of disciplines and products [2]. The short half-lives of these radionuclides require rapid transportation, in many cases, across the borders of several countries. Uniform international transport regulations are required to allow these materials to move freely. Enhanced security measures for radioactive materials that have been added in the last few years also threaten rapid transport of these materials. It is important to maintain security when shipping radioactive material, without causing delays.

2. Nuclear medicine uses of radiopharmaceuticals

Nuclear medicine is the medical specialty that uses radioactive material for the diagnosis and treatment of illnesses. Diagnostic radiopharmaceuticals typically use short half-life radionuclides that emit low-energy gamma rays. The pharmaceutical ligand of these products seeks out a specific organ or group of cells in the body. The gamma rays emitted by the radionuclide attached to the ligand allow images to be collected by an imaging device. The image formed allows physicians to study abnormalities or the function of the organ or group of cells being studied.

Table 1 lists several of the most used diagnostic radiopharmaceuticals [3].

Table I

Radionuclide	Nuclear Medicine Study	Half-life
Tc-99m	Diagnostic imaging of the brain, kidneys, lungs, heart	6 hours
Tl-201	Myocardial perfusion imaging	73 hours
Ga-67	Tumor and infection localization	79 hours
In-111	Blood pool imaging, tumor localization	67 hours

As compared to diagnostic radiopharmaceuticals, therapeutic radiopharmaceuticals utilize larger quantities of radionuclides to irradiate and destroy diseased tissue. These radionuclides can emit gamma rays or energetic beta particles. Clinical studies are also underway exploring the possible use of alpha emitting radionuclides for use in nuclear medicine. Therapeutic radiopharmaceuticals are designed to travel to the site of the diseased tissue, deposit large quantities of energy and destroy the tissue, while sparing the nearby healthy tissue. A newly approved therapeutic radiopharmaceutical [4] in the United States utilizes a monoclonal antibody to attach radioactive Y-90 to non-Hodgkin's lymphoma cells, destroying them. A list of common therapeutic radiopharmaceuticals is listed in Table II [5].

Table II

Radionuclide	**Therapeutic procedure**	**Half-life**
P-32	Polycythemia Vera	14.3 days
I-131	Graves Disease, Thyroid Cancer	8 days
Y-90	Non-Hodgkin's Lymphoma	2.7 days

New radionuclides and radiopharmaceuticals are continually being developed. New uses of therapeutic radiopharmaceuticals and medical radionuclides include the treatment of rheumatoid arthritis, use in intramuscular brachytherapy following angioplasty, treatment of Alzheimer's disease, and many others. Also, many new sources of radionuclides have appeared in the last few years including major suppliers from the Russian Federation and other former Soviet Union countries. Transport of the radioactive materials from these new suppliers to the manufacturers of radiopharmaceuticals and research products relies on uninhibited movement of these materials across state borders.

Shipments of medical radionuclides are increasing in the United States and other countries. It is estimated that there are more than 14 million shipments of radioactive materials for medical use each year in the United States alone [6]. Extensive use of radionuclides in biomedical research is paralleled by uses in research in chemistry, physics, biology, and geosciences in academics and in the commercial sector.

3. Transportation concerns

Uniformity of transportation regulations is essential for the timely transport of radiopharmaceuticals and medical radionuclides. Although most member states adopt IAEA Safety standards [7], delays in implementation and deviations can cause delays in transporting these products across country borders. Delays in the transport of short half-life medical radionuclides can lead to appreciable radioactive decay. Harmonization of transport regulations will ease the existing customs and security issues for these shipments, thereby reducing the probability of delays.

The radiopharmaceutical and medical radionuclides industry has also experienced difficulties in the last several years getting package certifications revalidated. The industry has witnessed competent authorities in one country requiring significant amounts of data on packages that were validated by the competent authority in the country of original approval. One of the benefits in international regulations is the ability of competent authorities to re-validate the work of their counterparts in another country. Delays in re-validation can also cause unnecessary delays and create difficulties in transporting these materials. In some cases the delay of re-validation can result in the loss in the ability to use a transport container, awaiting competent authority approval.

Several recent working sessions at IAEA [8] have dealt with appropriate radiation protection programs. This was also the subject of a session at the PATRAM '01 meeting [9] in Chicago.

At this session there was a general recognition that reasonable radiation protection program requirements were important. Tiered requirements based on the quantity of radioactive material being transported are important to assure the cost of developing the radiation protection program is commensurate with the level of risk. In 2000 IAEA published a technical document [10] (TECDOC) that addressed development for Radiation Protection Programs. The TECDOC was developed in late 2000 and early 2001 by an international panel at the meetings referenced above. This sort of guidance document and proper risk-based regulatory requirements help those that offer medical radionuclides for transport, and those that transport them.

4. Summary

Radiopharmaceuticals and medical radionuclides have led to significant improvements in healthcare and biomedical research. More radiopharmaceuticals are expected to enter the market in the next several years. This will allow physicians to diagnose and treat heart disease, cancer, dementia, and a variety of other illnesses more quickly and effectively. Medical radionuclides are also playing an increasingly important role in research on illnesses such as AIDS and SARS. Timely transport of these products is critical for the diagnosis, and treatment of patients worldwide, and for the medical research being conducted. Harmonization of international regulations is also important as these products move across state borders. Co-operation between competent authorities in the re-validation of shipping containers assures these products move in a safe and efficient manner, with minimal delays.

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REFLEX SAFETY DISTANCES TO BE IMPLEMENTED IN THE EVENT OF A TRANSPORT ACCIDENT INVOLVING RADIOACTIVE MATERIAL

F. Rancillac, G. Sert, T. Cleach

Institut de Radioprotection et de Sûreté Nucléaire
Fontenay-aux-Roses, France

Abstract.

The purpose of this paper is to set out the results of IRSN's assessment of the safety distances to be implemented as first response to a transport accident involving radioactive material. It details the public health criteria and criteria used for selecting the accident situations covered. It then presents the safety distances calculated for each of the adopted scenarios. As the aim of this work is to help the emergency response teams set safety perimeters, three so-called reflex distances of 100 m, 500 m and 1000 m appropriate to the accident circumstances have been identified from the calculated distances. These distances may change while the accident is being dealt with as and when more precise information becomes available.

1. Introduction

As part of the review of transport emergency response plans for radioactive material (PSS-TMR), the IRSN has redefined the land transport accident situations involving radioactive material for which safety perimeters should be set and has evaluated their distances.

The assessment of these safety perimeters is made on the assumption that the safety measures implemented for the transport of radioactive material have failed or are inadequate. This approach does not question these measures, but is part of defence in depth that provides for graded safeguard levels, that are the last line of consequence limitation procedures in the event of an accident.

This paper aims to present the methodology pursued and the results obtained [1]. It starts by outlining the public health criteria adopted, and then the approach retained for identifying the accident situations covered and finally arrives at the appropriate safety distances to apply.

2. General methodology

The broad approach for assessing safety distances was drawn up following consultation with the key ground forces to take on board their intervention experience, including coping with chemical accidents and incorporate feedback on the exercises. It provides for the following stages:

- identifying envelope accident situations in terms of their consequences for the population. This stage entails predicting the various types of radioactive material, packages, failures and acts of aggression, and assessing the radiological or toxic consequences of envelope accidents;
- comparing the calculated consequences against the population exposure thresholds for radioactive or chemical release that when exceeded warrant population protection measures, so that safety distances can be set;
- identifying which items of information (or criteria) could be gathered at the scene of the accident to assess its actual or potential severity and define the appropriate safety perimeter;
- grouping certain situations together to limit the number of reflex safety perimeters.

3. Health criteria

A dose criterion of 10 mSv was adopted to define the extent of the no-go perimeter for protecting the population from radiological risks arising from a transport accident.

This criterion is in line with the accident dose constraint of 50 mSv considered as the basis of the IAEA transport regulation, considering the safety margin needed to take into account the uncertainties that affect the performed assessment.

Certain situations involving packages that have lost their protection shields with yet no release of material, lead to direct radiation, for which an exposure time of 5 hours has been adopted. About one hour should be allowed to assess the reality or risk of high-level exposure with the appropriate measuring devices. Secondly assessment should be made of the time required to evacuate the population involved. A 4-hour deadline has been adopted which would appear to be the upper limit, bearing in mind that this depends very much on how built-up the affected area is.

The effect thresholds adopted for chemically related risks to health, are for irreversible health effects the IDLH quantities (Immediately Dangerous to Life and Health) for hydrofluoric acid and the "renal lesion" effect threshold for uranium.

4. Choice of accident scenarios

The regulations identify six types of package for transport purposes that are differentiated by their withstand levels, according to the activity concentration of the radioactive material transported and its radiotoxicity. Various types of realistic accident have been envisaged for these six types of package that could result in damage to or destruction of their containment barriers or radiation protection shields.

It was judged that the consequences of an accident involving exempt type packages would not reach the adopted dose criteria in the immediate vicinity of the destroyed package. Therefore no specific scenario for excepted packages has been studied.

Industrial packages are regularly transported in large number and may contain significant masses of radioactive material. These packages may be totally destroyed during an accident. The materials retained are concentrates of uranium, uranium-235 enriched uranium oxide in powder form, uranyl nitrate in solution and solid uranium hexafluoride, very large amounts of which (several metric tons) may be involved in a transport accident. Furthermore these materials are very prone to dispersal by wind or fire.

The consequences of an accident affecting a type-A package would be limited because of its low-level activity. Nonetheless many of these packages are often transported together ; so they have been included. Molybdenum has been retained because it is a major feature of type-A package consignments.

Type-B packages are used for transporting materials that present the highest risk because of their radiotoxicity and quantity of material transported. The radioactive materials retained for scenarios involving type-B packages are, for the nuclear fuel cycle, spent fuel and plutonium oxide in the form of powder or MOX fuel. The other, less easily dispersed materials have not been included. Accident situations involving gamma ray sources loaded with iridium-192 (very frequently transported) and consignments of intense sources of cobalt-60 have been included to represent packages of radioactive sources in industrial use.

Only those situations involving mechanical impact and fire have been included as possibly resulting in damage to the various containment barriers and release of radioactivity into the environment or a significant increase in radiation.

Acts of malevolence have not been explicitly considered in the study. Likewise, accidents involving aircraft crashes have not been assessed because the probability of serious consequences in this event has recently been reduced by the implementation of new tougher withstand requirements for type-C packages. Furthermore the information on the presence of a radioactive cargo in the aircraft would be hard to gather during the accident management reflex phase. Similarly, criticality accidents have not been included because of their low probability, and await the development of a realistic assessment method of their consequences.

5. Safety distances applied to the accident scenarios

Table 1 below presents the accident situations studied, and summarizes the safety distances calculated for the packages and materials included in the study.

Table 1: summary of calculated safety distances

<table>
<tr><th rowspan="2">Type of materials</th><th rowspan="2">Amount involved</th><th rowspan="2">Package type</th><th rowspan="2">Accident type</th><th rowspan="2">Amount released into the atmosphere</th><th colspan="2">Calculated safety distance</th></tr>
<tr><th>DF2(1)</th><th>DN5(1)</th></tr>
<tr><td>Other than those below</td><td></td><td>In excepted or industrial packages other than those below</td><td>impact + fire</td><td></td><td rowspan="9" colspan="2">≤ 100 m</td></tr>
<tr><td>U_3O_8</td><td>14 t</td><td>DV70</td><td>impact + fire</td><td>50 kg</td></tr>
<tr><td>UO_2</td><td>3.5 t</td><td>BU-J</td><td>impact + fire</td><td>1 kg</td></tr>
<tr><td>UF_6</td><td>12.5 t</td><td>48 Y</td><td>impact</td><td>a little</td></tr>
<tr><td>Uranyl nitrate</td><td>6.8 t of U</td><td>LR65</td><td>impact</td><td>a little</td></tr>
<tr><td>PuO_2</td><td>undisclosed</td><td>FS47</td><td>impact</td><td>0</td></tr>
<tr><td>Spent fuel</td><td>3168 rods</td><td>TN12</td><td>impact</td><td>0</td></tr>
<tr><td>Mo99</td><td>6 TBq</td><td>Type A</td><td>impact + fire</td><td>6 TBq</td></tr>
<tr><td>Ir192</td><td>10 TBq</td><td>Gamma ray source</td><td>impact</td><td>0</td></tr>
<tr><td>Co60</td><td>370 TBq</td><td>SV34</td><td>impact</td><td>0</td><td colspan="2">200 m(2)</td></tr>
<tr><td>PuO_2</td><td>undisclosed</td><td>FS47</td><td>impact + fire</td><td>0.07 g</td><td>200 m</td><td>150 m</td></tr>
<tr><td>Spent fuel</td><td>3168 rods</td><td>TN12</td><td>impact + fire</td><td>160 broken rods(3)</td><td>450 m</td><td>300 m</td></tr>
<tr><td>Co60</td><td>7400 TBq</td><td>F168X, SV34 (notified packages)</td><td>impact</td><td>0</td><td colspan="2">500 m(2)</td></tr>
<tr><td>Uranyl nitrate</td><td>6.8 t of U</td><td>LR65</td><td>fire</td><td>680 kg</td><td>1200 m</td><td>700 m</td></tr>
<tr><td>UF_6</td><td>12.5 t</td><td>48 Y</td><td>impact + fire</td><td>6 t of UO_2F_2 extracted by the plume</td><td>1800 m</td><td>1100 m</td></tr>
</table>

(1) : DF2 = low diffusion atmospheric conditions with a wind speed of 2 m/s, DN5 = normal diffusion atmospheric conditions with a wind speed of 5 m/s.

(2) : The distance is equivalent to a dose of 10 mSv by direct radiation, for an exposure time of 5 hours.

(3) : Here 160 broken rods are equivalent to an atmospheric release of 4.10^{16} Bq of krypton-85, 10^{11} Bq of iodine-129, and 2.10^{15} Bq of tritium.

The safety distances calculated for a given scenario are for class DF2 and DN5 atmospheric situations in a ratio of 1.5 to 2. It is reasonable to retain only the values that correspond to class DN5 conditions since conservative hypotheses have been adopted for defining envelope accident situations.

6. Conclusion: reflex safety distances retained

If table 1 is examined, three distances : 100 m, 500 m and 1000 m, stand out. A ballpark breakdown could spoil the applicability of the associated recommended measures, whereas too detailed a breakdown could spoil the practicality of the logic of implementing safety perimeters.

These safety distance groupings are presented in table 2 together with the criteria that determine the implementation of the safety perimeter.

A safety distance of 100 meters is adopted for the most frequent type of transport accident involving radioactive material, namely low risk accident situations.

A safety distance of 500 meters is adopted for transport accidents with the risk of widespread fire, involving type-B packages. This distance could also be adopted for transport accidents involving a notified consignment.

A safety distance of 1000 meters is adopted for transport accidents with the risk of widespread fire, involving tanks of uranyl nitrate or packages loaded with UF_6.

Table 2 : scenario groupings for three safety distances

Package type	**Safety distances as per initial assessment of the packages**	
	"Seriously damaged"	**Directly affected by a "serious fire"**
• Excepted • Industrial (excluding UF6 and UNH) • Type-A	100 m	100 m
• Type-B	100 m	500 m
• "Notified" packages (packages requiring prior notification to the authorities)	500 m	500 m
• Tanks of uranyl nitrate (UNH) • Industrial package of UF6	100 m	1000 m

Perimeter magnitude and population density will **however** dictate the contingency measures **actually** taken (confinement or evacuation).

Recommending these safety distance values in the specific emergency plans drawn up by the local French authorities responsible for accident management, completes the emergency measures provided for and strengthens the safety of radioactive material transport in defence in depth logic.

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EMERGENCY RESPONSE IN THE FIELD OF THE TRANSPORT OF RADIOACTIVE MATERIAL IN GERMANY

C. Fasten[a], F. Nitsche[a], D. Trepesch[b]

[a]Federal Office for Radiation Protection, Salzgitter,
[b]City of Munich, Fire Department, Munich,
Germany

Abstract.

The „Regulations for the Safe Transport of Radioactive Material" of the International Atomic Energy Agency contain also in the latest 1996 Edition (Revised) requirements for emergency response. As part of compliance assurance the relevant national and/or international organizations have to establish emergency provisions and procedures for the events of accidents or incidents during the transport of radioactive material to protect persons, property and the environment. In Germany due to its federal system the Ministries of Interior of the states have the main responsibility for emergency response. The responsible authorities have to give guidelines to the first responders (fire brigade, police, rescue service) for their first activities in case of an accident/incident. For this special case the European Chemical Industry Council (CEFIC) developed so called "Emergency Response Intervention Cards" (ERICs) for the ADR member states. The class 7 ERICs were developed in Germany and the preparation for their use in Europe is now underway. The paper gives an example of such an ERIC to show which activities are necessary in the first 30 minutes after an accident happened.

1. Regulations

Demands for planning and preparing for emergency response to transport accidents involving radioactive material are established in Germany by regulations under the German Atomic Law and under the Dangerous Goods Transport Law as well. The general requirements for emergency response according to the "Regulations for the Safe Transport of Radioactive Material No. TS-R-1, 1996 Edition (Revised) of the International Atomic Energy Agency [1] are implemented in the dangerous goods regulations for all modes of transport: road, rail air, see and inland waterway. In addition the German Radiation Protection Ordinance also contains specific emergency response requirements concerning technical and personnel precautions in case of transport of radioactive sources with high radioactivity and there is also a special order concerning notification for accidents/incidents.

2. Responsibilities

In the Federal Republic of Germany the federal government is responsible for establishing general laws, the framework and the responsibilities in the field of emergency response. Due to its federal system the Ministries of Interior of the federal states are responsible for the practical implementation of emergency response and have to give guidelines for the fire brigades, police and other rescue teams. The responsible authorities make use of special radiation protection centres, e.g. for measurements of contamination and dose rate or in the case of accidents with personally damage.

On the other hand in Germany the owners of nuclear facilities are obliged by para 53 of the German Radiation Protection Ordinance to take technical and personnel precautions to stabilize the nuclear facilities after an accident, to analyze the cause for it and to eliminate the effects caused by the accident. The legislator has left it up to the owners to organize this precaution alone or to place part of it in the hands of an appropriate institution.

In 1977 the German power supply companies (EVU) operating nuclear power plants, as well as all fuel cycle companies and big nuclear research institutes decided to place part of the precautions against an accident in the hands of a joint private institution and thus founded the Kerntechnische Hilfsdienst GmbH (KHG) in Eggenstein-Leopoldshafen near Karlsruhe. These three groups represent 43 individual companies with which KHG has entered into contracts for accidental missions. [2]

The KHG is also available for emergency response in case of transport accidents/incidents of nuclear material. Also if sources of high radioactivity are transported such an emergency response company like KHG is necessary and must provide emergency service during such a shipment.

3. Guidelines

It is very important especially for the first responder to have practical guidelines in the framework of emergency response and appropriate training. In 1999 the European Chemical Industry Council (CEFIC) developed the Emergency Response Intervention Cards (ERICs) as a practical guide for all classes of dangerous goods exclusive class 1 and class 7 to be available for the ADR member states. In Germany and in the Netherlands also ERICs for class 1 and 7 were created. In 2002 CEFIC decided to harmonize the ERICs in Europe for all classes of dangerous goods and the implementation is under way. For class 7 only *four* ERICs were created, depending on the different labelling on the packages, the potential of risk, the criticality aspect and the subsidiary risk for uranium hexafluoride as follows:

7-01: Radioactive material in excepted packages (low activity)
7-02: Radioactive material, non fissile or fissile excepted (medium – high activity)
7-03: Radioactive material, fissile (low – high activity)
7-04: Radioactive material, highly corrosive, toxic (uranium hexafluoride).

This kind of categorization basically agrees with the provisions of the IAEA Safety Standards Series No. TS-G-1.2 [3].

The Annex to this paper contains the ERI-Card **7-03** for fissile radioactive material as an example. The structure of all ERICs is the same: the title is followed by the characteristic group of substances and the hazards, the measures for the first 30 minutes, first aid and the measures after intervention.

After the completion of all class 7 ERICs within the involved European countries it is planned to submit them to the International Atomic Energy Agency for implementation into the TS-G-1.2. [3].

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Radioactive Material, fissile (low - high activity)

7
03

Characteristics

- Shipment as Type IF, Type AF, Type B(U)F, Type B(M)F, Type CF packaging or transport under special arrangement.
- Radiation presents limited risk to transport workers, emergency response personnel and the public in the case of a transport accident.
- Solid or liquid.
- Under normal transportation conditions and in the case of a transport accident a chain reaction is excluded.
- Labels outside packages means:
  Maximum radiation level on undamaged package surface:
  category I-white: *0,005 mSv/h*
  category II-yellow: *0,5 mSv/h*
  category III-yellow: *2 mSv/h* (transport under exclusive use: *10 mSv/h*)
- Criticality Safety Index (CSI)-label is presented.

Hazards

- Contents of damaged packages may released.
- Limited risk of external radiation.
- Risk of contamination and internal radiation hazards only for damaged packaging.
- High risk at failure of container (only for Type BF or Type CF packaging).

Personal Protection

- Self contained breathing apparatus.
- Coverall for protection against radioactive contamination.
- Personal dosemeter and doserate monitoring (if possible use teleprobe).

Intervention Actions

General

- Risk area: cordoning off a doserate of 25 μSv/h.
- Keep upwind – put on protection equipment before entering risk area.
- Minimize number of personnel in risk area.
- Inform competent authority immediately.
- Storage at scene of accident: store packaging in groups with maximal CSI of 50 (each group). Minimal distance between the groups: 6 m.

Spillage

- Avoid contact with spilled material.
- If substance has entered a water course or sewer, inform the responsible authority.

Fire (involving the cargo)

- Remove undamaged packages if possible away from heat radiation.
- Put not water into leaking area.
- Minimize use of extinguishing media and contain runoff.

Radioactive Material, fissile (low - high activity)

7
03

First Aid

- Rescue casualties out of risk area; medical attention takes priority over radiation protection measures.
- Remove contaminated clothing immediately, protect respiratory passages (e.g. facemask) and drench affected skin with plenty of water.
- Persons who have been in contact with the substance should get immediate medical attention. Pass on all available product information.
- Cover contaminated injuries with sterile surgical gauze.
- Mouth to mouth resuscitation should be avoided. Use alternative methods, preferably with oxygen or compressed air driven apparatus.
- Contact the regional centre for radiation protection.

Essential Precautions For Product Recovery

- Do not use standard recovery equipment. Seek radiation authority advice immediately.

Precautions After Intervention

Undressing

- Check personnel by radiation measuring of contamination, before removing facemask and protective suit.
- Use coveralls for protection against radioactive contamination and facemask, while undressing contaminated workers or handling contaminated equipment.
- Secure removed, contaminated clothing in plastic bags.
- Personnel who have been in contact with the substance should get immediate medical attention. Pass on all available product information.

Equipment Clean Up

- Only in case of contamination: Seek specialist advice before leaving incident.

For Additional Information Contact

- Emergency service for nuclear engineering.

EMERGENCY ARRANGEMENTS FOR CIVIL TRANSPORT OF RADIOACTIVE MATERIALS IN GREAT BRITAIN. *The Regulatory Framework*

E.J. Morgan-Warren

Department for Transport, 2/33 Great Minster House
76 Marsham Street, London
United Kingdom.

Abstract

The provision of effective emergency arrangements for the transport of radioactive materials is essential to ensure the protection of workers, the public and the environment. This paper presents a brief description of the regulatory framework for emergency provisions in Great Britain, and the plans that are put in place by both government and industry.

1. Introduction

Regulations governing the transport of radioactive materials are designed expressly to ensure that the materials are transported safely under all reasonably foreseeable conditions of transport. To this end a number of levels of safety provision are included and provide "defence in depth". The well known provisions of the IAEA regulations, TS-R-1 [1], include packaging and labelling standards which are graded according to the nature and quantity of the contents, quality assurance provisions, and a range of administrative requirements designed to ensure effective protection against incidents. Further to these provisions, the IAEA regulations also contain the requirement for suitable emergency arrangements to be put in place and included in the information to be provided by the consignor to the carrier. Health and safety legislation also includes the need for emergency preparedness, and the regulatory system also specifies criteria for intervention and the availability of information to the public. This paper presents a brief review of the regulatory provisions covering emergency response, and discusses the emergency planning and incident monitoring arrangements in Great Britain.

2. Requirements and recommendations

The basic requirement for contingency plans for work involving radioactivity is specified in The Ionising Radiations Regulations 1999 [2] (IRR), which are made under the wide-ranging Health and Safety at Work etc. Act 1974 [3]. The IRR require that before a new activity commences, an assessment be made of the associated risk to any employee or other person for the purpose of identifying the measures required to restrict exposure to ionising radiation. The IRR then state that where this assessment indicates that a radiation accident is reasonably foreseeable, then "the radiation employer shall prepare a contingency plan designed to secure, so far as is reasonably practicable, the restriction of exposure to ionising radiation and the health and safety of persons who may be affected by such an accident." The IRR also implement other provisions of the European Council Basic Safety Standards Directive 96/29/Euratom [4] relating to occupational radiation protection. Articles 48 to 52 of the directive, concerning intervention, are implemented in The Radiation (Emergency Preparedness and Public Information) Regulations 2001 [5] (REPPIR) for premises and rail transport, and transport across public places which involves non-standard modes of transport (e.g. fork-lift trucks). For road, sea and air transport purposes the intervention provisions are implemented separately in the modal transport regulations.

The IAEA transport regulations [1] go beyond this requirement in the statement that "In the event of accidents or incidents during the transport of radioactive material, emergency provisions, as established by relevant national and/or international organisations, shall be observed to protect persons, property and the environment." Thus the transport regulations apply to any accident or incident, without the qualification "reasonably foreseeable", and are required to protect property and the environment as well as persons. In Great Britain, evidence of a suitable emergency plan is required to gain competent authority package approval. The transport regulations are supported by the comprehensive guidance document, TS-G-1.2 [6], which provides recommendations on all stages of emergency response from the planning process through preparation for response, to the handling of accidents and the eventual post-emergency activities. A key recommendation in TS-G-1.2 is that there should be a national response plan, on which provincial and local plans should be based, and that consignors and carriers should have their own plans to fulfil their responsibilities for preparedness in relation to their shipments.

3. Regulatory provisions

3.1. Transport by road and rail

The requirements for emergency arrangements are implemented in the appropriate modal transport regulations. The Radioactive Material (Road Transport) Regulations 2002 [7] (the road transport regulations) specify the duties of the parties involved both in the preparation of emergency arrangements and in the event of a radiological emergency. Preparation of emergency arrangements for the transport of a package is the responsibility of the consignor who must have drawn up a documented plan of the emergency arrangements before the transport begins. The arrangements have to take into account the following principles (summarising from the regulations):

- intervention may be undertaken only if the damage resulting from the emergency is sufficient to justify the potential harm and cost (including social cost) of the intervention,
- the intervention must to optimised to ensure a positive benefit results from the intervention, and
- regard must be taken of the dose limits provided for in the IRR [2], and of the Emergency Reference Levels specified by the National Radiological Protection Board (NRPB).

The consignor may employ the services of another person with appropriate expertise (including a person who is a carrier) in the preparation of his emergency arrangements, and must review, and where necessary revise, the arrangements and ensure that they are tested at suitable intervals. A carrier, for his part, must not undertake the transport of a consignment unless he has a copy of the consignor's statement of emergency arrangements.

In the event of an emergency, the driver of the vehicle must notify the emergency services and the consignor, initiate the emergency arrangements, and assist in the intervention. The carrier is required to notify the police (unless the driver has already done so) and the Secretary of State, to assist in the intervention and to arrange for examination of the load and safe disposal. The consignor, in turn, is obliged to make similar notifications as appropriate, to assist in the intervention and to provide details of the incident to the Secretary of State. The consignor must also arrange for a package that has been involved in a radiological emergency to be examined, and to be satisfied that it complies with the regulations before onward transport.

The road transport regulations also specify provisions for the monitoring of persons, referring to the appropriate sections of the IRR, and ruling that persons involved in intervention must be classified persons according to the IRR and subject to the normal dose limits, excepting that, under exceptional conditions for the purpose of saving lives, the dose limits for employees over 18 and certain other persons may be exceeded provided that the persons are volunteers and have been informed of the risks. Significantly, the road transport regulations provide an exemption for the transport of a consignment that is undertaken by or under the supervision of the emergency services (including by breakdown vehicles), or in an emergency intended to save human life or to protect the environment, provided that all measures are taken to ensure safety.

Transport of radioactive materials by rail is regulated by the HSE through The Packaging, Labelling and Carriage of Radioactive Material by Rail Regulations 2002 [8] (the rail transport regulations). These regulations are constructed somewhat differently from the road transport regulations and refer extensively to the RID regulations [9]. Thus the duties of a consignor are given by reference to RID, which states that the consignor shall provide in the consignment note a statement of actions required to be taken by the carrier, including the emergency arrangements appropriate to the consignment. The rail transport regulations place a duty on every person involved in the carriage of radioactive material, where there is a risk of injury, to notify the emergency services (unless they know that this has been done) and to provide them with such information as they may require. Train operators, facility owners and infrastructure controllers are required to draw up and give effect to procedures to deal with emergencies, and to co-operate with each other to ensure effective co-ordination of their safety systems. In the case of rail transport, the intervention requirements of the Basic Safety Standards Directive [4] are implemented through REPPIR [5]. Many types of consignment by rail are exempt from the provisions of REPPIR, in recognition of the high levels of protection provided by compliance with the IAEA transport regulations. Such exemptions include Type B(U), Type B(M) and Type C packages and consignments carried under special arrangement.

3.2. Transport by sea and air

Transport of radioactive materials by sea is subject to the provisions of the International Maritime Dangerous Goods Code [10] (the IMDG Code) that is implemented through The Merchant Shipping (Dangerous Goods and Marine Pollutants) Regulations 1997 [11], as amended by Merchant Shipping Notices (MSN's) from time to time, and enforced by the Maritime and Coastguard Agency. The IMDG Code contains a number of special provisions for incidents involving radioactive material including the following:

- observation of emergency provisions as established by relevant national or international organisations in accordance with the IAEA guidance material [6],
- restriction of access to a damaged or leaking package and assessment of the package, conveyance and surrounding areas by a suitably qualified person, together with appropriate measures to limit the consequences of the damage,
- removal of packages to an acceptable interim location, and
- reference to the Emergency Procedures for Ships Carrying Dangerous Goods (EmS), and the Medical First Aid Guide for Use in Accidents Involving Dangerous Goods (MFAG), which are appended to the IMDG Code.

Where there is an actual or probable discharge of material from the ship, the master of the ship is required under The Merchant Shipping (Reporting Requirements for Ships Carrying Dangerous or Polluting Goods) Regulations 1995 [12] to notify the incident to the appropriate competent authority. Ships carrying INF Cargo as defined in the INF Code [13], are required under The Merchant Shipping (Carriage of Packaged Irradiated Nuclear Fuel etc.) (INF Code) Regulations [14] to carry an approved shipboard emergency plan incorporating the procedure to be followed for notification, and a list of the authorities to be notified, a detailed description of procedures to be followed to minimise the consequences of the incident, and the procedures and points of contact for co-ordination of shipboard action with national or local authorities. Reporting of loss or release of INF Cargo or of incidents affecting the safety of the ship are required by the INF Code to be reported as required by the International Convention for the Safety of Life at Sea [15].

Transport of radioactive material by air is regulated by the Civil Aviation Authority. The Air Navigation (Dangerous Goods) Regulations 2002 [16] give effect to the International Civil Aviation Organisation's Technical Instructions [17], which require that appropriate information for use in an emergency be provided by the operator to the pilot in command. There is a further duty on the operator to report accidents or incidents to the appropriate authority, which in Great Britain is the Civil Aviation Authority.

4. Emergency planning arrangements

4.1. Government plans

Government plans are designed to ensure the protection of both the public and the environment, by providing information for government ministers, official bodies, the media and the general public. Responsibilities are determined by the nature and origin of the incident, and are based on the concept of a Lead Government Department as defined in the government publication "Dealing with Disaster" [18]. Under this concept, the lead department's responsibilities include co-ordinating the government response and the management of information, and acting as the focal point for communications between central government and other agencies involved, including devolved administrations where appropriate. The distribution of lead department responsibilities for radioactive incidents is as follows:

- For incidents at civil nuclear installations in Great Britain, the Department of Trade and Industry is the lead department. In addition to leading government response in the event of an incident, the DTI chairs the Nuclear Emergency Planning Liaison Group (NEPLG), a forum which brings together organisations having an interest in off-site nuclear emergency planning and produces guidance material for use by responding organisations. The Department for Transport is represented on the NEPLG to cover the transport implications of fixed site incidents.
- For overseas nuclear incidents, the lead department is the Department for Environment, Food and Rural Affairs (DEFRA). DEFRA discharges its responsibilities through the Radiation Incident Monitoring Network (RIMNET). RIMNET consists of a network of monitoring stations throughout the country with links to overseas facilities to provide early warning of airborne radioactivity. The facility incorporates an extensive information handling facility to which may be added supplementary information. This may include data relating to transport incidents or other incidents affecting the transport infrastructure. RIMNET is directed by a co-ordinating committee chaired by DEFRA and including interested parties from both the regulatory and industrial communities.
- In the case of transport incidents, the lead department is mode dependent, and the lead role is taken by the department or agency responsible for enforcement, i.e. Department for Transport (DfT) for road, HM Inspectorate of Railways (part of the Health and Safety Executive) for rail, the Maritime and Coastguard Agency for sea, and the Civil Aviation Authority for air. Each of these agencies maintains its own arrangements for receiving and distributing information, bringing together the required representatives and facilities for briefing ministers, the media and the general public and for ensuring that the required measures are put in place for handling the incident and for remediation. Memoranda of Understanding exist between certain agencies to establish roles and responsibilities. The Maritime and Coastguard Agency has an extensive contingency plan to deal with polluting incidents at sea [19]. The DfT's Radioactive Materials Transport Division (RMTD) is available to provide advice to the lead division for any of the transport modes from its specialist knowledge as national competent authority under the IAEA transport regulations. Since the extension of the International Nuclear Events Scale to include transport incidents, the response includes an assessment of the likely INES rating, although this may be refined as the full extent of an incident becomes apparent. A database of transport events is maintained by NRPB under contract to DfT and HSE, to enable overall safety levels to be monitored and trends in incident occurrence to be identified and addressed [20, 21].

4.2. Industry plans and NAIR

The industry's plans are formulated to fulfil the consignors' and carriers' responsibilities, and the major consignors have grouped together to provide a nation-wide response capability. Known as RADSAFE, the scheme provides for the necessary notifications, provision of advice, and on-site requirements. RADSAFE is described in detail by Kelly [22], and so no further details are given here. Some organisations also maintain their own separate response plans to cover their specific situations, for example, specific routes and obligations under INF legislation as described earlier. Also many operators of small (usually local) consignors have their own independent arrangements appropriate to their particular operations.

The National Arrangements for Incidents Involving Radioactivity (NAIR) [23] have been set up to provide protection for the public in the event of a radiological emergency which is not covered by industry arrangements or if the industry arrangements cannot be implemented, for whatever reason. The NAIR scheme, which is co-ordinated by NRPB, draws on radiological expertise available throughout the country and can provide two stages of response, advice and intervention. It is available to the emergency services through the police. NAIR is strictly a service to the civil police and is not a substitute for operators' own arrangements that are required by statute.

5. Concluding remarks

Emergency preparedness for the transport of radioactive materials in Great Britain is founded on a comprehensive suite of regulations and emergency plans which provide for effective response to incidents and the provision of information to government, the media and the general public. Government response is covered by a lead department that is determined by the type of incident and the mode of transport involved. The major consignors have established a nation-wide response network, and an additional comprehensive backup service is provided to ensure public protection.

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RADSAFE – EXPERIENCE WITH THE APPLICATION OF A NATIONAL RESPONSE PLAN

T.D. Kelly

UKAEA, Building 521, Downs Way,
Harwell, Didcot, Oxfordshire,
United Kingdom

Abstract

A single 'one stop shop' to initiate a transport emergency response has many advantages. This paper describes the background to the formation of RADSAFE, how it operates and provides comment on two events, which were, responded to under the RADSAFE arrangements.

1. Introduction

Morgan-Warren [1] describes the legal framework requiring that emergency arrangements are established within the Great Britain. These have their basis in the IAEA Regulations, TS-R-1 [2] which are mirrored in the Packaging, Labelling and Carriage of Radioactive Material by Rail regulations 2002 [3] and the Radioactive Material (Road Transport) Regulations 2002 [4]. In addition, for the transport of radioactive material by rail, the Radiation (Emergency Preparedness and Public Information) Regulations 2001 [5] require that a 'hazard identification and risk evaluation' is undertaken and where that assessment indicates that it is reasonably foreseeable that a radiation emergency might arise then the operator shall prepare an adequate emergency plan.

Other guidance is provided on the structure of the emergency response such as the Emergency Planning Society's 'Transport of Dangerous Goods The Emergency Response [6], IAEA's Safety Guide 'Planning and Preparation for Emergency Response to Transport Accidents Involving Radioactive Material [7] and Arrangements for Responding to Nuclear Emergencies [8]. Thus comprehensive legislation and emergency response guidance is available within the United Kingdom.

2. History

Prior to RADSAFE being established a number of transport emergency plans existed within the United Kingdom. These included

- Irradiated Fuel Transport Flask Emergency Plan for England and Wales (IFTFEP)
- Scottish Nuclear Irradiated Fuel Transport Flask Emergency Plan (SNIFTFEP)
- Nuclear Industries Road/Rail Emergency Plan
- Consignor based emergency arrangements and
- National Arrangements for Incidents involving Radioactivity (NAIR)

(It should be noted that with the exception of NAIR all the above arrangements were formal arrangements whilst NAIR is a long stop voluntary set of arrangements which has no formal basis to it. NAIR is co-ordinated through the National Radiological Protection Board.)

As can be seen from the titles of the emergency plans that were in place they could easily cause confusion because of

- the location (Scotland or England/Wales) and
- the type of package (nuclear fuel flask or other package type)

In addition because of the existence of NAIR, it was sometimes activated rather than the appropriate plan.

3. Development of RADSAFE

A number of issues came together to drive the development of a single transport emergency arrangements response plan. These included

- the belief that REPPIR, because of the emphasis it would place on local authorities and carriers to have response plans that to minimise confusion a single response plan would help
- criticism of the current arrangements within the United Kingdom was being voiced by the emergency services because of the confusion over which plan to operate
- maintenance of a number of transport emergency plans was wasteful of effort given a diminishing nuclear industry
- the plans produced were written by the nuclear industry for the nuclear industry without clearly identifying that the emergency services were the customer for the response

Given these drivers the nuclear industry through the NIR/REP working group took the decision to streamline the number of transport emergency plans in existence. However, it was also recognised that a new unified transport emergency arrangements plan should not just be an amalgam of all the plans that existed at the time.

It was clear that the existing plans were not appropriate but it was also recognised that the nuclear industry should not reinvent the wheel. To this end a working party was formed with the remit of developing a plan which

- was simple
- relied upon a single notification point
- made use of already existing best practice and
- the emergency services were already familiar with.

Within Great Britain a road transport emergency scheme already existed based upon a three-step approach. The scheme was called Chemsafe and was co-ordinated through the Chemical Industries Association (CIA). The emergency services throughout the United Kingdom are aware of the scheme and how it operated. It was therefore considered that RADSAFE should use the same or similar features.

In discussion with the CIA it was agreed that RADSAFE could make use of the features of CHEMSAFE to ensure consistency of response for the emergency services. Using this as a basis the working group discussed the proposals with the following organisations

- Nuclear Industry
- Emergency Services
- Local Government Agencies
- National Agencies
- Specialist Nuclear Fuel Flask Carriers.

The result of these discussions was a clear requirement from the Nuclear Industry and responders that any transport emergency arrangements should have the following objectives

- a single, easy to use plan
- a single contact point which can be notified by anyone
- simple response information to be made available to the emergency services within minutes
- a guaranteed response to an event
- provision of training for the emergency services
- setting of standards to ensure a uniform response and
- that use should be made of already existing best practice.

To these points it was also recognised that the following features should be added

- there should be provision of standard training for responders
- a liaison group should be established and
- that there should be comprehensive documentation on likely packages that may be transported.

The nuclear industry, see Table 1, signed up to the implementation of RADSAFE. RADSAFE was implemented on the 1st August 1999 across Great Britain. It was also recognised that because the nuclear industry is concentrated in Great Britain that it would only be practicable to provide a response within Great Britain. A similar scheme to NAIR, 'Radiation Incidents in Public Places' provides a voluntary response in Northern Ireland.

Table 1: RADSAFE Members

AEAT	Amersham
British Energy	British Nuclear Fuels
Ministry of Defence	Rolls Royce
UKAEA	URENCO

Over time since the implementation of RADSAFE other features have been added or objectives set, in particular the following

- development of a Web-site and
- movement closer to NAIR to ensure a one stop shop approach.

4. Operation of RADSAFE

To mirror the operation of Chemsafe, RADSAFE has at its core a number of levels of response. These are:

Level 1 Notification/communication service, provision of generic radiological protection advice provided by Force Communications Centre

Level 2 Provision of Radiological advice/support at the incident scene by level 2 responding site

Level 3 Consigning owner response and 'clean up'

(note: levels 1 and 2 are deployed together)

At the core of the RADSAFE response are the following features: a single notification number 0800 834153; the emergency services level 2 responder consigning owner responsibility for 'clean up'.

If we imagine that an event has occurred somewhere in England then the actions that would be undertaken by RADSAFE in responding to the event are as follows, see Figures 1 – 6.

Level 1 Provision of Information Figures 1 - 4.

The initial activity will be notification of the RADSAFE communications centre, Figure 1. This may either be from a member of the public or from the emergency services. The effect is the same. The RADSAFE communications centre will record the relevant details, paying particular attention to the site code, this is a unique identifier that will indicate where the consignment has come from. The RADSAFE communications centre then sends generic advice to the emergency services that are responding to the event, see Figure 2. The nearest responding site is then contacted and a response is requested, see Figure 3. The next and key aspect is for the RADSAFE communications centre to notify the owner of the package that the consignment has been involved in an incident and that they should:

- liaise with the RADSAFE Level 2 responder to provide additional information, see Figure 4, and
- make preparations for the owner of the package to take over from the RADSAFE Level 2 responder.

(In some situations the Level 2 Responder and the owner of the package may be the same organisation. This will simplify the response.)

The Level 2 RADSAFE Responder will then respond to the incident site whilst being briefed by the owner of the package. In addition the emergency services may wish to contact the Level 2 Responder for additional interim advice.

Level 2 Respondent at Scene of Incident to provide advice, Figure 5.

Fig. 1: Level 1 Provision of Information

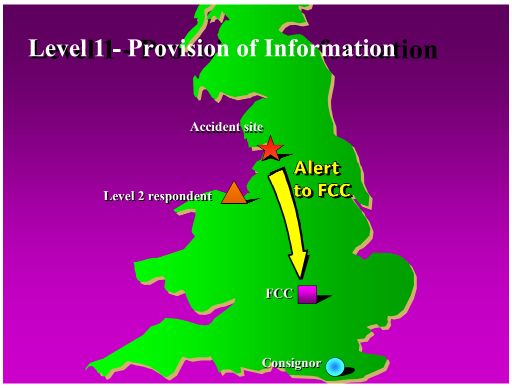


Fig. 2: Level 1 Provision of Information

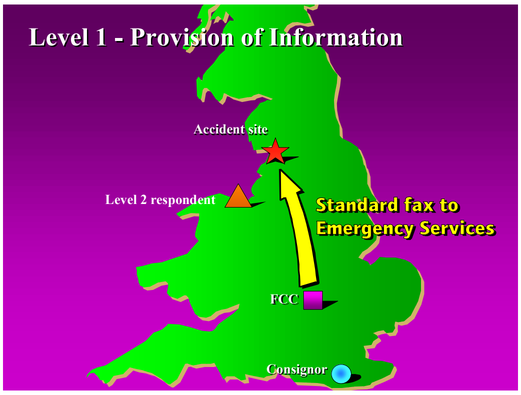


Fig. 3: Level 1 Provision of Information

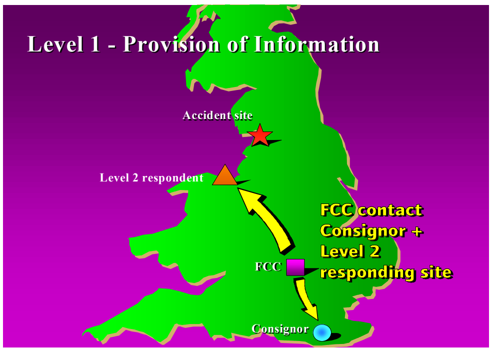


Fig. 4: Level 1 Provision of Information

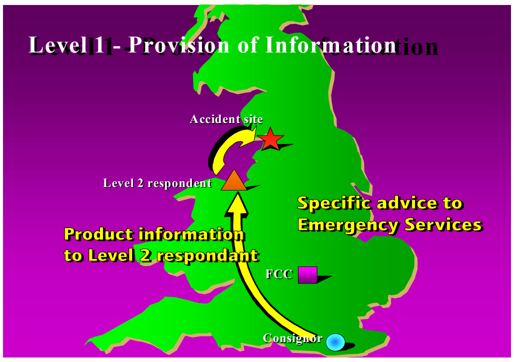


Fig. 5: Level 2 Respondent at Scene

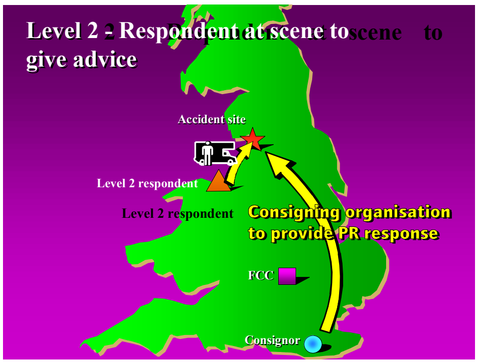


Fig. 6: Level 3 Recovery

The RADSAFE Level 2 Responder on arrival at the scene of the event will undertake the following activities, see Figure 5:

- advise the level 2 responding site of arrival
- establish contact with the emergency services officer who is leading the emergency response (normally a fire office)
- take part in multi-agency discussions to provide to provide radiological advice and support
- arrange for controlled access and egress from the scene of the of the event, it is likely that a cordon will have been established by the emergency services
- consider the need to increase or decrease the size of the cordon
- undertake radiological assessments for radiation and radioactivity
- institute contamination control procedures

- provide situation reports to the level 2 responding site, consignment owner and to the emergency services
- liaise with health physics support teams.

The aim of the Level 2 Responder is to ensure the situation is stabilised and made safe. This may be achieved by extending the cordon area or some other time, distance or shielding may have to be involved.

Note: the level 2 Responder is there to provide technical radiological support, the package owner is required to provide media support.

Level 3 Provision of Clean up and remediation by Owner.

The owner of the package will despatch a team from the relevant site in due course. The owner of the package may be some considerable distance and hence travelling time from the scene of the incident. In addition the responsibility of the owner will stretch from recovery of the package to dealing with the wider interests of remediation of the incident site and consideration of financial liability. Depending on the severity of the incident this may require little or no clean up activity to significant remediation of the site with a presence at the scene of the event for days or potentially weeks.

I have mentioned the RADSAFE communications centre and this plays an important part in ensuring a rapid response to an incident. The RADSAFE communications centre is actually the Force Communications for the United Kingdom Atomic Energy Authority Constabulary. This is a specialist constabulary linked to the nuclear industry with the remit of providing security nuclear matter and for the transport of special nuclear material. It is one of the few national constabulary's in the United Kingdom ranging from Dounreay in the North of Scotland to Winfrith in the south of England. It provides 24hr cover and is always available. Because of its historic links with the nuclear industry it has knowledge of the industry and what is transported. In addition because of its monitoring of the transport of special nuclear material it has a background of logistics. This provides links with the Ministry of Defence enabling helicopter support if required.

5. Learning from response of RADSAFE

There have been three situations when RADSAFE has been activated:

- Torness Power station siding derailment
- Locomotive on fire at Carlisle station
- Dungeness level crossing.

All of these events have provided learning points for RADSAFE and its responders. I will provide some description of the first and third of these events and identify some learning points.

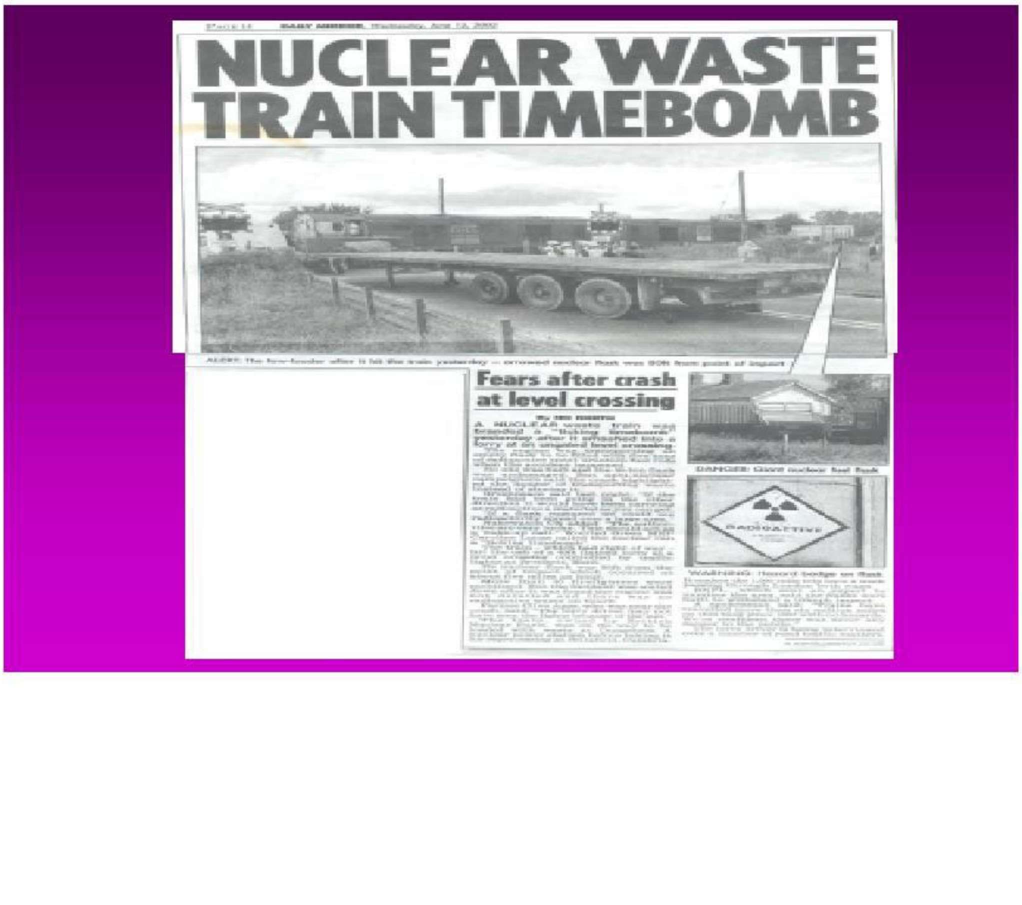
Torness Power Station Siding Derailment, Figure 7.

Whilst reversing off the main east coast railway line the leading barrier wagon, see Figure 7 derailed. As a consequence the leading rail bogies on a flatrol carrying a nuclear fuel flask was also derailed. The nuclear fuel flask did not contain any irradiated fuel and the flatrol dropped about 5inches (7.5 cms). The consequence of this event from a radiological viewpoint was insignificant. However, because the flatrol was being reversed into the siding the main part of the train was blocking the main East Coast railway line. Earlier in the week there had been a major incident involving loss of life further south on the same railway line. This lead to the railway line being closed for a period of time. The initial notification took place at about 09:30hrs with the incident being closed down at 22:00hrs the same day.

Initially there had been a significant press interest in the event but when it was realised that there was no risk this soon abated.

Figure 7: Torness Siding Incident, March 2002

Figure 8: Dungeness Level Crossing Incident, June 2002



NUCLEAR WASTE TRAIN TIMEBOMB

Fears after crash at level crossing

RADIOACTIVE

Learning points:

- Never underestimate the time that a response will take event for a non-event
- in Scotland in March the weather can be very inclement, always ensure adequate foul weather clothing
- the press can be fickle, expect the unexpected i.e. they most probably will turn up but equally on a cold day in March with no real significance to the event they may not in the numbers expected
- many, many people became involved in the incident, in round terms at the scene of the event there was about 100 people from many different organisations very close to a major transport route, management of the health and safety of these people is a key task, normally undertaken by the fire brigade, it would have been a tragedy if the someone had been injured for a non-event.

Dungeness Level Crossing Incident, see Figure 8.

A nuclear fuel flask train was heading north from Dungeness Power Station. It approached an unmanned, traffic light controlled level crossing, stopped and waited for permission to proceed. An articulated lorry was seen to stop on the road in response to the flashing red lights. Permission was given for the train to proceed which it did. The train was proceeding at about five miles per hour when the articulated lorry moved and drove into the front locomotive. The impact was not significant and the nuclear fuel flasks were some considerable distance away from the scene of the event. RADSAFE was called out and attended the scene. Significant media coverage was provided.

Learning Points:

- response to the scene of an event may be to provide reassurance
- media coverage is not dependent on the radioactive package being involved in the incident, only if it is near the incident.

6. Conclusion

RADSAFE has been in operation since August 1999, during that time it has responded to three incidents, none of which have been of any significance. Through its training programme RADSAFE has delivered training to about one thousand emergency services personnel and is now deploying training to RADSAFE responders. The intention being to maintain standards across the responders and to raise awareness of RADSAFE and how it operates with the emergency services. RADSAFE provides a model for other transport emergency arrangements.

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EMERGENCY RESPONSE ARRANGEMENTS FOR THE PACIFIC NUCLEAR TRANSPORT FLEET

M. Fox

International Transport, British Nuclear Fuels plc,
Warrington, Cheshire,
United Kingdom

Abstract.

Whilst the likelihood of an incident occurring during the transportation of radioactive material is very small and the safety arrangements are extensive, any organisation involved should ensure that comprehensive emergency management arrangements are in place. Details of the particular emergency response arrangements adopted for the Pacific Nuclear Transport Limited (PNTL) Fleet are covered by this paper.

1. Introduction

PNTL, the nuclear transport company owned by British Nuclear Fuels Limited (BNFL), Compagnie Generale des Matieres Nucleaires (COGEMA) and a consortium of Japanese Utilites, operate five purpose built marine vessels from the BNFL Marine Terminal at the Port of Barrow in the United Kingdom (UK). The PNTL fleet is responsible for transport of nuclear material between Europe and Japan. With over four and a half million miles covered without a single incident resulting in the release of radioactivity, the company has a safety record second to none [1]. However, in the unlikely event that an incident should occur during a transport movement then the PNTL vessel involved would call upon the dedicated emergency response arrangements prepared and maintained by BNFL International Transport.

2. Emergency response section

The Emergency Response Section is an integral part of BNFL International Transport, with the single aim to ensure that the company responds to any International Transport related incident in a swift combined and co-ordinated manner [2]. In order to meet this aim, the section is required to ensure that their emergency management arrangements comply with stringent safety measures, quality standards regulations and guidance including:

- IMDG Code – International Maritime Dangerous Goods Code [3].
- INF Code – The Code for the Safe Carriage of Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes in Flasks on Board Ships [4].
- Regulations for the Safe Transport of Radioactive Material (RM) [5].
- Planning & Preparing for Emergency Response to Transport Accidents Involving RM [6].

3. Incident prevention

Whilst the BNFL emergency arrangements focus on the response to an incident, it is important to recognise the particular measures adopted which could seek to prevent an incident occurring or reduce the severity should one occur. These measures constitute a vital part of the emergency planning process [7]. For the PNTL Fleet, which are all purpose built vessels, certified to INF3 classification [3] such prevention measure include the following:

- Double Hulls - the vessels are constructed with a double hull around the cargo holds in order to withstand a severe collision with a much larger vessel without penetrating the inner hull.

- Enhanced Buoyancy - the ships have enhanced buoyancy, enabling them to remain afloat even in extreme circumstances.
- Dual Systems - each vessel has two sets of navigation, communications, cargo, monitoring, electrical and cooling systems, so there is always a back up in the unlikely event that the main system should fail or become damaged.
- Fire Fighting - every part of the ship is covered by a fire detection system and each vessel is equipped with sophisticated fire fighting equipment. In a worst case scenario all of the cargo holds could be flooded and the vessel would still remain afloat.
- Satellite Navigation and Tracking - The most modern satellite navigation and tracking equipment enables the ships position to be transmitted back to the UK and whilst at sea each vessel maintains communications with the 24-hours report centre at Barrow.
- Experienced Crew – the crew that operates each PNTL vessel is approximately twice as large as those found on chemical tankers of a similar size. All navigation and engineering officers hold qualifications of their next higher-ranking officer [8].

Additional preventative measures include the design, maintenance and licensing of the transport packages and the environmental, health, safety and quality management systems, which cover all aspects of BNFL International Transport business activities.

4. Pre-planning

All activities associated with the transport of radioactive material are covered by the BNFL 'International Transport and PNTL Management System'. This set of documents defines the various interfaces, responsibilities, requirements, control and records each of which have been certified by Lloyd's Register Quality Assurance (LRQA) as compliant with ISO 9001:2000.

The specific management procedures relating to emergency response start with the 'Shipboard Marine Emergency Plans' (SMEPs) [9] carried on each of the PNTL vessels. The SMEPs, are approved by the UK Maritime and Coastguard Agency (MCA) and detail the action to be taken by the ship's Master in the event of an incident. The second plan, used to support the PNTL Master is the 'Emergency Response Procedures (ERP) for the BNFL/PNTL Fleet'. The ERP dovetail with the SMEPs and operate in conjunction with a 24 hour rota for emergency call out. Together, they provide detailed instructions on the actions personnel should take to ensure that BNFL are able to respond to any part of the world, where shipments are in transit.

Whilst the deployment of personnel is covered later in this paper, the plan used at the scene of an incident to provide specialist technical information and advice on package design, monitoring and remedial action, is known as the 'Flask Emergency Handbook'. The final two plans in this well-established and comprehensive emergency response system are the Sea Transport Contingency Manual (STCM) and the Coastal Landing Sites Manual (CLSM). The STCM covers background reading and advice on all aspects of sea transport including salvage and the CLSM provides data on the nearest helicopter landing sites for the deployment of personnel to the PNTL vessel involved.

5. Personnel and resources

BNFL personnel are retained on a 24-hour, 365-day rota system providing cover on all aspects of emergency response including management, operational engineers, health physics and package licensing. A Transport Operations Centre is located at BNFL Headquarters in Risley, Cheshire, UK. The centre is equipped with telephone, fax and computer communication systems together with technical information, maps and ship position monitoring systems. The centre provides a focal point for the technical information and advice to those deployed to the scene of an incident. In addition, an 'Emergency Control Centre' is located at Barrow, however this facility is staffed 24-hours a day, 365 days of the year to receive and log the two-hour position reports that are received from the ships. In the event of an incident at sea the centre would also co-ordinate the sea response including any marine and salvage operation, should these become necessary. An Emergency Response Team of personnel from flask engineering, marine engineering, health physics and public / media relations disciplines are specially trained and available to respond to any off site transport incident on a world-wide and 24-hours basis. Emergency equipment resources are held at various locations including onboard all PNTL vessels, at the BNFL Sellafield site, and at various locations within mainland Europe and Japan. The equipment will enable the emergency response teams to effectively contain any foreseeable incident and also to carry out appropriate remedial action to enable the package to be returned to a licensed site.

Each ship is fitted with a Sunken Vessel Location and Information System comprising of a number of transponders and data acquisition units linked to various sensors and monitors throughout the vessel. The system allows for the information gained by the sensors to be read at the surface when interrogated by a programmable acoustic navigator. Initially the system can be used to locate a sunken vessel and can then provide accurate information such as the condition of the ship, including the attitude of the vessel (roll, pitch), radiation levels in the holds and hatch cover status. The system has a maximum operating range of around 10,000 metres. Communications from ship to ship and ship to shore can be achieved using a variety of on board systems, for example the use of Digital Selective Calling and various satellite systems. Any combination of these systems permits the transfer of data, voice and facsimile transmissions. In addition, all PNTL vessels are equipped with HF, MF and VHF radio.

6. Emergency response contracts

BNFL have a contract in place with the UK's largest onshore operator of helicopter transport. The contract provides for the 24-hour call out of helicopter services in order to transport emergency response teams and associated equipment. An agreement for long haul air transport is also in place with one of the UK’s leading airlines. A “Salvage Resource / Equipment Database” is located at Risley, which comprises of a map-based computer system that can be used to identify salvage resources and associated equipment / services adjacent to any incident world-wide. It provides information regarding the resource, its current location, and contact details. The system is automatically updated on a weekly basis.

In relation to salvage and recovery, the services of one of the world’s best known salvage companies have been available to BNFL for many years. Smit Salvage of Rotterdam, are world leaders in the salvage business and have vast experience and resources available to them world-wide. They have produced, on BNFL/PNTL’s behalf a damage stability software programme for use by their salvage masters in the event of a maritime incident. The program can simulate a damaged vessel and is designed to assist a salvage master in determining the best course of action during a recovery. Under advice from Smit, all vessels within the PNTL Fleet are fitted with special additional bollards for use in righting operations, along with additional towing brackets fore and aft to enable quick and effective towing connections to be made. Although the Smit contract is in place, this in no way is exclusive or restrictive, and should the need arise, all or any salvage resources available may be used. A further long established contract in place is with Nuclear Services Company (NSC), Japan. The contracts relates to the provision of Radiological Protection and Safety Assistance and ensures that similar emergency response arrangements, communications, control centres and response team are all available to PNTL on a 24 hour basis.

7. Training, exercising and review

As with all emergency management arrangements, the above procedures are enhanced with by regular training, exercising and review. All BNFL, PNTL and NSC emergency response personnel receive regular training. The plans and arrangements are tested and exercised in accordance with an annual emergency exercise programme [2] with the findings being reported to the BNFL SAFTRAN Committee. All lessons learnt and recommendations from this committee are then incorporated into a review action list to ensure that the arrangements are updated or amended.

8. Audit

Internally, the emergency response arrangements for the PNTL Fleet are under constant audit through the International Transport and PNTL Management System 'self verification procedure'. Externally the plans and procedures have been inspected and audited by a number of independent national and international bodies such as the MCA, DfT, International Atomic Energy Authority (IAEA), International Maritime Organisation (IMO) and the International Civil Aviation Organisation in the form of the Transport Safety Appraisal Service (TranSAS). The TranSAS appraisal conducted in June, 2002 concluded that 'PNTL activities involving INF Code material are handled in a very commendable fashion' [10].

9. Conclusions

With over 20 year's experience, PNTL has transported more that 4,000 flasks in over 160 shipments without a single incident resulting in the release of radioactivity [1]. During this time their emergency response arrangements have evolved to meet the needs of the transport business. Further development through the emergency planning cycle [11] will ensure that in the unlikely event of an incident occurring, BNFL / PNTL will be able to respond in a swift combined and co-ordinated manner.

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INTEGRATED EMERGENCY MANAGEMENT AND THE PRIOR NOTIFICATION OF THE TRANSPORTATION OF RADIOACTIVE MATERIAL

M. Fox

International Transport, British Nuclear Fuels plc,
Warrington, Cheshire,
United Kingdom

Abstract.

Radioactive material is transported world-wide by various means. Each transport movement is heavily regulated and requires a high degree of emergency preparedness. If this preparedness is based upon the principles of Integrated Emergency Management then the States involved in the response to an incident should be in a position to respond no matter what the cause. The issue as to whether the State has, or has not, received prior notification of the movement should not effect the emergency preparedness or the response.

1. Introduction

The transportation of radioactive material, like that of many other dangerous goods, brings with it stringent safety measures and both national and international regulations [1]. It is recognised that there are hazards in any transport activity. While the safety arrangements for the transport of radioactive materials are extensive and the likelihood of an incident very small, detailed emergency arrangements are in place to deal with any identified eventuality. Indeed, the underlying aim of the various regulations and legislation is to reduce the likelihood of an incident occurring and to limit the effects to people, property and the environment should one occur [2].

In order to respond to a transport incident involving the radioactive material and to meet the aim and objectives of the various regulations, then governmental organisations, the consignor and the carrier all have responsibilities to discharge in respect of emergency preparedness and response [3]. Unfortunately, it would appear that some States might have misinterpreted the issue of preparedness as an obligation for prior notification by the consignor [4]. Furthermore, these States have expressed the opinion that in order to have appropriate emergency response plans in place to deal with incidents involving the transportation of radioactive material, then they must receive prior notification of all shipments. Finally, the same States argue that they should be permitted to exercise the right to stop shipments from entering their jurisdiction, on the grounds that their emergency plans may not be suitable and their personnel not adequately trained, to deal to an incident involving radioactive material [4]. So, is prior notification of the transportation of radioactive material vital to ensure that States are fully prepared for an emergency and how would the principles of Integrated Emergency Management (IEM) help?

2. Integrated emergency management

One of the most significant time periods for current emergency planners was known as the ‘Decade of Disaster’. The late 1980’s and early 1990’s found Britain facing an unprecedented number of major technological and ‘natural’ emergencies [5]. These incidents ranged from fires and explosions to terrorism, transport and weather related incidents.

Since this spate of incidents and the subsequent reviews that inevitably followed, emergency planning and response in the United Kingdom (UK) has been based upon the nationally agreed principles of IEM [6]. The main principle of IEM is that emergency planning must be based upon the response to an incident and not the cause of the incident. Other key emergency planning stages include assessment, prevention, preparedness response and recovery. Many of the concepts of IEM are embraced by the International Atomic Energy Agency in their Safety Guide on the Planning and Preparing for Emergency Response to Transport Accidents Involving Radioactive Material [3]. The aim of IEM highlights the development of flexible emergency plans that should enable organisations to deal effectively with an incident, whether foreseen or unforeseen. This aim is further emphasised by one of the main planning stages which defines preparedness as 'Preparation of plans to respond to known hazards as well as to unforeseen events' [6].

It is this generic style of emergency management that is covered in detail in the UK Emergency Planning Society Guidance Document 'Transportation of Dangerous Goods – The Emergency Response' [7]. The document eludes to the fact that there is no single model response to a transport incident and that every response will need to vary just as the nature and effects of the incident will vary. By adopting the principles of IEM and producing generic emergency response arrangements, then an organisation will be in a better position to deal with any transport related incident.

3. State emergency response arrangements and IEM

If States do not have adequate plans in place to protect their people, property and environment from the results of a transport accident or the release of radioactive material, then one must question why? Surely the events of the 11th September, 2001 and more recently the 'Bali Bombing' [8] have focused the minds of all those entrusted with the vial role of emergency management. If this new threat of global terrorism did not make each and every State review and revise their emergency preparedness then one must ask what would ?

In order to implement the principles of IEM into State emergency management arrangements, the following planning process is recommended. Following this structured approach would ensure that State is better placed to respond to any major incident:

Assessment

An assessment should be made of the emergency planning hazards facing a State i.e. what would be the likelihood and consequence on any major incident occurring. A recent study of UK hazards produced a total of 192 ranging from animal disease to air shows and water treatment and war [9]. This assessment should also consider incidents that could occur in another State but result in transboundary consequences [2]. This stage of the process would cover 'The Planning Basis' of the IAEA safety guide [3].

Prevention

The particular measures adopted which would seek to prevent an incident occurring or reduce the severity should one occur. This could include issues such as the regulating the particular hazard and defining the safety and security measures to be adopted.

Preparedness

The preparation of flexible, generic plans to deal with all types of incidents that could occur from those hazards identified during the above assessment stage. As previously mentioned, these plans should focus on the response to an incident rather than the cause i.e. the response to the collision of two trains should cover issues such as command and control, rescue and treatment of casualties, scenes of crime and media liaison. Should the same scenario involve the transportation of radioactive material then similarly the plan should focus on the response using the same elements i.e. command and control, rescue and treatment of casualties and scenes of crime. The introduction of radioactive material however, would mean that the generic section of the emergency plan relating to radiological protection etc. should also be initiated. The fact that the incident occurs as a result of a transport incident rather that a deliberate, terrorist release of radioactive material in a busy shopping centre should not affect the emergency preparedness and the generic plan.

Response

The initial response to an incident will normally be provided by the local civil emergency services using the emergency management arrangements produced during the above 'preparedness' planning stage.

Recovery

This final phase includes the activities necessary in order to restore and rebuild the community in the aftermath of an incident. Further details are included in the UK Home Office guide [10].

4. Consignors and carriers emergency response arrangements and IEM

As the primary responsibility for ensuring preparedness for a given shipment of radioactive material rests with the consignor [3] then their emergency management arrangements should also utilise the principals of IEM. An example of how a responsible consignor and carrier ensures that adequate emergency response arrangements are in place is that of British Nuclear Fuels Limited (BNFL) and the Pacific Nuclear Fuels Limited (PNTL) fleet. All of their transport movements not only comply with external regulations i.e. the International Maritime Dangerous Goods (IMDG) Code [11], adopted by the International Maritime Organisation (IMO) but also with BNFL's internal environment, health, safety and quality standards. These internal management systems are subject to periodic audit by Lloyds Register Quality Assurance and the UK Government Department for Transport (DfT).

The radioactive material is transported in packages, which are inherently safe and have exceeded a series of technical criteria established by the IAEA Transport Regulations [1]. The PNTL fleet transports the packages; a total of four vessels awarded the highest classification for the transportation of Irradiation Nuclear Fuel (INF) [12]. The structure and subdivision of the vessels hull is designed to ensure that, should the vessel sustain damage, then it will remain afloat. Other safety features include the duplication of essential systems and equipment.

BNFL has established comprehensive emergency management arrangements to ensure that they may respond to any International Transport related incident. In line with the principles of IEM these procedures focus on the response to an incident rather than the cause. In addition to the documented and audited procedures their emergency preparedness includes a 24 hour, 365 day, rota system ensuring the availability of management, operational, media, engineering, health physics and licensing personnel. Arrangements also exist to ensure that a team of these personnel would be able to travel to the incident on a world-wide basis.

Any response team deployed to an incident would be supported by a dedicated Emergency Control Centre and a backup technical Operations Centre. This may also call upon emergency equipment resources which are held at strategic locations including Europe and Japan. In addition to physical equipment, contracts exist for the provision of salvage services, damage and stability data, resource and equipment information and a sunken vessel location system. The provision of such emergency management arrangements ensures that the carrier is not reliant upon the assistance and the preparedness of the nearest State and therefore prior notification should not be an issue.

5. Conclusion

All States face the risk of some form of transport hazard in the same way that they are all at risk of the deliberate release of chemical, biological, radiological or nuclear material [13]. The use of IEM would ensure that States are able to respond to all major incidents no matter what the cause. Therefore, so long as those undertaking the assessment stage of the IEM process identified that there was a risk of both a radiological hazard and a transport hazard then the standard of emergency preparedness would not be dependant upon prior notification of the transportation of radioactive material.

6. Recommendations

It is recommended that States, consignors and carriers should consider basing their emergency management arrangements on the principles of IEM and that the assessment of hazards includes both transport and radioactive materials.

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TRANSPORTATION EMERGENCY PREPAREDNESS PROGRAM

E.B. McNeil

Office of Environmental Management
U.S. Department of Energy
United States of America

Abstract

In recent years, issues related to transporting hazardous materials of all types have received increased publicity. This is particularly true for radioactive materials. As a high-visibility shipper of radioactive materials, the U.S. Department of Energy (DOE) and its transportation activities have come under intense scrutiny from Congress, States, Tribes, local governments, and the public. An underlying concern is the adequacy of emergency preparedness along DOE shipping corridors.

1. Introduction

Since the terrorist attacks on September 11, 2001, approaches to funding for State, Tribal, and local governments have changed. Congress has significantly increased the funding made available by Federal agencies (such as the Department of Justice and the Federal Emergency Management Agency) for preparedness activities, including responder training, equipment, planning, and technical assistance. The approach to emergency preparedness and response will continue to change with the establishment of the Department of Homeland Security and resulting flow-down to State Homeland Security Offices. We have begun a closer working relationship with other Federal agencies that have the responsibility and funding authority for maintaining the emergency management infrastructure, and to focus the Department's efforts on transportation emergency preparedness and reducing the areas of redundancy.

DOE has implemented a complex-wide Transportation Emergency Preparedness Program (TEPP) to address issues for nonclassified/nonweapons radioactive materials shipments. As an element of the DOE Comprehensive Emergency Management System, TEPP provides support to DOE and other Federal, State, Tribal, and local authorities to prepare for a response to a transportation incident involving DOE shipments of radioactive materials. TEPP is implemented on a regional basis, with a TEPP Co-ordinator designated for each of the eight DOE Regional Co-ordinating Offices.

TEPP, by integrating transportation and emergency preparedness activities, takes a co-ordinated approach to addressing the emergency response concerns of State, Tribal, and local officials affected by DOE shipments. TEPP also ensures responders have access to the plans, training, and technical assistance necessary to safely, efficiently, and effectively respond to transportation incidents.

2. TEPP planning tools

Through TEPP, the planning tools have been developed to assist responders to prepare for a transportation incident involving radioactive materials:

- *Model Needs Assessment* assists jurisdictions in determining their readiness by identifying strengths and possible areas for improvement.
- *Model Planning Annex* provides a basic structure and annotated guidance for preparing an addendum to an existing emergency plan covering the transportation of radioactive material.

- *Model Initial Response Procedures* provides four procedures that can be incorporated into existing standard operating procedures:
  - Hazardous Materials Incident Response,
  - Model First Responder Procedure for Transportation Accidents Involving Radiological Materials,
  - Emergency Medical Services Care Provider Procedure, and
  - Medical-Examiner/Coroner Procedure.
- *Drills-In-A-Box* provides seven scenarios and materials for preparation and conduct of tabletop exercises, drills, and field exercises for transportation incidents.

3. TEPP training materials

DOE developed the Modular Emergency Response Radiological Transportation Training (MERRTT) program through various forums including the Transportation External Co-ordination Working Group (TEC), Training and Medical Issues Topic Group. DOE formed TEC to improve co-ordination with external groups interested in its transportation activities. TEC members represent national and regional State, Tribal and local government organizations, as well as labour, industry, technical and professional groups.

MERRTT addresses the training concerns of States, Tribes, and local jurisdictions, provides fundamental knowledge for responding to transportation incidents involving radioactive materials, and builds on existing hazardous materials training curricula. MERRTT was designed to meet the training needs of persons serving in fire service, law enforcement, emergency medical service, emergency management, public works, or on a hazardous materials team.

The MERRTT program is flexible and allows for delivery by a qualified instructor or as a student self-study using the new student version. Designed in modular format, the materials include student manuals, instructor guides and overheads to facilitate delivery. A "Go-Kit" provides aids to enhance MERRTT training and contains a radiation detection device, miscellaneous radiation sources such as a smoke detector, the inner container from a Type-A packaging, radiation warning labels and placards, and a copy of the *North American Emergency Response Guidebook*. Training "Go-Kits" will be made available to States and Tribes through their Regional TEPP Co-ordinators.

To assist qualified instructors in presenting the MERRTT materials to local responders, DOE Regional TEPP Co-ordinators provide train-the-trainers sessions. A video has also been developed, which explains how to use the instructor manual, the instructor guides, student manual, and the interactive exercise. The interactive exercise applies the training objectives by simulating a transportation incident and familiarizes students with response actions. The interactive exercise applies the training objectives by simulating a transportation incident and familiarizes students with response actions when radioactive material is involved. The MERRTT training modules are available on CD-ROM.

4. Technical assistance

TEPP provides technical assistance to State and Tribal governments to help them understand radiological risk, develop or update transportation emergency plans, train first responders, and test their plans for needed improvements. TEPP co-ordinates with State, Tribal, and local governments and industry to identify and address transportation emergency preparedness needs and to assist them with drills and exercises.

NNSA EMERGENCY RESPONSE ASSETS AND CAPABILITIES

S. Buntman

United States Department of Energy
Office of Emergency Operations, Washington, DC
United States of America

Abstract

The U.S. Department of Energy's (DOE) National Nuclear Security Administration (NNSA) is prepared to respond to any type of radiological transportation accident or incident. The seven NNSA radiological emergency response assets can be employed to varying degrees on a worldwide basis. NNSA's radiological emergency response assets include the *Aerial Measuring System (AMS), the National Atmospheric Release Advisory Capability (NARAC), the Accident Response Group (ARG), the Federal Radiological Monitoring and Assessment Center (FRMAC), the Nuclear Emergency Support Team (NEST), the Radiological Assistance Program (RAP), and the Radiation Emergency Assistance Center/Training Site (REAC/TS).*

1. Introduction

The U.S. Department of Energy's (DOE) National Nuclear Security Administration (NNSA) is prepared to respond to any type of radiological transportation accident or incident. Though primarily oriented for domestic responses, the seven NNSA radiological emergency response assets can be employed to varying degrees on a worldwide basis. NNSA's radiological emergency response assets include the *Aerial Measuring System (AMS), the National Atmospheric Release Advisory Capability (NARAC), the Accident Response Group (ARG), the Federal Radiological Monitoring and Assessment Center (FRMAC), the Nuclear Emergency Support Team (NEST), the Radiological Assistance Program (RAP), and the Radiation Emergency Assistance Center/Training Site (REAC/TS).* In addition, the triage system is in the process of being established and will be part of the overall emergency response plan supported by NNSA. It will provide the essential communications link between the local first-responders (police, firemen and paramedics) and NNSA's nuclear experts. Requests for radiological emergency response asset support are usually made through the DOE Headquarters Operations Center (OC).

Through many years of training and experience, NNSA has perfected an asset response system that includes initial notification, rapid and continuous monitoring and assessment of the situation, and inter-agency co-ordination to resolve the emergency. Each asset is equipped and staffed to handle certain aspects of the radiological emergency and performs a comprehensive, integrated response. It should be noted that all of the NNSA assets are designed for rapid response.

Below is a description in greater detail of each asset's role in responding to and resolving a radiological emergency.

2. Emergency response assets

Radiological Assistance Program (RAP)

RAP is usually the first NNSA responder contacted domestically for assessing the emergency situation and deciding what further steps should be taken to minimize the hazards of a radiological emergency. RAP's mission is to provide first-responder radiological assistance to protect the health and safety of the general public and the environment. It assists other Federal, state, Tribal and local agencies in the detection, identification and analysis, and response to events involving the use of radiological/nuclear material. As a general rule, this assistance is domestic, though will be available for events that occur along continental US borders.

In a highway transportation incident or accident involving radioactive materials, a state emergency operations center will call the appropriate RAP Regional Co-ordinating Officer (RCO) or DOE 24-hour emergency number to request assistance. The RCO will make a determination as to the type of assistance required -- either technical assistance over the telephone or deploying a team. Based on the assessment made by the team deployed to the accident or incident site, RAP members may determine the need for other NNSA emergency response assets.

While each RAP region is primarily responsible for supporting their home region, they may also support other regions upon direction of the DOE and/or NNSA. Regional RAP assets may also be used to backfill other regions when those teams are deployed. Each RAP region will maintain one team on-call at all times. The RAP Regional Response Co-ordinator (RRC) will tailor the actual response to the given incident.

The Home Team (HT), a network of experts located at the various weapons laboratories, will support both RAP and follow-on response teams with technical expertise and advice regarding Detection, Identification and Diagnostic (DID), dispersion and device modeling, Explosive Ordinance Disposal (EOD) procedures and all other relevant technical areas. As needed, response teams will deploy with secure communications and classified processing capability.

RAP team members are trained in the hazards of radiation and radioactive materials to provide initial assistance to minimize immediate radiation risks to people, property and the environment. Deployment of RAP will not preclude the follow-on deployment of other response teams. RAP may use other NNSA assets, such as AMS, NARAC, or REAC/TS in their response. RAP is able to quickly assess the affected area and advise decision-makers on what actions to take and determine if additional resources are necessary to manage the emergency.

During an emergency, RAP can provide:

- Each team traditionally consisted of 7 people: With the proposed addition of new operational requirements, additional team members may be required. The configuration of a deployed team will be tailored to the mission. The identified positions are: Federal Team Leader/SEO; Team Captain; Public Information Officer, as needed; Senior Scientist (gamma spectroscopy/neutron measurements/diagnostics); Team Member/Searcher (communications specialist and COMSEC custodian); Team Member/Searcher (logistics/geographic information system specialist); Team Member/Searcher; Team Member/Searcher; Team Member/Searcher.
- Radiological monitoring and assessment equipment including alpha, beta, gamma, and neutron detectors, air samplers, decontamination kits, communications equipment, and mobile laboratories.
- Initial responders for characterizing the radiation environment and minimizing the immediate radiological hazards and risk to people and the environment.
- Personnel decontamination support.

RAP is currently implemented on a regional basis, and its regions are proposed to be aligned with the Federal Emergency Management Agency (FEMA)/Federal regions. Regional co-ordination is between the emergency response elements of the States, Tribes, other Federal agencies, and DOE. Regional co-ordination is intended to provide a timely response capability and to foster a working relationship between DOE and the response elements of the State and local agencies within the region. RAP is proposed to be divided into 10 geographical regions with each region being managed by a Regional Co-ordination Office (RCO). This regional structure will be re-configured along the standard Federal region framework that is currently being used by the Federal Emergency Management Agency or will be implemented by the Department of Homeland Security.

The 10 proposed RAP Regional Co-ordination Offices

Region 1 - Brookhaven Area Office
Region 2 - Brookhaven Area Office
Region 3 - Nevada Site Office (Andrews Air Force Base [AFB])
Region 4 - Savannah River Operations Office
Region 5 - Chicago Operation Office

Region 6 - Albuquerque Operation Office
Region 7 - Oak Ridge Operation Office
Region 8 - Idaho Operations Office
Region 9 - Livermore Site Office
Region 10 - Richland Operations Office.

Aerial Measuring System (AMS)

The AMS is a deployable capability to detect, measure, and track ground and airborne radioactivity over large areas using both fixed and rotary wing aircraft. In general, AMS is used to do initial assessments of domestic sites impacted by radiological materials. Systems employed on AMS aircraft are designed to rapidly detect and measure radioactivity at sensitivities adequate to address protective measures established by the EPA Early Phase Protective Action Guide. The results are used to determine the location and degree of contamination in order to ascertain risk mitigation strategies for the affected population, environment, and significantly reduce exposure of emergency workers. Currently, AMS aircraft, equipment, and personnel capabilities are located at Nellis AFB, Nevada and Andrews AFB, Maryland. AMS will be developing a versatile detector pod format that can be placed on multiple airframes. In the future, RAP teams will be equipped with these pods and will support AMS missions in their regions using airframes.

In the event of an accident or incident involving radiological materials, NNSA, in consultation with state and/or other Federal partners, will deploy AMS immediately to the accident site. With the information generated by AMS, NNSA scientists are able to rapidly develop maps of the airborne and ground hazards. This enables the scientists to determine ground deposition of radiological materials and to project the radiation dose to which people and the environment are or could be exposed. This information gives officials at the site the information they need to effectively respond to the emergency.

During an emergency AMS can provide:

- Five to 10 scientists, technicians, and pilots
- Fixed and rotary wing aircraft (currently 4 helicopters and 3 airplanes) and ground support vehicles
- Real-time plume sampling, aerial assessment, and level of ground contamination and validated data on which to base protective actions
- Detailed mapping of contamination deposition
- Aerial photography and video
- Capability to conduct real-time plume sampling
- Multi-spectral analysis.

Accident Response Group (ARG)

The ARG is a deployable capability to manage the technical resolution of domestic accidents or significant incidents involving United States nuclear weapons that are in DOE custody at the time of an accident or incident. The ARG will also provide timely, worldwide support to the Department of Defense (DoD) in resolving accidents and significant incidents involving United States nuclear weapons in DoD custody.

ARG deploys on military or commercial aircraft using a time-phased approach. ARG advance elements deploy first and once at the scene; focus on initial assessment and providing preliminary advice to decision-makers. Once the follow-on elements arrive at the emergency scene, health and safety specialists perform evaluations for the safety and health of emergency response personnel, the public and the environment. ARG personnel will also focus on weapons recovery and independent safety reviews during weapons recovery operations.

ARG provides specialized support in weapon recovery operations and in evaluating, collecting, handling, and mitigating radioactive and other weapons associated hazards. The ARG Weapons Recovery Team work in close co-ordination with the military Explosive Ordnance Disposal (EOD) Team to render safe the nuclear weapons and/or components. Once the weapons and/or components are in a safe condition, the material will be packaged by ARG personnel for shipment to an appropriate location.

During an emergency, ARG can provide:

- Up to 150 nuclear weapons accident responders and scientists
- Rapid deployment from Kirtland AFB, AZ; Nellis AFB, NV; and Travis AFB, CA
- Radiological detection and monitoring equipment
- Mobile laboratories
- Equipment for weapons access, destructive and non-destructive recovery, and packaging (materials and containers)
- Contamination control station
- Expertise in weapons safing and recovery, collection, identification of components, and packaging.

When the weapons recovery operations are completed, the primary mission of ARG has been accomplished. At that time, the Lead Federal Agency (LFA) leads the site restoration operations and the role of ARG is to support the onsite radiological monitoring, analysis, assessment, and recovery activities as requested by the LFA.

Once the weapon leaves the site, the ARG mission is complete. NNSA's role turns to monitoring and assessment activities conducted by other NNSA assets, such as AMS, FRMAC, RAP, and REACT/TS.

Federal Radiological Monitoring And Assessment Center (FRMAC)

In the event of a major radiological incident, the full resources of the U.S. government will need to be co-ordinated to support activities of state, local and Tribal governments. The efforts of 17 Federal agencies are co-ordinated under the Federal Radiological Emergency Response Plan (FRERP) to integrate the Federal response to a radiological emergency. The FRERP assigns to DOE the responsibility for establishing and initially managing the FRMAC. Once activated, the FRMAC becomes a coalition of all Federal off-site monitoring and assessment efforts. NNSA's contribution to the FRMAC is the Consequence Management Response Team (CMRT). The CMRT draws from the capabilities and resources of other NNSA emergency response assets and becomes the NNSA co-ordination element for the FRMAC.

NNSA has further delegated the responsibility of FRMAC to the Nevada Site Office in Las Vegas, Nevada. The Nevada Site Office provides for 1) day-to-day management of FRMAC capabilities; 2) development of FRMAC plans, procedures, and exercise co-ordination; and 3) oversight of FRMAC working groups.

During an emergency, FRMAC can provide:

- 15 to 150+ scientists, technicians, and support personnel
- Rapid deployment from Nellis AFB
- Radiological monitoring and assessment equipment, mobile laboratories, and records management systems
- Radiological monitoring and sampling
- Database and GIS support to document and display data
- Radiological assessment expertise.

When a required FRMAC response is directed, the manager of Nevada Site Office, with concurrence of HQ, designates a FRMAC Director, and initiates FRMAC deployment. The FRMAC can deploy as a phased response. Each new phase complements the teams already in place.

Depending on the location of the incident and travel and weather conditions, Phase I can be expected to be on scene in approximately 8 hours. This phase consists of a 15-member, rapid response team with the initial responsibility to interface with the State(s), LFA, U.S. Department of State, and DoD officials. This phase is designed for quick radiological data collection and assessment in order to provide early health effects advice and timely characterization of the radiological situation to the officials responsible for making and implementing protective actions for the public. In addition, this phase has the capability to provide escort services for emergency workers entering potentially contaminated areas for lifesaving and/or forensic operations.

Phase II can be in place within three hours of Phase I. This phase consists of up to another 150+ team members that incorporates the Phase I personnel into an integrated field response, while augmenting initial monitoring and assessment capability. In addition, FRMAC can now provide a 24-hour emergency staffing capability; data, voice, and fax links with the Nevada Site Office and HQ; and Geographic Information System (GIS) support to the State and LFA. If appropriate, Phase II will initiate preparation for the arrival of the Full FRMAC. A FRMAC's size is tailored to the event and may consist of as few as 60 or as many as 500 people, depending upon the needs of the emergency situation.

The Full FRMAC provides long-term monitoring and assessment during the emergency phase and into the post-emergency phase of a response. The Full FRMAC is an interagency organization consisting of representatives from various Federal, State, and local radiological organizations responding to the radiological incident.

National Atmospheric Release Advisory Capability (NARAC)

The NARAC mission is to provide timely and accurate real-time assessment advisories to Departmental and non-Departmental Emergency Managers from actual or potential hazardous, nuclear or chemical material releases into the atmosphere. NARAC's computer-based system provides realistic plots, or maps, of potential radiation and/or chemical dose and exposure assessments, and estimates of the path of contaminants released into the atmosphere. For NARAC-supported sites—sites with computers and software for direct interactive service, the time to deliver these first plots can be as short as 5 to 10 minutes after the accident information is received. For non-supported sites, or accident sites without such computer equipment, the time to deliver these first plots, usually over the INTERNET, would usually be no longer than 1 hour.

Once notified of an event, NARAC team members download applicable, regional weather information and gather any specific information regarding the type/amount of radioactive material involved, topography, and meteorology at the site. Computer simulations are created to project the contamination dispersion paths and graphically display contour plots of the contamination overlaid on local maps. These plots also include the actual or estimated amount and rate of release of the hazardous material and are updated constantly throughout the period of the emergency. This information is then distributed to emergency response officials and their advance elements to rapidly determine the scope/potential impact of the event and develop appropriate response strategies.

During an emergency, NARAC can provide:

- Remote support from Lawrence Livermore National Laboratory
- Products showing the health and safety consequences from any hazardous atmospheric release(s) using real-time meteorological data in a 3-D computer model
- Consequence forecasts out to 2 days into the future.

Nuclear Emergency Support Team (NEST)

NEST is NNSA's program for preparing and equipping specialized response teams to deal primarily with the technical aspects of nuclear or radiological terrorism. NEST capabilities include search and identification of nuclear materials, diagnostics and assessment of suspected nuclear devices, technical operations in support of render safe procedures, and packaging for transport to final disposition.

NEST capabilities are drawn from across the nation's nuclear weapons complex. Response teams vary in size from a five person technical advisory team to a tailored deployment of dozens of searchers and scientists who can locate and then conduct or support technical operations on a suspected nuclear device or material. NEST personnel and equipment are ready to deploy worldwide at all times.

During an emergency NEST can provide:

- Technical advice and DOE asset command and control
- Nuclear/Radiological Advisory Team (NRAT)

- Search support
- Search Response Team (SRT)
- Search Augmentation Team (SAT)
- Technical operations support
- Lincoln Gold Augmentation Team (LGAT)
- Joint Technical Operations Team Phase II (JTOT II)
- Joint Technical Operations Team Phase III (JTOT III).

If a crisis develops over time and information is available from various sources or other types of warnings, response teams may be alerted or activated for pre-deployment planning. When the main party arrives, pre-designated functional teams will have been identified to initiate activities to mitigate the threat and its potential consequences.

DOE headquarters directs all response team activations and deploymemts after co-ordination with other concerned agencies. This interagency process may involve strict operational security to protect classified or sensitive details of the response operation. The FBI or State Department co-ordinates U.S. government assistance to support the resolution of the crisis with state and local officials or foreign governments. When the incident has been resolved, NEST personnel and their equipment will be released to return to their home bases.

Radiation Emergency Assistance Center/Training Site (REAC/TS)

REAC/TS was established to provide rapid medical attention to individuals exposed to radioactive material through direct or consultative help with medical and health physics problems for local, national, and international incidents. The center, located in Oak Ridge, Tennessee, is on call 24 hours a day and can provide advice regarding assessment and treatment of contamination, conduct radiation dose estimates, diagnose and provide prognosis of radiation-induced injuries, conduct medical and radiological triage, perform decontamination procedures and therapies for external and internal contamination, and calculate internal radiation doses from medically induced procedures. REAC/TS also provides medical support to other NNSA emergency response assets.

During an emergency, REAC/TS can provide:

- 24 hour emergency medical consultation support
- 4 to 30 deployable medical personnel capable of providing radiation exposure medical support
- 7-days worth of deployable medical supplies
- Expertise on treating exposed personnel and handling of contamination injuries
- Medical support and advice to deployed DOE elements

REAC/TS has physicians, registered nurses, EMT paramedics, health physicists, radiobiologists, and co-ordinators on its emergency response team. Sophisticated state-of-the-art laboratory facilities are among REAC/TS resources. REAC/TS also maintains a Radiation Accident Registry System and conducts medical follow-up of radiation accident patients. Information from the REAC/TS Registry System is used to track treatment procedures and trends in radiation-induced medical conditions. Medical advisory and assistance capabilities from REAC/TS will be integrated into all of the deployment elements either as part of the deployed team or in consultation via communications.

Triage

The triage system is in the process of being established and will be an indispensable part of the overall emergency response plan for nuclear/radiological emergencies. It will provide the essential communications link between the local First Responders (police, firemen and paramedics) and DOE's nuclear/radiological experts. The triage desk will have an Emergency Response Officer (ERO) on-call 24 hours a day. This officer will have the detailed knowledge necessary to provide immediate advice and/or direct the appropriate DOE/NNSA follow-on actions to handle any nuclear emergency. The ERO will have 24-hour direct access to a designated on-call Duty Scientist. Finally, NNSA has the world’s leading scientists from more than 50 years of managing the nation’s nuclear weapons program. NNSA is prepared to respond immediately to any type of radiological accident or incident anywhere in the world with these radiological emergency response assets.

CURRENT STATUS OF EMERGENCY RESPONSE FOR RADIOACTIVE MATERIAL TRANSPORT ACCIDENT IN JAPAN

Y. Nakagome

Research Reactor Institute, Kyoto University,
Kumatori-cho, Sennan-gun, Osaka 590-0494,
Japan

Abstract

On 30 September 1999, a critical accident occurred in a uranium conversion company, JCO in Japan. With this as a turning-point, the Law on Special Actions for Measures against Nuclear Disaster (NDL) was legislated and an emergency response system for nuclear material transport accident was established legally. From long ago, emergency response actions based on the IAEA/SS No.87 guide have been properly taken by the concerned consignor, and in case of serious accident, the Emergency Response Council for Radioactive Material Transport Accidents is systematised and generalises the situation since 1984. The Council consists of the staffs of six governmental organizations concerned. After the legislation of NDL, in accordance with the "Declaration of Emergency" announced by the Prime Minister in extremely severe transport accident, the Council is automatically reorganized to the Cabinet. Now, standard emergency response action manuals are reviewed and revised or newly prepared by governmental offices. Further, a Nuclear Emergency Assistance and Training Center was established in 2001 by the co-operation of the Japan Nuclear Cycle Development Institute and the Japan Atomic Energy Institute, and the actual emergency supporting system has been organized.

2. Introduction

The development and use of nuclear energy have progressed steadily in Japan, and especially the nuclear power generation has taken an important part of electric power supply. As the nuclear power generation capacity increases, the amount of transportation of nuclear materials such as uranium hexafloride, uranium oxide, nuclear fuel assembly and spent fuel assembly increases more and more. In Japan, all such transportations are controlled by domestic laws which have completely adopted the IAEA Regulations (1996 Edition) [1]. In particular, type B and/or fissile nuclear packages should be certified by the Competent Authority (Ministry of Education, Culture, Sports, Science and Technology: MEXT for research and test reactor facilities, Ministry of Economy, Trade and Industries: METI for nuclear power electric utilities, or Ministry of Land, Infrastructure and Transport: MLIT) to be satisfied the safety requirements of the IAEA Regulations.

On September 30, 1999, the critical accident occurred in a uranium conversion company, JCO in Tokai-mura, Japan. After the critical accident, the Law on Special Actions for Measures against Nuclear Disasters (NDL) was legislated and emergency response system for not only nuclear facility accident but also transport accident of nuclear material was established legally. From long ago, however, the concerned consignor has taken emergency countermeasures for the transport accident under the provisions of domestic laws and it has been scheduled in case of serious accident to be systematized the Emergency Response Council for Radioactive Material (RAM) Transport Accidents which consists of the staffs of six concerning governmental organizations METI, MEXT, MLIT, National Police Agency (NPA), Fire Defense Agency (FDA) and Maritime Safety Agency (MSA). After the legislation of NDL, in accordance with the "Declaration of Emergency" announced officially by the Prime Minister, the Council is automatically reorganized to the Nuclear Incident Office of the Cabinet.

In this paper, we describe the concept for response actions in RAM transport accidents and the current situation for preparing standard emergency response action manuals in concerning organizations in Japan, and also introduce an emergency assistance and training center which has been established by the co-operation of Japan Nuclear Cycle Development Institute (JNC) and Japan Atomic Energy Research Institute (JAERI) after the JCO accident.

2. Emergency response measures in standard manuals

According to the IAEA guide ST-3 [2], the response actions in any RAM transport accidents can be divided into three phases: initial phase, accident control phase and post-emergency phase. The initial phase includes immediate and temporary measures by carrier and local government organizations. In Japan, the actual actions of persons and organizations concerned in each phases, which are shown in below, are adopted into a standard emergency response manual.

2.1. Initial response phase. Just after the accident occurs, at the accident site the transport head or vehicle crew has to take the following actions (priority response), but no special order is observed:

- to save lives,
- to give first aid to injured person(s),
- to report to a local fire department and a police station, and the consignor,
- to prevent or put out fires,
- to control traffic to avoid a secondary traffic accident,
- to identify the package condition,
- to survey the radiation level,
- to set a temporary limited access area.

After the arrival of fireman and/or police to the accident site: at the accident site, the consignor has to take the following actions (initial response):

- to set an emergency response organization and,
- to continue the action mentioned in the priority response in co-operation with the fireman and/or police,
- to determine and set a limited access area,
- to perform a visual inspection of package,
- to execute radiological monitoring,
- to judge whether the contamination or leakage of radioactive material occurs or not.

Fireman and/or police have to take the following actions:

- to collect information,
- to operate the initial response described in an operation manual,
- to make contact with relevant organizations and personnel,
- to judge whether the accident is serious or not.

2.2. Accident control phase. In case of occurrence of contamination and/or leakage of radioactive material, the Emergency Response Council for RAM Transport Accidents (the Council) shall be organized: at the accident site. The consignor’s emergency response organization has to take the following actions:

- to perform the monitoring precisely,
- to determine and set a cordoned off area, if necessary,
- to prevent to spread the radioactive contamination,
- to collect or remove the radioactive material and the packaging,
- to conduct the public to a safety area, if necessary, and
- a local operation headquarters of emergency response shall be established at the site by the Council.

The Competent Authority, METI or MEXT and MLIT call the Council. The Council has to take the following action: at the Headquarters,

- to dispatch experts and /or necessary resources to the accident site,
- to ask near-by nuclear facilities human and/or material assistance,
- to collect the detailed information concerned package itself and circumstance,
- to evaluate the accident,
- to indicate an appropriate response measures to the local operation headquarters of emergency response,
- to review and indicate the cleanup procedures.

In case of the following situations,

(a) under the fire and/or explosive condition, radiation level of more than 100 μSv/h at 1 m from the surface of the package is detected or estimated, and
(b) under the fire and/or explosive condition, leakage of RAM is identified or estimated except Type L and Type IP-1 packages,

the consignor should inform such situation to the government organizations concerned and take the actions mentioned above. If necessary, the Nuclear Emergency Assistance and Training Center (NEAT) sends an emergency response team by the request of the Council.

Further in case of the following situations,

(a) under the fire and/or explosive condition, radiation level of more than 10 mSv/h at 1 m from the surface of the package is detected, and
(b) under the fire and/or explosive condition, leakage of RAM ofA2-value is identified or estimated,

"Declaration of Emergency" is announced by the Prime Minister and the Nuclear Incident Office is established in the Cabinet. The office makes an emergency response operation center (EOC) at the accident site. Consignor and the Council are automatically combined to the EOC.

2.3. Post-emergency phase. After the accident control phase, the following actions are taken at the accident site.

The consignor's emergency response organization has to take the following actions:

- to evacuate or remove the damaged package(s), if necessary,
- to decontaminate any RAM, if necessary,
- to recover the accident area to its original state.

The EOC at the site has to take the following actions:

- to confirm no radioactive material contamination after clean-up,
- to evaluate the radiological exposure dose,
- to decontrol the cordoned off area and limited access areas,
- to release the public from evacuation,
- to declare completion of the accident.

3. Emergency response action manual

In 1978, FDA prepared a standard emergency response action manual standing on fire fighting to RAM transport accident. It is the first regular manual in Japan and has been used as a bible of emergency response to RAM transport accident. The contents of FDA manual was reviewed and revised in 2001. After the publication of first edition of FDA manual, Science and Technology Agency (present name is MEXT) or Ministry of Transport (present name is MLIT) made a regular emergency response action manual to RAM transport accidents for land transportation from a standpoint of each competent authority. Such manual contains the actual procedures in each phase mentioned in Section 2. After the JCO accident and the legislation of NAL, a standard emergency response action manual to nuclear material transport accident for sea transportation was newly prepared by the MSA in 2001.

In Japan, each competent authority has a respective standard action manual of emergency response for RAM transport accident standing on each position. However, it has basically the same contents because of basing the IAEA Safety Series No.87 [3] or the ST-3 document. These standard manuals are distributed to the local government offices and organizations concerned, and used in case of making an actual manual.

4. Nuclear Emergency Assistance and Training Center (NEAT)

The NEAT was established in 2001 by the co-operation of JNC and JAERI. Such institute is designated as an emergency response assistance board by the Japanese Government. The headquarters of NEAT is in Ibaraki, which covers eastern part of Japan and the branch in Fukui which covers western part of Japan. The purpose of NEAT is, in case of emergency, to give technical support including manpower and material supply, and to send experts and/or an emergency response team to the accident site and EOC. In normal (no accident) condition, NEAT is active to study persons concerning prevention of disaster and to collect accident/trouble information in nuclear facilities or nuclear material transportation. Further, NEAT co-operates with and takes part in a disaster drill actively.

5. Summary

In Japan, the measures to RAM transport accidents have been prepared and described in standard emergency response action manuals since 1978 by the Fire Defense Agency chiefly. After the legislation of Law on Special Actions for Measures against Nuclear Disasters following the JCO critical accident, standard manuals have been reviewed and revised or newly prepared by several Ministries or Agencies of the Japanese government regulating of RAM transport. The contents of such standard manual comply with that of the IAEA ST-3 guide. Further, the Nuclear Emergency Assistance and Training Center (NEAT) was established as an actual supporting body by the co-operation of Japan Nuclear Cycle Development Institute and Japan Atomic Energy Research Institute. Many study meetings for safe transport of RAM have been taken in local cities with the participation of local government officers by using each standard manual.

In Japan, we have no serious accidents for RAM transportation. This means that we have no experience for actual emergency response action. Standard emergency response action manuals have been already prepared and an assistant body has been established, but it is best that such manuals and body are not used in future.

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EMERGENCY PREPAREDNESS DURING MARITIME TRANSPORT OF NUCLEAR AND RADIOACTIVE MATERIALS IN INTERNATIONAL WATERS.

W. Standring, F. Ugletveit, I.M. Eikelmann, E.N. Holo, O. Reistad

Norwegian Radiation Protection Authority (NRPA),
Grini Næringspark 13, P.O. Box 55, N-1332, Østerås,
Norway

Abstract

The maritime transport of radioactivity creates insecurity and uncertainty for people relying on the sea. This paper discusses the maritime transport of radioactive materials and the possible effects of an accident. The paper highlights the need for international regulations regarding the early notification of accidents in international waters and improved co-operation between the relevant international organisations, in particular regarding notification and assistance in response to emergencies during maritime transport of RAM.

1. Introduction

Several types of radioactive materials are and have been regularly transported by sea during the nuclear era. For example, many nuclear utilities transport spent fuel for reprocessing overseas, both to recover unused ^{235}U and by-product plutonium and to isolate highly radioactive fission products that can be vitrified for eventual disposal. Such shipments have caused controversy and attracted public attention, especially among coastal states along the chosen routes. Norway and other coastal states are concerned about the continuous uncertainty associated with such transports. Concerns centre on the safety and security of RAM shipments, the liability of transport states and potential impacts on the marine environment and those dependent upon it in the event of an accident at sea. The vulnerable marine environment, especially in the Arctic areas, is another important issue to Norway. Essential spawning grounds for several fish stocks are found around the Arctic region. The marine ecosystems in the Barents sea are among the most productive areas in the world. Norway has a long tradition of utilising these renewable resources.

Even if the number of accidents is low and the releases few and insignificant regarding actual effects on people and the environment, the maritime transport of radioactive materials creates insecurity and uncertainty to fish catchers, fish producers and consumers. This aspect shoud be taken into account when discussing the need for international efforts to regulated such shipments.

2. Accidents do happen

There are many examples of accidents at sea involving merchant shipping that have led to severe environmental consequences and proven costly to remediate. Although stringent regulations are in place regarding containers used for specific types of RAM transport [1], nuclear transport ships are neither immune to accidents. An example is the British Nuclear Fuels (BNFL) nuclear transport ship, the *Atlantic Osprey*, which caught fire while sailing from dry dock in Manchester to the Irish Sea on Monday 25 March 2002. The ship, a 16-year old, single-hulled vessel that was not originally designed for such shipments, was on route to the Irish Sea for sea trials. It had no nuclear cargo onboard, and had recently undergone modifications and upgrades in dry dock. The fire occurred in the starboard engine around midday and the crew failed to extinguish it by themselves. Following activation of the ship's fire-suppression system and with the assistance of the local Salford Fire Department, the fire was extinguished, though BNFL was unable to confirm the length of time the fire burned.

The potential radiological consequences of an accident are insignificant as transport containers for radioactive and nuclear material are designed to withstand physical damage. This has been pointed out, among other places, in a recent study completed by the IAEA. [1]. However, the loss of such containers near the coast is likely to have non-radiological consequences for the affected coastal States in the short term.

3. The Norwegian perspective

The nuclear industries in Japan are seeking less expensive routes for transporting RAM to and from Europe. They are evaluating the possibility of transporting reprocessing materials via the "Northern Maritime Corridor" along the Norwegian coast, and via the Northern Sea Route with the aid of ageing nuclear-powered Russian icebreakers. This may lead to less controversy for the industry, as using southern (Pacific) routes gives rise to much protest from countries potentially affected by accidents [2]. However, accidents involving such shipments pose a potential threat to Norwegian coastal settlements, the fishing industry and the environment. In addition, if such a shipment were to sink near the coast, there would be a great need for information about possible long-term consequences and salvage operations, both nationally and internationally, as was the case with the Kursk accident. After arriving in Europe from Japan, the spent fuel is reprocessed in dedicated plants before being recycled (MOX) and sent back to Japan for end storage. Each voyage generally takes six to eight weeks and the ships are capable of completing the voyage without having to call at port en route.

For many years, Norway has, due to the high number of nuclear sources in parts of the Arctic and the Arctic eco-systems vulnerability to radioactive contamination, contributed to a continued focus on radioactivity in the Arctic region. In 1991, the Arctic Monitoring and Assessment Program (AMAP) was established, and the program will released its next report in 2003 [3].In this work, as for existing and future RAM transports, it is vital at this point to foster increased international co-operation to improve monitoring and response strategies.

4. Consequences of potential maritime accidents

Norway believes that serious consequences could arise after an accident involving the transport of RAM near coastal areas, and that the special conditions in certain areas, such as high dependence on resources from the sea and particular vulnerable areas, should be taken into account when considering how to address the insecurity and potential consequences associated with such transports. Contamination of coastal environments with long-lived radionuclides is not desirable for any coastal state as it could have detrimental economic effects, e.g., for the fishing industry and tourism, and could cause concern and uncertainty in the local population. Moreover, the radioecological outcome of such an accident is related to the specific nature of the accident and can be difficult to predict in the long term. Experience has shown that relatively small amounts of radioactivity have leaked from sunken vessels carrying nuclear materials onboard (e.g., the *Komsomolets* submarine in the Norwegian Sea), though such accidents closer to the coast create a demand for information and assistance, especially from adjacent coastal states.

5. Conclusions and recommendations

International co-operation that enables rapid containment and assessment of risks and ensures public safety in the event of accidents is viewed as essential. Concern about potential accidents during the transport of RAM by sea, the need to protect the environment and human health, and the socio-economic importance of, in particular, the North Sea and Barents Sea make it important for Norway and the IAEA to conscientiously implement international regulations and safety measures that are relevant to the international maritime transport of RAM. In case of an accident the affected coastal state must be notified directly, as specified in the 1986 *Convention on Early Notification of a Nuclear Accident*. In addition, there is a need for improving international assistance frameworks for responding to nuclear accidents or radiological emergency, as reflected in GC(46)/RES/9. The Norwegian government has committed itself also to work for the establishment of an international regulations with makes it obligatory to notify concerned states when dangerous goods are being transported.

Regarding the international regulations, the 1982 United Nations Convention on the Law of the Sea, a network of treaties and customary international law recognise a number of specific obligations to which all users of the sea must adhere. Vessel source pollution falls largelyunder the treaty framework of the SOLAS Convention and MARPOL 73/78. Both the IAEA and the IMO are, however, competent regulatory bodies in relation to promotion of safety standards for the transport of radioactive materials and regulation of such shipping. Both in terms of these organisations individual achievements and commitment, and in terms of co-operation between them, there is room for improvement.

In addition, the existing conventions might not be sufficient in case of an accident in international waters. The responsibilities of the freighter as a commercial transporter that could potentially affect a coastal state due to an accident are not fully clarified. For example, a ship transporting RAM may have an accident in international waters and the flag state may not be the owner of the nuclear material onboard.

Norway urges states transporting radioactive materials, in accordance with the IAEA's Regulation GC (45)/RES/10, to provide appropriate assurances to potentially affected states that their national regulations are in accordance with the IAEA's Regulations for the Safe Transport of Radioactive Material. Norway welcomes the fact that a number of states and operators notify affected states in advance of shipments and encourages others to do so, ensuring that the information provided is not contradictory to measures for physical security and safety. Agreement and implementation of effective liability mechanisms for sea transport of RAM, as presented in the *Joint Protocol Relating to the Application of the Vienna Convention* and the *Paris Convention* (1998), are also important. The Joint Protocol established a link between the Conventions, combining them into one expanded liability regime aimed at providing a better system of compensation in the event of a nuclear accident, where operators and owner states are subject to insurance requirements that cover liability. All types of radioactive materials transport should be included under this Protocol.

Norway supports the call for further efforts to examine and further improve international regulations relevant to transboundary maritime transport of RAM that are consistent with UNCLOS. Increased international co-operation, especially regarding co-ordinated accident emergency planning and agreements for covering the potential costs of remediation, is of prime importance. Norway does not, however, support unilateral actions by states to keep nuclear shipments out of territorial seas and exclusive economic zones, that are not based on international law.

References

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REPORTING AND RECORDING OF ACCIDENTS AND INCIDENTS INVOLVING THE TRANSPORT OF RADIOACTIVE MATERIALS IN THE UK

S. M. Warner Jones, J. S. Hughes and K. B. Shaw

National Radiological Protection Board,
Chilton, Didcot, Oxfordshire. OX11 0RQ
United Kingdom

Abstract.

Accidents and incidents involving the transport of radioactive materials are rare. However, there is always a potential for such an event, which could lead to a release of the contents of a package or an increase in radiation level caused by damaged shielding. These events could result in radiological consequences for transport workers and members of the public. The UK legislation on the transport of radioactive materials requires significant events to be reported to the competent authority. This allows for investigations to be carried out which may result in corrective actions to be implemented and wider lessons to be learned. The Department for Transport (DfT), together with the Health and Safety Executive (HSE) have supported, for almost twenty years, work to compile analyse and report on accidents and incidents that occur during the transport of radioactive materials. The details of these events are recorded in the Radioactive Materials Transport Event Database (RAMTED) maintained by NRPB [1, 2] on behalf of the DfT and HSE. Information on accidents and incidents date back to 1958. RAMTED currently includes information of 747 accidents and incidents, covering the period 1958 to 2001. Annual reports on these events have been produced for twelve years. Also, information on these events is provided annually to the IAEA's EVTRAM database, for wider circulation. This paper presents a summary of the reporting requirements in the UK. Also, summary data on accidents and incidents are presented, identifying trends and lessons learned together with a discussion of some examples. It was found that, historically, the most significant exposures were received as a result of accidents involving the transport of industrial radiography sources. However, the frequency and severity of these events has decreased considerably in the later years of this study due to improvements in training, awareness and equipment.

1. UK reporting requirements for accidents and incidents

Road transport is the main mode for the great majority of packages containing radioactive materials. The requirements for reporting accidents and incidents by road are therefore described here: there are similar requirements for the other modes of transport. The regulations set basic criteria, which if exceeded, require the event to be notified to the Secretary of State for Transport. In effect, this requirement is fulfilled by notification to the competent authority, which is the Radioactive Materials Transport Division (RMTD) of the Department for Transport (DfT).

1.1. Reporting criteria

The reporting criteria are given in the Radioactive Material (Road Transport) Regulations 2002 [3]. The regulations make use of definitions of "notifiable event" and "radiological emergency", to establish these criteria, as follows:

"notifiable event" means any event where

1. radioactive material is lost, escapes or is unlawfully removed from the vehicle carrying the material;
2. any package carried in or on a vehicle is opened or otherwise damaged (whether or not the package is still in or on the vehicle);
3. the vehicle carrying the radioactive material overturns (including being turned on its side) or suffers serious damage or is involved in a fire; or
4. a radiological emergency occurs; where, a "radiological emergency" means a situation arising during the course of the transport of a consignment that requires urgent action in order to protect workers, members of the public or the population (either partially or as a whole) from exposure.

1.2. Reporting and other obligations of the driver, carrier and consignor

The UK regulations set out in detail the actions required of the driver, carrier and consignor in relation to an event as follows: The driver of the vehicle transporting radioactive material who discovers or has reason to believe that a notifiable event has occurred in relation to the vehicle he is driving must

- immediately notify the police and (where appropriate) the fire brigade and the consignor of that event;
- initiate the emergency arrangements in respect of any radiological emergency and
- assist in the intervention that is made in connection with that radiological emergency.

A carrier of radioactive material who becomes aware of the occurrence of a notifiable event in relation to the material he is carrying must

- immediately notify the police (unless the driver of the vehicle has already done so) and the Secretary of State of that event;
- assist in the intervention that is made in connection with any radiological emergency; and
- as soon as is reasonable practicable, arrange for the examination of the load that is carried in or on the vehicle so as to determine whether contamination has arisen and, if it has, to arrange for the safe disposal of any part of the load that has been contaminated and for the decontamination of the vehicle.

A consignor of radioactive material who becomes aware of the occurrence of a notifiable event in relation to his consignment must

- immediately notify the police and the Secretary of State of that event (unless either the driver or the carrier has already done so);
- assist in the intervention that is made in connection with any radiological emergency; and
- provide the Secretary of State with details of the incident that gave rise to that emergency.

Moreover, whenever a consignor becomes aware that emergency arrangements have been initiated in relation to his consignment he must notify the Secretary of State of the initiation of those arrangements even if, in the event, no intervention was subsequently made.

Events involving excess radiation exposure of workers, or members of the public, or loss of radioactive material may also be required to be notified to other government bodies, under other legislation, such as the Health and Safety Executive (HSE).

2. Collection of data on accidents and incidents

Information on accidents and incidents is received by the regulatory authorities such as the DfT, HSE, Civil Aviation Authority (CAA) and the Environment Agency (EA). These events can include accidents during transport (possibly including other vehicles), incidents involving breaches of the regulations [3, 4] such as mislabelling of packages missing or incorrect paperwork or radionuclide activities in excess of the limits for a given package type or conveyance. Further information can be received from consignors, consignees, carriers, and their appointed Radiation Protection Advisers (RPAs), and in cases where it has been invoked, reports from the National Arrangements for Incidents involving Radioactivity (NAIR) scheme.

The police are usually the first emergency service present at traffic accidents, if they suspect the presence of radioactive materials, they have the authority to invoke NAIR [5]. NAIR assistance is provided in two stages. The first stage is usually provided by a radiation expert (usually a hospital physicist or similar) equipped with simple monitoring and protective equipment. The stage 1 respondent advises as to whether a radiological hazard exists and can carry out any basic remedial actions should they be suitably equipped. In the case of large incidents, it is likely that a stage 1 respondent will not have the necessary resources and will recommend to the police that stage 2 response be invoked. Stage 2 response is provided by major nuclear establishments whose expertise, manpower and range of equipment enables them to deal with large-scale accidents and incidents.

Organisations transporting radioactive materials are required to have emergency arrangements; they cannot use NAIR for this purpose. The major consignors of radioactive materials have together formed an emergency response scheme known as RADSAFE. Should an incident occur during the transport of radioactive materials by (or on behalf of) one of the major UK producers then RADSAFE may be invoked. All RADSAFE signatories carry details on the conveyances about how to invoke RADSAFE. RADSAFE response is at various levels depending upon the significance of the event.

The transport of radioactive material rarely leads to radiation exposures in excess of low levels. However, such events have occurred. In cases where a worker may have received a radiation dose in excess of three-tenths of any statutory limit [6], HSE requires an investigation to be carried out which includes an estimate of the dose received. Records of these investigations are kept on file, and provide a further source of information.

Reports are made to the DfT of any untoward incident that takes place during the shipment of irradiated nuclear fuel flasks and discharged flasks by rail. These include reports of malfunctions on flatrols and adjacent vehicles, fire, derailments, decouplings and collisions. Criteria have been established to avoid including trivial events, such as suspected events that were not substantiated following inspection.

3. Criteria for inclusion of events in the RAMTED database

The transport of radioactive materials involves a number of activities, including the preparation of the package by the consignor, and loading onto a vehicle, followed by the shipment phase by carriers using various modes of transport. This may involve a number of loading and unloading operations, before final delivery to the consignee. The reported accidents and incidents included in these reviews come within the scope of these activities, for shipments within or into the UK. Events involving shipments from the UK are also included if the cause occurred in the UK. However, events occurring within consignors' and consignees' premises; that is “on-site”, are not included unless they are relevant to transport in public areas or occur during transit. The normal transport of radioactive materials may give rise to small radiation doses to transport workers and in some circumstances, members of the public might also receive very low doses. Conditions of transport that are intended to minimise these exposures are given in national legislation, and international agreements, for example by road [7], rail [8, 9], sea [10] and air [11]. These conditions include, for example, the specification of segregation distances for packages during stowage.

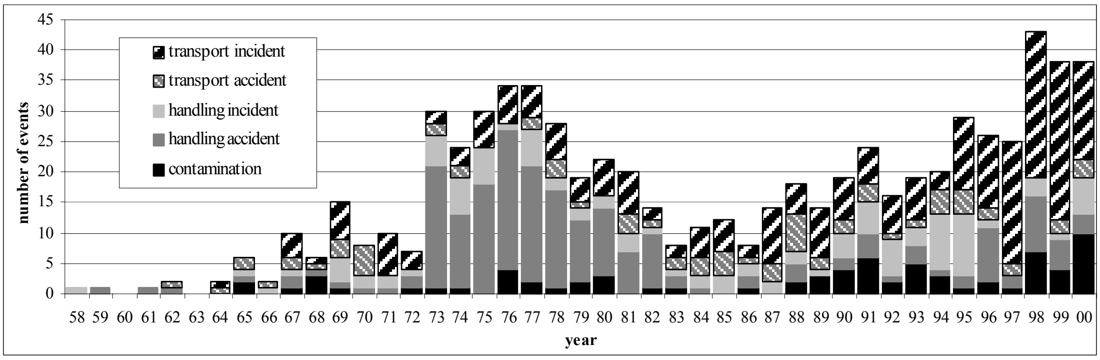
The most significant accidents and incidents that are included in these reviews are those that give rise to increased radiation exposures during transport. In addition to these, events are included that had the potential for increased radiation exposures. There are some events in this group that may seem trivial, such as those involving administrative errors. However, experience has shown that in some circumstances such errors can have serious consequences. In practice, all but the most trivial of reported events are included in these reviews. Many other less serious events are reported voluntarily by consignors, carriers and consignees. Other types of events that are relevant to the transport of radioactive materials may also be reported by others, such as the police, suppliers and manufacturers. There have also been a few instances where members of the public have found lost packages, and taken them to police stations. Incidents involving the transport of dangerous goods by rail are subject to standard reporting procedures. This system can result in quite minor events being reported very efficiently. Each year during the transport of irradiated nuclear fuel (INF) flasks there are a number of incidents where the train has been stopped following the detection of overheated axles or brakes. The detectors operate at temperature levels that do not pose a threat to the integrity of the INF flask. However, on occasions the overheating can result in smoke production and fires. The criterion for including such events in these reviews is whether smoke is apparent.

INF flasks are mainly loaded and unloaded underwater in ponds at nuclear power stations and reprocessing plants. The water in these ponds tends to be contaminated with radioactive material, and this contamination may become attached to the flask surfaces. Before transport, the flasks are thoroughly cleaned and monitored. The level of contamination by radionuclides must be below the regulatory limit of 4 Bq cm^{-2} for beta emitters (and low toxicity alpha emitters) and 0.4 Bq cm^{-2} for alpha emitters. For non-fixed contamination, the operational quantities related to these values are termed derived working levels (DWLs). Some of the contamination on the surface of the INF flasks is fixed on the surface, having been adsorbed onto the paint or metal on the surface. During the shipment of these flasks natural weathering effects may lead to some of the fixed contamination becoming non-fixed. This can result in the detection of levels of non-fixed contamination by the consignee that are in excess of those measured on despatch and can be in excess of the above DWLs.

The measurement of non-fixed contamination involves wiping the surface of the flask at up to 60 positions, each with an area of up to 300 cm^2. The assessment of the level of non-fixed contamination involves the conservative assumption that the wipe removes only 10% of the non-fixed contamination on the area wiped. It is known that in practice, a much higher proportion may be removed by wiping and therefore it is possible to overestimate the level of non-fixed contamination by up to a factor of 10 by this method. Consequently, reports of excess levels of contamination on INF flasks are included in these reviews if at any point on the surface the level is 10 DWLs or above. This criterion separates out those events where the regulatory limit is likely to have been exceeded.

4. Analysis of all events in the RAMTED database

All events have been analysed with respect to material category, mode of transport, event class and type of event, i.e. accident, incident or contamination. Accidents and incidents have been further categorised into handling or transport events. Events that occur during the movement phase have been classified as transport events. In many cases, the difference between an accident and an incident is very slight. For the purpose of this report, accidents are taken to be events in which the consignment/conveyance was damaged accidentally so that for example the conveyance could not continue its journey. All other events are therefore incidents (except those that are due to the presence of contamination, which are classified separately).



The annual trend in transport events can be observed in Figure 1 above. These events have been categorised into the five types of event; transport incident, transport accident, handling incident, handling accident and contamination. The peak in the mid 1970s is due largely to an increased number of handling accidents involving medical isotopes at airports. This led to the adoption of improved handling procedures, which greatly reduced the number of events of this kind. This is evident in the drop in events in the mid 1980s. Overall event numbers have increased since the early 1990s due to a number of factors, these include more efficient reporting and the addition of a number of orphan source events at scrap yards and steel producers. In recent years, many of these sites have erected radiation monitors at the entrance gate, these are set to levels at just above background, so any material that has an enhanced background level, contains contaminated material or orphan sources triggers an alarm. There are a number of reasons for these events to occur including failures at the originating site, illegal disposal or simply higher background radiation levels at the originating site. All of these events are reported to the Environment Agency. There are tens of events each year of this kind mainly due to varying background levels around the country. Only a small number of these events breach transport regulations and are entered on the database. Contamination events have increased slightly in the past few years, these occurrences are being addressed.

5. Analysis by event classification

All events in the database are classified by the cause, these being administrative errors, and events occurring during shipment – categorised into general shipment and shipment of nuclear fuel flasks. Each class is subdivided into events occurring due to package or conveyance anomalies plus, in the case of administrative errors, general anomalies such as lack of training and documentation.

Table 1 gives the number of events that have occurred in each category of the event classification system. Of the 112 administrative anomalies, 74 were due to general deficiencies, which mainly consisted of documentation errors. These also included 27 significant false alarms that required investigation or attendance by the emergency services. There were 9 events due to placard errors and 2 due to excessive Transport Index on the conveyance. Incorrect labelling or marking of packages was the cause of 27 events.

Table 1: Numbers of events in each classification

Area/subject	**Items covered**	**Number**
Administrative		
General	*Training, documentation, delivery mistakes and significant false alarms*	74
Conveyance	*Placarding errors*	9
	Excessive Transport Index on conveyance	2
Package	*Package wrongly labelled or marked*	27
Shipments (non-INF flasks)		
Conveyance	*Loading and stowage errors, and faulty conveyance*	16
	Accidents without fire	45
	Accidents with fire	6
	Spontaneous fire on conveyance	5
Package	*Incorrect package preparation*	51
	Material in supposedly empty package	11
	Contaminated package	11
	Package stolen, lost, found, including temporary loss	61
	Transport for unauthorised disposal	25
	Package damage or failure during transport	34
	Package damage during cargo handling	194
Shipments of INF flasks		
Conveyance	*Faulty conveyance, or significant overheating of brakes/axles*	19
	Fire on locomotive	3
	Collision, derailment and inadvertent decoupling	43
	Contamination above 10 Derived Working Levels	24
Package	*Errors in package preparation/ tie down*	16
	Incorrect/ unintended contents	6
	Mechanical problem/ mishandling during transport	7
	Contamination above 10 Derived Working Levels	58

In the shipment of general radioactive materials (not fuel flasks) there were 459 events, about half of which resulted in package damage either during cargo handling or other phases of transport. There were 51 cases in which packages were wrongly prepared including 24 in which insufficient shielding was provided. Fifty-one incidents involved conveyance collisions, six of which resulted in fire, which could have led to dispersal of contamination, but there were no serious incidents of that type. There were 61 cases of missing or found packages, and in 17 of these cases the packages were stolen with the vehicle.

During the shipment of irradiated nuclear fuel flasks, there have been 176 events entered on the database. These are split fairly evenly between conveyance and package events. The mechanical irregularities and low speed collisions or derailments have not led to any significant damage or risk of release from a flask. There have been 58 occurrences of package contamination, and a further 24 of conveyance contamination, in excess of 10 Derived Working Levels (an operational level based on the derived limit for surface contamination). These account for 47% of the fuel flask shipment events. Events have been further classified by material category, and mode of transport. The overwhelming majority of incidents occur during the transport of medical and industrial radioisotopes, accounting for 47% of all incidents. Events by mode of transport are fairly evenly spread with 24% of the events occurring during handling at an airport, a further 25% during rail movements and 31% during road transport. Shipments by air and sea accounted for 13 % and 7% of all events respectively.

6. Effects on packages

Accidents and incidents may result in damage to the package; all events have been classified with respect to the condition of the package as a result of the incident. There was no package damage (or no package) in over half of all events, but there was the potential for damage in almost half of these events - a further 9% of events were as a result of contamination – not necessarily due to package damage. One third of all events resulted in damaged or defective packages but without loss of shielding or containment and therefore no increase in radiation dose. Loss of shielding or containment occurred in 6% of all events. Improper packaging was the reason for 5% of the events recorded. The results are listed in Table 2.

Table 2: Nature of package deficiency by type of package

Package deficiency or damage		Type of package					
Main effect	Further detail	A	B	Excepted	Industrial	None	Totals
No package		0	0	1	0	46	47
No damage		45	62	20	17	0	144
Potential for damage	Minor	26	66	7	9	0	108
	Major	30	7	15	10	0	62
Damaged	Poor condition/ defective	6	16	2	2	0	26
or defective	Minor damage	98	7	14	8	0	127
	Severe damage	61	3	23	0	0	87
Shielding loss		6	0	0	0	0	6
Containment loss		10	0	5	22	0	37
Contamination	Contamination inside	3	4	1	1	0	9
	Contamination outside	0	59	0	1	0	60
Improper package with loss of shielding or containment	Wrong contents	3	5	0	2	0	10
	Poor condition and/or shielding	14	7	0	3	0	24
Totals		302	236	88	75	46	747

7. Radiological consequences

All events were reviewed to assess the radiological consequences. These events were graded based on the level of effect they may have. Four levels have been established:

- None - where dose rates and contamination levels were not above those expected during routine transport, or no evidence of exposures having been received;
- Extremely low - this is used when there is some increased exposure above that associated with routine transport, but considered to be so low that it was not assessed
- Below 1 mSv - Some increased exposure above that associated with normal transport but assessed to be low.
- Above 1 mSv or exposure to significant contamination - Some increased exposure above that associated with routine transport and assessed to be above 1 mSv (50 mSv extremity dose).

There were no increased doses in 71% of events. These include the majority of the fork lift truck events where there was no loss of containment or shielding, together with the numerous conveyance and administrative incidents where the package was not in danger. In 24% of events, there was likely to have been some very low exposure but no assessment of the doses was warranted. Assessed doses of above 1 mSv accounted for just 3% of cases, almost all of which were incidents involving industrial radiography sources that had not been wound back correctly into the shielding of the container. Assessed doses below 1 mSv occurred in 16 cases, the majority of these being due to loss of containment or shielding in packages containing medical or industrial isotopes. Table 3 lists the radiological consequences by material category. Most of the assessed doses over 1 mSv were accidental exposures to industrial radiographers and occurred some time ago. Current regulations require a Radiation Protection Programme (RPP) to be established by the operator. The objectives of such a programme are to: provide for adequate consideration of radiation protection measures, ensure that the system of radiological protection is applied, enhance the safety culture, and provide practical measures to meet these objectives. The application of RPPs will help ensure that accidental exposures are rare.

Table 3: Radiological consequences by material category

Material category	None	Not assessed- extremely low	Assessed- lower category (< 1 mSv)	Assessed- upper category (> 1 mSv)	Total
	Radiological consequences				
UOC	14	18	1	0	33
Pre-fuel material	17	2	0	0	19
New fuel	4	2	1	0	7
Irradiated fuel	67	28	0	0	95
Residues	39	64	1	0	104
Wastes	31	17	3	1	52
Radioisotopes	299	43	9	3	354
Radiography sources	49	7	1	15	72
No material	10	0	0	0	10
Total	531	181	16	19	747

8. The International Nuclear Event Scale

Events on the International Nuclear Event Scale (INES) are classified at seven Levels (1-7) and one below scale (0) [12]. The upper Levels, 4-7, are termed accidents and the lower Levels, 1-3, are termed incidents. Events with no safety significance are classified as deviations. Deviations (0, or below scale) are events where operational limits and conditions are not exceeded and which are properly managed in accordance with adequate procedures. Incidents (Levels 1-3) are events ranging from anomalies to serious incidents all with no offsite implications. Accidents (Levels 4-7) range from accidents without significant offsite risk (but may result in early death of one or more workers) to a major accident (the Chernobyl accident was rated 7). The INES has been in existence for over a decade and initially included only a limited scope for transport events. Recently [12], the system has been broadened to fully include transport events. The INES Information System includes a database of all significant events, from which lessons may be learned. Transport events that have a rating of 2 or more are notified to the INES Information System, through the UK INES Reporting Officer.

The events in RAMTED have been provisionally classified on the International Nuclear Event Scale. Transport accidents in the UK have never resulted in significant offsite risks and only one event resulted in a worker dose sufficiently high enough to be considered Level 4. This incident involved an inexperienced industrial radiographer, who was exposed to a 920 GBq ^{192}Ir source. He received a dose to the chest of 50 Sv resulting in radiation burns. Most of the 747 events (719) can be classified at rating 0 or 1 on the International Nuclear Event Scale, in broadly equal numbers. For both ratings, there was a spread across all material types, though the majority concerned medical or industrial radioisotopes.

9. Discussion and Conclusions

The UK experience of transport accidents and incidents involving radioactive materials is that releases and exposures of any consequence are very unlikely. The few cases involving high exposures have been mainly due to human error. Training and control have improved this situation. Quality control is an important feature of the transport regulations.

During the period covered by the database of events, there have been minor changes in the types of material transported and the modes of transport used. There has been a steady increase in the use of radioactive materials for medical purposes, which has resulted in an increase in the number of shipments of these materials. This may have been a possible contributing factor in the increase of airport handling events involving packages of medical isotopes in the 1970s and 1980s. These events have since been reduced significantly through improved handling procedures and the redesign of packages to make crushing by forklift trucks less likely. Spills of UOC from drums mishandled at docksides were virtually eliminated by the use of freight containers for the transport of the drums. Over the whole period, there has been an overall decrease in the number of serious incidents and a slight increase in the number of less serious incidents. The latter could be due to an increase in package movements and more efficient reporting of events including those which may have previously been undetected.

The most significant exposures received in the review period were to industrial radiographers as a result of incorrect preparation of the packages following use of the sources. In many instances this was due to defective equipment together with inexperience (simple monitoring would have shown that the source was still exposed). These events occurred mainly in the 1960s and 1970s, since this time there have been much improved procedures and training which have virtually eliminated these events. As the potential for receiving high doses is still there, it remains an area requiring continuing attention.

Correctly assembled packages that are stowed correctly very rarely cause any concern. There were very few reports of loss of containment of Excepted and Type A packages, even with severe package damage. There were no reports of loss of containment involving Type B packages.

There was a general trend towards increase in events in the mid to late 70s (mainly due to handling incidents at airports) improved procedures reduced the regularity of these events over the 1980s. In recent years the trend has been towards more events of all types, this is mainly due to improved reporting procedures, the inclusion of scrap yard events and larger volumes of packages transported. At present there are no sources of concern and previous concerns have been dealt with through improved training, procedures and package design.

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