

6 November 2020

# **IAEA SAFETY STANDARDS**

**for protecting people and the environment**

## **Radiation Protection Programmes for the Transport of Radioactive Material**

SPESS Step 8 – Soliciting  
comments by Member States

**DS521 (Revision of Safety Guide No. TS-G-1.3)**

**DRAFT SAFETY GUIDE**

## CONTENTS

1.	INTRODUCTION .....	1
	BACKGROUND.....	1
	OBJECTIVE.....	1
	SCOPE .....	1
	STRUCTURE.....	2
2.	RADIATION PROTECTION PROGRAMMES FOR THE TRANSPORT OF RADIOACTIVE MATERIAL.....	2
	OBJECTIVES OF RADIATION PROTECTION PROGRAMMES FOR THE TRANSPORT OF RADIOACTIVE MATERIAL.....	2
	APPLICATION OF A GRADED APPROACH TO RADIATION PROTECTION PROGRAMMES FOR TRANSPORT OF RADIOACTIVE MATERIAL .....	3
3.	SCOPE OF A RADIATION PROTECTION PROGRAMME FOR THE TRANSPORT OF RADIOACTIVE MATERIAL .....	3
	GENERAL SCOPE OF A RADIATION PROTECTION PROGRAMME FOR TRANSPORT .....	3
	OVERVIEW OF ELEMENTS OF A RADIATION PROTECTION PROGRAMME .....	4
4.	ASSIGNMENT OF ROLES AND RESPONSIBILITIES FOR A RADIATION PROTECTION PROGRAMME FOR THE TRANSPORT OF RADIOACTIVE MATERIAL .....	5
	RESPONSIBILITIES OF TRANSPORT ORGANIZATIONS.....	5
	RESPONSIBILITIES OF THE COMPETENT AUTHORITY .....	7
5.	DOSE ASSESSMENT AND OPTIMIZATION FOR THE TRANSPORT OF RADIOACTIVE MATERIAL.....	7
	PRIOR RADIOLOGICAL EVALUATION FOR THE TRANSPORT OF RADIOACTIVE MATERIAL .....	7
	RADIATION MONITORING IN THE TRANSPORT OF RADIOACTIVE MATERIAL.....	9
	Workplace and package monitoring.....	9
	Individual monitoring of workers involved in the transport of radioactive material.....	10
	Records of workplace monitoring and individual monitoring.....	10
	METHODS FOR ESTIMATING EXTERNAL EXPOSURES FROM THE TRANSPORT OF RADIOACTIVE MATERIAL.....	11
	Estimating exposures from the transport of radioactive material using published data .....	12
	Estimating exposures from the transport of radioactive material using the transport index.....	13
	Estimating exposures from the transport of radioactive material using analysis by computer code .....	14
	DOSE LIMITS AND THE OPTIMIZATION OF PROTECTION IN THE TRANSPORT OF RADIOACTIVE MATERIAL.....	14

6.	SURFACE CONTAMINATION CONSIDERATIONS IN THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT .....	16
7.	SEGREGATION AND OTHER PROTECTIVE MEASURES IN THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT .....	17
	SEGREGATION MEASURES IN THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT .....	17
	LIMITING EXPOSURE TIMES IN THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT .....	18
	USE OF SHIELDING IN THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT .....	18
	CONTROLLED AND SUPERVISED AREAS IN THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT .....	18
8.	EMERGENCY PREPAREDNESS AND RESPONSE AS PART OF THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT .....	19
	EMERGENCY PREPAREDNESS AS PART OF THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT .....	20
	EMERGENCY RESPONSE AS PART OF THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT .....	21
	PROTECTION OF EMERGENCY WORKERS AND HELPERS AS PART OF THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT .....	21
9.	TRAINING AS PART OF THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT.....	22
10.	MANAGEMENT SYSTEM FOR THE SAFE TRANSPORT OF RADIOACTIVE MATERIAL.....	24
	REFERENCES .....	25
	NOTE ON ANNEXES.....	29
	ANNEX I: GENERIC EXAMPLE OF A RADIATION PROTECTION PROGRAMME .....	30
	ANNEX II: EXAMPLE OF A RADIATION PROTECTION PROGRAMME FOR THE TRANSPORT OF RADIOPHARMACEUTICALS .....	37
	ANNEX III: EXAMPLE OF A RADIATION PROTECTION PROGRAMME FOR AN AIR CARGO CARRIER.....	41

ANNEX IV: EXAMPLE OF A RADIATION PROTECTION PROGRAMME FOR THE TRANSPORT OF RADIOACTIVE MATERIAL BY AN INDUSTRIAL RADIOGRAPHY COMPANY.....	45
ANNEX V: EXAMPLE OF A RADIATION PROTECTION PROGRAMME FOR THE TRANSPORT OF RADIOACTIVE MATERIAL FOR PUBLIC AUTHORITIES.....	49
ANNEX VI: EXAMPLE OF A RADIATION PROTECTION PROGRAMME FOR A VESSEL.....	51
ANNEX VII: QUESTIONNAIRE FOR EVALUATING THE EFFECTIVENESS OF RADIATION PROTECTION PROGRAMMES .....	55
ANNEX VIII: SEGREGATION REQUIREMENTS FOR MARITIME TRANSPORT .....	56
CONTRIBUTORS TO DRAFTING AND REVIEW .....	59

DRAFT

# 1. INTRODUCTION

## BACKGROUND

1.1. IAEA Safety Standards Series No. SSR-6 (Rev. 1), Regulations for the Safe Transport of Radioactive Material, 2018 Edition [1] (hereinafter referred to as ‘the Transport Regulations’) provides a regulatory framework for the safe transport of all categories of radioactive material such as naturally occurring radioactive material containing uranium and thorium, radiation sources used in academic, industrial and medical applications, nuclear fuel and radioactive waste. The Transport Regulations cover all facets of safe transport by means of a set of technical and administrative safety requirements and controls, including the actions required by transport organizations<sup>1</sup>.

1.2. Requirements for radiation protection are stated in para. 301 of the Transport Regulations. Paragraph 302 of the Transport Regulations states that “A *radiation protection programme* shall be established for the transport of *radioactive material*. The nature and extent of the measures to be employed in the programme shall be related to the magnitude and likelihood of radiation exposure.” Para. 234 of the Transport Regulations defines a radiation protection programme (RPP) as “systematic arrangements that are aimed at providing adequate consideration of radiation protection measures.”

1.3. IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards [2] establishes radiation protection requirements for planned exposure situations, including the transport of radioactive material. Recommendations on meeting the requirements of GSR Part 3 [2] for occupational radiation protection, including the development of an RPP, are provided in IAEA Safety Standards Series No. GSG-7, Occupational Radiation Protection [3]. Guidance on meeting the requirements of GSR Part 3 [2] for public exposures is provided in IAEA Safety Standards Series No. GSG-8, Radiation Protection of the Public and the Environment [4].

## OBJECTIVE

1.4. This Safety Guide provides recommendations and guidance on meeting the requirements established in para. 302 of the Transport Regulations for an RPP for the transport of radioactive material. The intended audience of the Safety Guide includes competent authorities, consignors, carriers, consignees, and public authorities (e.g. airport authorities, harbour/port authorities, customs authorities and modal authorities).

## SCOPE

1.5. The Scope of this Safety Guide is the same as in para. 106 of the Transport Regulations, that is the transport of radioactive material by all modes on land, water, or in the air, including transport that is incidental to the use of the radioactive material.

---

<sup>1</sup> In this Safety Guide, a “transport organization” is a person or an organization associated with, and involved in, the movement of radioactive material that prepares, consigns, loads, carries (including in-transit storage), ships after storage, unloads, receives or otherwise uses a package in connection with the transport of radioactive material.

## STRUCTURE

1.6. This Safety Guide consists of 10 sections. Section 2 discusses the objectives and the application of a graded approach to RPPs. Section 3 discusses the scope and provides an overview of the basic elements of an RPP. Sections 4–10 provide recommendations on the elements of an RPP, namely the associated roles and responsibilities, dose assessment and optimization, control of surface contamination, segregation and other protective measures, emergency preparedness and response, training and the management system.

1.7. Eight annexes are included in this Safety Guide. They include examples of RPPs, questions that can be used for evaluating the effectiveness of RPPs and an excerpt from the International Maritime Dangerous Goods (IMDG) Code [5] on segregation distances.

## **2. RADIATION PROTECTION PROGRAMMES FOR THE TRANSPORT OF RADIOACTIVE MATERIAL**

### OBJECTIVES OF RADIATION PROTECTION PROGRAMMES FOR THE TRANSPORT OF RADIOACTIVE MATERIAL

2.1 Paragraph 3.49 of GSG-7 [3] states:

“The general objective of the radiation protection programme is to fulfil the management’s responsibility for protection and safety through the adoption of management structures, policies, procedures and organizational arrangements that are commensurate with the nature and extent of the risks. The radiation protection programme should cover all the main elements contributing to protection and safety.”

2.2. Paragraph 302.1 of IAEA Safety Standards Series No. SSG-26 (Rev. 1), Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material (2018) [6] states:

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

- (a) To provide for adequate consideration of radiation protection measures in transport;
- (b) To ensure that the system of radiological protection is adequately applied;
- (c) To enhance a safety culture in the transport of radioactive material;
- (d) To provide practical measures to meet these objectives.”

The primary aim of an RPP is to optimize radiation protection in the transport of radioactive material.

2.3. An RPP is required by para. 302 of the Transport Regulations to incorporate the requirements of paras 301, 303–305, 311 and 562 of the Transport Regulations. The RPP may be documented in one or several documents and may be a separate programme or may be a part of the transport organization’s management system for the transport of radioactive material (see para. 306 of the Transport Regulations) or may be part of a facility’s RPP (See para. 3.6). General requirements on leadership and management for safety, including establishing, sustaining and continuously improving an effective management system, are established in IAEA Safety Standards Series No. GSR Part 2, Leadership and Management for Safety [7]. Guidance on management systems for the safe transport of radioactive material is given in IAEA Safety Standards Series No. TS-G-1.4, The Management System for the Safe Transport of Radioactive Material [8].

2.4. An RPP does not usually address arrangements for criticality safety. Recommendations about such arrangements are provided in SSG-26 (Rev. 1) [6] and IAEA Safety Standards Series No. SSG-27 (Rev. 1), Criticality Safety in the Handling of Fissile Material [9].

#### APPLICATION OF A GRADED APPROACH TO RADIATION PROTECTION PROGRAMMES FOR TRANSPORT OF RADIOACTIVE MATERIAL

2.5. The radiation protection provisions incorporated into an RPP may be diverse and may reflect, for example, regulatory, managerial and operational requirements and criteria for radiation protection in the transport of radioactive material. Para. 302 of the Transport Regulations states “The nature and extent of the measures to be employed in the programme shall be related to the magnitude and likelihood of radiation exposure.”

2.6. Paragraph 303 of the Transport Regulations establishes a graded approach to the assessment of occupational exposures, as follows:

“For occupational exposures arising from transport activities, where it is assessed that the effective dose either:

- (a) Is likely to be between 1 and 6 mSv in a year, a dose assessment programme via workplace monitoring or individual monitoring shall be conducted; or
- (b) Is likely to exceed 6 mSv in a year, individual monitoring shall be conducted.”

In situations in which occupational exposures are likely to be less than 1 mSv in a year, initial confirmatory monitoring and repeat confirmatory monitoring at suitable periods should be considered.

2.7. Transport operations involving only a small number of shipments of packages of lower potential radiological hazard would warrant a basic dose assessment programme, while more significant operations (e.g. involving diverse types of radioactive material and with the potential for significant exposures) would warrant a comprehensive programme.

2.8. Transport operations that result in low occupational exposures or those organizations that only occasionally transport radioactive material are still required to be covered by an RPP; for example, transport of radioactive material with high activity in heavily shielded packages generally results in low occupational exposures, but nevertheless requires thorough consideration of other elements such as emergency response and training.

### **3. SCOPE OF A RADIATION PROTECTION PROGRAMME FOR THE TRANSPORT OF RADIOACTIVE MATERIAL**

#### GENERAL SCOPE OF A RADIATION PROTECTION PROGRAMME FOR TRANSPORT

3.1. An RPP should cover all aspects of transport and the associated conditions, as described in para. 106 of the Transport Regulations, as follows:

- (a) Routine conditions of transport (incident free);
- (b) Normal conditions of transport (minor mishaps);
- (c) Accident conditions of transport.

3.2. The RPP should include the measures that are needed to meet the requirements of the Transport Regulations for radiation protection, including monitoring provisions. As stated in para. 3.52 of GSG-7 [3], "... the radiation protection programme could include protection of both workers and the public." Requirement 24 of GSR Part 3 [2] requires the establishment of a "radiation protection programme for occupational exposure". The scope of RPPs for the transport of radioactive material is as described in para. 302 of the Transport Regulations and includes protection of both workers and the public.

3.3. The focus of an RPP for the transport of radioactive material should generally be on transport and handling operations that have the potential to result in radiation exposures or contamination of people, property and the environment. This includes, for example, packing, preparation, loading, handling, storage in transit, carriage, intermodal transfer, delivery, and unloading of packages of radioactive material, and inspection and maintenance of packaging (if contaminated or containing residual radioactive material).

3.4. An RPP should define and document a systematic framework of controls to be applied by a transport organization, with the primary aim of optimizing radiation protection in the transport of radioactive material. The RPP should be developed and implemented during the pre-operational stage with regard to transport operations such as the selection of appropriate package type, and the scheduling and preparation of packages containing radioactive material. Even if radiation protection has been optimized at the pre-operational stage of the shipment of radioactive material, there will still be a need for radiation protection arrangements at the various stages of transport operations.

3.5. Transport related operations that do not involve occupational exposure or public exposure do not need to be covered by an RPP for transport.

3.6. Transport operations such as the packing, preparation, loading, handling, delivery, and unloading of packages containing radioactive material usually occur at facilities that are subject to regulatory requirements, for example nuclear power plants, nuclear fuel cycle facilities (including uranium mining and processing facilities), isotope production facilities and nuclear medicine departments in hospitals. Such facilities are required to have their own RPP that applies to their operations (see Requirement 24 of GSR Part 3 [2]), including the onsite movement of radioactive material. Transport operations associated with these facilities are usually within the purview of the facility RPP, but in some cases may be covered by a transport specific RPP. See also paras 4.3–4.5.

## OVERVIEW OF ELEMENTS OF A RADIATION PROTECTION PROGRAMME

3.7. Paragraph 302.2 of SSG-26 (Rev. 1) [6] states:

"The RPP should include, to the extent appropriate, the following elements:

- (a) Scope of the programme (see paras 302.2—302.4 [of SSG-26 (Rev. 1) [6]]);
- (b) Roles and responsibilities for the implementation of the programme (see para. 302.5 [of SSG-26 (Rev. 1) [6]]);
- (c) Dose assessment and optimization (see para. 303 [of the Transport Regulations]);
- (d) Assessment of surface contamination (see paras 508, 513 and 514 [of the Transport Regulations]);

- (e) Segregation and other protective measures (see paras 562.1—562.14 [of SSG-26 (Rev. 1) [6]]);
- (f) Emergency response arrangements (see paras 304, 305 [of the Transport Regulations]);
- (g) Training (see paras 311—315 [of the Transport Regulations]);
- (h) Management system (see para. 306 [of the Transport Regulations]).”

3.8. Examples of RPPs are provided in Annexes I–VI.

## **4. ASSIGNMENT OF ROLES AND RESPONSIBILITIES FOR A RADIATION PROTECTION PROGRAMME FOR THE TRANSPORT OF RADIOACTIVE MATERIAL**

4.1. The Transport Regulations assign specific roles and responsibilities to transport organizations and competent authorities. This Section provides recommendations on these duties and responsibilities in relation to the establishment and implementation of an RPP for the transport of radioactive material.

### **RESPONSIBILITIES OF TRANSPORT ORGANIZATIONS**

4.2. Requirement 4 of GSR Part 3 [2] states that “**The person or organization responsible for facilities and activities that give rise to radiation risks shall have the prime responsibility for protection and safety**”. Therefore, activities of each transport organization involved with a shipment (e.g. the consignor, carriers, public authorities (i.e. airport authorities, harbour/port authorities, customs authorities and modal authorities), and consignees) are required to be covered by an RPP. It is the responsibility of the management of transport organizations that are physically involved in the radioactive material transport chain to establish and implement an RPP for their operations. It is unreasonable to assign the duty of the establishment of an RPP to a transport organization (e.g. the consignor) that has no direct control over radiation protection provisions that are applied by subsequent transport organizations (e.g., carriers).

4.3. Transport organizations should cooperate to fulfil the objectives of their RPP. In more complex transport operations (e.g. a transboundary shipment of radioactive material by road, rail and sea), this may involve many independent carriers, where each party operates under its own management system, or when several transport organizations carry out operations at the same site (e.g. port, airport) involving the same individuals, leading to an accumulation of doses for those individuals.

4.4. The RPP should address interfaces among the different transport organizations. A dedicated carrier may be contracted solely for transport operations by a consignor or consignee, and in such cases the consignor or consignee may have an RPP in place that covers the carrier’s operations. In such circumstances the competent authority may not require the carrier to have a separate RPP solely for transport if the relevant consignor or consignee organization assumes responsibility for meeting all relevant radiation protection requirements. In the case of shipments under exclusive use (para. 221 of SSR-6 (Rev. 1)) the consignor or consignee, as appropriate, takes responsibility that applicable directions for loading, unloading and shipment of the conveyance or the large freight container are included in the RPP.

4.5. In some cases, a transport organization may prepare shipments at a facility operated by another organization. The transport organization should normally have its own RPP (i.e. for transport), and the facility also has its own RPP (i.e. for activities it conducts within the facility). The purviews of the two RPPs and the interfaces between them should be determined in advance and should be recorded.

4.6. The competent authority may require the consignor to evaluate the adequacy of the RPPs of subcontractors involved in the transport of its consignments of radioactive material. Consignors or other individuals and organizations with relevant experience and expertise, such as transport companies specialized in the organization of shipments of radioactive material, may also assist subcontractors in the development of their own RPPs.

4.7. The management of transport organizations should adopt policies, establish management systems and organizational arrangements, and provide sufficient resources so that the objectives of the RPP can be achieved. The management should also identify and document the radiation protection objectives of the RPP.

4.8. The management system should reflect the management's commitment to radiation protection by means of written policy statements and by clear support for those with responsibility for radiation protection. The organizational arrangements should include specifying and documenting the roles and responsibilities of the individuals involved and the functions to be performed by them. Infrastructure, arrangements and resources that may be necessary to achieve the objectives of the RPP include: facilities, suitably qualified personnel, equipment, training, feedback mechanisms and the delegation of authority to individuals to carry out actions to ensure compliance with regulatory requirements, and managerial and operational procedures. The individuals responsible for managing the RPP should be clearly designated and should be given the necessary authority to implement the programme.

4.9. Concerning the RPP, as stated in para. 302 of the Transport Regulations, "Programme documents shall be available, on request, for inspection by the relevant competent authority."

4.10. Requirement 22 of GSR Part 3 [2] states that "**Workers shall fulfil their obligations and carry out their duties for protection and safety.**" This requirement reflects the fact that workers can contribute, by their own actions, to protection for themselves and others at work [3]. In addition, para. 3.83(a) of GSR Part 3 [2] states that workers "shall follow any applicable rules and procedures for protection and safety as specified by the employer, registrant or licensee".

4.11. Tasks associated with an RPP may be performed by a qualified expert<sup>2</sup> with relevant expertise (e.g. radiation protection, quality management). However, the overall responsibility for ensuring radiation protection and for compliance with regulatory requirements remains with the management of the transport organization.

---

<sup>2</sup> A qualified expert is an individual who, by virtue of certification by appropriate boards or societies, professional licence or academic qualifications and experience, is duly recognized as having expertise in a relevant field of specialization, e.g. medical physics, radiation protection, occupational health, fire safety, quality management or any relevant engineering or safety specialty [2].

## RESPONSIBILITIES OF THE COMPETENT AUTHORITY

4.12. Paragraph 307 of the Transport Regulations states that “the competent authority shall assure compliance with these Regulations.” To assure compliance with the requirements for an RPP, various activities should be implemented by the competent authority, for example inspections of management systems and transport operations, the implementation of enforcement actions where appropriate, participation in training (i.e. providing training material, holding training courses and making personnel from the competent authority available to provide presentations at training courses) and distribution of information.

4.13. Guidance on the development and maintenance of compliance assurance programmes is provided in IAEA Safety Standards Series No. SSG-XX, Compliance Assurance for the Safe Transport of Radioactive Material [10]. Furthermore, information about inspections of management systems, consignors, carriers, and maintenance operations, including RPPs, is provided in Annexes III, IV, V, VI, and VIII of SSG-XX [10]. This information can be adapted and applied to other organizations involved in the transport of radioactive material.

4.14. Paragraph 308 of the Transport Regulations states that “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 GSR Part 3. [2]” Examples of such an assessment are presented in Ref. [11] (for transport by road and rail), Ref. [12] (for transport by sea) and Ref. [13] (for transport by air).

## **5. DOSE ASSESSMENT AND OPTIMIZATION FOR THE TRANSPORT OF RADIOACTIVE MATERIAL**

### PRIOR RADIOLOGICAL EVALUATION FOR THE TRANSPORT OF RADIOACTIVE MATERIAL

5.1. A first step in establishing an RPP is the conduct of a prior radiological evaluation of the transport operations to be performed. Paragraph 3.55 of GSG-7 [3] states:

“The prior radiological evaluation should identify the following for all aspects of operations:

- (a) The sources of routine exposure and reasonably foreseeable potential exposure, such as surface contamination, airborne contamination and sources of external radiation.
- (b) The nature and magnitude of exposures in normal operations.
- (c) The nature, likelihood and magnitude of potential exposures. ...
- (d) The measures for protection and safety that are necessary to implement the optimization process.
- (e) Appropriate monitoring systems.

...”

5.2. Paragraph 3.56 of GSG-7 [3] states:

“The assessment of exposures in the prior radiological evaluation may be made by one or more of the following methods:

- (a) Use of workplace monitoring. This method can give a good assessment of the doses that workers will receive, provided that the radiological conditions in the workplace are reasonably predictable over a long period (at least for several months). Workplace monitoring should be repeated at appropriate intervals, and certainly when the working conditions change significantly.
- (b) Use of data from the scientific literature and information from comparable facilities. Some dose values are given in the literature for various workplace situations. These can, in principle, be used to judge whether monitoring is needed.
- (c) Use of simulations. Numerical simulations can be powerful and can provide information instantly on the parameters that influence doses that would be received in given exposure situations. The results of simulations should be verified by measurement.
- (d) Use of confirmatory measurements. Performing confirmatory measurements with personal dosimeters can help to determine whether individual monitoring is needed.”

5.3. With regard to transport operations, the prior radiological evaluation should take into account the following information, which should be included in the documentation of the evaluation:

- (a) The radionuclide(s), activity levels, chemical and physical form of radioactive material, the package type and category being transported;
- (b) The magnitude and likelihood of occupational exposures and public exposures arising from routine (incident free), normal (minor mishaps) and accident conditions of transport which include consideration of the use of overpacks or freight containers; ad hoc stops, parking and delays due to traffic conditions during land transport; the necessity of in-transit storage; the use of different modes of transport or conveyances and stowing within the conveyance; and specific handling procedures (e.g. for small packages or packages that are handled remotely);
- (c) The number of workers involved;
- (d) The duration and frequency of operations;
- (e) The distance between workers and packaged or unpackaged radioactive material;
- (f) The distance between members of the public and packaged or unpackaged radioactive material;
- (g) Shielding and other protective measures that are implemented to optimize radiation protection.

## RADIATION MONITORING IN THE TRANSPORT OF RADIOACTIVE MATERIAL

5.4. A programme of monitoring radiation exposure will be a fundamental part of any RPP. Paragraph 3.98 of GSG-7 [3] states:

“A programme of monitoring may serve various purposes, depending on the nature and extent of the practice. These purposes include the following:

- (a) Assessing the exposure of workers and demonstrating compliance with regulatory requirements.
- (b) Confirming the effectiveness of working practices (e.g. the adequacy of supervision and training) and engineering standards.
- (c) Determining the radiological conditions in the workplace, whether these are under adequate control and whether operational changes have improved or worsened the situation.
- (d) Evaluating and improving operating procedures from a review of the collected monitoring data for individuals and groups. Such data may be used to identify both good and bad features of operating procedures and design characteristics, and thereby contribute to the development of safer working practices in relation to radiation.
- (e) Providing information that can be used to enable workers to understand how, when and where they are exposed, and to motivate them to take steps to reduce their exposure.
- (f) Providing information for the evaluation of doses in the event of accidental exposures.”

5.5. Consignors, carriers and consignees all have some responsibilities for workplace, package and individual monitoring, depending on their individual circumstances.

### **Workplace and package monitoring**

5.6. Workplace monitoring comprises measurements made in the working environment and the interpretation of such measurements. Routine monitoring in the workplace may be performed both to demonstrate that the work conditions remain satisfactory and to meet regulatory requirements. Additionally, the results of the monitoring may be used to assess radiation exposures to workers. The measurements can be made anywhere transport operations are undertaken, such as areas (including conveyances) in which the packing, preparation, loading, handling, storage in transit, carriage, intermodal transfer, delivery, unloading, and inspection and maintenance of packages of radioactive material are performed. Such measurements comprise monitoring for external radiation, for surface contamination, and in rare cases (e.g., the loading of drums with uranium oxide concentrate), for air contamination.

5.7. As described in para. 2.6, workplace monitoring may be used in the dose assessment programme for workers where occupational exposures are likely to be between 1 and 6 mSv in a year.

5.8. The nature and frequency of workplace monitoring should be determined on the basis of the prior radiological evaluation and should be specified in the RPP. A procedure should be described in the RPP for assigning doses to workers that are based on the results of workplace monitoring.

5.9. Routine monitoring made on and at the surface of and at a certain distance from packages containing radioactive material should be specified in the RPP. This monitoring should confirm compliance with the limits for dose rate and surface contamination specified in the Transport Regulations, and confirm that the dose rates and contamination levels are consistent with the assumptions in the prior radiological evaluation. The nature and frequency of the monitoring, which will be based on the prior radiological evaluation, should be specified.

5.10. The equipment to be used for workplace monitoring and for package monitoring should be suitable for the types of radiation encountered and should be regularly calibrated, and this calibration should be traceable to recognized national standards. Further recommendations on the establishment of a workplace monitoring programme are provided in GSG-7 [3].

### **Individual monitoring of workers involved in the transport of radioactive material**

5.11. Individual monitoring is based on measurements made using equipment worn by individual workers, such as dosimeters for external exposure or personal air samplers for the rare cases in which internal exposure is assessed. Individual monitoring is useful in ensuring that radiation exposures are as low as reasonably achievable and for demonstrating compliance with dose limits. Individual monitoring allows a value of external or internal dose to be assigned to an individual. Where an individual monitoring programme is necessary, it should be part of the RPP.

5.12. As described in para. 2.6, individual monitoring may be used in the dose assessment programme for workers where occupational exposures are likely to be between 1 and 6 mSv in a year. Where practicable, it is considered that individual monitoring should be used for the assessment of occupational doses in this range. Individual monitoring is required to be undertaken where occupational exposures are likely to exceed 6 mSv in a year.

5.13. Personal dosimeters that are used for individual monitoring should be suitable for the types of radiation encountered (i.e. in most cases, gamma radiation, and sometimes neutron radiation) and should be calibrated to meet the appropriate performance standards. The placement of personal dosimeters should account for the radiation fields that are present (e.g. consideration should be given to the placement of dosimeters of drivers to account for radiation fields that are emitted from radioactive material behind them). The use of electronic personal dosimeters should be considered in situations in which occupation doses above specified levels may occur. Further recommendations on the establishment of an individual monitoring programme are provided in GSG-7 [3].

5.14. Data on airborne radioactive material and surface contamination may be used to estimate possible internal doses (e.g. from the packing, preparation, loading and unloading of consignments containing naturally occurring radioactive material associated with mining and processing). Internal exposures can be assessed through methods such as bioassay or whole body monitoring; however, these methods are usually not necessary in relation to packages that are transported under routine and normal conditions. Further recommendations on the assessment of internal occupational exposure are provided in GSG-7 [3].

### **Records of workplace monitoring and individual monitoring**

5.15. Paragraph 303 of the Transport Regulations states that “when workplace monitoring or individual monitoring is conducted, appropriate records shall be kept.” Requirements for keeping records of occupational exposure are established in paras 3.103–3.107 of GSR Part 3 [2], and recommendations are provided in paras 7.251–7.273 of GSG-7 [3].

5.16. Paragraph 3.105 of GSR Part 3 [2] states that:

“Records of occupational exposure shall include:

- (a) Information on the general nature of the work in which the worker was subject to occupational exposure;
- (b) Information on dose assessments, exposures and intakes at or above the relevant recording levels specified by the regulatory body and the data upon which the dose assessments were based;
- (c) When a worker is or has been exposed while in the employ of more than one employer, information on the dates of employment with each employer and on the doses, exposures and intakes in each such employment;
- (d) Records of any assessments made of doses, exposures and intakes due to actions taken in an emergency or due to accidents or other incidents, which shall be distinguished from assessments of doses, exposures and intakes due to normal conditions of work and which shall include references to reports of any relevant investigations.”

5.17. Paragraph 7.252 of GSG-7 [3] states:

“As well as used in demonstrating compliance with the legal requirements, record keeping may be used for several additional purposes, such as the following:

- (a) Demonstrating the effectiveness of the optimization process;
- (b) Providing data for the compilation of dose distributions;
- (c) Evaluating trends in exposure and thus providing the information necessary for the evaluation of the radiation protection programme;
- (d) Developing effective procedures and programmes for monitoring;
- (e) Providing exposure data from new medical procedures and programmes;
- (f) Providing data for epidemiological and research studies;
- (g) Providing information that may be necessary for litigation related purposes or for workers’ compensation claims, which can arise years after the actual or claimed exposure.”

## METHODS FOR ESTIMATING EXTERNAL EXPOSURES FROM THE TRANSPORT OF RADIOACTIVE MATERIAL

5.18. Workplace monitoring and individual monitoring are required to form the basis of the dose assessment programme for workers who receive occupational exposures above 1 mSv in a year: see para. 303 of the Transport Regulations. However, other methods of estimating external exposures are needed, for example for occupational exposures below 1 mSv in a year, and for public exposure. In addition, these methods can be used as part of a prior radiological evaluation, which is performed before the results of workplace monitoring and individual monitoring are available.

5.19. A fundamental consideration in any estimation of external dose is the dose rates associated with packages and conveyances, which may range up to specified maximum values depending on the conditions of transport. The limits on dose rate and transport index (TI) specified in the Transport Regulations for different package categories are shown in Table 1.

Type of package or package category	Surface dose rate (mSv/h)	TI
Excepted package	Not more than 0.005	0
I-WHITE	Not more than 0.005	0
II-YELLOW	More than 0.005 but not more than 0.5	More than 0 but not more than 1
III-YELLOW	More than 0.5 but not more than 2	More than 1 but not more than 10
III-YELLOW + under exclusive use <sup>a</sup>	More than 2 but not more than 10	More than 10

<sup>a</sup> Under exclusive use, limits apply to dose rates outside vehicles (see, for example, para. 573 of the Transport Regulations.)

### Estimating exposures from the transport of radioactive material using published data

5.20. Various publications are available that give the results of dose assessments that have been performed for different modes of transport and for different types of radioactive material, for example as follows:

- (a) Several publications give the results of dose assessments for workers and for members of the public for radioactive material that is transported by specific modes of transport, for example Refs [11], [12], [13], [14].
- (b) The results of a coordinated research programme that included the assessment of doses to workers and members of the public that resulted from the transport of naturally occurring radioactive material is documented in Ref. [15].
- (c) An example of a dose assessment for the transport of radioactive waste from a <sup>99</sup>Mo production facility is documented in Ref. [16].
- (d) A dose assessment for workers and the public for nuclear fuel cycle material, including fresh fuel, spent fuel and high level waste, and for various modes of transport, is summarized in Ref. [17].
- (e) Information about dose assessments related to the transport of spent nuclear fuel have been published in Ref. [18]. Information about dose assessments for workers involved in the transport of spent nuclear fuel and high-level waste by rail has been published in Ref. [19].
- (f) Data on occupational exposure arising from the transport and handling of large numbers of packages for medical use and for industrial use are provided in Ref. [20].

5.21. Data may also be available from calculations made for safety analysis reports. All these sources of information can be useful in developing a prior radiological evaluation, but care should be taken to ensure that the results are applicable within the scope of any particular RPP. Special attention should be given to whether the package handling activities are comparable.

## **Estimating exposures from the transport of radioactive material using the transport index**

5.22. The total number of TIs of the packages handled by workers under specific circumstances may be used as a general indicator of external exposures, for example as follows:

- (a) To establish a relationship between the total number of TIs of packages transported and the external exposures received;
- (b) To determine the external exposure associated with the transport of packages with a unit TI, on the basis of good practices in a specific transport operation;
- (c) To define a threshold value for the total number of TI handled in a year below which the occupational exposures are likely to be below 1 mSv in a year.

5.23. Information from several studies has indicated a general correlation between the numbers of TIs handled and the dose to workers with greater numbers of TIs resulting in higher doses to workers [11], [14], [21]. In cases for which a reproducible correlation between TI and occupational exposure for specific transport operations can be demonstrated, this correlation can be used to establish a screening level in terms of the total number of TIs below which workplace monitoring and individual monitoring would not be required. When the characteristics of these activities change in a way that might result in an increase in occupational exposure, the screening level should be reassessed.

5.24. By taking into account the dose rate limits of the different package categories, it is possible to calculate the number of packages that could be transported before occupational exposures are likely to exceed 1 mSv in a year. Table 2 provides estimates of the number of packages of each category that can be handled in a year before a worker would receive an external exposure exceeding 1 mSv in a year. The numbers are based on the maximum dose rate expected from a package in each category, and on the handling and transport of packages under routine and normal conditions.

5.25. In using Table 2, allowance should be made for the occurrence of unforeseen events in which the dose received is more than that expected from the normal conditions of transport. In such a case, the exposure received should be evaluated to determine whether the continued use of the numbers in Table 2 is appropriate.

5.26. The external dose rates from excepted packages are so low that they are generally considered to be safe to handle without restrictions, and occupational exposures are expected to not exceed 1 mSv in a year.

**TABLE 2. NUMBERS OF PACKAGES OF DIFFERENT TYPES THAT CAN BE HANDLED ANNUALLY WITHOUT OCCUPATIONAL EXPOSURES EXCEEDING 1 MILLISIEVERT IN A YEAR**

Category of packages	Maximum number of packages handled annually	
	Scenario: for each package, worker is located at 1 m for 30 min	Scenario: for each package, worker is located in contact with package for 5 min and at 1 m for 25 min
I-WHITE	4000	1600
II-YELLOW	200	40 <sup>a</sup>
III-YELLOW	20	6 <sup>b</sup>
III-YELLOW + exclusive use	0	0

<sup>a</sup> Forty packages with an average dose rate of 0.25 mSv/h at contact and TI = 1.  
<sup>b</sup> Six packages with an average dose rate of 1.25 mSv/h at contact and TI = 10.

**Estimating exposures from the transport of radioactive material using analysis by computer code**

5.27. In some cases, occupational exposures and public exposures can be estimated using computer codes such as RADTRAN [22], INTERTRAN [23], RISKIND [24], MICROSIELD [25], MCNP [26], SCALE Code System [27] or HotSpot Health Physics Codes [28]. Any computer codes used should be validated to be used in such an application.

**DOSE LIMITS AND THE OPTIMIZATION OF PROTECTION IN THE TRANSPORT OF RADIOACTIVE MATERIAL**

5.28. Paragraph 301 of the Transport Regulations states that “Doses to persons shall be below the relevant dose limits.” Dose limits for occupational exposure and public exposure are established in GSR Part 3 [2].

5.29. Paragraph 1.15 of GSR Part 3 [2] states:

“The optimization of protection and safety, when applied to the exposure of workers and members of the public ... is a process for ensuring that the likelihood and magnitude of exposures and the number of individuals exposed are as low as reasonably achievable, with economic, societal and environmental factors taken into account. This means that the level of protection would be the best possible under the prevailing circumstances.”

Practical guidance on the optimization of protection is provided in Ref. [29].

5.30. In accordance with the application of a graded approach, for transport operations that give rise to low levels of occupational exposure, only a basic implementation of the optimization principle is likely to be necessary.

5.31. Efforts by transport organizations to optimize protection may involve various arrangements for radiation protection in the use, handling, carriage and delivery of packages containing radioactive material. Such arrangements may include the following:

- (a) Reviews of individual and collective doses, and comparison with the results of the prior radiological evaluation to identify any problem areas;
- (b) Application of suitable segregation distances;
- (c) Adequate shielding arrangements;
- (d) Specific stowing, loading, unloading and tie-down instructions for packages with large TIs;
- (e) The application of dose constraints and operational limits;
- (f) Restrictions on access to areas with high dose rates;
- (g) Implementation of work schedules that are designed to optimize occupational exposures;
- (h) Use of equipment for movement and lifting of packages to reduce work time and/or increase distance between workers and packages;
- (i) Implementing driving and routing restrictions (depending on the road conditions and the weather).

5.32. Paragraph 3.93 of GSR Part 3 [2] states:

“Employers, registrants and licensees shall minimize the need to rely on administrative controls and personal protective equipment for protection and safety by providing well engineered controls and satisfactory working conditions, in accordance with the following hierarchy of preventive measures:

- (1) Engineered controls;
- (2) Administrative controls;
- (3) Personal protective equipment.”

5.33. Dose constraints are an important feature of the optimization of protection. Dose constraints for workers are operations-related values of individual dose that should reflect what is achievable by the application of good practices. Dose constraints should be set at some fraction of the dose limit. A benchmark for an appropriate dose constraint is the level of individual dose that is likely to be incurred in well managed transport operations. Dose constraints may be established or agreed to by the competent authority. In setting dose constraints, the cumulative doses from exposures due to other sources should be taken into account. Dose constraints can be developed for specified tasks. Dose constraints need not be established where operations already result in insignificant doses. Operational limits (i.e. which bound operational parameters) that are intended to contribute to the control of radiation exposure should not be confused with dose constraints.

5.34. Paragraph 1.15 of GSR Part 3 [2] states that “Optimization is a prospective and iterative process that requires both qualitative and quantitative judgements to be made.” Therefore, as part of the establishment or revision of the RPP, information about transport operations, radiation measurements and dose assessments should be analysed to ensure that protection is optimized. In addition to routine and normal conditions of transport, information from accident conditions should also be reviewed. Internal and external doses or surface contamination that are greater than expected should be analysed to determine their causes and corrective actions should be implemented, as appropriate.

## 6. SURFACE CONTAMINATION CONSIDERATIONS IN THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT

6.1. Paragraph 508 of the Transport Regulations states:

“The *non-fixed contamination* on the external surfaces of any *package* shall be kept as low as practicable and, under routine conditions of transport, shall not exceed the following limits:

- (a) 4 Bq/cm<sup>2</sup> for beta and gamma emitters and *low toxicity alpha emitters*;
- (b) 0.4 Bq/cm<sup>2</sup> for all other alpha emitters.

These limits are applicable when averaged over any area of 300 cm<sup>2</sup> of any part of the surface.”

6.2. Many packages that contain radioactive material have no contamination on their outer surfaces; for other packages, contamination needs to be removed to ensure that the levels are as low as practicable and do not exceed the limits specified in para. 508 of the Transport Regulations. Strategies for the management of surface contamination include the design of facilities and activities to prevent the outer surfaces of packages from becoming contaminated, contamination monitoring of packages, decontamination and the application of other corrective measures.

6.3. Transport casks that are loaded under water such as those that transport spent nuclear fuel are more likely to have surface contamination than other packages. Consequently, more intensive monitoring for surface contamination is needed for spent nuclear fuel casks than is needed for the majority of other packages containing radioactive material.

6.4. Paragraph 512 of the Transport Regulations states:

“A *conveyance* and equipment used regularly for the transport of *radioactive material* shall be periodically checked to determine the level of *contamination*. The frequency of such checks shall be related to the likelihood of *contamination* and the extent to which *radioactive material* is transported.”

6.5. Periodic monitoring for surface contamination on packages including empty packages, overpacks, freight containers, components, equipment, conveyances and personnel should also be conducted, as appropriate. Monitoring programmes for surface contamination can assist in detecting loss of containment or deviations from good operating procedures, and in providing information for monitoring programmes for possible internal exposures. The frequency of monitoring should be implemented in accordance with a graded approach that takes into account the potential for surface contamination in transport operations.

6.6. The criteria for controlling (fixed and non-fixed) surface contamination in facilities and on packages, conveyances and equipment within a transport organization should be described in the RPP, and an outline of the type and extent of the contamination monitoring programme should be provided.

6.7. Further recommendations on establishing a contamination monitoring programme including the selection of monitoring techniques and monitoring equipment, is provided in paras 9.34–9.41 of GSG-7 [3].

## 7. SEGREGATION AND OTHER PROTECTIVE MEASURES IN THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT

7.1. Occupational exposures and public exposures from the transport of radioactive material can be reduced by the segregation of packages from persons and by the application of other protective measures. A description of arrangements concerning the segregation of packages from persons and other protective measures should be included in the RPP. Guidance on the determination of segregation distances, the limitation of exposure times, the use of shielding and the concept of controlled and supervised areas is provided in the following paragraphs.

### SEGREGATION MEASURES IN THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT

7.2. The Transport Regulations establish requirements for segregation of packages that include dose criteria to be used for the calculation of segregation distances. Specifically, para. 562 of the Transport Regulations states:

*“Packages, overpacks and freight containers containing radioactive material and unpackaged radioactive material shall be segregated during transport and during storage in transit:*

- (a) From workers in regularly occupied working areas by distances calculated using a dose criterion of 5 mSv in a year and conservative model parameters;
- (b) From members of the public in areas where the public has regular access by distances calculated using a dose criterion of 1 mSv in a year and conservative model parameters”

7.3. Example calculations for establishing minimum segregation distances are provided in Appendix III of SSG-26 (Rev. 1) [6]. The International Maritime Organization has established two methods for satisfying segregation requirements in respect of transport by sea, as illustrated in Annex VIII, which is an excerpt from Ref. [5].

7.4. Segregation distances that correspond to the total TI of a consignment have historically been presented in segregation tables that have been developed for different modes of transport (See Appendix III of SSG-26 (Rev. 1) [6] and Annex VIII, which is an excerpt from Ref. [5]). Assessments of exposures during air transport and sea transport have shown that the use of such segregation tables has resulted in public exposures well below the dose limits, and doses to workers not involved in direct handling that are below 1 mSv in a year [14]. The use of segregation distances does not in itself satisfy the requirement for optimization of protection (see paras 5.29–5.34).

7.5. Paragraph 563 of the Transport Regulations states:

*“Category II-YELLOW or III-YELLOW packages or overpacks shall not be carried in compartments occupied by passengers, except those exclusively reserved for couriers specially authorized to accompany such packages or overpacks.”*

7.6. With regard to the incorporation of segregation requirements into an RPP, consideration should be given to segregation requirements that are not intended as radiation protection

measures, i.e. those concerning undeveloped photographic film (para. 562 (c) of the Transport Regulations) and other dangerous goods (para. 562 (d) of the Transport Regulations). If applicable, separation requirements for groups of packages containing fissile material from each other (see paras. 568 and 569 of the Transport Regulations) should also be taken into account (see also Annex I, para I-22).

#### LIMITING EXPOSURE TIMES IN THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT

7.7. Work processes should be evaluated and adjusted to reduce the amount of time that workers are present in radiation fields to reduce their radiation dose. Examples of adjustments to work processes are as follows:

- (a) Preparing transport documents in a low background area instead of near the package;
- (b) Performing TI measurements and measurements of the package surface dose rate by remote means;
- (c) Using mechanical means such as trolleys or carts to move packages to and from a conveyance instead of carrying individual packages against the body;
- (d) Planning work processes so that a conveyance can be loaded or unloaded in the minimum amount of time.

#### USE OF SHIELDING IN THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT

7.8. In some cases, it may be reasonably practicable to reduce the exposure of workers by installing shielding, for example between the driver and the cargo area on a conveyance, or between work areas and package storage or loading or unloading areas in a facility.

7.9. Where possible, groups of packages should be arranged, both in storage areas and in conveyances, so that the packages giving rise to higher dose rates are farthest from workers, so as to increase the segregation distance and use the packages emitting lower dose rates to provide additional shielding. The arrangement of packages based on the optimization of radiation protection should not compromise non-radiological aspects of transport safety.

#### CONTROLLED AND SUPERVISED AREAS IN THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT

7.10. A controlled area is “A defined area in which specific protection measures and safety provisions are or could be required for controlling exposures or preventing the spread of contamination in normal working conditions, and preventing or limiting the extent of potential exposures.” [2]. A supervised area is “A defined area not designated as a controlled area but for which occupational exposure conditions are kept under review, even though specific protection measures or safety provisions are not normally needed.” [2]. Requirements for controlled areas and supervised areas are established in paras 3.88–3.92 of GSR Part 3 [2], and associated recommendations are provided in GSG-7 [3].

7.11. The area around a moving conveyance is not normally designated as a controlled area or supervised area, but areas within a conveyance might be designated as such. For storage in transit, controlled areas and supervised areas are commonly designated. However, for

scheduled and non-scheduled stops and overnight stops during road transport, such areas are not normally designated. Instead, other measures should be implemented, such as parking a vehicle carrying a package containing radioactive material away from areas that are regularly occupied by members of the public.

7.12. Paragraph 566(b) of the Transport Regulations states:

“The *dose rate* under routine conditions of transport shall not exceed 2 mSv/h at any point on the external surface of the *vehicle or freight container*, and 0.1 mSv/h at 2 m from the external surface of the *vehicle or freight container*, except for *consignments* transported under *exclusive use* by road or rail for which the radiation limits around the *vehicle* are set forth in para. 573(b) [of the Transport Regulations] and 573(c) [of the Transport Regulations].”

7.13 The RPP may specify a maximum dose rate for the driver’s compartment. The RPP should account for relevant national requirements (e.g., in some States, a maximum dose rate for the driver’s compartment of 20 µSv/h has been established).

## **8. EMERGENCY PREPAREDNESS AND RESPONSE AS PART OF THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT**

8.1. Compliance with the requirements established in the Transport Regulations ensures a high level of safety for the transport of radioactive material. However, emergencies involving the transport of radioactive material may happen. Paragraph 304 of the Transport Regulations recognizes that advance planning and preparation are required to provide a sufficient and safe response to such accidents. It is necessary that consignors, carriers, consignees and all relevant national or international organizations establish emergency plans and procedures, and that these procedures are followed in the event of a transport accident involving radioactive material. Thus, a description of applicable arrangements and instructions concerning emergency preparedness and response based on a graded approach should be included in the RPP, taking into account the requirements and recommendations provided by the following paragraphs.

8.2. Requirements for an adequate level of preparedness and response for a nuclear or radiological emergency<sup>3</sup>, including an emergency involving the transport of radioactive material, are established in IAEA Safety Standards Series No. GSR Part 7, Preparedness and Response for a Nuclear or Radiological Emergency [30].

8.3. Paragraph 1.4 of IAEA Safety Standards Series No. DS469, Preparedness and Response for a Nuclear or Radiological Emergency Involving the Transport of Radioactive Material [31] states:

“Packages used for transport of radioactive material are designed with a graded approach to meet requirements that include considerations of the effects on the package of prescribed accident conditions of transport. Consequently, most emergencies during

---

<sup>3</sup> A nuclear or radiological emergency is an emergency in which there is, or is perceived to be, a hazard due to (1) the energy resulting from a nuclear chain reaction or from the decay of the products of a chain reaction; or (2) radiation exposure [30].

transport have limited radiological consequences and can be resolved in a relatively short period. The emergency response may last only hours or days.”

8.4. In accordance with para. 302 of the Transport Regulations, the RPP is required to incorporate the requirements for emergency response stated in paras 304–305 of the Transport Regulations. Para. 305 of the Transport Regulations states:

“The arrangements for preparedness and response shall be based on the graded approach and shall take into consideration the identified hazards and their potential consequences, including 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 a nuclear or radiological emergency.”

8.5. Paragraph 304 of the Transport Regulations states:

“*Consignors and carriers* shall establish, in advance, arrangements for preparedness and response in accordance with the national and/or international requirements and in a consistent and coordinated manner with the national and/or international emergency arrangements and emergency management system.”

8.6. Recommendations on preparedness and response for a nuclear or radiological emergency involving the transport of radioactive material are provided in DS469 [31].

#### EMERGENCY PREPAREDNESS AS PART OF THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT

8.7. For consignors and carriers, the goal of emergency preparedness is to ensure that an adequate capability is in place for an effective response to a nuclear or radiological emergency involving the transport of radioactive material. As stated in para. 3.1 of GSR Part 7 [30]:

“This capability relates to an integrated set of infrastructural elements that include, but are not limited to: authority and responsibilities; organization and staffing; coordination; plans and procedures; tools, equipment and facilities; training, drills and exercises; and a management system.”

8.8. Paragraph 2.17 of DS469 [31] states:

“The consignor has the primary responsibility for ensuring that adequate emergency arrangements are in place for a given shipment of radioactive material and follow the national emergency arrangements of all the States relevant to the shipment.”

8.9. Paragraph 6.18. of GSR Part 7 [30] states:

“The appropriate responsible authorities shall ensure that a ‘concept of operations’<sup>37</sup> for emergency response is developed at the beginning of the preparedness stage.”

<sup>37</sup> A concept of operations is a brief description of an ideal response to a postulated nuclear or radiological emergency, used to ensure that all those personnel and organizations involved in the development of a capability for emergency response share a common understanding.

## EMERGENCY RESPONSE AS PART OF THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT

8.10. Paragraph 3.2 of GSR Part 7 [30] states:

“In a nuclear or radiological emergency, the goals of emergency response are:

- (a) To regain control of the situation and to mitigate consequences;
- (b) To save lives;
- (c) To avoid or to minimize severe deterministic effects;
- (d) To render first aid, to provide critical medical treatment and to manage the treatment of radiation injuries;
- (e) To reduce the risk of stochastic effects;
- (f) To keep the public informed and to maintain public trust;
- (g) To mitigate, to the extent practicable, non-radiological consequences;
- (h) To protect, to the extent practicable, property and the environment;
- (i) To prepare, to the extent practicable, for the resumption of normal social and economic activity.”

8.11. Paragraph 304 of the Transport Regulations states:

“In the event of a nuclear or radiological emergency during the transport of *radioactive material*, provisions as established by relevant national and/or international organizations shall be observed to protect people, property and the environment.”

## PROTECTION OF EMERGENCY WORKERS AND HELPERS AS PART OF THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT

8.12. Paragraph 5.52 of GSR Part 7 [30] states:

“The operating organization [i.e., consignors and carriers] and response organizations shall ensure that arrangements are in place for the protection of emergency workers<sup>[4]</sup> and protection of helpers in an emergency<sup>[5]</sup> for the range of anticipated hazardous conditions in which they might have to perform response functions. These arrangements, as a minimum, shall include:

- (a) Training those emergency workers designated as such in advance;
- (b) Providing emergency workers not designated in advance and helpers in an emergency immediately before the conduct of their specified duties with instructions on how to perform the duties under emergency conditions (‘just in time’ training);
- (c) Managing, controlling and recording the doses received;
- (d) Provision of appropriate specialized protective equipment and monitoring equipment;
- (e) Provision of iodine thyroid blocking, as appropriate, if exposure due to radioactive iodine is possible;
- (f) Obtaining informed consent to perform specified duties, when appropriate;

---

<sup>4</sup> An emergency worker is a person having specified duties as a worker in response to an emergency [30].

<sup>5</sup> A helper in an emergency is a member of the public who willingly and voluntarily helps in the response to a nuclear or radiological emergency [30].

- (g) Medical examination, longer term medical actions and psychological counselling, as appropriate.”

8.13. Emergency workers may include first responders, radiological assessors<sup>6</sup>, and workers associated with carriers and consignors. Requirements for protecting emergency workers and helpers are established in paras 5.49–5.61 of GSR Part 7 [30]. Further recommendations and guidance on the protection of emergency workers and helpers are provided in DS469 [31] and in IAEA Safety Standards Series No. GSG-2, Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency [32].

## **9. TRAINING AS PART OF THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT**

9.1. The successful application of the Transport Regulations and the achievement of their objectives are greatly dependent on the appreciation, by all individuals concerned, of the risks involved and on a detailed understanding of the Transport Regulations. This can only be achieved by properly planned and maintained initial and recurrent training programmes for all individuals concerned in the transport of radioactive material. Therefore, the appropriate training programmes for organizations of consignors, carriers, consignees and any other organization involved in transport of radioactive material and their continued update in compliance with the actual working tasks should be described in the RPP, taking into account the requirements and guidance provided by the following paragraphs.

9.2. In accordance with para. 302 of the Transport Regulations, the RPP is required to incorporate the requirements of para. 311 of the Transport Regulations, which states:

“Workers shall receive appropriate training concerning radiation protection, including the precautions to be observed in order to restrict their occupational exposure and the exposure of other persons who might be affected by their actions.”

9.3. Paragraph 311.1. of SSG-26 (Rev. 1) [6] states:

“The provision of information and training is an integral part of any system of radiation protection. The level of instruction provided should be appropriate to the nature and type of work undertaken. Workers involved in the transport of radioactive material require training with respect to the radiological risks in their work and how they can minimize these risks in all circumstances.”

9.4 Paragraph 311.2. of SSG-26 (Rev. 1) [6] states:

“Training should relate to specific jobs and duties, to specific protective measures to be undertaken in the event of an accident or to the use of specific equipment. It should include general information relating to the nature of radiological risk and knowledge of the nature of ionizing radiation, its effects and its measurement, as appropriate. Training

---

<sup>6</sup> A radiological assessor is a person or team who in the event of a nuclear or radiological emergency assists the operator or off-site response organizations by performing radiological surveys, performing dose assessments, controlling contamination, ensuring the radiation protection of emergency workers and formulating recommendations on protective actions and other response actions [30].

should be a continuous commitment provided throughout employment and involves initial training and refresher courses at appropriate intervals. The effectiveness of the training should be periodically checked.”

9.5. In accordance with para. 313 of the Transport Regulations, persons who are directly involved in the transport of radioactive material are required to receive three types of training, as follows:

- “(a) General awareness/familiarization training;
  - (i) Each person shall receive training designed to provide familiarity with the general provisions of these Regulations.
  - (ii) The general awareness/ familiarization training shall include a description of the categories of *radioactive material*; labelling, marking, placarding and *packaging* and segregation requirements; the purpose and content of the *radioactive material* transport document; and the available emergency response documents.
- (b) Function specific training: Each person shall receive detailed training concerning specific *radioactive material* transport requirements that are applicable to the function that person performs.
- (c) Safety training: Commensurate with the risk of exposure in the event of a release, and with the functions performed, each person shall receive training on:
  - (i) Methods and procedures for avoidance of accident conditions during transport, such as proper use of *package* handling equipment and appropriate methods of stowage of *radioactive material*.
  - (ii) Available emergency response information and how to use it.
  - (iii) General hazards presented by the various categories of *radioactive material* and how to prevent exposure to those hazards, including, if appropriate, the use of personal protective clothing and equipment.
  - (iv) Procedures to be immediately followed in the event of an unintentional release of *radioactive material*, including any emergency response procedures for which the person is responsible and personal protection procedures to be followed.”

9.6. Paragraph 314 of the Transport Regulations states that “Records of all safety training undertaken shall be kept by the employer and made available to the employee if requested.”

9.7. Some workers involved in the transport of radioactive material may have received training in radiological protection for reasons other than the transport of radioactive material (e.g. as nuclear plant workers or isotope laboratory staff). In such cases, some of this training may be deemed sufficient to satisfy at least part of the training needs that form part of the RPP for the transport of radioactive material.

9.8. Carriers will usually be required to provide specific training in accordance with the requirements of the applicable modal regulations.

9.9. The training of workers for the transport of radioactive material should be oriented towards his or her specific or potential job functions and work environment. A graded approach should be applied, in which the amount, type and complexity of training is commensurate with the nature of the hazards and the type and complexity of the duties associated with the transport of radioactive material.

## **10. MANAGEMENT SYSTEM FOR THE SAFE TRANSPORT OF RADIOACTIVE MATERIAL**

10.1. Paragraph 228 of the Transport Regulations defines a management system as “a set of interrelated or interacting elements for establishing policies and objectives and enabling the objectives to be achieved in an efficient and effective manner.” Management systems apply to all activities within the scope of the Transport Regulations including the development and implementation of the RPP. Therefore, all elements of a management system may impact the RPP, such as its organization, procedures for controlling documents and records, human resources and training considerations, process controls, design control, purchasing procedures including traceability, inspection procedures, measurement and test control, processes for servicing equipment, the performance of self-/independent assessments, processes for non-conformance control, and corrective and preventative actions.

10.2. Requirements for the management system are established in GSR Part 2 [7], and associated recommendations are provided in TS-G-1.4 [8] and in IAEA Safety Standards Series No. GS-G-3.1, Application of the Management System for Facilities and Activities [33]. Further information is presented in paras 306.1–306.5 of SSG-26 (Rev. 1) [6].

## REFERENCES

- [1] INTERNATIONAL ATOMIC ENERGY AGENCY, Regulations for the Safe Transport of Radioactive Material (2018 Edition), IAEA Safety Standards Series No. SSR-6 (Rev. 1), Vienna (2018).
- [2] EUROPEAN COMMISSION, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, WORLD HEALTH ORGANIZATION, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GSR Part 3, IAEA, Vienna (2014).
- [3] INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR OFFICE, Occupational Radiation Protection, IAEA Safety Standards Series No. GSG-7, IAEA, Vienna (2018).
- [4] INTERNATIONAL ATOMIC ENERGY AGENCY, Radiation Protection of the Public and the Environment, IAEA Safety Standards Series No. GSG-8, IAEA, Vienna (2018).
- [5] INTERNATIONAL MARITIME ORGANIZATION, International Maritime Dangerous Goods Code (IMDG Code) (amendment 40-20), IMO, London (2020).
- [6] INTERNATIONAL ATOMIC ENERGY AGENCY, Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material (2018), IAEA Safety Standards Series No. SSG-26 (Rev. 1), IAEA, Vienna (202X).
- [7] INTERNATIONAL ATOMIC ENERGY AGENCY, Leadership and Management for Safety, IAEA Safety Standards Series No. GSR Part 2, IAEA, Vienna (2016).
- [8] INTERNATIONAL ATOMIC ENERGY AGENCY, The Management System for the Safe Transport of Radioactive Material, IAEA Safety Standards Series No. TS-G-1.4, Vienna (2008).
- [9] INTERNATIONAL ATOMIC ENERGY AGENCY, Criticality Safety in the Handling of Fissile Material, IAEA Safety Standards Series No. SSG-27 (Rev. 1), IAEA, Vienna (in preparation).
- [10] INTERNATIONAL ATOMIC ENERGY AGENCY, Compliance Assurance for the Safe Transport of Radioactive Material, IAEA Safety Standards Series No. TS-G-1.5, IAEA, Vienna (2009). (a revision of this publication is in preparation that will be assigned a publication number within the Safety Standards Series in the form of SSG-XX, where 'XX' is a number.)
- [11] JONES, A.L., CABIANCA, T., Survey into the Radiological Impact of the Normal Transport of Radioactive Material in the UK by Road and Rail, PHE-CRCE-035, Public Health England, Oxfordshire, UK (2017).

- [12] HUGHES, J.S., HARVEY, M.P., A Survey into the Radiological Impact of the Normal Transport of Radioactive Material by Sea, HPA-RPD-050, Public Health England, Oxfordshire, UK (2009).
- [13] HARVEY, M.P., JONES, A.L., CABIANCA, T., Potter, M, Survey into the Radiological Impact of the Normal Transport of Radioactive Material by Air, PHE-CRCE-006, Public Health England, Oxfordshire, UK (2014).
- [14] SHAPIRO, J., Exposure of Airport Workers to Radiation from Shipments of Radioactive Materials: A Review of Studies Conducted at Six Major Airports, NUREG-0154, United States Nuclear Regulatory Commission, Washington, DC (1977).
- [15] INTERNATIONAL ATOMIC ENERGY AGENCY, Regulatory Control for the Safe Transport of Naturally Occurring Radioactive Material (NORM); Report of a Coordinated Research Project 2007–2010, Vienna (2013).
- [16] ABDELHADY, A., Radiological risks associated with transportation of liquid waste generated from <sup>99</sup>Mo production, Journal of Environmental Waste Management and Recycling, Volume 1, Issue 1 (2017).
- [17] WORLD NUCLEAR TRANSPORT INSTITUTE, Radiation Dose Assessment for the Transport of Nuclear Fuel Cycle Materials, Information Paper, WNTI, London (2013).
- [18] U.S. NUCLEAR REGULATORY COMMISSION, Spent Fuel Transportation Risk Assessment–Final Report, NUREG-2125, USNRC, Washington, DC (2014).
- [19] U.S. DEPARTMENT OF TRANSPORTATION, Railroad Carrier Employee Exposure to Radiation–Report to Congress, USDOT, Washington, DC (2010).
- [20] SCHWARZ, G., FETT, H.J., LANGE, F., “Occupational and public exposures arising from the normal transport of radioactive material: Experience in Germany”, Safety of Transport of Radioactive Material (Proc. Int. Conf. Vienna, 2003), Vienna, IAEA (2004).
- [21] WATSON, S.J., OATWAY, W.B., JONES, A.L., HUGHES, J.S., Survey into the Radiological Impact of the Normal Transport of Radioactive Material in the UK by Road and Rail, Rep. NRPB-W66, National Radiological Protection Board, Chilton, UK (2005).
- [22] WEINER, R.F., HINOJOSA, D., HEAMES, T.J., FARNUM, C.O., KALININA, E.A., RADTRAN 6/RadCat 6 User Guide, SAND2013-8095, Sandia National Laboratories, Albuquerque, NM (September 2013).
- [23] ERICSSON, A.M., JAERNRY, C., INTERTRAN 2: Transportation Risk Assessment Package, <http://www.amckonsult.se/>

- [24] YUAN, Y.C., CHEN, S.Y., LEPOIRE, D.J., ROTHMAN, R., RISKIND: A Computer Program for Calculating Radiological Consequences and Health Risks from Transportation of Spent Nuclear Fuel, Rep. ANL/EAIS-6, Argonne Natl Lab., IL (1993).
- [25] GROVE ENGINEERING, INC., MicroShield® Version 12, <https://radiationsoftware.com/microshield> (2019).
- [26] WERNER, C.J., MCNP Users' Manual – Code Version 6.2, Rev. 0, LA-UR-17-29981, Los Alamos National Laboratory, Los Alamos, NM (2017).
- [27] REARDEN, B.T., JESSEE, M.A., SCALE Code System, ORNL/TM-2005/39, Version 6.2.3, Oak Ridge National Laboratory, Oak Ridge, Tennessee (2018).
- [28] HOMANN, S., ALUZZI, F., HotSpot Health Physics Codes Version 3.0 User's Guide, LLNL-SM-636474, Lawrence Livermore National Laboratory, Livermore, CA (2014).
- [29] INTERNATIONAL ATOMIC ENERGY AGENCY, Optimization of Radiation Protection in the Control of Occupational Exposure, Safety Reports Series No. 21, IAEA, Vienna (2002).
- [30] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL CIVIL AVIATION ORGANIZATION, INTERNATIONAL LABOUR ORGANIZATION, INTERNATIONAL MARITIME ORGANIZATION, INTERPOL, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, PREPARATORY COMMISSION FOR THE COMPREHENSIVE NUCLEAR-TEST-BAN TREATY ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, UNITED NATIONS OFFICE FOR THE COORDINATION OF HUMANITARIAN AFFAIRS, WORLD HEALTH ORGANIZATION, WORLD METEOROLOGICAL ORGANIZATION, Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GSR Part 7, IAEA, Vienna (2015).
- [31] INTERNATIONAL ATOMIC ENERGY AGENCY, Preparedness and Response for a Nuclear or Radiological Emergency Involving the Transport of Radioactive Material, IAEA Safety Standards Series No. DS469, IAEA, Vienna (202X).
- [32] INTERNATIONAL ATOMIC ENERGY AGENCY, Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GSG-2, IAEA, Vienna (2011).
- [33] INTERNATIONAL ATOMIC ENERGY AGENCY, Application of the Management System for Facilities and Activities, IAEA Safety Standards Series No. GS-G-3.1, IAEA, Vienna (2006). (a revision of this publication is in preparation[Under revision].)

DRAFT

## NOTE ON ANNEXES

Annex I presents a generic example of an RPP. Annexes II to VI present practical examples of the elements of an RPP for operators carrying radiopharmaceuticals, air cargo carriers, industrial radiography companies, public authorities, and a vessel. The elements of these RPPs can be adapted to a range of transport operations. The information presented in these annexes is not comprehensive, but it is illustrative and the information may go beyond regulatory requirements. Questions that can be used for evaluating the effectiveness of RPPs are provided in Annex VII. An excerpt from the IMDG Code concerning segregation distances is provided in Annex VIII. The material in the annexes has not been endorsed by the IAEA or its Member States.

DRAFT

# ANNEX I: GENERIC EXAMPLE OF A RADIATION PROTECTION PROGRAMME

I-1. This annex presents an example of an outline of a document describing the elements of a generic RPP. For each element, information and example text that could be used in developing a document describing the elements of an RPP is provided.

## Scope

I-2. The scope of the work covered by the RPP would be included; for example: “The scope of this RPP covers the transport and in-transit storage of radioactive material, but does not include criticality aspects.” The scope may also include a brief description of the operations, such as: “This RPP covers the transport of radiography sources.” Further details on the scope of the transport operations could be included as appropriate.

## Roles and responsibilities

I-3. The roles and responsibilities in the organization may, for example, be specified as follows:

“The RPP will be managed by a suitably qualified person.

“The person having overall responsibility for the RPP will ensure that all of the elements of the RPP are implemented, including:

- (a) Training of workers and implementation of proper working procedures;
- (b) Assessment of worker exposures, if necessary, by individual monitoring or workplace monitoring;
- (c) Emergency procedures.

“The person(s) appointed for the role of managing the RPP is/are:

.....  
.....

“Specific roles

“The roles of various categories of workers with regard to the RPP should be described:

“The role of the dispatch staff is to prepare packages for transport including the following tasks:

- (a) Complete transport documents;
- (b) Measure dose rates, contamination and TI;
- (c) Complete and apply package labels;
- (d) Load packages on to the vehicle;
- (e) Segregate of packages;
- (f) Implement emergency procedures, if appropriate.

“The following persons have responsibility for the above duties:

.....

.....  
“(e.g. dispatch staff, driver)”

### **Dose assessment and optimization**

I-4. A prior radiological evaluation is necessary to determine the level of individual potential exposure and to determine the monitoring programme. Worked examples are given below. A prior radiological evaluation that includes a dose assessment needs to be made on the basis of the following:

- (a) The number and type of packages;
- (b) The category of packages and the TI moved;
- (c) The radionuclides being shipped;
- (d) The frequency of shipment;
- (e) The duration of storage and transport.

I-5. The information presented in Section 5, for example in Table 2, may give some initial guidance on this assessment.

#### *Optimization*

I-6. In some transport organizations, a full optimization study may be appropriate. For small to medium sized transport organizations, there may be a number of ways to optimize exposures, and, depending on the work circumstances, practical measures can be specified in the RPP, for example as follows:

“During transport and in-transit storage, exposures are to be kept as low as reasonably achievable by increasing segregation distances, where possible.”

“A trolley is to be used to take the packages from the storeroom to the loading area.”

“In the storage room, packages are to be kept in the shielded bays until as late as possible before loading.”

“The distance between workers and packages will be maximized, for example, when completing transport documents and taking breaks.”

#### *Example 1*

I-7. The company will transport approximately three category III-YELLOW packages per week, with an average TI of 3 per package. The weekly number of packages may vary, but the annual volume of shipment is expected to be about 150 packages. In this company the tasks of the driver and the handler who loads the vehicle are separate.

#### *Handler*

I-8. Table 2, column 3, indicates that annual doses below 1 mSv may be expected if six packages each with a TI of 10 are handled annually. For packages with a TI of 3, an annual dose of about 1 mSv would correspond to an annual number of about 20 packages. The expected

number of packages to be shipped is some eight times greater, and therefore dose assessment by individual monitoring will be conducted for the handler.

### *Driver*

I-9. The driver is expected to make one 4 h journey each week to take the three packages to the consignee, giving an annual driving time of about 200 h. The packages will be 3 m from the driver, and there is no significant shielding in the truck. The dose rate at the driver's position from three packages with a TI of 3 per package and the application of the inverse square law for a distance of 3 m is therefore approximately:

$$3 \times 30/3^2 \mu\text{Sv/h} \approx 10 \mu\text{Sv/h}$$

For an exposure time of 200 h, the driver is therefore expected to receive about 2 mSv annually, and either individual monitoring or workplace monitoring is required. The former would be easier to implement than workplace monitoring, because of the expected variability in exposure conditions. Regardless, both individual monitoring and workplace monitoring will be conducted.

### *Example 2*

I-10. A driver will transport an industrial gauge to the company's sites for it to be used by technicians at those sites. All loading and unloading operations are carried out by technicians. The annual driving time is expected to be about 200 h. The gauge is carried within a category II-YELLOW package with a TI of 0.1 and is located in the vehicle 2 m from the driver. The dose rate at the driver's position from one package with a TI of 0.1 and the application of the inverse square law for a distance of 2 m is therefore approximately:

$$\approx 1/2^2 \mu\text{Sv/h} \approx 0.25 \mu\text{Sv/h}$$

I-11. The driver's annual dose is therefore expected to be about 0.05 mSv, and therefore no dose assessment programme will be necessary. However, individual monitoring will be conducted for a limited period to confirm this assessment.

### **Surface contamination**

I-12. This section may include, for example:

“The radioactive material to be transported is either special form sources or non-special form sources, carried in intact packages. Situations may arise involving damage to packages, and in these situations the person responsible for managing the RPP will make checks for contamination by using instruments and techniques (such as taking swabs of the package surface and surrounding areas) that are appropriate for the types, levels and energies of the radiation encountered according to documented, specific instructions of the organization. Periodic checks for contamination are made of the work area and conveyances.”

I-13. Other conditions may be specified, depending on the organization's procedures, for example:

“When necessary, the company's radiation specialist will be called in to perform contamination checks.”

“Conveyances (or areas of conveyances) that have been used for the transport of radioactive material are to be checked for contamination before being used for other purposes.”

“The results of the periodic checks are to be recorded and retained.”

### **Segregation and other protective measures**

I-14. The relevance of package segregation will depend on the type of operations carried out. If category II-YELLOW or III-YELLOW packages are stored or loaded on a conveyance, or if the consignment is under exclusive use, specific or special procedures for storage, loading, unloading, tie-down, etc., could be used. These instructions or procedures would be issued under the responsibility of a qualified person.

I-15. For example, in the case of a single radiography container or gauge, the following might be used:

“The container is to be kept in the store when not in use. During transport, the container is to be placed in the rear of the goods compartment of the vehicle.”

I-16. Package segregation is usually relevant for operations involving the transport and in-transit storage of many packages containing medical radiopharmaceuticals, especially  $^{99}\text{Mo}/^{99\text{m}}\text{Tc}$ , Rb/Kr generators or  $^{131}\text{I}$ .

I-17. A number of factors need to be taken into account in determining the segregation of packages from occupied areas, and it may be necessary to consult a qualified expert in radiation protection. As an example, the RPP could set out the arrangements for an in-transit storage area as follows:

“Packages are stored in a storeroom with 40 cm thick concrete walls that is 10 m from the office. Packages are stored for a maximum of 1 h per day, and the maximum cumulative TI in the storage area is limited to 10.

The company regards office workers as members of the public in the context of radiation protection. With the limits placed on the storage of packages (i.e., storage for a maximum of 1 h per day and a maximum number of TI of 10) and without considering the effect of shielding by the walls, the dose rate at 10 m would be 1  $\mu\text{Sv}/\text{h}$ , giving 1  $\mu\text{Sv}$  per day and an annual dose of about 250  $\mu\text{Sv}$  (0.25 mSv). However, the concrete storeroom walls, which are 40 cm thick, provide a dose rate reduction factor of over 100, and therefore annual doses are anticipated to be on the order of 2  $\mu\text{Sv}$ . The office walls provide some extra shielding, and the average TI stored will not normally be at the maximum; this will therefore be an upper estimate of the doses received by the office workers.”

I-18. Another situation in which segregation from package handling operations is appropriate is in the receipt and dispatch of medical radioisotopes at an air cargo shed, for example:

“A consignment of packages containing radiopharmaceuticals is received at a cargo shed from a large consignor on four working days each week. The packages are unloaded from the truck in an area of the shed well away from the nearest area normally occupied by other workers. The packages are sorted and placed on pallets according to their respective destinations. The prepared pallets are immediately moved into a shielded storeroom from which they are taken out when they are to be loaded on to a cargo aircraft. The cargo

handling staff who carry out this work are subject to individual monitoring and typically receive annual doses in the range of 2–3 mSv. The sorting procedure takes approximately 15 minutes. At 3 m from the consignment of packages the dose rate is about 20  $\mu$ Sv/h. Occupancy at that distance for 15 minutes would give a dose of 5  $\mu$ Sv daily and around 1 mSv annually. Although no other persons are normally present in the vicinity, warning signs and a tape barrier would be placed at about this distance to demarcate the limit of the supervised area, for the duration of the work.”

I–19. Consideration also has to be given to other methods of dose reduction; for example, for road transport:

“Where possible, all packages, especially the high TI packages, are to be placed at the rear of the goods compartment. Shielding of about 3 mm of lead is provided in the vehicle behind the driver’s cabin.”

I–20. This will minimize the exposure of the driver. As an additional method of dose constraint, this RPP may specify a maximum dose rate for the driver’s cabin, although this is not a requirement of the Transport Regulations [I–1].

I–21. The following will reduce the dose to the loaders:

“The high TI packages are to be kept in the storeroom as long as practicable, and would be the last to be loaded.”

I–22. Although it is not part of a general RPP, if criticality safety is an issue, then segregation in storage and limitation of the criticality safety index on conveyances will need to be considered for the purpose of criticality control.

### **Emergency response**

I–23. Arrangements for preparedness and response to emergencies are required (see paras 304–305 of the Transport Regulations [I–1]), and such arrangements include a procedure concerning the provision of instructions given by the consignor. For accidents involving radioactive material in storage areas, or carried by road or rail, the procedures to be followed are often specified in national legislation, and they may vary slightly from State to State. Similarly, for accidents involving packages being handled at air cargo centres, procedures may be specified in national legislation. These procedures will be reflected in the RPP. The requirements for emergency response procedures are similar, despite national variations. An example of emergency response procedures for road transport is given below:

“In the event of an accident during the road transport of radioactive material, the driver of the vehicle will:

- (a) Implement life-saving measures and administer first aid;
- (b) Assess the risk of, or occurrence of, fire and use the fire extinguisher if appropriate;
- (c) Contact first responders, as appropriate (e.g., fire fighters, emergency medical service, security services);
- (d) Contact a qualified expert in radiation protection and request guidance;

(e) Inform the ‘responsible person’ at the main (carrier’s) office;

(f) Maintain the ability to communicate electronically via telephone, radio and/or internet.

“These instructions are included on the information card in all the vehicles. However, the driver could be injured or not in a condition to act, and vehicles carrying radioactive material are therefore provided with a fireproof notice in the cab to alert the police that there may be radioactive material on the vehicle.”

I-25. Following notification of an emergency to the main office:

“The responsible person will inform the consignor/consignee and competent authority of the accident.”

I-26. Subsequent procedures may be included regarding recovery and cleanup, but these will vary from State to State. An example is as follows:

“The responsible person will arrange, with the consignor and competent authority, for recovery of any damaged packages, decontamination and disposal of any waste or debris.”

I-27. In practice, more specific, details would normally be included, for example details of names, 24 h telephone numbers and exact procedures for dealing with decontamination and waste disposal. Similar procedures can be specified for storage areas and for other modes of transport.

### **Training**

I-28. The training of the relevant workers has to be specified, and normally a graded approach is necessary to cover the range of tasks involved. Normally there will be tasks at a managerial/supervisory level (responsible officers) and other training for workers carrying out particular tasks; for example:

“The following responsible persons have received training and have gained the appropriate certificates for fulfilling their duties:

.....

.....”

I-29. An example of a consignor’s RPP may include:

“The following persons have received job specific training:

.....

.....

“This training verified that they are able to carry out the following duties:

(a) Completion of transport documents;

(b) Preparation of packages;

- (c) Measurements of dose rates and TI;
- (d) Completion and application of package labels;
- (e) Loading of packages on to the vehicle;
- (f) [Include further tasks as appropriate].”

The RPP can include a statement on the revalidation of certificates that are subject to the requirements of the competent authority and to the employer’s policies.

**Management system for procedures and practices**

I–30. The RPP is part of the employer’s system of documents on the management system, including the documented policies, objectives and responsibilities of the management, and is subject to all the requirements of the management system for procedures and practices, such as those for document and version control, document review, issuing and review of instructions and procedures, and follow-up of non-conformances. The RPP has to be approved by a suitable person, and in some cases by the competent authority; for example:

I–31. “The RPP, as described in this document, is approved.

Signature....., Date: .....

(Name and designation)”

**REFERENCE TO ANNEX I**

[I–1] INTERNATIONAL ATOMIC ENERGY AGENCY, Regulations for the Safe Transport of Radioactive Material (2018 Edition), IAEA Safety Standards Series No. SSR-6 (Rev. 1), Vienna (2018).

## **ANNEX II: EXAMPLE OF A RADIATION PROTECTION PROGRAMME FOR THE TRANSPORT OF RADIOPHARMACEUTICALS**

II-1. This is an example of documentation of an RPP for ABC Radiopharmaceuticals.

### **Scope**

II-2. The scope of this RPP covers the transport and in-transit storage of radiopharmaceuticals incorporating radioactive iodine and technetium generators. ABC Radiopharmaceuticals supplies typically 50 000 packages per year to users all over the world. The packages used are, with the exception of a few excepted packages, all of Type A. About 10% of the packages are category III-YELLOW, 30% of the packages are category II-YELLOW, 55% of the packages are category I-WHITE and 5% are excepted packages. The maximum TI encountered is 3.5, and the packages with this TI would be a small fraction of those of category III-YELLOW. ABC Radiopharmaceuticals has a delivery van to transport the packages to the carrier.

### **Roles and responsibilities**

II-3. The RPP will be managed by Mr./Ms. X, who is trained in radiation protection. Mr./Ms. X will ensure that all of the elements of the RPP are implemented, including:

- (a) Training of workers and implementation of proper work procedures;
- (b) Assessment of worker exposures, if necessary, by individual monitoring or workplace monitoring;
- (c) Emergency procedures.

II-4. The role of the dispatch staff is to prepare packages for transport including the following tasks:

- (a) Complete transport documents;
- (b) Measure dose rates, contamination and TI;
- (c) Complete and apply package labels;
- (d) Load packages on to the vehicle;
- (e) Segregate of packages;
- (f) Implement emergency procedures, if appropriate.

II-5. The role of the driver of the delivery van is to deliver packages including the following tasks:

- (a) Obtain information about:
  - 1. Emergency procedures;
  - 2. Conditions for storage, loading and securing of the packages on to the conveyance;
  - 3. Placarding of the conveyance;
  - 4. Measurements of dose rates around the loaded conveyance.
- (b) Deliver packages including driving the van and dropping off packages;

(c) Implement emergency procedures, if appropriate.

### **Dose assessment and optimization**

II-6. In order to evaluate the possible levels of individual exposure and to determine the monitoring programme, ABC Radiopharmaceuticals used the services of a qualified expert in radiation protection (Mr./Ms. Y). The evaluation was made on the basis of:

- (a) The number and type of packages handled by the firm;
- (b) The category of packages and the TI moved;
- (c) The radionuclides being shipped;
- (d) The frequency of shipment;
- (e) The duration of storage prior to transport.

II-7. The study showed that the maximum radiation dose that a member of the dispatch staff of ABC Radiopharmaceuticals would receive would be about 3 mSv in a year on the basis of the present workload, while the estimated dose for the driver was 2 mSv and for the acceptance staff 1 mSv. Workplace monitoring will be conducted as determined by a qualified expert in radiation protection. Individual monitoring of doses will also be conducted. Dose records will be maintained.

II-8. The dose rate monitors and the contamination monitors recommended by a qualified expert in radiation protection have been procured and are available to ABC Radiopharmaceuticals for regular use. These monitors are calibrated as recommended by a qualified expert in radiation protection. Packages, conveyances and the workplace are monitored by Mr./Ms. X to verify the continued validity of the results of the initial dose assessment.

II-9. Occupational exposures are kept as low as reasonably achievable by the following means:

- (a) Increasing the segregation distances beyond the minimum requirements, where possible;
- (b) Minimizing the presence of workers in the vicinity of the packages (i.e. within a distance of 5 m);
- (c) Using a trolley to take the packages from the storeroom to the loading area;
- (d) Keeping the packages in the shielded bays in the storeroom until as late as possible before loading.

### **Surface contamination**

II-10. The radioactive material to be transported is not in a special form and is carried in appropriate packages in good condition. If damage to packages is suspected, checks for contamination will be made by Mr./Ms. X by taking swabs of the package surface and surrounding areas using the contamination monitors available to ABC Radiopharmaceuticals. Periodic (weekly) checks for contamination are made of the work area and conveyances. Conveyances (or areas of conveyances) that have been used for the transport of radioactive material are checked for contamination before being used for other purposes. The results of the contamination checks will be recorded and retained.

## **Segregation and other protective measures**

II-11. Packages are stored in a storeroom with 40 cm thick concrete walls that is 10 m from the office. Packages are stored for a maximum of 1 h per day, and the maximum total TI in the storeroom is limited to 20.

The office workers are expected to receive the same level of protection as members of the public. With the limits placed on the storage of packages (i.e., storage for a maximum of 1 h per day and a maximum total TI of 20) and without considering the effect of shielding by the walls, the dose rate at 10 m would be 2  $\mu\text{Sv/h}$ , giving 2  $\mu\text{Sv}$  per day and an annual dose of about 500  $\mu\text{Sv}$  (0.5 mSv). However, the concrete storeroom walls, which are 40 cm thick, provide a dose rate reduction factor of over 100, and therefore annual doses are anticipated to be on the order of 5  $\mu\text{Sv}$ . The office walls provide some extra shielding, and the average TI stored will not normally be at the maximum; this will therefore be an upper estimate of the doses received by the office workers.

II-12. Where possible all packages, especially the high TI packages, are placed at the rear of the goods compartment when loading the packages on to the vehicle. This will minimize the exposure of the driver.

II-13. The high TI packages will be kept in the storeroom for as long as practicable and will be the last to be loaded. This will reduce the dose to the loaders. Lead shielding of 3 mm thickness is provided behind the driver's cabin of the delivery van.

## **Emergency response**

II-14. In the event of an incident (falling, crushing or fire) during storage or loading of the radioactive consignment on to the vehicle, Mr./Ms. X will implement the following measures:

- (a) Implement life-saving measures and administer first aid;
- (b) Assess the risk of, or occurrence of, fire and use the fire extinguisher if appropriate;
- (c) Contact first responders, as appropriate (e.g., fire fighters, emergency medical service, security services);
- (d) Contact a qualified expert in radiation protection and request guidance;
- (e) Maintain the ability to communicate electronically via telephone, radio and internet
- (f) With the help of and under the direction of a qualified expert in radiation protection, clean up the affected area and collect the damaged packages and radioactive material, if any;
- (g) Obtain documentation from the qualified expert in radiation protection to confirm that the affected area is safe for normal use again;
- (h) Terminate the emergency;
- (i) Arrange for the transport of radioactive material involved in the accident to an authorized recipient, as recommended by a qualified expert in radiation protection;
- (j) Inform the competent authority of the incident.

II-15. These instructions are displayed prominently in the storage bay, the vehicle loading area and the vehicle so that, in the absence of Mr./Ms. X, any other responsible person would be able to take these measures.

II-16. Emergency contact details:

Telephone numbers

Person Office Residence

Mr./Ms. X #####

Radiation specialist #####

Others #####

**Training**

II-17. The persons listed below, being employees of ABC Radiopharmaceuticals engaged in the preparation and transport of packages containing radiopharmaceuticals, have received appropriate training that is commensurate with their duties:

Mr./Ms. ....(Dispatch Staff/Driver)

Mr./Ms. ....(Dispatch Staff/Driver)

Mr./Ms. ....(Dispatch Staff/Driver)

II-19. The training that they have received fulfils the applicable requirements of the competent authority and the policies of ABC Radiopharmaceuticals. They will be subject to retraining every two years.

**Management system for procedures and practices**

II-20. The RPP is part of ABC Radiopharmaceuticals' system of documents on the management system, including the documented policies, objectives and responsibilities of the management, and is subject to all the requirements of the management system for procedures and practices, such as document and version control, document review, issuing and review of instructions and procedures, and follow-up of non-conformances.

The RPP, as described in this document, is approved.

Signature....., Date: .....

(Name and designation)

## **ANNEX III: EXAMPLE OF A RADIATION PROTECTION PROGRAMME FOR AN AIR CARGO CARRIER**

III-1. This is an example of documentation of an RPP for XYZ Cargo Carriers.

### **Scope**

III-2. The scope of this RPP covers the transport and in-transit storage of packages containing radioactive material. XYZ Cargo Carriers moves typically 5000 packages containing Class 7 goods per year to consignees (users) all over the world. The packages carried are of all types, namely excepted packages, Type A and Type B(U)/(M). About 10% of the packages are category III-YELLOW, 30% of the packages are category II-YELLOW, 55% of the packages are category I-WHITE and 5% are excepted packages. The maximum TI encountered is 3.0, and these packages are a small fraction of those of category III-YELLOW. Consignors deliver the packages to the airport cargo office of XYZ Cargo Carriers. This RPP is applicable to all the cargo offices of XYZ Cargo Carriers.

### **Roles and responsibilities**

III-3. The RPP will be managed by Mr./Ms. A, who is trained in radiation protection. Mr./Ms. A will ensure that all of the elements of the RPP are implemented, including:

- (a) Training of workers and implementation of proper work procedures;
- (b) Assessment of worker exposures, if necessary, by individual monitoring or workplace monitoring;
- (c) Emergency procedures.

III-4. The role of the acceptance staff is to verify the following for each package/shipment for compliance with the applicable ICAO/IATA requirements:

- (a) Transport documents;
- (b) Labelling and marking of the packages;
- (c) Measurement of dose rates and TI;
- (d) Emergency procedures appropriate for the package/shipment.

III-5. The role of the cargo handlers is to move packages including the following tasks:

- (a) Load packages on to aircraft in accordance with requirements for segregation and securing packages;
- (b) Implement emergency procedures, if appropriate.

### **Dose assessment and optimization**

III-6. To evaluate the possible levels of individual exposure and to determine the monitoring programme, XYZ Cargo Carriers employed the services of a qualified expert in radiation protection (Mr./Ms. B). The evaluation was made on the basis of:

- (a) The number and type of packages handled by the firm;

- (b) The category of packages and the TI moved;
- (c) The radionuclides being shipped;
- (d) The frequency of shipment;
- (e) The duration of storage prior to transport.

III-7. The study revealed that the maximum radiation dose that any individual employee of XYZ Cargo Carriers would receive would be less than 1 mSv in a year at the present workload. The qualified expert in radiation protection advised that a dose assessment programme (using individual monitoring or workplace monitoring) was not necessary. However, dose rate monitors and contamination monitors have been recommended by a qualified expert in radiation protection, for routine verification of dose rates and for emergency response. These monitors have been procured and are available to XYZ Cargo Carriers for regular use. These monitors are calibrated as recommended by a qualified expert in radiation protection. Packages, conveyances and the workplace are monitored by Mr./Ms. A to verify the continued validity of the results of the initial dose assessment.

III-8. Occupational exposures are kept as low as reasonably achievable by the following means:

- (a) Using a trolley to take the packages from the cargo office to the storage area and the loading area;
- (b) Keeping the packages in the storage room in the shielded bays until as late as possible before loading;
- (c) Increasing segregation distances beyond the minimum requirements, where possible;
- (d) Minimizing the presence of workers in the vicinity of (within a distance of 5 m from) the packages.

#### **Surface contamination**

III-9. The radioactive material to be transported is carried in appropriate packages in good condition. If damage to packages is suspected, checks for contamination will be made by Mr./Ms. A by taking swabs of the package surface and surrounding areas using the contamination monitors available to XYZ Cargo Carriers.

III-10. Periodic (weekly) checks for contamination are made of the work area and the cargo hold, forklift trucks and other loading equipment. The results of the contamination checks will be recorded and retained.

#### **Segregation and other protective measures**

III-11. Packages are stored in a storeroom with 40 cm thick concrete walls that is 10 m from the office. Packages are stored for a maximum of 3 h per day.

The office workers are expected to receive the same level of protection as members of the public. The maximum anticipated sum of TIs from the packages present in the storeroom is 10, which would result in an annual dose to an office worker of 0.75 mSv without considering the shielding effect of the storeroom's concrete walls. However, the concrete storeroom walls, which are 40 cm thick, provide a dose rate reduction factor of over 100, and therefore annual doses are anticipated to be on the order of 7.5  $\mu$ Sv.

III-12. The high TI packages would be kept in the storeroom until as late as practicable and would be the last to be loaded. This would reduce the dose to the loaders. Shielding of 3 mm of lead would be provided in the vehicle behind the driver's cabin.

### **Emergency response**

III-13. In the event of an incident (falling, crushing or fire) during storage or loading of the radioactive consignment on to the aircraft, or upon receipt of information about an accident during taxiing, takeoff, flight or landing, Mr./Ms. A will take the following measures:

- (a) Implement life-saving measures and administer first aid;
- (b) Assess the risk of, or occurrence of, fire and use the fire extinguisher if appropriate;
- (c) Contact first responders, as appropriate (e.g., fire fighters, emergency medical service, security services);
- (d) Contact a qualified expert in radiation protection and request guidance;
- (e) Inform the concerned airport authority and/or relevant public official;
- (f) Maintain the ability to communicate electronically via telephone, radio and/or internet;
- (g) With the help of and under the direction of a qualified expert in radiation protection, clean up the affected area and collect the damaged packages and radioactive material, if any;
- (h) Obtain documentation from a qualified expert in radiation protection to confirm that the affected area is safe for normal use again;
- (i) Terminate the emergency;
- (j) Arrange for the transport of the radioactive material involved in the accident to an authorized recipient, as recommended by a qualified expert in radiation protection;
- (k) Inform the competent authority of the incident.

III-14. These instructions are displayed prominently in the storage bay and the areas where packages are delivered and picked up in connection with ground transport so that, in the absence of Mr./Ms. A, any other responsible person would be able to implement these measures.

III-15. Emergency contact details:

### **Training**

III-16. The persons listed below, being employees of XYZ Cargo Carriers engaged in the handling of packages containing radioactive material for transport, have received appropriate training that is commensurate with their duties:

Mr./Ms. .... (Acceptance Staff/Cargo Handler)

Mr./Ms. .... (Acceptance Staff/Cargo Handler)

Mr./Ms. .... (Acceptance Staff/Cargo Handler)

III-17. The training that they have received fulfils the applicable requirements of the competent authority and of the ICAO/International Air Transport Association regulations and the policies of XYZ Cargo Carriers. They will be subject to retraining every two years.

**Management system for procedures and practices**

III-18. The RPP is part of XYZ Cargo Carriers’ system of documents on the management system, including the documented policies, objectives and responsibilities of the management, and is subject to all the requirements of the management system for procedures and practices, such as document/version control, document review, issuing and review of instructions and procedures, follow-up of non-conformances, etc.

The RPP, as described in this document, is approved.

Signature....., Date: .....

(Name and designation)



## **ANNEX IV: EXAMPLE OF A RADIATION PROTECTION PROGRAMME FOR THE TRANSPORT OF RADIOACTIVE MATERIAL BY AN INDUSTRIAL RADIOGRAPHY COMPANY**

IV-1. This is an example of documentation for an RPP for LMN Industrial Gamma Radiographers.

### **Scope**

IV-2. The scope of this RPP covers the transport and in-transit storage of gamma radiography sources duly housed in their approved shielded containers/devices. LMN Industrial Gamma Radiographers transports its own gamma radiography devices once a month. The packages used are all of Type A and Type B(U). Almost all packages transported by the firm are category II-YELLOW. The maximum TI encountered is 1.0. LMN Industrial Gamma Radiographers has a delivery van that transports the packages to the carrier or to the radiography sites.

### **Roles and responsibilities**

IV-3. The RPP will be managed by Mr./Ms. X, who is trained in radiation protection. Mr./Ms. X will ensure that all of the elements of the RPP are implemented, including:

- (a) Training of workers and implementation of proper work procedures;
- (b) Assessment of worker exposures, if necessary, by individual monitoring or workplace monitoring;
- (c) Emergency procedures.

IV-4. The role of the radiographer is to prepare packages (i.e., radiograph devices containing sealed sources) for transport and to transport these packages including the following tasks:

- (a) Complete transport documents;
- (b) Measure dose rates and TI;
- (c) Complete and apply package labels and markings;
- (d) Load packages on to the vehicle;
- (e) Segregate and secure packages;
- (f) Implement emergency procedures, if appropriate.

IV-6. Usually, loading the device on to the vehicle and also driving the vehicle are the responsibilities of the radiographer. As the driver of the vehicle, the following tasks should be performed information should be obtained:

- (a) Obtain information about actions to be taken in the event of an emergency;
- (b) Obtain information about dose rates around the loaded vehicle;
- (c) Placard the vehicle.

### **Dose assessment and optimization**

IV-7. To evaluate the possible levels of individual exposure and to determine the monitoring programme, LMN Industrial Gamma Radiographers deployed the services of a qualified expert in radiation protection (Mr./Ms. Y). The evaluation was made on the basis of:

- (a) The number and type of packages handled by the firm;
- (b) The category of packages and the TI moved;
- (c) The radionuclides being shipped;
- (d) The frequency of shipment;
- (e) The duration of storage prior to transport.

IV-8. The study showed that, since the radiographer would often act as the cargo handler, the maximum individual radiation dose that he or she would receive would be at least 6 mSv in a year at the present workload. Dose assessment by individual monitoring will be conducted as determined by a qualified expert in radiation protection. Dose records will be maintained.

IV-9. The dose rate monitors and the individual dosimeters recommended by a qualified expert in radiation protection have been procured and are regularly used. The dose rate monitors are calibrated as recommended by a qualified expert in radiation protection. Packages, conveyances and the workplace are monitored by Mr./Ms. X to verify the continued validity of the results of the initial dose evaluation.

IV-10. Occupational exposures are kept as low as reasonably achievable by the following means:

- (a) Using a trolley to take the packages from the storeroom to the loading area;
- (b) Keeping the packages in the storeroom in the shielded bays until as late as possible before loading;
- (c) Increasing segregation distances beyond the minimum requirements, where possible;
- (d) Minimizing the presence of workers in the vicinity of (within a distance of 5 m from) the packages.

### **Surface contamination**

IV-11. The radioactive material to be transported is in special form and carried in appropriate packages in good condition. If damage to packages is suspected, checks for shielding integrity will be made by Mr./Ms. X. Periodic (weekly) radiation protection surveys are made of the work area and conveyances. The results of these checks will be recorded and retained.

### **Segregation and other protective measures**

IV-12. The storage area is 10 m from the office. The office workers are expected to receive the same level of protection as members of the public. The packages are stored for a maximum of 8 h per day. Not more than five packages would be stored in this area. The storage is always in an underground pit provided with sufficient shielding to ensure that the dose rate outside the pit is no more than 0.1  $\mu$ Sv/h. The occupancy in the immediate vicinity of the pit would be occasional.

IV-13. Where possible, all packages, especially the high TI packages, are placed at the rear of the goods compartment when loading the packages on to the vehicle. This will minimize the exposure of the driver.

IV-14. The packages would be kept in the storage room for as long as practicable and would be the last to be loaded. This would reduce the dose to the loader. Lead shielding of 3 mm thickness is provided behind the driver's cabin of the delivery van.

IV-15. For scheduled and non-scheduled stops and overnight stops during road transport, the vehicle is to be parked away from areas that are regularly occupied by members of the public.

**Emergency response**

IV-16. In the event of an incident (falling, crushing or fire) during storage or loading of the radioactive consignment on to the vehicle, Mr./Ms. X will take the following measures:

- (a) Implement life-saving measures and administer first aid;
- (b) Assess the risk of, or occurrence of, fire and use the fire extinguisher if appropriate;
- (c) Contact first responders, as appropriate (e.g., fire fighters, emergency medical service, security services);
- (d) Contact a qualified expert in radiation protection and request guidance;
- (e) Maintain the ability to communicate electronically via telephone, radio and/or internet;
- (f) With the help of and under the direction of a qualified expert in radiation protection, clean up the affected area and collect the damaged packages and radioactive material, if any;
- (g) Obtain documentation from a qualified expert in radiation protection to confirm that the affected area is safe for normal use again;
- (h) Terminate the emergency;
- (i) Arrange for the transport of the radioactive material involved in the accident to an authorized recipient, as recommended by a qualified expert in radiation protection;
- (j) Inform the competent authority of the incident.

IV-17. These instructions are displayed prominently in the storage bay, the vehicle loading area and the vehicle so that, in the absence of Mr./Ms. X, any other responsible person would be able to take these measures.

IV-18. Emergency contact details:

Telephone numbers

Person Office Residence

Mr./Ms. X #####

Radiation specialist #####

Others #####

**Training**

IV-19. The persons listed below, being employees of LMN Industrial Gamma Radiographers engaged in the preparation of packages containing radiopharmaceuticals for transport, have received the appropriate training that is commensurate with their responsibilities:

Mr./Ms. ....(Radiographer)

Mr./Ms. ....(Radiographer)

Mr./Ms. ....(Radiographer)

IV–20. The training that they have received fulfils the applicable requirements of the competent authority and the policies of LMN Industrial Gamma Radiographers. They will be subject to retraining every two years.

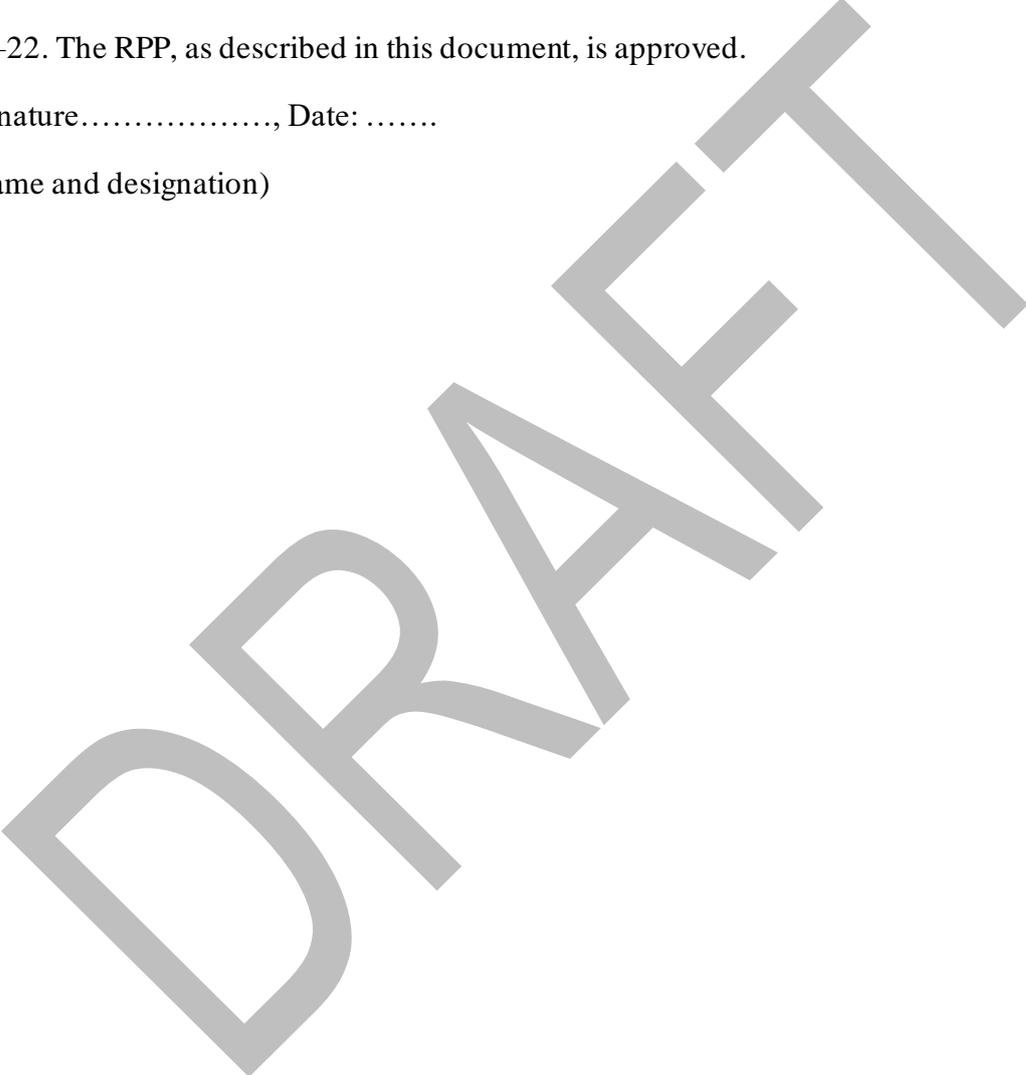
**Management system for procedures and practices**

IV–21. The RPP is part of LMN Industrial Gamma Radiographers’ system of management system documents, including the documented policies, objectives and responsibilities of the management, and is subject to all the requirements of the management system for procedures and practices, such as document/ version control, document review, issuing and review of instructions and procedures, follow-up of non-conformances, etc.

IV–22. The RPP, as described in this document, is approved.

Signature....., Date: .....

(Name and designation)



## **ANNEX V: EXAMPLE OF A RADIATION PROTECTION PROGRAMME FOR THE TRANSPORT OF RADIOACTIVE MATERIAL FOR PUBLIC AUTHORITIES**

V-1. This is an example of documentation of an RPP that is applicable to the following public authorities:

- (a) Airport authorities;
- (b) Harbour/port authorities;
- (c) Customs authorities;
- (d) Modal authorities (civil aviation, rail, road and sea transport).

### **Scope**

V-2. Package: All packages containing radioactive material; namely excepted packages, industrial packages, Type IP-1, 2 and 3, Type A and Type B(U) and B(M) packages.

### **Roles and responsibilities**

V-3. The authority hereby designates Mr./Ms. X as the person who will monitor the implementation of:

- (a) The smooth carriage of radioactive cargo;
- (b) Training of personnel;
- (c) Dose assessment;
- (d) Emergency response.

### **Facilitating the carriage of radioactive cargo**

V-4. Mr./Ms. X will ensure that the handling of radioactive cargo is facilitated, provided that such cargo has been forwarded in compliance with the applicable regulations for the safe transport of radioactive material.

### **Training of personnel**

V-5. Mr./Ms. X:

- (a) Has received the basic training relating to dangerous goods, including radioactive cargo;
- (b) Is aware of the basic regulatory requirements;
- (c) Is capable of recognizing labels for different types of dangerous cargo, reporting incidents and acting as directed by experts in the event of an emergency.

### **Dose assessment**

V-6. Dose assessment of employees of the public authority by monitoring is not required because doses to workers and the public in a year are well below 1 mSv due to preestablished segregation and the limitation of access to the radioactive cargo.

**Emergency response**

V-7. Mr./Ms. X will ensure that arrangements for emergency preparedness and response are :

- (a) commensurate with the hazards of the radioactive materials to be transported,
- (b) updated regularly, and
- (c) in compliance with the relevant international and national emergency response requirements.

V-8. All applicable instructions for emergency preparedness and response are listed in Document No. XYZ.

**Documentation**

V-9. Documents to be maintained by Mr./Ms. X include particulars relating to (a) the consignee/licensee, if the cargo is off-loaded; (b) the radioactive cargo permitted to be off-loaded and to remain on board in transit; (c) instances of denial of permission for carriage or transit of radioactive cargo; and (d) reasons for such denial.

**Management system for procedures and practices**

V-10. A management system that is capable of evaluating the implementation of the procedures and practices is established. The management system is documented in Document No. ABC. The RPP is part of the system of management system documents, including the documented policies, objectives and responsibilities of the management, and is subject to all the requirements of the management system for procedures and practices, such as document/version control, document review, issuing and review of instructions and procedures, follow-up of non-conformances, etc.

V-11. The RPP, as described in this document, is approved.

Signature....., Date: .....

(Name and designation)

## ANNEX VI: EXAMPLE OF A RADIATION PROTECTION PROGRAMME FOR A VESSEL<sup>1</sup>

VI-1. This is an example of documentation of an RPP for Vessel X.

### Scope

VI-2. The scope of this RPP covers the transport and in-transit storage of packages containing uranium oxide concentrate and packages containing sealed sources of Co-60 that are used in industrial irradiators. Vessel X transports consignments of uranium oxide concentrate and special form sources containing Co-60 that are used in industrial irradiators.

VI-3. *Uranium oxide concentrate*: Each year, twelve consignments are transported that consist of 960 steel drums that are loaded into 20 x 20-foot freight containers. The steel drums are Type IP-1 industrial packages. The uranium ore concentrate is classified as low specific activity material (LSA material) in the group LSA-I. Each 20-foot container that has been loaded with 48 steel drums has the following dose rates: 0.06 mSv/h at contact and 0.02 mSv/h at 1 m. Each 20-foot freight container is labelled with a III-YELLOW label with a TI of 6.0.

VI-4. *Co-60 sealed sources*: Each year, twelve consignments are transported that consist of two Type B(U) packages containing Co-60 sealed sources that are placed in a 20-foot shipping container. Each shipping container has the following dose rates: 0.9 mSv/h at contact and 0.03 mSv/h at 1 m. Each 20-foot freight container is labelled with a III-YELLOW label with a TI of 9.0.

VI-5. The scope of this RPP applies from the loading of the consignment onto Vessel X at the originating port facility to the unloading of the consignment at the destination port facility.

### Roles and responsibilities

VI-6. The RPP will be managed by Mr./Ms. A, who is a qualified expert in radiation protection. Mr./Ms. A will ensure that all of the elements of the RPP are implemented, including:

- (a) Training of workers and implementation of proper work procedures;
- (b) Assessment of worker exposures, if necessary, by individual monitoring or workplace monitoring;
- (c) Emergency procedures.

VI-7. The role of the vessel's crew and captain is to:

- (a) Obtain information on the following:
  1. Information on actions to be taken in the event of an emergency for each consignment;
  2. Conditions for storage, loading and securing of the packages for each consignment.

---

<sup>1</sup> Guidance on radiation protection programmes for special use vessels (see paras 576 and 802(d) of the Transport Regulations) is provided in paras 576.1-576.7 of SSG-26 (Rev.1) [VII-1].

- (a) Load shipping containers on to the vessel;
- (b) Segregate and secure packages;
- (c) Implement actions to reduce doses to workers;
- (d) Implement emergency procedures, if appropriate.

### **Dose assessment and optimization**

VI-8. The owners of Vessel X arranged for a qualified expert in radiation protection (Mr./Ms. B) to perform a study to evaluate the possible levels of individual exposure and to determine the monitoring programme. The evaluation was made on the basis of:

- (a) The number and type of packages transported;
- (b) The category of packages and the TI moved;
- (c) The radionuclides being shipped;
- (d) The frequency of shipment.

VI-9. The study revealed that the maximum radiation dose that any individual crew member of Vessel X would receive would be significantly less than 1 mSv in a year at the present workload. Mr./Ms. B advised that a dose assessment programme (using individual monitoring or workplace monitoring) was not necessary.

VI-10. Occupational exposures are kept as low as reasonably achievable by the following means:

- (a) Stowing all 20-foot containers under deck within the vessel hull.
- (b) Positioning all 20-foot containers door-to-door to lessen that chances that the doors will open as a result of some external event that results in a significant impact or force applied to the containers during transit;
- (c) Minimizing the crew members' presence in the vicinity of the shipping containers;
- (d) Increasing segregation distances beyond the minimum requirements, where possible.

### **Surface contamination**

VI-11. Under normal conditions, 20-foot shipping containers that have been prepared for transport do not have any external contamination above allowed limits. If shipping containers appear to have been ruptured as a result of an accident, checks for contamination will be performed and appropriate action taken if contamination is detected.

### **Segregation and other protective measures**

VI-12. All 20-foot shipping containers are stowed in accordance with the segregation requirements of the IMDG Code [VI-2]. If possible, the 20-foot shipping containers will be stowed such that the minimum segregation distances are exceeded.

### **Emergency response**

VI-13. In the event of an incident, the following will be implemented:

- (a) For dealing with fires and spillages (leakages), implement the recommendations in The EmS GUIDE: Emergency Response Procedures for Ships Carrying Dangerous Goods [VI-3].
- (b) Implement life-saving measures and administer first aid;
- (c) Assess the risk of, or occurrence of, fire and use the fire extinguisher if appropriate;
- (d) Contact first responders, as appropriate (e.g., fire fighters, emergency medical service, security services);
- (e) Contact a qualified expert in radiation protection and request guidance;
- (f) Maintain the ability to communicate electronically via telephone, radio and/or internet;
- (g) With the help of and under the direction of a qualified expert in radiation protection, clean up the affected area and collect the damaged packages and radioactive material, if any;
- (h) Obtain documentation from a qualified expert in radiation protection to confirm that the affected area is safe for normal use again;
- (i) Terminate the emergency;
- (j) Arrange for the transport of the radioactive material involved in the accident to an authorized recipient, as recommended by a qualified expert in radiation protection;
- (k) Inform the competent authority of the incident.

VI-14. These instructions are to be available to crew members and emergency responders in the event of an accident.

VI-15. Emergency contact details:

Telephone numbers

Person Office Residence

Mr./Ms. X #####

Qualified Expert in Radiation Safety #####

Others #####

**Training**

VI-16. The persons listed below, being crew members of Vessel X engaged in the transport of packages containing radioactive material, have received appropriate training that is commensurate with their duties:

Mr./Ms. ....(Crew Member)

Mr./Ms. ....(Crew Member)

Mr./Ms. ....(Crew Member)

VI-17. The training that they receive fulfils the applicable requirements of the competent authority. They will be subject to retraining every two years.

**Management system for procedures and practices**

VI-18. The RPP is part of Vessel X’s system of management system documents, including the documented policies, objectives and responsibilities of the management, and is subject to all the requirements of the management system for procedures and practices, such as document/version control, document review, issuing and review of instructions and procedures, follow-up of non-conformances, etc.

The RPP, as described in this document, is approved.

Signature....., Date: .....

(Name and designation)

**REFERENCE TO ANNEX VI**

- [VI-1] INTERNATIONAL ATOMIC ENERGY AGENCY, Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material (2018), IAEA Safety Standards Series No. SSG-26 (Rev. 1), IAEA, Vienna (202X).
- [VI-2] INTERNATIONAL MARITIME ORGANIZATION, International Maritime Dangerous Goods Code (IMDG Code) (amendment 40-20), IMO, London (2020).
- [VI-3] INTERNATIONAL MARITIME ORGANIZATION, Revised Emergency Response Procedures for Ships Carrying Dangerous Goods (EMS Guide), MSC.1/Circ.1588, IMO, London (2018).

## ANNEX VII: QUESTIONNAIRE FOR EVALUATING THE EFFECTIVENESS OF RADIATION PROTECTION PROGRAMMES

VII-1. The following questions may be used in evaluating the effectiveness of RPPs:

- (a) How does the RPP fit within the transport organization's management system?
- (b) Does the scope of the RPP reflect completely and accurately what the RPP needs to cover?
- (c) Is the management commitment sufficiently demonstrated?
- (d) Are the resources (human and technical) available to fulfil the objectives of the RPP?
- (e) Are the roles and responsibilities of all workers concerned adequately described and fully outlined?
- (f) Has the dose assessment of the workers in different workplaces been carried out correctly? And is it still valid?
- (g) Has this assessment been validated and/or verified through, for example, periodic checks or workplace dose verification?
- (h) Are the personnel involved in the different actions sufficiently and correctly trained and familiar with equipment and instruments (including those that are not routinely used)?
- (i) Is the training correctly documented (certificates, expiry dates, etc.)?
- (j) If applicable (e.g. to consignors): Are the decisions on classification (UN number, proper shipping name), package requirements (using the correct and optimized package design), labelling, etc., taken by sufficiently skilled personnel, verified and properly documented and recorded?
- (k) Are the necessary approvals and certificates in place and valid?
- (l) Are there working instructions and procedures in place (and implemented by the workers) that give clear and adequate guidance to ensure the maximum efficiency and to minimize doses?
- (m) Are these instructions and procedures up to date and consistent with the objectives of the RPP?
- (n) Do they cover all aspects, including emergency procedures?
- (o) Is the measuring equipment (for dose rate, contamination and air monitoring) adequate for the measurements, either routinely or during an emergency, to be taken?
- (p) Are calibration certificates in place and valid for the task to be done?
- (q) Are the proper user instructions followed?
- (r) Are the results of measurements recorded?

## ANNEX VIII: SEGREGATION REQUIREMENTS FOR MARITIME TRANSPORT

VIII-1. The contents of this Annex have been reproduced from the International Maritime Dangerous Goods (IMDG) Code [IX-1]. The applicable version of this guidance is the current edition of the IMDG Code, which is revised every two years.

- 7.1.4.5.13** Radioactive material shall be segregated sufficiently from crew and passengers. The following values for dose shall be used for the purpose of calculating segregation distances or radiation levels:
- .1** for crew in regularly occupied working areas, a dose of 5 mSv in a year;
  - .2** for passengers, in areas where the passengers have regular access, a dose of 1 mSv in a year, taking account of the exposures expected to be delivered by all other relevant sources and practices under control.
- 7.1.4.5.14** Category II-YELLOW or III-YELLOW packages or overpacks shall not be transported in spaces occupied by passengers, except those exclusively reserved for couriers specially authorized to accompany such packages or overpacks.
- 7.1.4.5.15** Any group of packages, overpacks and freight containers containing fissile material stored in transit in any one storage area shall be so limited that the total sum of the criticality safety indexes in the group does not exceed 50. Each group shall be stored so as to maintain a spacing of at least 6 m from other such groups.
- 7.1.4.5.16** Where the total sum of the criticality safety indexes on board a conveyance or in a freight container exceeds 50, as permitted in the table under 7.1.4.5.3.4, storage shall be such as to maintain a spacing of at least 6 m from other groups of packages, overpacks or freight containers containing fissile material or other conveyances carrying radioactive material.
- 7.1.4.5.17** Any departure from the provisions in 7.1.4.5.15 and 7.1.4.5.16 shall be approved by the Administration and, when requested, by the competent authority at each port of call.
- 7.1.4.5.18** The segregation requirements specified in 7.1.4.5.13 may be established in one of the following two ways:
- by following the segregation table for persons (table 7.1.4.5.18) in respect of living quarters or spaces regularly occupied by persons.
  - by demonstration that, for the following indicated exposure times, the direct measurement of the radiation level in regularly occupied spaces and living quarters is less than:
    - for the crew:*  
0.0070 mSv/h up to 700 h in a year, or  
0.0018 mSv/h up to 2750 h in a year; and
    - for the passengers:*  
0.0018 mSv/h up to 550 h in a year,taking into account any relocation of cargo during the voyage. In all cases, the measurements of radiation level must be made and documented by a suitably qualified person.

**Table 7.1.4.5.18 – CLASS 7 – Radioactive material  
Segregation table for persons**

Sum of transport indices (TI)	Segregation distance of radioactive material from passengers and crew			
	General cargo ship <sup>1</sup>		Ferry, etc. <sup>2</sup>	Offshore support vessel <sup>3</sup>
	Break bulk (m)	Containers (TEUs) <sup>4</sup>		
Up to 10	6	1	Stow at bow or stern furthest from living quarters and regularly occupied work areas	Stow at stern or at platform midpoint
More than 10 but not more than 20	8	1	as above	as above
More than 20 but not more than 50	13	2	as above	not applicable
More than 50 but not more than 100	18	3	as above	not applicable
More than 100 but not more than 200	26	4	as above	not applicable
More than 200 but not more than 400	36	6	as above	not applicable

<sup>1</sup> General cargo, break bulk or ro-ro containership of 150 m minimum length.

<sup>2</sup> Ferry or cross channel, coastal and inter-island ship of 100 m minimum length.

<sup>3</sup> Offshore support vessel of 50 m minimum length (in this case the practical maximum sum of TIs carried is 20).

<sup>4</sup> TEU means "20 ft Equivalent Unit" (this is equivalent to a standard freight container of 6 m nominal length).

DRAFT

## REFERENCE TO ANNEX VIII

[VIII-1] INTERNATIONAL MARITIME ORGANIZATION, International Maritime Dangerous Goods Code (IMDG Code) (amendment 39-38), IMO, London (2018).

DRAFT

## CONTRIBUTORS TO DRAFTING AND REVIEW

Cabianca, T.	Public Health England, United Kingdom
Fulford, G.	Nordion, Canada
Fuller, M.	QSA Global, Inc., United States
Harris, F.	Rio Tinto Uranium, Australia
Johnson, S.	Source Production & Equipment Co., United States
Miller, J.	International Isotopes, United States
Nitsche, F.	Consultant, Germany
Reber, E.	International Atomic Energy Agency
Rooney, K.	International Civil Aviation Organization
Song, B.	International Maritime Organization
Stewart, J.	Consultant, United Kingdom

DRAFT