SURVEY OF RADIATION PROTECTION PROGRAMMES FOR TRANSPORT

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ABSTRACT
One of the major changes in the IAEA Transport Regulations (No. TS-R-1 (ST-1, Revised)) is the explicit requirement for the establishment and application of a Radiation Protection Programme (RPP) for the transport of radioactive material. This paper provides guidance and information relevant to the establishment of RPPs for the transport of radioactive material thereby assisting both transport operators in their obligation regarding the development, implementation and maintenance of RPPs for transport and competent authorities in their role of exercising control of compliance with all relevant safety standards and criteria. The material provided may also be helpful in facilitating the interaction between operators, applicants, licensees and other organisations concerned in their interaction with competent authorities. The paper draws upon work [1] undertaken by IPSN France, NRPB UK and GRS Germany on behalf of the European Commission and several national agencies.

INTRODUCTION, OBJECTIVES
This paper presents the findings and conclusions of a study performed on behalf of the European Commission (EC). The goals of this multilateral EC-Project were to assess and evaluate the new regulatory requirement on the development, implementation and application of radiation protection programmes (RPPs) for the transport of radioactive materials by (1) reviewing currently existing radiation protection programmes for transport and related studies and (2) developing guidance for the development, implementation and evaluation of RPPs consistent with the basic requirements of the Regulations. The EC project was carried out jointly by organisations from three EU Member States (IPSN : France, NRPB : United Kingdom and GRS : Germany). The study results served to a significant extent as a basis for the development of an International Atomic Energy Agency TEChnical DOCument on basic requirements for the implementation and application of RPPs for transport. At the same time, it is recognised that this multilateral project greatly benefited from the deliberations and international discussions associated with the development of this TECDOC. The requirement for the establishment of RPPs for transport will - based on the international modal regulations - become mandatory not later than 1st of July 2001 for air transport and on 1st of January 2002 for all other modes of transport, i.e. road, rail and sea.
RPPs are a new key element of the radiation protection provisions of the Regulations, and define and document the radiation protection objectives of a transport organisation (operator). They also describe the operator's response to meeting these safety objectives. The stated purposes of a RPP are to: a) provide for adequate consideration of radiation protection measures, b) ensure that the system of radiological protection is adequately applied, c) enhance the safety culture, and d) provide practical measures to meet these safety objectives. RPPs thereby assist in meeting the radiation protection principles of the international Basic Safety Standards (BSS) and the 1990 ICRP Recommendations. They should also ensure that the magnitude of individual doses, the number of persons exposed (public or workers) and the likelihood of incurring exposure (routine or potential) are kept as low as reasonably achievable, economic and social factors being taken into account, and

that doses to persons are below the relevant dose limits (paragraph 302 of TS-R-1) during the transport of radioactive material (see paragraph 106 of TS-R-1 for the definition of transport).

RESPONSIBILITY FOR THE IMPLEMENTATION AND APPLICATION OF A RPP

It is understood that the radiation protection objectives embodied in the Transport Regulations are best established through the co-operation of the parties engaged in the transport operations. In more complex transport situations, however, close co-operation between operators may be difficult to achieve in practice. Therefore the responsibility for the establishment and application of a RPP rests essentially on each transport organisation being independently involved in transport operations that give rise to radiation exposures of persons, property or the environment. These transport-related activities are typically carried out under the sole responsibility of the consignor, carrier and consignee of radioactive material. It is, however, being acknowledged that competent authorities may require alternative systems to be implemented and applied on a national basis, for example, by requiring the consignor to examine and evaluate the adequacy and effectiveness of the RPP of his subcontractors involved in the transport activities of his own transport programme. Consignors may also decide to voluntarily assist subcontractors in the development and implementation of their RPP.

Note: According to para 107 TS-R-1 the Regulations do not apply to "radioactive material movements within an establishment which is subject to appropriate safety regulations in force in the establishment and where the movement does not involve public roads and railways".

SURVEY OF EXISTING RADIATION PROTECTION PROGRAMMES AND RELEVANT STUDIES OF RADIOACTIVE MATERIAL TRANSPORT

Existing RPP

In the 1985 edition of the Transport Regulations, Safety Series No. 6 (amended 1990), there is a requirement for a RPP for special use vessels. Additional guidance is given in para. A-472 and in Appendix VIII of Safety Series No. 37. The establishment of RPPs in the transport of radioactive materials is a new requirement. However, preliminary enquiries in France, Great Britain and Germany indicate that comprehensive RPPs for transport consistent with the new provisions of the Regulations are not yet widely developed and applied by consignors or carriers. For operators of fixed nuclear installations, the establishment of a transport-specific RPP will generally involve a synthesis of existing arrangements. In general, consignees and consignors are already subjected to a facility RPP through a licensing authority and, for those transport operations which are entirely performed within a facility, for example package loading, preparation, the relevant radiological considerations would be an integral part of that facility RPP. Carriers are required to have emergency provisions for accidents involving the transport of radioactive materials, but very few specialist carriers have developed arrangements to cover the wider aspects of radiological protection. In this respect, it is therefore carriers who have the more significant task in providing comprehensive RPPs, and who are in most need of advice on this topic.

Relevant dose assessment studies

The radiation exposure of the public and transport personnel from routine transportation of radioactive material have been assessed for transport of spent fuel, vitrified wastes, U3O8, UF6, technetium generators and radiopharmaceuticals. It has been found that transport operations associated with supply and distribution of radioisotopes for medical, scientific and general industrial applications result in transport worker effective doses in the range of 10 – 14 mSv/year in four EU Member States (Germany, the Netherlands, Sweden and UK) [4] and 18 mSv/year in France [5]. Significantly lower transport worker doses have been found to prevail in transport operations arising from nuclear fuel cycle operations. Doses arising from these shipments were generally less than 2

mSv/year, with most values below 1 mSv/year in the UK and Sweden [4], and a maximum of 4 mSv/h in France for a handler at the railway terminal of Valognes near La Hague [6]. Some studies indicate that individual radiation exposures are broadly related to the Transport Index (TI) handled. Whatever the radioactive material transported, doses incurred by members of the public in routine condition of transport are shown to be very low (typically well below 100 μSv/year) in comparison to exposures arising from natural or cosmic radiation.
Several investigations have been made to establish a relationship between the total number of TI transported or handled by an operator and the dose received by the workers. This relationship can be used to determine the dose per unit TI of well managed practices for specific operations. An upper bound value can then be specified for the number of TI transported in a year below which the annual dose to workers is unlikely to exceed 1 mSv. For example, from the result of a UK study related to the transport of technetium generators it was concluded that it is unlikely that a transport worker handling less than 300 TI a year will exceed an annual dose of 1 mSv. But such a relationship does not take into account the working methods and therefore should be used with caution.

RPP ELEMENTS AS A FUNCTION OF OCCUPATIONAL EXPOSURE

The principal considerations and functional elements to be addressed in a RPP for transport should be documented as described below. Documentation gives proof of the effectiveness of the programme and may be useful to demonstrate to workers the level of safety and protection of their workplace. A graded approach should be employed to ensure proper use of resources. Therefore, each of the following programme elements should be implemented and documented to the level of detail appropriate to the operation.

Scope of the programme

An important first step in the establishment of an RPP is to define the field of application of the RPP. Therefore a description of the type, nature and volume of radioactive materials being shipped, the number of workers potentially involved and the type and duration of the operations covered by the programme are essentials of the programme documentation. These will allow the operator to identify and define the necessary radiation protection arrangements and assist the competent authority in judging the adequacy of the radiation protection and safety provisions covered in the programme.
The transport programme description also provides an indication of the protection measures needed to meet the optimisation and dose limitation requirements of the Regulations, the basis for classification of the workers, the necessary operational radiation protection arrangements and the type and extent of the dose monitoring programme to be implemented under the RPP.

Roles and responsibilities for the implementation of the RPP at the operator level

The operator's management has the principal responsibility for establishing safety objectives and ensuring that the safety-related duties and requirements, including optimisation of protection, is implemented through the adoption of an adequate management structure and the provision of adequate resources. The management structure should reflect the management’s commitment to safety by written policy statements and by clear support for those with direct responsibility for radiation protection and safety in the workplace and the public domain. The organisational arrangements should clearly identify and document the roles and responsibilities of the individuals involved and the functions to be performed by them. Adequate infrastructure and resources should be available, i.e. providing - where relevant - facilities, suitably qualified staff, equipment, training, feedback mechanisms and the authority to perform the activities in compliance with all relevant legislative, regulatory and managerial requirements and operational procedures in an effective manner and verify that the goals are met. Conduct of the administrative and operational functions

including the establishment and application of a RPP may be allocated to a suitably qualified external expert (e.g. a radiation protection officer or safety officer) or expert organisation with the required authority to carry out actions and tasks related to safety relevant duties. However, the final responsibility for ensuring compliance with all relevant regulations, decrees, directives, ordinances and standards rests on the transport organisation.
It is also recognised that workers can by their action contribute to the protection and safety for themselves and others at work (BSS para 1.10 [3]) and, thus, there are responsibilities on both the workers and employers/transport organisation to meet the radiation protection objectives. Workers are in particular responsible for following all relevant safety procedures and for carrying out their duties correctly as well as for providing feedback to the management on any occurrences and irregularities with relevance to safety and protection.

Dose assessment and evaluation
Dose assessment and evaluation is a key issue within the framework of RPPs and relates to two fundamental radiation protection considerations: a) a prior radiological evaluation of all aspects of the operations to identify the routine and reasonably foreseeable potential sources of exposure to make realistic estimates of the doses and to determine the radiological protection measures needed to satisfy the optimisation principle and b) radiation monitoring and/or dose assessment demonstrating compliance with all relevant radiological standards and criteria during transportation thereby establishing confidence in and continuation of good practice.
For the assessment and evaluation of the transport-related radiation dose arising from both routine transportation and potential accidents the package type, the package category and the transport volume need to be considered. For routine transport dose assessment the external package dose rate is important and the package category provides an indication for this; under accident conditions, however, it is the package type (e.g. excepted, industrial, Type A, Type B or Type C) that is important. Dose assessments may not be warranted for the transport of excepted packages and category I white packages which are intrinsically safe in normal conditions of transport.
Several dose assessment methods are available and should be utilised depending on the scope of the RPP. To the extent possible reliance on (historical) transport dose monitoring data is the preferred method when representative occupational exposure data are accessible, i.e. exposure data from the same type of transport operations or practices undertaken under similar conditions. In the absence of such data, dose assessment must be based on some alternative methods including exposure analysis data, approximate point source calculations, analysis of relevant literature data, assessment of exposure based on relationship between the total number of transport index and the doses received (dose-to-TI ratio), use of computer dose assessment tools such as IntertranII, Radtran4, Microshield etc. Where necessary the external dose assessment may be complemented by airborne radioactivity and surface contamination monitoring data for the assessment of the potential internal dose. Moreover, internal exposure to a worker can be based on measurements of quantities of radioactive materials in his body, such as whole-body monitoring or biological analysis. The approaches and models involved in the assessment for the potential internal dose are, however, generally more complex than for external exposure.
The nature and extent of personal monitoring and record keeping is related to the occupational dose arising from transport activities. The Regulations (para 305 TS-R-1) define three categories of occupational exposure of personnel for monitoring and dose assessment: a) The assessed effective dose is unlikely to exceed 1 mSv/y. Very little action needs to be taken in this dose range for evaluating and controlling dose. b) The assessed effective dose is likely to be between 1 and 6 mSv/y. In this dose range a dose assessment programme has been suggested via work place monitoring or individual dose monitoring and c) The assessed effective dose is likely to exceed 6 mSv/y. In this dose category individual monitoring of the transport personnel is mandatory.

Descriptions of the radiation monitoring methods and procedures (package and conveyance radiation monitoring, workplace monitoring, worker monitoring) should be provided with some guidance related to the method of measurement, frequency of monitoring, frequency and method of calibration, maintenance of equipment, recording and record keeping of the measured doses. Monitoring equipment should be suitable to the types of radiation encountered and calibrated to meet the appropriate performance standards.

Surface contamination assessment
The type and likelihood of occurrence of the surface contamination in transport reflect both the degree of containment and the effectiveness of the operational controls. The RPP should identify the applicable criteria for controlling (fixed and non-fixed) surface contamination in working areas and on packages, conveyances and equipment within a transport organisation and provide an outline of the type and extent of the contamination monitoring programme. Details of the monitoring techniques depend strongly on the type of radioactive material in question (fission products, isotopes etc.), therefore proper selection must be made with respect to monitoring equipment which should be suitable to the types of radiation encountered and calibrated to meet the appropriate performance standards.

Dose limits, dose constraints and optimisation
The radiation protection requirements, given in the Basic Safety Standards (BSS [3]), underlying the Transport Regulations set a limit on effective dose for members of the public of 1 mSv/y and for workers 20 mSv/y averaged over five consecutive years. Additionally, there are limits on equivalent doses for lens, skin and extremities. Dose constraints are an important feature of the optimisation procedure and may be established to represent some fraction of the dose limit. They should be used in a prospective sense to help prevent individuals from receiving unacceptable levels of dose. Investigation levels, above which an investigation is initiated, should be defined.
In order to provide a high level of protection against radiation exposure, the IAEA Transport Regulations have adopted the principle, that for practices giving rise to exposures, radiation protection should be optimised to keep exposures "as low as reasonably achievable", a principle known as ALARA. Formal optimisation of protection against both normal and potential exposures simultaneously is generally considered difficult and may not always be applicable and useful. Much can be achieved in optimisation of protection, particularly in everyday control, through the use of professional judgement by suitable qualified, experienced and competent staff. The following are suggested to help judge if an action is reasonable (para 92 ICRP Publ. 75): a) common sense and b) good practice. Optimisation of protection may where possible, for example include periodic reviews of dose profiles and comparisons with predicted doses, application of adequate segregation distance tables, provision of adequate shielding arrangements and periodic feedback analysis.

Segregation and other relevant protective measures.
The use of segregation distance does not in itself remove the requirement for undertaking a dose assessment. Preventive and operational arrangements have to be undertaken during transport to limit possible worker and public exposure. These may include implementation of specific working instructions, adequate shielding provisions, protective measures such as wearing of personal protective clothing and routine use of remote handling equipment.

Radiation protection information and training
The provision of information, training and refresher courses are an important part of the system of radiological protection with the ultimate goal to control normal and potential exposures. The amount of training should be commensurate with the potential hazard and the responsibilities of the

individual. Generally, initial training courses and periodic refresher-courses are required. Training may be provided at three levels: a) General awareness training: A basic course on the relevant regulations and regulatory requirements, basic principles of radiation protection, radiological hazards, protective measures, what to do in case of an accident, b) Function specific training: Training should relate to specific jobs, to specific measures to be undertaken while fulfilling normal job functions or in the event of an accident, c) Safety training, including emergency response training: A more intensive course including training on accident assessment techniques and detailed instructions on the transport regulations and on the packaging of radioactive materials.

Emergency preparedness and response

There must be a plan for incidents and accidents involving transport of radioactive material, which may take place in the public domain. The plan must cover limited radiological emergency situations but, for large operators, also include measures to be applied to significant accidents. The emergency response plan must be clear and structured. The consignor must make sure that the various carriers know their duties and procedures to be followed. In particular the carrier must immediately notify the consignor and the appropriate national agencies and authorities. Further guidance on the principles and criteria to be applied in emergency response planning and preparedness can be found in two IAEA documents: Safety Series No. 87 (1988) and IAEA Safety Guide TS-G-1.2 (ST-3 revised), 2000 [3].

Quality assurance

QA of a RPP starts typically with a study and review of the organisation's radiation protection objectives and the way in which these objectives are achieved. A QA programme for RPP may be a part of the general QA programme.

Synthesis

Table 1 provides an example of the application of a graded approach to radiation protection controls to be considered in a RPP as a function of the magnitude of the radiation dose incurred by transport workers.

Table 1 : Proposed scheme of radiation protection controls for transport operations

RPP elements	**Occupational dose category*** **		
	< 1 mSv/year	1-6 mSv/year	> 6 mSv/year
Scope	Yes	Yes	Yes
Roles/Responsibilities	Yes	Yes	Yes
Dose assessment	No monitoring required	Workplace or individual dose monitoring	Individual dose monitoring mandatory
Surface contamination assessment	In some cases**		
Dose limits/dose constraints/optimisation	Yes, but basic	Yes	Yes
Segregation and other protective measures*	Yes, where justified	Yes	Yes
Training and information*	Yes	Yes	Yes
Emergency preparedness and response*	Required but not dose category dependant		
Quality assurance*	As required		

*Not only a RPP element, broader considerations involved. A RPP can, however, refer to programme elements existing or covered elsewhere, **TS-R-1 paragraphs 508 to 514. Normally only applies to consignors of packages. However conveyances and equipment need to be checked periodically, *** A graded approach may be used as appropriate for each RPP functional element.

ASSESSMENT APPROACH OF A COMPETENT AUTHORITY

Certain requirements vital to protection and safety are so important that compliance with them should be independently verified. It is the principal role and responsibility of the competent authority (CA) to enforce compliance with all relevant requirements and standards including optimisation of protection and safety in transport by independent verification and evaluation. Of particular importance is the assessment of whether there is effective optimisation of radiation protection to ensure that radiation doses to workers and members of the public are below the regulatory limits and kept as low as reasonably achievable. Additional advice on developing and implementing compliance assurance programmes effectively by CAs may be found in publication IAEA Safety Series No. 112 [3]. The elements addressed by a CA in reviewing RPP may include the following: to ensure a) that the RPP is documented and implemented and commensurate with the hazards of the transport programme of the organisation/operator, b) that optimisation of protection and safety is adequate and effectively implemented, (i.e. that all reasonable and practical steps have been taken to keep normal and potential exposures as low as reasonably achievable, for workers and members of the public), c) that adequate training and information to workers is being provided, d) that experience feedback mechanisms are in place, e) that formal arrangements for periodic retrospective reviews of the safety performance and for the radiation protection programme are in place. Where appropriate, the CA may, in line with para. 304 of TS-R-1, arrange for periodic assessment of radiation doses. The programme documents should be made available, on request, for inspection and evaluation by the relevant CA. A brief check list is given in Table 2 to facilitate the effective assessment and evaluation of RPPs by the CA.

CONCLUSION

The new requirement for the establishment of a systematic and structured RPP for transport of radioactive material is - although somewhat complex - a useful tool to promote the safety and protection in transport operations and to enhance the safety culture in the transport of radioactive materials by all modes. The effort and resources required for the development and application of a RPP depend on the type, phase and magnitude of the transport operations involved.

Several issues have been identified which require further examination in the establishment of a RPP in practice and are given here for further consideration : optimisation methods for normal and potential exposures, quality assurance programmes for RPPs, development of dose constraints, and development of approved user-friendly transport dose assessment methods.

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Table 2 Proposed check list for assessment and evaluation by a Competent Authority

Scope Annual volume of operations (number of packages, type of package, TI, workers involved…). Field of application of the RPP.
Roles and responsibilities for the implementation of the RPP at the operator level Organisation chart. Review of the management objectives in radiation protection and safety. Procedure for the management of the RPP and description of the duties and function of the person in charge of the implementation and maintenance of the RPP.
Dose assessment Prior dose assessment. Classification of workers. Radiation monitoring (adequacy between radiation exposure encountered and the nature and frequency of monitoring, calibration, maintenance of equipment,..). Dose record keeping (frequency, period of retention,…). Dose assessment (database, point source calculation, codes,…..). Adequacy and reliability of the dose estimates Is internal dose assessment necessary?
Surface contamination assessment Routine monitoring of workplace and equipment Procedures to prevent surface contamination (special care for loading, handling, storage in transit and unloading areas) Surface contamination monitoring (adequacy between surface contamination encountered and the nature and frequency of monitoring, calibration, maintenance,..) Surface contamination record keeping (frequency, period of retention,…) Procedure for converting count/s into Bq/cm^2
Dose limits, dose constraint and optimisation Are the dose limits clearly defined? Are the dose constraints defined? Description of the means and method of optimisation (segregation distances, shielding arrangements, working instructions taking into account dose assessment,..) Is there a periodic review of the performance in optimisation (by comparison between occupational dose incurred and predicted dose,..)? Is a feedback analysis provided for?
Segregation and others protective arrangements Description
Information and training Description of the training requirements (initial training, refreshing course, records, ..). Adequacy of the contents of the training with the nature of the risks.
Emergency response and preparedness Presence and clarity of plan for limited and more significant radiological emergency situations Accident exercices
Quality assurance (QA)