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RADIOACTIVE MATERIALS and EMERGENCIES AT SEA

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Pursuant to article 1 of the Convention signed in Paris on 14th December, 1960, and which came into force on 30th September, 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, the Federal Republic of Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter: Japan (28th April, 1964), Finland (28th January, 1969), Australia (7th June, 1971) and New Zealand (29th May, 1973).

The Socialist Federal Republic of Yugoslavia takes part in some of the work of the OECD (agreement of 28th October, 1961).

The OECD Nuclear Energy Agency (NEA) was established in 1957 under the name of the OEEC European Nuclear Energy Agency. It received its present designation on 20th April, 1972, when Japan became its first non-European full Member. NEA membership today consists of all European Member countries of OECD as well as Australia, Canada, Japan and the United States. The commission of the European Communities takes part in the work of the Agency.

The primary objective of NEA is to promote co-operation between the governments of its participating countries in furthering the development of nuclear power as a safe, environmentally acceptable and economic energy source.

This is achieved by:

- *encouraging harmonisation of national, regulatory policies and practices, with particular reference to the safety of nuclear installations, protection of man against ionising radiation and preservation of the environment, radioactive waste management, and nuclear third party liability and insurance;*
- *assessing the contribution of nuclear power to the overall energy supply by keeping under review the technical and economic aspects of nuclear power growth and forecasting demand and supply for the different phases of the nuclear fuel cycle;*
- *developing exchanges of scientific and technical information particularly through participation in common services;*
- *setting up international research and development programmes and joint undertakings.*

In these and related tasks, NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has concluded a Co-operation Agreement, as well as with other international organisations in the nuclear field.

FOREWORD

Recent events have heightened awareness of the problems raised by accidents at sea involving radioactive materials.

The NEA Committee on Radiation Protection and Public Health (CRPPH) noted that, while the transport of radioactive materials at sea is governed by extensive international regulations, deficiencies remained, particularly concerning mechanisms for early accident reporting and the development of generic safety assessments and accident analyses for various kinds of sea transport.

As a contribution towards improving international guidance in this field, the NEA appointed a consultant to review the current status of activities carried out by the principal international organisations concerned with the transport of radioactive materials (the IAEA, IMO and the CEC), to identify the various areas where additional work is required and to suggest appropriate improvements. Only the radiation protection aspects of sea transport have been considered here.

After having examined the consultant report, the CRPPH felt that its wide distribution to national regulatory authorities in OECD countries would serve a useful purpose.

The report is published under the responsibility of the Secretary-General of the OECD and does not commit Member Governments or the Organisation.

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CONTENTS

1. INTRODUCTION

Transport is a vital part of any industrial process. Raw materials, wastes, components and finished products are all transported. Items that are potentially harmful to people and the environment during transport are known as dangerous goods: these include some chemicals, fertilisers, fuels, pharmaceutical products and radioactive materials.

The transport of dangerous goods is regulated both nationally and internationally. For radioactive materials, regulations are based on the International Atomic Energy Agency's (IAEA's) Regulations for the Safe Transport of Radioactive Material[(1)]. These regulations are subject to periodic review and revision and they are updated as necessary.

The transport of radioactive materials by sea is particularly significant for the Member countries of the Organisation for Economic Co-operation and Development (OECD). The growth in this traffic and the further increase in future years require efficient use of resources and uniformity of standards. The use of agreed standards does much to facilitate transport and to maintain a high degree of safety.

During transport, emergencies do occur and emergency procedures are required. Emergencies at sea are such that several countries may be involved particularly if an accident involving radioactive materials occurs near to shore. On 25 August 1984 the cargo ship Mont-Louis sank in the North Sea following a collision with a car ferry. The Mont-Louis' cargo included 350 tonnes of uranium hexafluoride in 30 containers together with 22 empty containers. The international nature of this shipment and the large number of countries involved can be demonstrated from the following facts: the consignment was loaded in France to be enriched in the Soviet Union for return to France, Belgium and the Federal Republic of Germany to be used in the manufacture of fuel for pressurised-water reactors. The containers for the uranium hexafluoride were designed in the United States and the collision occurred off the Belgian coast.

Media and public interest in the Mont-Louis was intense both nationally and internationally. The words "nuclear" and "accident" inspired extensive media coverage, sustained over several months, of the accident and the recovery operations.

Rapid response is necessary in any emergency. Immediate information is clearly required by those on the spot dealing with the accident. Relevant data would include a concise description of potential radioactive hazards and preventative measures to be taken together with details of any other potential hazards such as chemical toxicity. Information is also urgently required by the relevant authorities of countries involved. This would enable a speedy and accurate response to be made to news media enquiries and could help to lessen the degree of sensational reporting of the event.

This study is concerned with the radiation protection aspects of transport and covers the main types of radioactive materials transported by sea and their packaging. The appropriate regulatory controls are detailed and the results are given of assessments of accidents involving radioactive materials at sea. The radiological protection impact of such accidents is considered and recommendations are made for future work in this area.

2. MATERIALS AND MOVEMENTS

Radioactive materials are routinely shipped around the world. Packages consisting of all types of radioactive materials in their appropriate packaging are transported by sea[2]. Safety measures, appropriate to the nature and quantity of the radioactive materials, are built-in to the design of the packaging in which the material is to be transported on the premise that there could be an accident during transport. The consignor must ensure that the radioactive material is properly prepared for transport; the carrier must ensure the packages are properly stowed and must exercise due care in the carriage of the radioactive consignments; and the consignee is expected to check that no leakage or loss of material has occurred during transit.

For transport purposes, radioactive materials are divided into four general categories:

(i) small concentrations and limited quantities which are excepted from special packaging requirements,

(ii) low specific activity materials and surface contaminated objects which require various packaging integrity levels of Industrial Packagings,

(iii) quantities which require packaging that will retain the contents and shielding under conditions likely to be met in normal transport : such quantities are limited and are transported in Type A packages, and,

(iv) quantities which require packaging capable of retaining the contents and most of the shielding under normal and accident conditions : such quantities are unlimited and are transported in Type B packages.

All four categories of radioactive materials are transported by sea on cargo ships or roll-on/roll-off ships or ferries. In most cases radioactive materials are a small part of the total goods carried but dedicated vessels are also used whereby a special-use vessel, by virtue of its design or by reason of its being chartered, is dedicated to the purpose of carrying radioactive material.

In the regulations governing the transport of radioactive materials by sea, a conveyance is defined as any vessel, or any hold, or any compartment or defined deck area of a vessel. A defined deck area means the area, of the weather deck of a vessel, or of a vehicle deck of a roll-on/roll-off ship or ferry, which is allocated for the stowage of radioactive material. Exclusive use means the sole use, by a single consignor, of a conveyance or of a large freight container with a minimum length of 6 m, in respect of which all initial, intermediate, and final loading and unloading is carried out in accordance with the directions of the consignor or consignee.

The IAEA has, since 1980, collected data on numbers and types of radioactive shipments and distances covered by different modes of transport(3). The data are however very limited and are subject to many uncertainties.

3. REGULATIONS, CONVENTIONS, AGREEMENTS AND RECOMMENDATIONS

The IAEA's transport regulations(1) govern its own activities and serve as recommendations for national authorities and international organisations to use as a basis for their own requirements. The Agency's transport regulations are reviewed and revised periodically and a new edition is produced as necessary. For transport by sea the modal authority is the International Maritime Organisation (IMO) whose recommendations are published in the International Maritime Dangerous Goods (IMDG) Code[4].

It is important, to ensure consistency and uniformity of practice, to have international agreement on the packing, marking, labelling, placarding stowage and segregation of dangerous goods carried by sea. The IMDG Code is widely accepted and used for regulatory purposes over wide areas of the world. A recent survey[5] of IAEA Member States showed that over 60% use the IMDG Code to regulate sea carriage.

3.1 IAEA Transport Regulations

The scope of the IAEA Transport Regulations is designed to:

(i) establish basic requirements for limiting the exposure of persons to radiations;

(ii) specify general accident, quality assurance and compliance assurance provisions;

(iii) provide specific package design requirements and test and inspection procedures, package activity contents limits, controls for transport, controls for storage-in-transit, special controls for fissile materials; and

(iv) provide approval procedures for packages and shipments.

The main responsibilities, under the IAEA Regulations, are placed on the designers, manufacturers and users of packagings or packages: they must demonstrate that they have adequately satisfied the regulatory standards. The consignor is, in particular, required to certify that the contents of his consignments are fully described and are classified, packaged, marked, labelled and in proper condition for transport in accordance with all applicable national and international regulations. Safety during transport is dependent upon the package containing the radioactive material. The carriers and transport workers have a responsibility to treat radioactive material consignments with care.

The packaging and package requirements are the key features of the Regulations. They provide for adequate containment of contents, limitation on external radiation and contamination, prevention of criticality if the contents are fissile, and heat control if the contents generate heat. A graded approach to package design requirements and to controls placed on the design and use of packages is used whereby more stringent requirements and controls are imposed on packages containing more potentially hazardous materials. In addition, effective quality assurance methods are required, based upon a graded approach accounting for the nature of the package and its contents.

In the specific provisions of the IAEA Regulations emphasis is placed on requirements related to packaging and package design and testing, endeavouring to simplify as far as possible any requirements for controls in carriage. As the regulations have evolved, consideration has consistently been given to the principle of keeping radiation exposures as low as reasonably practicable. Experience has shown that compliance with the Agency's Transport Regulations ensures a high degree of safety. However, the emphasis on optimization in radiation protection has made it necessary to re-examine the provisions of the Transport Regulations and provide a more definitive determination that appropriate consideration has been given to optimization. Cost benefit analysis is one methodology that can be applied and this requires data on exposure levels to workers and the public that have been incurred under existing provisions of the regulations, and on differential costs and benefits for various alternatives to present provisions. There is a need for further development of the methodology that should be applied in the optimization of protection in the transport of radioactive materials.

For individual members of the public the dose limits apply to the critical group of the population and to the total individual dose from all sources of exposure, excluding natural background and medical exposure of patients. In practice, to take into account other sources of exposure, requirements in the regulations for segregating radioactive material packages from members of the public are formulated using conservative assumptions in the definition of the critical group, to provide reasonable assurance that actual doses from transport of such packages will not exceed small fractions of the dose limits.

3.2 IMDG Code Class 7 - Radioactive materials

The main requirements for the carriage of radioactive materials by sea are given in Class 7 of the IMDG Code. IMO maintains close liaison with IAEA and the Code is revised regularly to be consistent with revisions in the Agency's transport regulations. The Code is designed to assist compliance with the general requirements of the International Convention for the Safety of Life at Sea (SOLAS). It deals with matters of direct concern to the carriers such as provisions for stowage and segregation of radioactive materials from persons and other goods. The Code does not directly cover all the consignor's responsibilities such as the design and testing of packages and measures concerned with fissile materials. It makes reference to the relevant provisions of the IAEA regulations on such matters.

Class 7 of the IMDG Code includes recommendations on the following:-

- quality assurance and compliance assurance;
- stowage and segregation from persons and undeveloped film and plates;
- contamination;
- labelling and marking;
- segregation from other dangerous goods;
- transport document;
- accidents;
- undeliverable packages;
- exposure of crew; and
- approval and prior notification.

Some of these provisions are presented in the form of Schedules which are specific to each of the various types of consignment concerned and thus help the carrier identify the procedure appropriate in any given case.

3.3 IMO Codes of Practice

IMO has published Codes of Practice as follows:-

(a) Code of Safe Practice for Solid Bulk Cargoes[6],

(b) Emergency Procedures for Ships Carrying Dangerous Goods (EmS)[7],

(c) Recommendations on Safe Transport, Handling and Storage of Dangerous Substances in Port Areas[8], and

(d) Medical First Aid Guide for Use in Accidents involving Dangerous Goods (MFAG)[9].

It is essential that persons involved in the handling and transport of radioactive materials should be informed of the characteristics and potential hazardous properties of the materials and of any precautions to be observed. They will also need information on safety rules, first aid, emergency procedures and action to be taken in accident situations. Advice, for masters of ships, on the immediate action to be taken in emergency situations is given in the Emergency Procedures for Ships Carrying Dangerous Goods. Materials are grouped together in schedules where the emergency action is the same or similar. The appropriate Emergency Schedule can be identified through the United Nations Number assigned to the given material; this is especially useful for radioactive materials which have a significant subsidiary chemical hazard. Radioactive materials are covered in emergency schedules Class 7.

3.4 Response to accidents and incidents

In the event of an emergency at sea, immediate ction is taken by the master of the ship. If the scale of the emergency is such that external aid is required then assistance can be obtained through emergency response plans and mutual assistance.

Arrangements to cover transport accidents can be considered in three stages in order of increasing severity of the event:- contingency plans, emergency response plans and mutual assistance. Contingency plans are the responsibility of the carrier or consignor.

These plans are intended to cover minor events and would only trigger a response from the next stage, the emergency response plan, if individuals were at risk and the accident was outside the sphere of competence of the representative of the carrier or consignor. Emergency plans can involve a number of organisations and may therefore require co-ordination by a central group.

Ships often engage in multi-national arrangements whereby ships of different nationalities share trade or carriers share cargo space. Mutual emergency assistance in the event of severe emergencies may be required and mutual assistance agreements between countries should be encouraged.

A great deal of information exists on the requirements and procedures for the safe transport of radioactive materials. Emergency arrangements exist and Competent Authorities from different countries regularly meet to exchange information as for example in the Radioactive Transport Study Group (RTSG), an international group of regulatory experts in this field. There is no lack of procedures or requirements but often a lack of knowledge that such systems exist. The inability to rapidly find facts, often because of the complexity of the situation, could be avoided if a suitable data bank were available.

The IAEA has published a TECDOC on emergency response planning for transport accidents involving radioactive materials(10). The Commission of the European Communities (CEC) has issued a report(11) on mutual emergency assistance in the event of an accident during the transport of radioactive materials. Both stress the importance of appropriate arrangements and good information. The IAEA has also published two relevant documents containing useful guidelines in emergencies[12][13].

3.5 Reporting of Incidents

Where the International Convention for the Prevention of Pollution from Ships (MARPOL) is implemented, there is an obligation on the Master of a ship to report an incident involving the actual or likely loss into the sea of a harmful substance. In order to facilitate such reporting, the IMO has produced Guidelines[14] which recommend a uniform reporting system to be used by ships of all nations when within 200 miles of land. Systems are required such that reports are relayed without delay to Government, the flag state of the ship involved and any other state which may be affected.

The content of reports should include the following:-

i) name, identity and flag of the ship;

ii) date and time of incident;

iii) position at time of incident or, true bearing and distance from a clearly identified landmark;

iv) radiocommunications frequencies;

v) brief details of any defect, damage or deficiency to the ship or any other limitation,

vi) brief details of the incident to include:

correct technical names of the radioactive materials,

United Nations (UN) numbers,

IMO hazard classes,

names of manufacturers of the materials,

types of packages including identification marks, an estimate of the quantity and likely condition of the radioactive materials,

whether the loss floated or sank,

whether the loss is continuing and,

cause of the loss;

vii) details of weather, wind, sea and swell conditions;

viii) name and address of ship's representative; and

ix) ship size and type and any other appropriate details.

The immediate reporting of any consignment of radioactive material that is lost into the sea is important for all ships particularly when within 200 miles of land. Such systems should be developed internationally using the IMO Guidelines.

3.6 Practical guide

In the event of an emergency at sea involving radioactive materials, national authorities would be expected to respond quickly and to be able to answer questions on the significance of the incident. Authorities may be called upon to provide radiation protection advice to those performing rescue operations if their flag ships were involved, if the shipment originated in their country or if the emergency occurred close to their shores.

The Regulatory Authority in each country should establish an emergency response organisation and set out emergency response procedures to be followed in case of emergencies, incidents and accidents. There is a need for exchange of such information between authorities so that, in the event of an emergency, rapid exchanges of information can occur. The CEC is currently studying the formation of a data bank of the arrangements within member states for transport accidents involving radioactive materials. The IAEA is currently considering a data base on shipments and accident and incident reporting systems. The outcome of such work will be of benefit to international and national authorities.

There would be a considerable advantage in producing, for authorities, a concise guide on emergencies at sea. It could contain information on appropriate international and national organisations together with contacts. Details of emergency arrangements and reporting systems could be covered. As with any such practical guide it would need to be maintained and updated.

Current work by organisations such as IAEA, IMO and CEC will facilitate the production of a practical guide. However it will require the involvement of international organisations together with national authorities to ensure that an adequate guide is produced. As part of the input to this process, the Nuclear Energy Agency (NEA) should ask Member countries for views on the content of a practical guide and for information on their national arrangements for emergencies at sea involving radioactive materials.

4. ASSESSMENTS OF ACCIDENTS AT SEA

4.1 Postulated events

Emergencies at sea can arise due to extreme weather situations, unforeseen events on board the ship or as a result of collision. The level of emergency response will depend upon the materials and packages involved together with the prevailing events and conditions.

The emergency procedures will depend upon whether the radioactive materials or packages remain intact, whether there is a spillage and/or whether there is fire involved. The radiological impact of such potential scenarios can be assessed using mathematical models.

There are various types of accident that may occur at sea, they can be classified as accidents due to collision, grounding, onboard emergencies such as fire, severe weather and, various combinations of these events. The outcome of an accident will depend upon many factors and can range from a floating ship where all radioactive materials can be safely removed to a sunken ship where recovery may be impossible. Some accidents will not have any effect on the radioactive materials whilst others could result in their release.

4.2 Accident assessment methodology

The postulated events will result in either of the following:-

(i) no change in radiation exposure conditions,

(ii) loss of shielding resulting in enhanced external radiation levels,

(iii) spillage of radioactive material, and/or

(iv) the release of an aerosol of radioactive material.

The loss of shielding events, which give rise to enhanced external radiation levels, can be addressed using mathematical models developed for the assessment of normal transport operations. Several computer models exist which are able to estimate the dose contribution from penetrating gamma radiation emerging directly from the package. Examples of these models are RADTRAN II[(15)], INTERTRAN[(16)] and TRANSDOS[(17)] a model developed by the National Radiological Protection Board (NRPB).

Events involving the spillage of radioactive material or the release of an aerosol of radioactive material following loss of containment can be addressed by models such as CRAC 2[18], RADTRAN II[15], INTERTRAN[16] and the methodology developed by NRPB called MARC[19] (Methodology for Assessing Radiological Consequences). These models were originally developed for, or derived from, methodologies for assessing the consequences of reactor accidents. Such models have been used to assess consequences of radioactive releases on land but they could also be applied to releases at sea.

The model INTERTRAN was developed for the IAEA with the aim of facilitating the assessment of the radiological impact of the transport of radioactive materials in individual Member States leading to assessment on a world-wide basis. However because of the generic and simplified modelling employed in INTERTRAN it must be used with knowledge and care, especially in the modelling of accidents: it is of very limited use in the assessments of accidents at sea.

4.3 Assessments of the impact of incidents at sea

The essential principle for the safe transport of substantial quantities of radioactive material in type B packages is the containment of the material in packaging adequate to retain the contents in the event of a severe accident. Absolute certainty cannot ever be guaranteed and assessments have been performed on the probability of an incident occurring and breaching the containment and the subsequent probability of such an event causing radiation exposures and health effects.

As an example, the UK Nuclear Installations Inspectorate has performed a safety assessment on the transport, by sea and land, of plutonium in the form of nitrate solution between Dounreay and Windscale[20] (now Sellafield). The conclusions of the assessment were that the transport operation presented risks substantially lower than those common in industrial operations, transport and everyday life and that there were no grounds associated with the health and safety of members of the public or of workers for advising against the transport operation.

Recent work associated with the storage and disposal of radioactive wastes has included studies of accidents occurring to ships at sea. The NEA/OECD Seabed Working Group has considered a number of accident scenarios that could occur during the transport of high-level waste to a seabed disposal site[21]. The cases considered included a shipwreck in coastal waters with 25 containers damaged. In general these studies were intended not to provide information on potential radiation exposures but rather to focus on the priorities for future research.

A sensitivity analysis has recently been published of the consequences of a ship carrying high-level radioactive wastes sinking in the northwestern Atlantic[22]. The evaluation of the consequences of such an accident involves the modelling of many complex physical processes. Sensitivity analyses help identify the most significant parameters and assumptions. Collective doses and individual doses were calculated for very long periods after the accident. The calculated doses were not significant compared to the levels of natural background. The main objectives of the study were once more to help with establishing research priorities.

As part of the Subseabed Disposal Program at Sandia National Laboratories, a study has been made of potential damaging accidents at sea, package failure mechanisms and radionuclide release rates[23]. A series of accidents were considered and three key accident sequences identified for ships carrying high level waste cannisters. These accidents were as follows:- the ship strikes another ship, or is struck by another ship or, runs aground in coastal waters. The most likely scenario identified (2.5 chances in 10,000) was the sinking of a ship in the open ocean following a collision accident. Release parameters were calculated covering the number of failed packages, the time of failure and the potential release duration. The probability of release of radioactivity in a 25 year operational period was then calculated and the potential individual radiation doses were determined. The highest individual exposure occurred for the accident sequence of a ship sinking in coastal waters with no recovery. However even in this case the maximum individual dose was only 7 mSv per year, some seven times the average value of exposure due to natural background radiation.

Most assessments associated with the sea transport of radioactive wastes have tended to be concerned with research priorities and radiation exposures in the long-term. There is a requirement for assessments of the near-field situation, of potential exposures to ships' crew and emergency teams.

5. REPORTED ACCIDENTS AT SEA

Accidents at sea, although very rarely involving radioactive materials, have occurred and some have received considerable media, political and public attention. An accident involving radioactive materials attracts attention but if "nuclear" radioactive materials are involved then the interest is overwhelming.

A recent study[24] of the radiological impact of accidents and incidents in the United Kingdom over the past 20 years shows that the overall radiological impact of transport is low. For this study, events were included if they occurred:-

(i) during transport - when the transported materials or transporter were damaged or liable to be affected; and

(ii) pre-transport - when events, prior to the transport taking place, resulted in any enhanced radiological impact during transport.

All UK movements of radioactive materials were covered in this study. The results show that, during this 20 year period, the largest contribution to worker and public exposure arose from incorrect loading of site-radiography sources by the users prior to despatch: this included three cases of incorrectly loaded packages being returned to the UK from overseas.

Prior to 1978, shipments of uranium ore concentrate were brought to the UK in drums. Storms at sea and handling incidents at docksides resulted in some slight spillages of ore. Since 1978 such shipments have been containerized and no further spills have been reported.

Norway has reported[25] three radioactive logging sources lost in the North Sea. One loss was due to a shipwreck, one source was lost overboard and the third was lost during a loading operation.

The sinking of the cargo ship Mont-Louis in August 1984 and the subsequent recovery of its cargo of uranium hexafluoride in cylinders produced intense media interest world-wide for several months. A recent report of the incident[26] stresses that this accident had no radiological or chemical consequences. The cylinders displayed the expected degree of resistance both during the collision impact and when submerged. All the cylinders were recovered with no leakage of radioactive material. The report of the incident does make some useful points concerned with the incident. It notes the benefit from having a shielded container available as a precautionary measure and the advantage to be gained by having valve protection caps. The report comments on the need to review stowage arrangements and the importance of accurate information on potential hazards and emergency procedures. Finally it emphasises that the potential hazard from the transport of natural or depleted uranium hexafluoride is essentially a chemical one.

6. TRAINING AND INFORMATION

6.1 Training

International and national regulations require that appropriate training be given to transport workers. The training provided should be appropriate to the work and to the workers involved.

Many of the workers associated with "transport work" rarely come into direct contact with the packages. Within the broad definition of "transport workers" there are many sub-divisions such as crew, loaders, inspectors, maintenance persons, clerical/administrative staff and workers in many varied supporting roles. For this range of workers the training needs will vary from basic to comprehensive and in some cases could focus solely on the labelling and administrative requirements rather than on radiological protection issues.

The training programme covering the spectrum of transport workers can be broken down into specific training elements as follows:-

- Introduction to the Transport Regulations;
- provisions for handling, stowage and segregation;
- detail of packaging and package design and performance testing;
- introduction to radiation protection;
- information on radiation exposures and risk from transport of radioactive materials;
- detail of radiation risks;
- radiation monitoring;
- contingency planning; and
- emergency response.

For those workers providing a supportive role and, therefore, not directly involved with the handling or movement of packages containing radioactive material, a programme using the first element would probably be sufficient. At the other extreme, workers continuously associated with specific consignments of radioactive materials would need to be trained in many of the elements. Decisions regarding the specific training needs will be dependent on an analysis of the particular role of the worker.

6.2 Information, approval and prior notification

Approval and prior notification requirements are contained in the IAFA Transport Regulations and in the IMDG Code. For some packages and for certain materials, Competent Authority approval is required from the country of origin and countries through or into which the consignment is transported. Additionally, for each such shipment, the consignor is required to notify the country of origin and countries through or into which the consignment is transported. A summary of these requirements is contained in Annex II of IAEA Safety Series No. 80[27].

The IAEA Transport Regulations require that the relevant Competent Authority shall arrange for periodic assessments to be carried out as necessary to evaluate the radiation doses to workers and to members of the public due to the transport of radioactive materials. The IMDG Code Class 7 requires the Competent Authority to arrange for periodic assessment of annual radiation doses received by passengers and crew. The assessment and measurement of radiation exposures resulting from the transport of radioactive materials by sea is essential to provide the proper perspective.

A CEC report[28] on mutual emergency assistance in the event of an accident concludes that an important aspect is the availability of information in the event of an emergency. Information is required at different levels and should be readily understood.

7. DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

There exists comprehensive regulatory provisions for the safe transport of radioactive materials by sea. The main organisations involved are the IAEA and the IMO together with national authorities. The regulations are regularly revised to ensure consistency with other international standards and recommendations, for example with those of the International Commission on Radiological Protection.

In addition there are several codes of practice, providing guidance on stowage and transport by sea. At a more basic level, there are publications aimed at informing groups of workers but even so it is considered that this is an area that requires more detailed attention. Education and training needs, and the provision of information to workers, are very important considerations. The work of IAEA, IMO, CEC and the national regulatory authorities in this area has been of benefit and should be encouraged.

The experience of transporting radioactive materials by sea has proved that the radiological impact is very low and that the international requirements, properly complied with, are effective. The lessons learnt, from the few emergencies that have occurred, are taken into account and amendments will continue to be required in the light of new information. Quality assurance and compliance assurance are areas that require careful consideration and adequate allocation of resources.

Stowage and segregation provisions for radioactive materials are areas that should receive detailed consideration because of their importance in emergency situations. A data bank for transport emergencies would be helpful to those directly involved in an emergency as well as to officials who require to be fully informed. Such a data base should include detailed emergency procedures together with information on potential radiation hazards and other subsidiary risks.

7.1 Recommendations

(i) The loss or likely loss into the environment of any consignment of radioactive material should be reported immediately. Systems are required such that reports are relayed without delay to Government, the flag state of the ship involved and any other state that may be affected. The report should be in accordance with the

IMO General Principles for ship reporting systems and ship reporting requirements.

(ii) Current work by IAEA and CEC on accident and incident reporting systems and emergency arrangements should be supported. International organisations and national authorities should co-operate in the production of a practical guide in this area. As part of the input to this process, Member countries should provide views on the content of such a guide together with information on their own arrangements for emergencies at sea involving radioactive materials.

(iii) Assessments of the radiological impact of severe incidents at sea are important. Generic assessments are required for various accident conditions and realistic release quantities. Input data is sparse and work is required on source terms, particularly potential release fractions. In addition, further work is required on the near-field situation, for example regarding potential exposures to ships officers and crew and other emergency workers.

(iv) Training and information should be provided to workers at levels dependent upon the role of the worker. Consideration should be given to the need for simple basic information to be readily available to transport workers to ensure that high standards are maintained. The work of IAEA, IMO, CEC and national authorities should be encouraged in this area. The IAEA and IMO sponsored training aids deserve further attention.

(v) Quality assurance and compliance assurance are important and adequate resources must be available to ensure compliance with regulatory provisions.

(vi) Mutual assistance agreements in the event of emergencies at sea should be encouraged. The CEC is active in this field.

(vii) A data bank including relevant emergency procedures, risks and precautions should be prepared. International organisations are considering this matter.

(viii) Information on potential radiation hazards must be accompanied by information on subsidiary risks where they are relevant.

(ix) Although the traffic in radioactive materials has increased, there is no evidence that accidents at sea have increased. On the contrary, evidence suggests that modern ships and handling procedures have reduced the probability of such events. Future trends may alter this situation and it is essential to provide for the periodic assessment and measurement of radiation exposures.

(x) The IAEA transport information collection system should be supported and Member countries encouraged to provide comprehensive data.

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