IAEA Safety Standards

for protecting people and the environment

Radiation Protection Programmes for the Transport of Radioactive Material

Specific Safety Guide

No. SSG-86

IAEA
International Atomic Energy Agency

IAEA SAFETY STANDARDS AND RELATED PUBLICATIONS

IAEA SAFETY STANDARDS

Under the terms of Article III of its Statute, the IAEA is authorized to establish or adopt standards of safety for protection of health and minimization of danger to life and property, and to provide for the application of these standards.

The publications by means of which the IAEA establishes standards are issued in the **IAEA Safety Standards Series**. This series covers nuclear safety, radiation safety, transport safety and waste safety. The publication categories in the series are **Safety Fundamentals**, **Safety Requirements** and **Safety Guides**.

Information on the IAEA's safety standards programme is available on the IAEA Internet site

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The site provides the texts in English of published and draft safety standards. The texts of safety standards issued in Arabic, Chinese, French, Russian and Spanish, the IAEA Safety Glossary and a status report for safety standards under development are also available. For further information, please contact the IAEA at: Vienna International Centre, PO Box 100, 1400 Vienna, Austria.

All users of IAEA safety standards are invited to inform the IAEA of experience in their use (e.g. as a basis for national regulations, for safety reviews and for training courses) for the purpose of ensuring that they continue to meet users' needs. Information may be provided via the IAEA Internet site or by post, as above, or by email to Official.Mail@iaea.org.

RELATED PUBLICATIONS

The IAEA provides for the application of the standards and, under the terms of Articles III and VIII.C of its Statute, makes available and fosters the exchange of information relating to peaceful nuclear activities and serves as an intermediary among its Member States for this purpose.

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Other safety related IAEA publications are issued as **Emergency Preparedness and Response** publications, **Radiological Assessment Reports**, the International Nuclear Safety Group's **INSAG Reports**, **Technical Reports** and **TECDOCs**. The IAEA also issues reports on radiological accidents, training manuals and practical manuals, and other special safety related publications.

Security related publications are issued in the **IAEA Nuclear Security Series**.

The **IAEA Nuclear Energy Series** comprises informational publications to encourage and assist research on, and the development and practical application of, nuclear energy for peaceful purposes. It includes reports and guides on the status of and advances in technology, and on experience, good practices and practical examples in the areas of nuclear power, the nuclear fuel cycle, radioactive waste management and decommissioning.

RADIATION PROTECTION PROGRAMMES FOR THE TRANSPORT OF RADIOACTIVE MATERIAL

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The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world".

IAEA SAFETY STANDARDS SERIES No. SSG-86

RADIATION PROTECTION PROGRAMMES FOR THE TRANSPORT OF RADIOACTIVE MATERIAL

SPECIFIC SAFETY GUIDE

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2023

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www.iaea.org/publications

Printed by the IAEA in Austria
November 2023
STI/PUB/2052

IAEA Library Cataloguing in Publication Data

Names: International Atomic Energy Agency.
Title: Radiation protection programmes for the transport of radioactive material / International Atomic Energy Agency.
Description: Vienna : International Atomic Energy Agency, 2023. | Series: IAEA safety standards series, ISSN 1020–525X ; no. SSG-86 | Includes bibliographical references.
Identifiers: IAEAL 23-01607 | ISBN 978–92–0–103623–0 (paperback : alk. paper) | ISBN 978–92–0–103723–7 (pdf) | ISBN 978–92–0–103823–4 (epub)
Subjects: LCSH: Radioactive substances — Transportation. | Radioactive substances — Safety measures. | Radioactive substances — Safety regulations.
Classification: UDC 656.073 | STI/PUB/2052

FOREWORD

by Rafael Mariano Grossi
Director General

The IAEA's Statute authorizes it to "establish…standards of safety for protection of health and minimization of danger to life and property". These are standards that the IAEA must apply to its own operations, and that States can apply through their national regulations.

The IAEA started its safety standards programme in 1958 and there have been many developments since. As Director General, I am committed to ensuring that the IAEA maintains and improves upon this integrated, comprehensive and consistent set of up to date, user friendly and fit for purpose safety standards of high quality. Their proper application in the use of nuclear science and technology should offer a high level of protection for people and the environment across the world and provide the confidence necessary to allow for the ongoing use of nuclear technology for the benefit of all.

Safety is a national responsibility underpinned by a number of international conventions. The IAEA safety standards form a basis for these legal instruments and serve as a global reference to help parties meet their obligations. While safety standards are not legally binding on Member States, they are widely applied. They have become an indispensable reference point and a common denominator for the vast majority of Member States that have adopted these standards for use in national regulations to enhance safety in nuclear power generation, research reactors and fuel cycle facilities as well as in nuclear applications in medicine, industry, agriculture and research.

The IAEA safety standards are based on the practical experience of its Member States and produced through international consensus. The involvement of the members of the Safety Standards Committees, the Nuclear Security Guidance Committee and the Commission on Safety Standards is particularly important, and I am grateful to all those who contribute their knowledge and expertise to this endeavour.

The IAEA also uses these safety standards when it assists Member States through its review missions and advisory services. This helps Member States in the application of the standards and enables valuable experience and insight to be shared. Feedback from these missions and services, and lessons identified from events and experience in the use and application of the safety standards, are taken into account during their periodic revision.

I believe the IAEA safety standards and their application make an invaluable contribution to ensuring a high level of safety in the use of nuclear technology. I encourage all Member States to promote and apply these standards, and to work with the IAEA to uphold their quality now and in the future.

THE IAEA SAFETY STANDARDS

BACKGROUND

Radioactivity is a natural phenomenon and natural sources of radiation are features of the environment. Radiation and radioactive substances have many beneficial applications, ranging from power generation to uses in medicine, industry and agriculture. The radiation risks to workers and the public and to the environment that may arise from these applications have to be assessed and, if necessary, controlled.

Activities such as the medical uses of radiation, the operation of nuclear installations, the production, transport and use of radioactive material, and the management of radioactive waste must therefore be subject to standards of safety.

Regulating safety is a national responsibility. However, radiation risks may transcend national borders, and international cooperation serves to promote and enhance safety globally by exchanging experience and by improving capabilities to control hazards, to prevent accidents, to respond to emergencies and to mitigate any harmful consequences.

States have an obligation of diligence and duty of care, and are expected to fulfil their national and international undertakings and obligations.

International safety standards provide support for States in meeting their obligations under general principles of international law, such as those relating to environmental protection. International safety standards also promote and assure confidence in safety and facilitate international commerce and trade.

A global nuclear safety regime is in place and is being continuously improved. IAEA safety standards, which support the implementation of binding international instruments and national safety infrastructures, are a cornerstone of this global regime. The IAEA safety standards constitute a useful tool for contracting parties to assess their performance under these international conventions.

THE IAEA SAFETY STANDARDS

The status of the IAEA safety standards derives from the IAEA's Statute, which authorizes the IAEA to establish or adopt, in consultation and, where appropriate, in collaboration with the competent organs of the United Nations and with the specialized agencies concerned, standards of safety for protection of health and minimization of danger to life and property, and to provide for their application.

With a view to ensuring the protection of people and the environment from harmful effects of ionizing radiation, the IAEA safety standards establish fundamental safety principles, requirements and measures to control the radiation exposure of people and the release of radioactive material to the environment, to restrict the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation, and to mitigate the consequences of such events if they were to occur. The standards apply to facilities and activities that give rise to radiation risks, including nuclear installations, the use of radiation and radioactive sources, the transport of radioactive material and the management of radioactive waste.

Safety measures and security measures[1] have in common the aim of protecting human life and health and the environment. Safety measures and security measures must be designed and implemented in an integrated manner so that security measures do not compromise safety and safety measures do not compromise security.

The IAEA safety standards reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from harmful effects of ionizing radiation. They are issued in the IAEA Safety Standards Series, which has three categories (see Fig. 1).

Safety Fundamentals

Safety Fundamentals present the fundamental safety objective and principles of protection and safety, and provide the basis for the safety requirements.

Safety Requirements

An integrated and consistent set of Safety Requirements establishes the requirements that must be met to ensure the protection of people and the environment, both now and in the future. The requirements are governed by the objective and principles of the Safety Fundamentals. If the requirements are not met, measures must be taken to reach or restore the required level of safety. The format and style of the requirements facilitate their use for the establishment, in a harmonized manner, of a national regulatory framework. Requirements, including numbered ‘overarching’ requirements, are expressed as ‘shall’ statements. Many requirements are not addressed to a specific party, the implication being that the appropriate parties are responsible for fulfilling them.

Safety Guides

Safety Guides provide recommendations and guidance on how to comply with the safety requirements, indicating an international consensus that it

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[1] See also publications issued in the IAEA Nuclear Security Series.

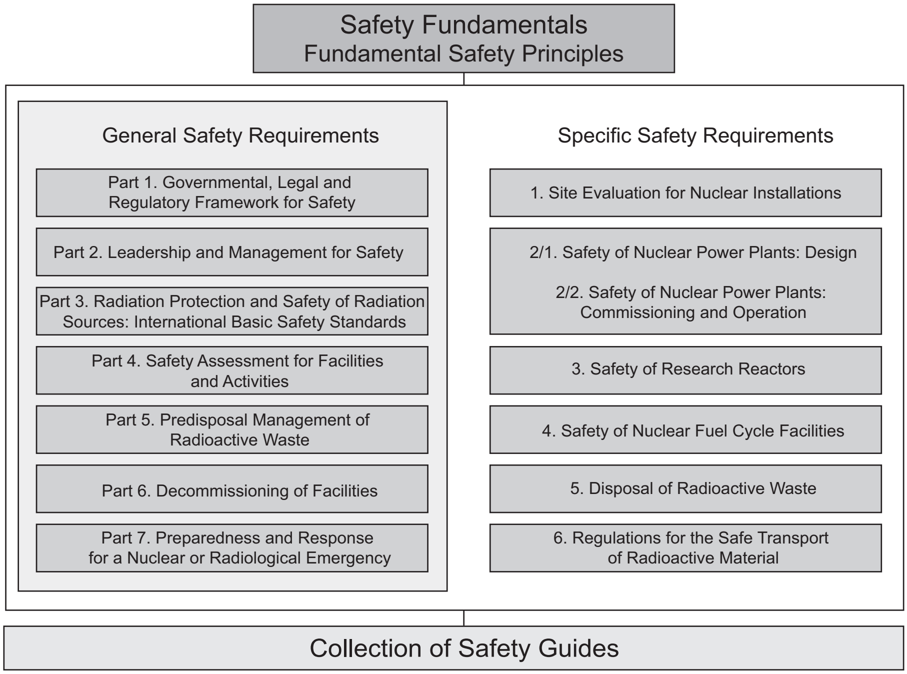

FIG. 1. The long term structure of the IAEA Safety Standards Series.

is necessary to take the measures recommended (or equivalent alternative measures). The Safety Guides present international good practices, and increasingly they reflect best practices, to help users striving to achieve high levels of safety. The recommendations provided in Safety Guides are expressed as 'should' statements.

APPLICATION OF THE IAEA SAFETY STANDARDS

The principal users of safety standards in IAEA Member States are regulatory bodies and other relevant national authorities. The IAEA safety standards are also used by co-sponsoring organizations and by many organizations that design, construct and operate nuclear facilities, as well as organizations involved in the use of radiation and radioactive sources.

The IAEA safety standards are applicable, as relevant, throughout the entire lifetime of all facilities and activities — existing and new — utilized for peaceful purposes and to protective actions to reduce existing radiation risks. They can be used by States as a reference for their national regulations in respect of facilities and activities.

The IAEA's Statute makes the safety standards binding on the IAEA in relation to its own operations and also on States in relation to IAEA assisted operations.

The IAEA safety standards also form the basis for the IAEA's safety review services, and they are used by the IAEA in support of competence building, including the development of educational curricula and training courses.

International conventions contain requirements similar to those in the IAEA safety standards and make them binding on contracting parties. The IAEA safety standards, supplemented by international conventions, industry standards and detailed national requirements, establish a consistent basis for protecting people and the environment. There will also be some special aspects of safety that need to be assessed at the national level. For example, many of the IAEA safety standards, in particular those addressing aspects of safety in planning or design, are intended to apply primarily to new facilities and activities. The requirements established in the IAEA safety standards might not be fully met at some existing facilities that were built to earlier standards. The way in which IAEA safety standards are to be applied to such facilities is a decision for individual States.

The scientific considerations underlying the IAEA safety standards provide an objective basis for decisions concerning safety; however, decision makers must also make informed judgements and must determine how best to balance the benefits of an action or an activity against the associated radiation risks and any other detrimental impacts to which it gives rise.

DEVELOPMENT PROCESS FOR THE IAEA SAFETY STANDARDS

The preparation and review of the safety standards involves the IAEA Secretariat and five Safety Standards Committees, for emergency preparedness and response (EPReSC) (as of 2016), nuclear safety (NUSSC), radiation safety (RASSC), the safety of radioactive waste (WASSC) and the safe transport of radioactive material (TRANSSC), and a Commission on Safety Standards (CSS) which oversees the IAEA safety standards programme (see Fig. 2).

All IAEA Member States may nominate experts for the Safety Standards Committees and may provide comments on draft standards. The membership of the Commission on Safety Standards is appointed by the Director General and includes senior governmental officials having responsibility for establishing national standards.

A management system has been established for the processes of planning, developing, reviewing, revising and establishing the IAEA safety standards.

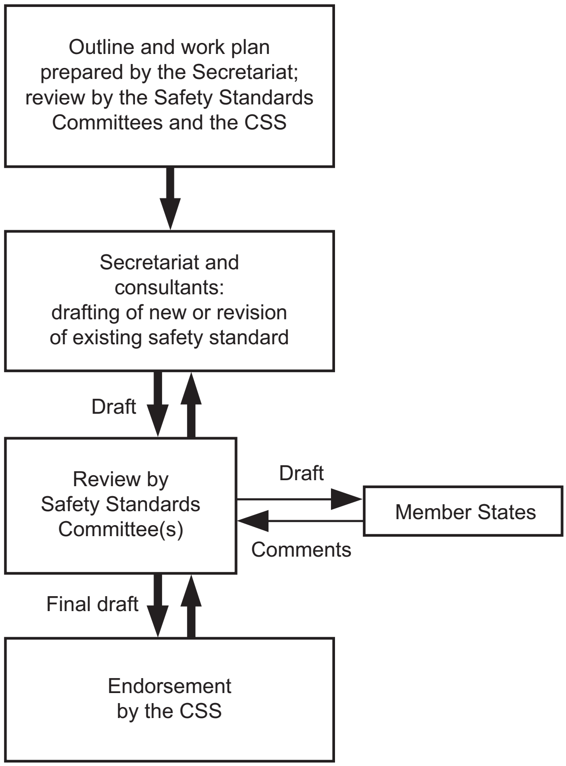

FIG. 2. The process for developing a new safety standard or revising an existing standard.

It articulates the mandate of the IAEA, the vision for the future application of the safety standards, policies and strategies, and corresponding functions and responsibilities.

INTERACTION WITH OTHER INTERNATIONAL ORGANIZATIONS

The findings of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the recommendations of international expert bodies, notably the International Commission on Radiological Protection (ICRP), are taken into account in developing the IAEA safety standards. Some safety standards are developed in cooperation with other bodies in the United Nations system or other specialized agencies, including the Food and Agriculture Organization of the United Nations, the United Nations Environment Programme, the International Labour Organization, the OECD Nuclear Energy Agency, the Pan American Health Organization and the World Health Organization.

INTERPRETATION OF THE TEXT

Safety related terms are to be understood as defined in the IAEA Nuclear Safety and Security Glossary (see https://www.iaea.org/resources/publications/iaea-nuclear-safety-and-security-glossary). Otherwise, words are used with the spellings and meanings assigned to them in the latest edition of The Concise Oxford Dictionary. For Safety Guides, the English version of the text is the authoritative version.

The background and context of each standard in the IAEA Safety Standards Series and its objective, scope and structure are explained in Section 1, Introduction, of each publication.

Material for which there is no appropriate place in the body text (e.g. material that is subsidiary to or separate from the body text, is included in support of statements in the body text, or describes methods of calculation, procedures or limits and conditions) may be presented in appendices or annexes.

An appendix, if included, is considered to form an integral part of the safety standard. Material in an appendix has the same status as the body text, and the IAEA assumes authorship of it. Annexes and footnotes to the main text, if included, are used to provide practical examples or additional information or explanation. Annexes and footnotes are not integral parts of the main text. Annex material published by the IAEA is not necessarily issued under its authorship; material under other authorship may be presented in annexes to the safety standards. Extraneous material presented in annexes is excerpted and adapted as necessary to be generally useful.

CONTENTS

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 types of radioactive material, such as naturally occurring radioactive material; radioactive 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, including for the actions of transport organizations[1] and competent authorities.

1.2. The fundamental requirements for radiation protection are stated in para. 301 of the Transport Regulations. Paragraph 302 of the Transport Regulations states:

> "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."

Paragraph 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]. Recommendations on meeting the requirements of GSR Part 3 [2] for public exposures are provided in IAEA Safety Standards Series No. GSG-8, Radiation Protection of the Public and the Environment [4].

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[1] In this Safety Guide, a 'transport organization' is a person or an organization associated with, and involved in, the transport of radioactive material that prepares, consigns, loads, carries (including storage in transit), ships after storage, unloads, receives or otherwise uses a package in connection with the transport of radioactive material.

OBJECTIVE

1.4. This Safety Guide provides recommendations on meeting the requirements established in para. 302 of the Transport Regulations for an RPP for the transport of radioactive material. The intended audience for the Safety Guide includes competent authorities, consignors, carriers, consignees and operators of ports (e.g. harbours, seaports, airports). This Safety Guide will also be of interest to the employees of public authorities (e.g. custom authorities, harbour authorities, port authorities, modal authorities) concerning activities associated with the transport of radioactive material that involve radiation exposure.

SCOPE

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

STRUCTURE

1.6. This Safety Guide consists of ten 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 to support the development 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 Edition) [6], states:

> "The objectives of the 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 radiation 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 should be to optimize radiation protection in the transport of radioactive material [2, 3].

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. Relevant national requirements should also be incorporated into the RPP.

2.4. The RPP may be documented in one or more documents (and may be either a separate programme or part of a facility's RPP; see para. 3.6) and should be included in the management system of the transport organization (see Section 10).

2.5. General requirements on leadership and management for safety, including establishing, sustaining and continually 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].

2.6. An RPP does not usually address arrangements for criticality safety. Recommendations on 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].

OVERVIEW OF ELEMENTS OF A RADIATION PROTECTION PROGRAMME FOR THE TRANSPORT OF RADIOACTIVE MATERIAL

2.7. 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 302.3–302.5 [of SSG-26 (Rev. 1) [6]]);
> (b) Roles and responsibilities for the implementation of the programme (see para. 302.6 [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 562.1–562.13 [of SSG-26 (Rev. 1) [6]]);
> (f) Emergency response arrangements (see paras 304 and 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)."

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

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

2.9. 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 from transport activities are likely to be less than 1 mSv in a year, initial confirmatory monitoring and repeat confirmatory monitoring at suitable periods should be considered.

2.10. Transport operations involving only a small number of shipments of packages of lower potential radiological hazard should have at least a basic programme for the assessment of occupational exposures, while more significant operations (e.g. transport operations involving diverse types of radioactive material and transport operations with the potential for significant exposures) should have a more comprehensive programme.

2.11. Transport operations that result in low occupational exposures or those organizations that only occasionally transport radioactive material still require an RPP, in accordance with para. 302 of the Transport Regulations.

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

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

(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 needed to meet the requirements of the Transport Regulations for radiation protection, including monitoring provisions. Requirement 24 of GSR Part 3 [2] requires the establishment of an RPP for occupational exposure. However, as stated in para. 3.52 of GSG-7 [3], "the radiation protection programme could include protection of both workers and the public". Consistent with para. 302 of the Transport Regulations, which requires that RPPs incorporate the requirements for, inter alia, limitation and optimization of doses to persons (para. 301 of the Transport Regulations), emergency response (paras 304 and 305 of the Transport Regulations) and segregation (para. 562 of the Transport Regulations), all of which may involve public exposure, the RPP for the transport of radioactive material should include the 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 or the environment. Such operations include the packing, preparation, loading, handling, storage in transit, carriage, intermodal transfer, delivery and unloading of packages of radioactive material, as well as the 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 of the shipment of radioactive material, for example for such transport operations as the selection of an 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, there will still be a need for radiation protection arrangements and their optimization at the various stages of transport operations.

3.5. Transport related operations that do not involve occupational exposure or public exposure (e.g. administrative work; design and manufacture of packaging; repair of packaging that does not involve any radiation 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 often 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, nuclear medicine departments in hospitals, and industrial facilities that use radioactive sources. Such facilities are required to have their own RPP that applies to their operations (see Requirement 24 of GSR Part 3 [2]), including the on-site movement of radioactive material. Transport operations associated with these facilities are often within the scope of the facility RPP, and in these cases the facility RPP should have provisions that address the transport activities that take place at the facility; however, in some cases, such transport operations may be covered by a transport specific RPP. See also paras 4.2–4.5.

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 IN RELATION TO RADIATION PROTECTION PROGRAMMES

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, the activities of each transport organization involved with a shipment of radioactive material (e.g. consignors; carriers; operators of harbours, seaports and airports; consignees) are required to be covered by an RPP. These activities should be specified under the scope of the RPP of the organization. It is the responsibility of the management of transport organizations directly involved in the radioactive material transport chain to establish and implement an RPP for their operations. It is unreasonable to assign the duty of establishing an additional RPP to a transport organization (e.g. the consignor) for a transport activity it has no direct control over (i.e. no staff are involved) and for which radiation protection provisions are applied by subsequent transport organizations (e.g. carriers).

4.3. Transport organizations should cooperate to fulfil the objectives of their RPPs. In more complex transport operations (e.g. a transboundary shipment of radioactive material by road, rail, air and sea), this may involve many independent carriers, where each party operates under its own management system (see Section 10), or several transport organizations that perform operations at the same site (e.g. port, airport) involving the same individuals, leading to an accumulation of doses to 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 that covers the carrier's operations. In such circumstances, the competent authority might not require the carrier to have a separate RPP solely for transport if the relevant consignor or consignee ensures that the radiation protection measures to be followed by the carrier are included in the consignor's or consignee's RPP. In the case of shipment under exclusive use of a conveyance or a large freight container (para. 221 of the Transport Regulations), the consignor or consignee, as appropriate, is responsible for ensuring that directions for loading, unloading and shipment 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 should also have its own RPP (i.e. for activities it conducts within the facility). The scope 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, carrier or consignee to evaluate the adequacy of the RPPs of its 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 are required to establish safety policies, management systems and organizational arrangements, and provide sufficient resources, to ensure that the objectives of the RPP can be achieved (see Requirements 3 and 6–9 of GSR Part 2 [7]). The management of each transport organization should also identify and document the objectives of the RPP.

4.8. The management system is required to reflect the management's commitment to radiation protection by means of written policy statements (see para. 4.16 of GSR Part 2 [7]) and by clear support for those with responsibility for radiation protection (see para. 3.3 of GSR Part 2 [7]). The organizational arrangements include specifying and documenting the roles and responsibilities of the individuals involved and the functions to be performed by them (see para. 4.16 of GSR Part 2 [7]).

4.9. 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 perform actions to ensure compliance with regulatory requirements and with managerial and operational procedures. The individuals responsible for managing the RPP and the measures specified in it should be clearly designated and should be given the necessary authority to implement the programme and those measures.

4.10. With regard to the RPP, para. 302 of the Transport Regulations states that "Programme documents shall be available, on request, for inspection by the relevant *competent authority*."

4.11. 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 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".

4.12. Some tasks associated with the development or implementation of an RPP may be performed by a qualified expert[2] 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.

RESPONSIBILITIES OF THE COMPETENT AUTHORITY IN RELATION TO RADIATION PROTECTION PROGRAMMES

4.13. 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 in para. 302 of the Transport Regulations, various activities should be implemented by the competent authority, for example establishment of regulations and guidance concerning RPPs; 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.

4.14. Recommendations on the development and maintenance of compliance assurance programmes are provided in IAEA Safety Standards Series No. SSG-78, Compliance Assurance for the Safe Transport of Radioactive Material [10]. Furthermore, guidance, procedures and checklists that may be used by a competent authority in relation to inspections of management systems, consignors, carriers and maintenance operations, including RPPs, are provided in annexes III–VII and IX to SSG-78 [10]. This information can be adapted and applied to other organizations involved in the transport of radioactive material.

4.15. 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).

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[2] 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, any relevant engineering or safety specialty) [2].

5. DOSE ASSESSMENT AND OPTIMIZATION OF PROTECTION 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:

(a) The radionuclides, the activity levels, the physical and chemical form of radioactive material, the package type and category being transported, and the dose rates around packages and in and around vehicles.
(b) The magnitude and likelihood of occupational exposures and public exposures arising from routine (incident free), normal (minor mishaps) and accident conditions of transport, taking into account the following: use of overpacks or freight containers; ad hoc stops, parking and delays due to traffic conditions during land transport; the necessity of storage in transit; the use of different modes of transport or conveyances and stowage within the conveyance; and specific handling procedures (e.g. for small packages or packages that are handled remotely). If applicable, this may also include consideration of potential exposures arising from failures to correctly assemble and use packages.
(c) The number of workers involved and their activities that might involve exposure to radiation.
(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 implemented to optimize radiation protection.

RADIATION MONITORING IN THE TRANSPORT OF RADIOACTIVE MATERIAL

5.4. A programme of radiation monitoring 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 can 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. All transport organizations, including consignors, carriers and consignees, have some responsibilities for workplace, package and individual monitoring, depending on the radiological characteristics of the transport operations they undertake.

Workplace monitoring and package monitoring

5.6. Workplace monitoring comprises measurements made in the working environment as appropriate to the transport organization 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 the 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, carriage, storage in transit, intermodal transfer, delivery, unloading and inspection of packages of radioactive material, and the maintenance of packaging for 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. 2.9, 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 first be determined on the basis of the prior radiological evaluation and should be specified in the RPP, then updated if necessary to take into account actual results of workplace monitoring. The RPP should include a procedure for assigning doses to workers based on the results of workplace monitoring.

5.9. Routine monitoring 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 should 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 should 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. 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 personal dosimeters for external exposure or personal air samplers for the rare cases in which internal exposure is assessed (e.g. during the packing, preparation, loading and unloading of consignments containing naturally occurring radioactive material associated with mining and processing; during emergency situations involving potential airborne activity). 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. 2.9, 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. Individual monitoring should be used for the assessment of occupational doses in this range, unless impracticable. Individual monitoring is required to be undertaken where occupational exposures are likely to exceed 6 mSv in a year (see para. 303(b) of the Transport Regulations).

5.13. Personal dosimeters used for individual monitoring should be suitable for the types of radiation encountered (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 take into account the radiation fields that are present (e.g. consideration should be given to the placement of dosimeters on drivers of vehicles to ensure the reliable assessment of individual exposure from radiation emitted from radioactive material behind them). The complementary use of direct-reading or audible alarming personal dosimeters should be considered in situations in which external exposures above specified levels might 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. Internal exposures can be assessed through methods such as measurements of radionuclides in the whole body, measurements of radionuclides in biological samples or measurements of activity concentrations in air samples collected using personal air samplers worn by the worker. 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:

> "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 use 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/or 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 (e.g. as outlined in paras 5.19–5.26) 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 the

TABLE 1. DOSE RATES AND TRANSPORT INDICES FOR PACKAGES

Type of package or category	Maximum surface dose rate (mSv/h)	Transport index
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[a]	More than 2 but not more than 10	More than 10

[a] Under exclusive use, these limits apply if the requirements of para. 573 of the Transport Regulations are met.

prior radiological evaluation, which is performed before the results of workplace monitoring or individual monitoring are available.

5.19. Paragraph 302.5 of SSG-26 (Rev. 1) [6] states that “The external dose rates from excepted packages and category I-WHITE label packages are sufficiently low as to be safe to handle without restriction, and a dose assessment is therefore unnecessary.” For other packages, 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 values relating to dose rate and transport index (TI) specified in the Transport Regulations for different package types and categories, which apply also to overpacks and freight containers, are shown in Table 1.

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 results of assessments of doses to workers and to members of the public from the transport of radioactive material by specific modes of transport, for example Refs [11–14].

(b) The results of a coordinated research project that included the assessment of doses to workers and to members of the public from the transport of naturally occurring radioactive material are documented in Ref. [15].
(c) An assessment of the doses to workers and to members of the public from the transport of radioactive waste from a ^{99}Mo production facility is documented in Ref. [16].
(d) An assessment of the doses to workers and to members of the public from 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 relating to the transport of spent nuclear fuel is provided in Ref. [18]. Information about dose assessments for workers involved in the transport of spent nuclear fuel and high level waste by rail is provided in Ref. [19].
(f) Data on doses to workers from the transport and handling of large numbers of packages for medical use and for industrial use are provided in Ref. [20].

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 representative for and applicable within the scope of any particular RPP.

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

5.21. The sum of the TIs for the packages handled by workers undertaking specific transport operations may be used as a general indicator of external exposures, for example as follows:

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

5.22. Information from several studies has indicated a general correlation between the sum of the TIs for the packages handled and occupational exposure, with higher 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

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

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

[a] Forty packages with an average dose rate of 0.25 mSv/h at contact and transport index = 1.
[b] Six packages with an average dose rate of 1.25 mSv/h at contact and transport index = 10.

to establish a screening level, in terms of the sum of the TIs for the packages handled, below which workplace monitoring or individual monitoring would not be necessary. When the characteristics of the transport operations change in a way that might result in an increase in occupational exposure, the screening level should be reassessed.

5.23. By taking into account the dose rate limits of the different package categories (see Table 1), it is possible to calculate the number of packages that could be transported under normal conditions of transport 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 could 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, except as specified in footnotes a and b in Table 2 for the surface dose rate.

5.24. In using the results in Table 2, allowance should be made for the occurrence of unforeseen events in which the dose received is more than expected based on the scenarios stated in Table 2 (e.g. longer exposure time, shorter distance).

In such a case, the exposure received should be evaluated to determine whether continued use of the numbers in Table 2 is appropriate.

5.25. The external dose rates from excepted packages are so low that occupational exposures are not expected to exceed 1 mSv in a year under routine conditions of transport.

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

5.26. In some cases, occupational exposures and public exposures can be estimated using computer codes such as RADTRAN [22], Intertran [23], RISKIND [24], MicroShield [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

5.27. 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 schedule III of GSR Part 3 [2].

5.28. 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].

5.29. 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.

5.30. Efforts by transport organizations to optimize protection may involve various measures 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 high TIs;
(e) Restrictions on access to areas with high dose rates;
(f) Implementation of work schedules designed to optimize occupational exposures;
(g) Use of equipment for movement and lifting of packages to reduce exposure time and/or increase distance between workers and packages;
(h) Implementation of driving and routing restrictions (depending on the road conditions and the weather).

5.31. 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."

5.32. 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 for workers are required to be established and used by transport organizations (see para. 3.25 of GSR Part 3 [2]). Dose constraints for public exposure are established or approved by the competent authority. In setting dose constraints for public exposure, 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 and conditions (i.e. that bound operational parameters) intended to contribute to the control of radiation exposure should not be confused with dose constraints.

5.33. 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. Any doses, dose rates or levels of surface or airborne 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^2 for beta and gamma emitters and *low toxicity alpha emitters*;
> (b) 0.4 Bq/cm^2 for all other alpha emitters.
>
> These limits are applicable when averaged over any area of 300 cm^2 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 protective measures.

6.3. Packages 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 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 workers 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 can provide 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 arrangements and criteria for controlling (fixed and non-fixed) surface contamination 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, are 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 the arrangements for the segregation of packages from persons and other protective measures should be included in the RPP. Recommendations on the segregation of packages, the restriction of exposure times, the use of shielding and the concept of controlled and supervised areas are provided in the following paragraphs.

SEGREGATION MEASURES IN THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT

7.2. The Transport Regulations establish requirements for the segregation of packages that include the 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. 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*."

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

7.5. Segregation distances that correspond to the total TI of a consignment have historically been presented in segregation tables developed for different modes of transport (see appendix III to SSG-26 (Rev. 1) [6] and Annex VIII to this Safety Guide). Assessments of exposures during air transport [13, 14] and sea transport [12] have shown that the use of such segregation tables has resulted in public exposures well below dose limits and doses to workers not involved in direct handling that are below 1 mSv in a year. However, the use of segregation distances does not in itself ensure that protection is optimized (see paras 5.28–5.33).

7.6. With regard to the incorporation of segregation measures into an RPP, consideration should also be given to segregation from undeveloped photographic film and other dangerous goods (see para. 562(c) and (d) of the Transport Regulations). If applicable, requirements for the spacing of packages containing fissile material from one another (see paras 568 and 569 of the Transport Regulations) should also be taken into account (see also para. I–22 of Annex I to this Safety Guide).

RESTRICTION OF 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 exposure. Examples of adjustments to work processes are as follows:

(a) Preparing transport documents in a low dose rate area instead of near the package(s);
(b) Performing dose rate measurements at the package surface and at 1 m from the surface of the package 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 (see paras 7.2–7.6) 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-radiation-related aspects of transport safety.

CONTROLLED AND SUPERVISED AREAS IN THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT

7.10. A controlled area is defined in GSR Part 3 [2] as "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." A supervised area is defined in GSR Part 3 [2] as "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." 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 considered as such by applying measures similar to those that are applicable in a controlled area or in a supervised area. 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. If a stop occurs at an authorized facility (e.g. at a nuclear facility), the applicable requirements of that facility should be observed.

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) and 573(c) [of the Transport Regulations]."

7.13. The RPP may specify a maximum dose rate for the driver's compartment that is based on an estimated amount of time that the driver will be present. The RPP should also take into account any relevant national requirements (e.g. in some States, a maximum dose rate for the driver's compartment of 20 μSv/h has been stipulated).

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 the importance of advance planning and preparation to provide a sufficient and safe response to any such emergencies. For this purpose, it is necessary that all transport organizations and relevant national or international organizations establish appropriate emergency plans and procedures relevant to their own activities and responsibilities and that these plans and procedures are followed in the event of an emergency involving the transport of radioactive material. Thus, a description of applicable arrangements and instructions concerning emergency preparedness and response should be included in the RPP.

8.2. Requirements for an adequate level of preparedness and response for a nuclear or radiological emergency[3], including an emergency involving the

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

transport of radioactive material (emergency preparedness category IV), 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. SSG-65, Preparedness and Response for a Nuclear or Radiological Emergency Involving the Transport of Radioactive Material [31], states:

> "Packages used for the 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 transport have limited radiological consequences and can be resolved in a relatively short period. The emergency response may last only hours or days. However, this Safety Guide considers a wide range of possible emergencies, including those associated with very low probability events that might have significant radiological consequences."

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 and 305 of the Transport Regulations. Paragraph 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 SSG-65 [31].

EMERGENCY PREPAREDNESS AS PART OF THE RADIATION PROTECTION PROGRAMME FOR TRANSPORT

8.7. Paragraph 3.1 of GSR Part 7 [30] states:

> "The goal of emergency preparedness is to ensure that an adequate capability is in place within the operating organization and at local, regional and national levels and, where appropriate, at the international level, for an effective response in a nuclear or radiological emergency. 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 SSG-65 [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 that those arrangements follow the national emergency arrangements of all the States relevant to the shipment. Some aspects of this responsibility may be assigned to the carrier."

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

> "The appropriate responsible authorities shall ensure that:
>
> (a) A 'concept of operations'[37] for emergency response is developed at the beginning of the preparedness stage.
> (b) Emergency plans and procedures are prepared and, as appropriate, approved for any facility or activity, area or location that could give rise to an emergency warranting protective actions and other response actions.
>
> "[37] 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. Emergency workers may include first responders, radiological assessors[4], 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]. Recommendations and guidance on the protection of emergency

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[4] 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].

workers and helpers are provided in IAEA Safety Standards Series No. GSG-2, Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency [32], and recommendations specific to emergency workers relevant to the transport of radioactive material are provided in SSG-65 [31].

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

9.1. The successful application of the Transport Regulations can only be achieved by properly planned and implemented initial training and periodic retraining programmes for all individuals involved in the transport of radioactive material. These training programmes should be described in the RPP.

9.2. In accordance with para. 302 of the Transport Regulations, the RPP is required to meet 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 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. As stated in 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 expected 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 their job functions and work environment. A graded approach should be applied, in which the amount, type, level of detail and frequency of training is commensurate with the nature of the hazards and the type and complexity of the workers’ 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; therefore, the RPP, including its development and implementation, is part of the management system. All elements of a management system apply to 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-assessments and independent assessments, processes for identifying non-conformances, and corrective and preventive actions.

10.2. Requirements for establishing, applying and continuously improving a management system are established in GSR Part 2 [7], and associated recommendations are provided in IAEA Safety Standards Series No. GS-G-3.1, Application of the Management System for Facilities and Activities [33]. Recommendations specific to management systems for the transport of radioactive material are provided in TS-G-1.4 [8], and further recommendations are provided in paras 306.1–306.5 of SSG-26 (Rev. 1) [6].

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Annex I

GENERIC EXAMPLE OF A RADIATION PROTECTION PROGRAMME FOR THE TRANSPORT OF RADIOACTIVE MATERIAL

I–1. This annex presents an example outline of the contents of a generic radiation protection programme (RPP). For each element, information and example text is provided that could be used in developing a specific RPP.

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 storage in transit 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 is managed by [Name of individual], who is a suitably qualified person.
>
> [Name of individual] will ensure that all 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 role of the dispatch staff is to prepare packages for transport, including the following tasks:

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

The following members of the dispatch staff have responsibility for the tasks indicated above:

[Names of the responsible individuals] …………………

…………………’

DOSE ASSESSMENT AND OPTIMIZATION OF PROTECTION

I–4. A prior radiological evaluation (see paras 5.1–5.3) is necessary to determine the level of individual exposure (including potential exposures) and to determine the monitoring programme. Worked examples are given below. The prior radiological evaluation needs to be made on the basis of the following:

(a) The number and type of packages;
(b) The category and the transport index (TI) of packages;
(c) The radionuclides being shipped;
(d) The frequency of shipment;
(e) The duration of storage and transport;
(f) The tasks performed by the individual that involve radiation exposure.

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

Example 1

I–6. A company will transport approximately three category III-YELLOW packages per week with an average TI of 3 per package. The weekly number of packages transported 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 package handler who loads the vehicle are separate.

Exposure of the package handler

I–7. Footnote b to Table 2, 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 if the same handling scenario as specified in the third column of Table 2 is assumed. In this example, the expected number of packages to be shipped is more than seven times that amount (150 packages), and therefore dose assessment by individual monitoring will be conducted for the package handler.

Exposure of the driver

I–8. The driver is expected to make one 4 hour journey each week to take the three packages to the consignee, giving an annual driving time of about 200 hours. 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 each with a TI of 3, with 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 hours, the driver is therefore expected to receive a dose of 2 mSv annually, and an assessment of individual dose by either individual monitoring or workplace monitoring is needed. The former would be easier to implement than workplace monitoring, because of the expected variability in exposure conditions.

Example 2

I–9. A driver will transport an industrial gauge to the company's sites for use by technicians at those sites. All loading and unloading operations are performed by technicians. The annual driving time is expected to be about 200 hours. 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, with the application of the inverse square law for a distance of 2 m, is approximately:

$$1/22\ \mu Sv/h \approx 0.25\ \mu Sv/h$$

I–10. The driver's annual dose is therefore expected to be about 0.05 mSv, and no dose assessment programme will be necessary. However, individual monitoring will be conducted for a limited period to confirm this assessment.

Example 3

I–11. Packages are stored in a storeroom with 40 cm thick concrete walls that is 10 m from the office. The packages are stored for a maximum of 1 hour per day, and the maximum cumulative TI in the storage area is limited to 10. With these limits placed on the storage of packages and without considering the effect of shielding by the walls, the dose rate at 10 m would be 1 μSv/h, giving an annual dose of 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 negligible. Furthermore, the office walls provide some extra shielding, and the average TI of the packages stored will not normally be at the maximum; this will therefore be an upper estimate of the doses received by the office workers.

Optimization of radiation protection

I–12. 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:

> 'During transport and storage in transit, 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.'

> ‘Further measures to optimize radiation protection are given in the following sections.’

SURFACE CONTAMINATION

I–13. This section may include, for example:

> ‘The radioactive material to be transported is either classified as special form or as non-special form, carried in intact packages. Situations may arise involving damage to packages, and in these situations the person responsible for managing the radiation protection programme 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 in accordance with the documented, specific instructions of the organization. Periodic checks for contamination are made of the work area and conveyances.’

I–14. Other conditions may be specified, depending on the organization’s procedures, for example with one of the following examples, or a combination of them:

> ‘When necessary, the company’s qualified expert 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 in accordance with the management system.’

SEGREGATION AND OTHER PROTECTIVE MEASURES

I–15. The need for package segregation and other protective measures will depend on the dose rates or the TI of the package and the type of operations performed. 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 and tie-down could be used.

These instructions or procedures would be issued under the responsibility of a qualified person.

I–16. 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 storeroom when not in use. During transport, the container is to be placed in the rear of the goods compartment of the vehicle.’

I–17. Package segregation is usually needed for operations involving the transport and storage in transit of large numbers of packages containing medical radioisotopes, especially ^{99}Mo/^{99m}Tc or ^{81}Rb/^{81m}Kr generators or ^{131}I.

I–18. A number of factors need to be taken into account in determining the segregation of packages from occupied working 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 storage in transit 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 hour per day, and the maximum cumulative TI in the storage area is limited to 10.’

I–19. Another situation in which segregation from package handling operations is appropriate is the receipt and dispatch of medical radioisotopes at an air cargo shed; for example, a consignment of packages containing medical radioisotopes 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 in accordance with 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 onto a cargo aircraft. The cargo handling staff who perform 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 μSv/h. Occupancy at that distance for 15 minutes would give a dose of 5 μSv 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–20. Consideration also has to be given to other methods of dose reduction; for example, for road transport:

> ‘Where possible, all packages, especially packages with a high transport index, are to be placed at the rear of the goods compartment. Shielding of about 3 mm of lead is to be provided in the vehicle behind the driver’s cabin.’

This will reduce the exposure of the driver. In addition, the RPP may specify a maximum dose rate for the driver’s cabin, although this is not a requirement of IAEA Safety Standards Series No. SSR-6 (Rev. 1), Regulations for the Safe Transport of Radioactive Material, 2018 Edition [I–1] (‘the Transport Regulations’).

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

> ‘Packages with a high transport index are to be kept in the storeroom for as long as practicable and will 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), and such arrangements include the provision of instructions 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 need to be reflected in the RPP.

I–24. 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 (e.g. firefighting service, emergency medical service, response forces) as appropriate;
(d) Contact a qualified expert in radiation protection and request advice;
(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 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 (see point (e) in the example in para. I–24), appropriate actions will be taken by the office, for example as follows:

‘The responsible person will inform the consignor and/or consignee and the competent authority of the accident.’

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

‘The responsible person, as designated under para. I.3, will arrange, with the consignor and competent authority, for recovery of any damaged packages, for decontamination, and for disposal of any waste or debris.’

I–27. In practice, more specific details would normally be included, for example details of names, 24 hour 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. More guidance on and examples of such specific emergency response actions and procedures are provided in IAEA Safety Standards Series No. SSG-65, Preparedness and Response for a Nuclear or Radiological Emergency Involving the Transport of Radioactive Material [I–2].

TRAINING

I–28. The training of the relevant workers needs to be specified, and a graded approach is necessary to cover the range of tasks involved. Normally, there will be tasks at a managerial or 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 perform the following duties:
>
> (a) Completion of transport documents;
> (b) Preparation of packages;
> (c) Measurement of dose rates and contamination, and determination of the transport index;
> (d) Completion and application of package labels;
> (e) Loading of packages onto the vehicle;
> (f) [Further tasks as appropriate].’

The RPP can include a statement on the revalidation of certificates in accordance with the requirements of the competent authority and the policies of the transport organization.

MANAGEMENT SYSTEM FOR THE TRANSPORT OF RADIOACTIVE MATERIAL

I–30. The RPP and associated procedures are part of the transport organization's management system and are subject to management system processes, such as those for document and version control, document review, issuance and review of instructions and procedures, and follow-up of non-conformances. The RPP will be approved by a suitable person within the transport organization, and, if required by national legislation, by the competent authority. Thus, this section of the RPP could state, for example:

> 'The RPP, as described in this document, is approved.
>
> Signature……………….. Date: ………………..
>
> (Name and designation)'

REFERENCES 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), IAEA, Vienna (2018).

[I–2] INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL CIVIL AVIATION ORGANIZATION, INTERNATIONAL MARITIME ORGANIZATION, Preparedness and Response for a Nuclear or Radiological Emergency Involving the Transport of Radioactive Material, IAEA Safety Standards Series No. SSG-65, IAEA, Vienna (2022).

Annex II

EXAMPLE OF A RADIATION PROTECTION PROGRAMME FOR THE TRANSPORT OF MEDICAL RADIOISOTOPES

SCOPE

II–1. This radiation protection programme (RPP) covers the preparation, storage and transport of packages containing medical radioisotopes, including radioactive iodine and technetium generators. ABC Radiopharmaceuticals typically supplies 50 000 packages per year to users all over the world. The packages used are, other than a few excepted packages, all Type A. About 10% of the packages are category III-YELLOW, 30% are category II-YELLOW, 55% are category I-WHITE and 5% are excepted packages. The maximum transport index (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 delivery vans to transport the packages to end users and air cargo carriers.

ROLES AND RESPONSIBILITIES

II–2. The RPP is managed by [Name of individual], who is a suitably qualified person. [Name of individual] will ensure that all 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–3. The role of the dispatch staff is to prepare packages for transport, including the following tasks:

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

II–4. The role of the drivers of the delivery vans is to deliver packages, including the following tasks:

(a) Obtain information about:
    (i) Emergency procedures;
    (ii) Conditions for storage, loading and securing of the packages onto the conveyance;
    (iii) Placarding of the conveyance;
    (iv) Measurements of dose rates around the loaded conveyance.
(b) Deliver packages, including driving the vans and dropping off packages.
(c) Implement emergency procedures, if appropriate.

DOSE ASSESSMENT AND OPTIMIZATION OF PROTECTION

II–5. ABC Radiopharmaceuticals used the services of a qualified expert in radiation protection to evaluate the possible levels of individual exposure and to determine the monitoring programme. This evaluation was made on the basis of:

(a) The number and type of packages handled and transported;
(b) The categories of package and the TIs;
(c) The radionuclides in the packages;
(d) The frequency of shipment;
(e) The duration of storage prior to transport.

II–6. The study (document No. RRR) showed that the maximum radiation dose a member of the dispatch staff would receive would be about 3 mSv in a year at the present workload, while the estimated annual dose for a driver was 2 mSv. Workplace monitoring and individual monitoring will be conducted as determined by the qualified expert. Dose records will be maintained.

II–7. The dose rate monitors and surface contamination monitors recommended by the qualified expert have been procured and are available to ABC Radiopharmaceuticals for regular use. These monitors are calibrated as recommended by the qualified expert. Packages, conveyances and the workplace are monitored by [Name of individual] to verify the continued validity of the results of the initial evaluation.

II–8. 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 within 5 m of packages, and implementing job rotation among dispatch workers where there is the potential for high levels of radiation exposure and no other practicable means for controlling exposure is available;
(c) Keeping the packages in the shielded bays in the storeroom until as late as possible before loading;
(d) Using a trolley to take the packages from the storeroom to the loading area.

SURFACE CONTAMINATION

II–9. The radioactive material to be transported is not special form and is carried in appropriate packages in good condition. If damage to packages is suspected, checks for surface contamination will be made by [Name of individual] by taking swabs of the package surface and surrounding areas and by using the contamination monitors available to ABC Radiopharmaceuticals, as appropriate. Periodic (frequency based on a graded approach) checks for contamination are made of the work area and in the delivery vans. The vans that are used for the transport of radioactive material are also 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–10. 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 hour per day, and the maximum total TI in the storeroom is limited to 20.

II–11. 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 and the shielding provided by the storeroom walls, the doses received by the office workers are expected to be negligible.

II–12. Where possible, all packages, especially packages with high TIs, are placed at the rear of the goods compartment when loading the packages onto the vehicle. This will minimize the exposure of the drivers.

II–13. The packages with high TIs 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 dispatch workers. Lead shielding of 3 mm thickness is provided behind the drivers' cabins of the delivery vans.

EMERGENCY RESPONSE

II–14. In the event of an incident (e.g. falling, crushing, fire) during storage or loading of a radioactive consignment onto the vehicle, [Name of individual] will take the following actions:

(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 (e.g. firefighting service, emergency medical service, response forces) as appropriate;
(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) 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;
(i) Inform the competent authority of the incident, in accordance with the applicable rules established by the competent authority.

II–15. These instructions are displayed prominently in the storage bay, the vehicle loading area and the vehicles so that, in the absence of [Name of individual], any other responsible person would be able to take these actions.

II–16. Emergency contact details are as follows:

(a) Person responsible for this RPP ([Name of individual]): ………………..
(b) Qualified expert in radiation protection: ………………..
(c) Other contacts: ………………..

TRAINING

II–17. The persons listed below, being employees of ABC Radiopharmaceuticals engaged in the preparation and transport of packages containing medical radioisotopes, have received training commensurate with their duties:

(a) [Name of individual]…………………… (dispatch staff/driver)
(b) [Name of individual]…………………… (dispatch staff/driver)
(c) [Name of individual]…………………… (dispatch staff/driver)

II–18. The training they have received fulfils the applicable requirements of the competent authority and the policies of ABC Radiopharmaceuticals. These individuals will be subject to retraining every three years or at an interval specified by the competent authority.

MANAGEMENT SYSTEM FOR PROCEDURES AND PRACTICES

II–19. The RPP and associated procedures are part of ABC Radiopharmaceuticals' management system and are subject to management system processes, such as document and version control, document review, issuing and review of instructions and procedures, and follow-up of non-conformances.

II–20. 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

SCOPE

III–1. This radiation protection programme (RPP) covers the acceptance, storage in transit, handling and transport of packages containing radioactive material carried on aircraft operated by XYZ Airlines (an air cargo carrier) that depart from or arrive at ABC Airport[1]. XYZ Airlines carries approximately 5000 packages containing Class 7 goods per year from ABC Airport to consignees (users) all over the world. All types of package are carried (i.e. excepted packages, Type A and Type B(U)/(M) packages). About 10% of the packages are category III-YELLOW, 30% are category II-YELLOW, 55% are category I-WHITE and 5% are excepted packages. The maximum transport index (TI) encountered is 3.0, and these packages are a small fraction of those of category III-YELLOW.

ROLES AND RESPONSIBILITIES

III–2. The RPP is managed by [Name of individual], who is a suitably qualified person. [Name of individual] will ensure that all the elements of the RPP are implemented, including:

(a) Training of workers and implementation of proper work procedures;
(b) Assessment of worker exposures by workplace monitoring;
(c) Emergency procedures.

III–3. Packages containing radioactive material are delivered to or collected from the airport cargo terminal of XYZ Airlines by road carriers. The role of the acceptance staff is, for each package or shipment, to verify the following

[1] This annex provides an example in which employees of XYZ Airlines perform all these activities. In cases where an airline operator contracts with a ground service provider to perform some or all these activities, the ground service provider is responsible for developing, implementing and maintaining its own RPP. In this case, XYZ Airlines will audit the applicable ground service provider to verify that the RPP has been implemented.

for compliance with the applicable International Civil Aviation Organization (ICAO)/International Air Transport Association (IATA) requirements:

(a) Transport documents;
(b) Labelling and marking of the packages or overpacks;
(c) Emergency procedures appropriate for the package or shipment.

III–4. The role of the cargo handler is to handle and move packages, including the following tasks:

(a) Load/unload packages onto/from unit load devices[2] and/or barrows that are transported to/from the aircraft. All packages are loaded onto the floor of the unit load device and onto the floor of the barrow in accordance with ICAO/IATA requirements for segregation and securing of packages.
(b) Drive the unit load devices and/or barrows within the warehouse or storage area and to/from the aircraft.
(c) Load/unload packages and unit load devices into/from the aircraft cargo compartment in accordance with the load plan.
(d) Implement emergency procedures, as appropriate.

DOSE ASSESSMENT AND OPTIMIZATION OF PROTECTION

III–5. XYZ Airlines employed the services of a qualified expert in radiation protection 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 handled;
(b) The categories of package and the TIs;
(c) The radionuclides in the packages;
(d) The frequency of shipment;
(e) The length of time that packages are stored prior to or following air transport.

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[2] A unit load device is any type of freight container, aircraft container, aircraft pallet with a net, or aircraft pallet with a net over an 'igloo' that is used to load freight onto an aircraft. An igloo is a contoured shell attached to an aircraft pallet to facilitate loading and provide protection for its contents but with the addition of a pallet net to provide restraint capability. A 'freight container', as defined in para. 223 of IAEA Safety Standards Series No. SSR-6 (Rev. 1), Regulations for the Safe Transport of Radioactive Material, 2018 Edition [III–1], is not a unit load device.

III–6. The study (document No. RRR) showed that the maximum radiation dose any individual employee of XYZ Airlines would receive is less than 1 mSv in a year at the present workload. The qualified expert advised that a dose assessment programme (using individual monitoring or workplace monitoring) was not necessary. However, dose rate monitors have been recommended by the qualified expert for routine verification of dose rates. These monitors have been procured and are available to XYZ Airlines for regular use. These monitors are calibrated as recommended by the qualified expert. Packages and the workplace are monitored by [Name of individual] to verify the continued validity of the results of the initial evaluation.

III–7. Occupational exposures are kept as low as reasonably achievable by the following means:

(a) For packages that have not been loaded into a unit load device, using a trolley to move them between various locations (e.g. from the airport cargo acceptance area to the storage area; from the storage area to the loading area; from the loading area to the aircraft);
(b) Keeping the packages in the storage room in a shielded bay, if available, until it is necessary to handle the packages;
(c) Prior to loading packages containing radioactive material into unit load devices, ensuring that the necessary equipment, such as shoring material and tie-down straps, are positioned at the unit load device before the packages are brought from the storage area;
(d) Increasing segregation distances beyond the minimum ICAO/IATA requirements, where possible;
(e) Minimizing the presence of workers within 5 m of the packages;
(f) When carts and dollies carrying unit load devices are coupled together in series and transported, ensuring that unit load devices containing packages of radioactive material are put in the position farthest away from the driver;
(g) When practicable, loading packages and/or unit load devices containing radioactive material into the aircraft cargo compartment last and unloading them first.

Further measures to optimize radiation protection are given in the following sections.

SURFACE CONTAMINATION

III–8. The radioactive material to be transported is carried in appropriate packages in good condition. If packages are suspected of being damaged, the appropriate emergency specialist agency will be contacted. The area around the damaged package will be cordoned off to a distance appropriate for the type of package and its contents. The package will be assessed by the appropriate agency and handled in accordance with applicable procedures. Areas that may have been contaminated by the package will be surveyed to ensure that no contamination is present, and if contamination is present, they will be decontaminated.

III–9. XYZ Airlines' [operations or other appropriate] manual describes the actions to be taken in the event of possible contamination of the aircraft cargo compartment due to a damaged package. A qualified person will, as soon as possible, assess the extent of contamination and the dose rates. The scope of the survey will also include any areas that may have been contaminated, for example the aircraft, aircraft equipment, the adjacent loading and unloading areas and, if necessary, all other material that has been carried on the aircraft. The aircraft will remain out of service until it has been determined that the non-fixed contamination does not exceed:

(a) 4 Bq/cm^2 in the case of beta and gamma emitters and low toxicity alpha emitters;
(b) 0.4 Bq/cm^2 for all other alpha emitters.

SEGREGATION AND OTHER PROTECTIVE MEASURES

III–10. Packages are stored in the cargo terminal in a holding area that is 20 m from the airport cargo office. Packages, including those loaded onto unit load devices, may be stored in the holding area for a maximum of 72 hours prior to being transported to the aircraft for loading. The maximum anticipated sum of TIs from the packages present in the holding area is 10.

III–11. 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 and the distance between the office and the holding area, the doses received by the office workers are expected to be negligible.

III–12. All persons on board the aircraft, including flight crew and cabin crew, are considered to be members of the public and as such are not expected to receive an annual dose of greater than 1 mSv.

III–13. The location of packages in the cargo compartment is based on the applicable segregation tables in the ICAO Technical Instructions for the Safe Transport of Dangerous Goods by Air (ICAO-TI) (tables 7-3 and 7-4) [III–2] and the IATA Dangerous Goods Regulations (tables 10.9.C and 10.9.D) [III–3]. The loading location of packages to be carried by an aircraft is determined by XYZ Airlines and is specified in writing and provided to the pilot in command; compliance with the loading location is verified and confirmed by the person responsible for loading the aircraft.

EMERGENCY RESPONSE

III–14. In the event of an incident or accident that affects a package containing radioactive material at ABC Airport, XYZ Airlines will immediately advise the airport rescue firefighting service and the appropriate emergency specialist agency. The area around the package will be cordoned off to a distance appropriate for the type of package and its TI until the package has been assessed by the appropriate agency and either it has been determined that there has been no release of radioactivity or the area has been decontaminated.

III–15. In the event of:

(a) An aircraft accident or serious incident, where the flight is carrying radioactive material, XYZ Airlines will provide information, without delay, to emergency services responding to the accident or serious incident about the radioactive material on board, as shown in the information to the pilot in command. As soon as possible, XYZ Airlines will also provide this information to the appropriate authorities of the State where the principal place of business of XYZ Airlines is located and the State in which the accident or serious incident has occurred.

(b) An aircraft accident or serious incident involving an aircraft carrying radioactive material, XYZ Airlines will activate the company emergency response plan, which includes instructions on the following:
   (i) Support of the activities of the ABC Airport emergency response plan;
   (ii) Provision of information relating to the flight by the incident commander.

III–16. These instructions are contained in the XYZ Airlines emergency response plan, displayed prominently in the storage bay and the areas where packages are delivered and picked up in connection with ground transport so that the responsible member of the management of XYZ Airlines is able to implement these measures.

III–17. Emergency contact details are as follows:

(a) Person responsible for this RPP ([Name of individual]): ………………..
(b) Qualified expert in radiation protection: ………………..
(c) Other contacts: ………………..

TRAINING

III–18. The persons listed below, being employees of XYZ Airlines engaged in the handling of packages containing radioactive material for transport, have received training commensurate with their duties:

(a) [Name of individual]……………… (acceptance staff/cargo handler)
(b) [Name of individual]……………… (acceptance staff/cargo handler)
(c) [Name of individual]……………… (acceptance staff/cargo handler)

III–19. The training they have received fulfils the applicable requirements of the competent authority and of the ICAO/IATA regulations and the policies of XYZ Airlines. These individuals will be subject to retraining every two years.

MANAGEMENT SYSTEM FOR PROCEDURES AND PRACTICES

III–20. The RPP and associated procedures are part of XYZ Airlines' management system and are subject to management system processes, such as document and version control, document review, issuing and review of instructions and procedures, and follow-up of non-conformances.

III–21. The RPP, as described in this document, is approved.

Signature: ……………….. Date: ………………..

(Name and designation)

REFERENCES TO ANNEX III

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

[III–2] INTERNATIONAL CIVIL AVIATION ORGANIZATION, Technical Instructions for the Safe Transport of Dangerous Goods by Air: 2023–2024 Edition, ICAO, Montreal (2022).

[III–3] INTERNATIONAL AIR TRANSPORT ASSOCIATION, Dangerous Goods Regulations, IATA, Montreal (2022).

Annex IV

EXAMPLE OF A RADIATION PROTECTION PROGRAMME FOR THE TRANSPORT OF RADIOACTIVE MATERIAL BY AN INDUSTRIAL RADIOGRAPHY COMPANY

SCOPE

IV–1. This radiation protection programme (RPP) covers the transport and storage in transit of gamma radiography sources in their shielded devices. LMN Industrial Gamma Radiographers transports these gamma radiography devices on most working days. The packages used are all Type A or Type B(U), and almost all are category II-YELLOW. The maximum transport index (TI) encountered is 1.0. LMN Industrial Gamma Radiographers has a van that transports the packages to and from radiography sites.

ROLES AND RESPONSIBILITIES

IV–2. The RPP is managed by [Name of individual], who is a suitably qualified person. [Name of individual] will ensure that all the elements of the RPP are implemented, including:

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

IV–3. The role of the radiographer is to prepare packages (i.e. radiography devices containing sealed sources) for transport and to transport these packages, including the following tasks:

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

IV–4. The radiographer is also the driver of the vehicle and performs the following tasks:

(a) Obtain information about actions to be taken in the event of an emergency, and implement these actions, if appropriate;
(b) Obtain information about dose rates around the loaded vehicle;
(c) Placard the vehicle.

DOSE ASSESSMENT AND OPTIMIZATION OF PROTECTION

IV–5. LMN Industrial Gamma Radiographers deployed the services of a qualified expert in radiation protection 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 handled;
(b) The category of packages and the TIs;
(c) The radionuclides in the packages;
(d) The frequency of shipment;
(e) The duration of storage prior to transport.

IV–6. The study (document No. RRR) showed that the individual radiation dose the radiographer would receive from transport activities and radiographic operations would be likely to exceed 6 mSv in a year at the present workload. Dose assessment by individual monitoring will be conducted as determined by the qualified expert. Dose records will be maintained.

IV–7. The dose rate monitors and individual dosimeters recommended by the qualified expert are available. The dose rate monitors are calibrated as recommended by the qualified expert. The radiography devices, the van and the workplace are monitored by [Name of individual] to verify the continued validity of the results of the initial evaluation.

IV–8. Occupational exposures are kept as low as reasonably achievable by the following means:

(a) Using a trolley to take the radiography devices from the storeroom to the loading area;
(b) Keeping radiography devices 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 within 5 m of the packages.

Further measures to optimize radiation protection are given in the following sections.

SURFACE CONTAMINATION

IV–9. The radioactive material to be transported is special form and carried in appropriate packages in good condition. If damage to packages is suspected, checks for contamination will be made by [Name of individual]. 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–10. The storage area is 10 m from the office. The packages are stored for a maximum of 8 hours per day. Not more than five packages will 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 μSv/h. The occupancy of the area in the immediate vicinity of the pit is occasional. As a result of these measures, the radiation exposure of the office workers is expected to be negligible.

IV–11. Where possible, all packages, especially those with a high TI, are placed at the rear of the goods compartment when loading the packages onto the vehicle. This will minimize the exposure of the driver.

IV–12. For scheduled and non-scheduled stops during road transport, the vehicle is to be parked away from areas regularly occupied by members of the public.

EMERGENCY RESPONSE

IV–13. In the event of an incident (e.g. falling, crushing, fire) during storage or loading of the radioactive consignment onto the vehicle, [Name of individual] will take the following actions:

(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 (e.g. firefighting service, emergency medical service, response forces) as appropriate;
(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) 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;
(i) Inform the competent authority of the incident, in accordance with the applicable rules established by the competent authority.

IV–14. These instructions are displayed prominently in the storage bay, the vehicle loading area and the vehicle so that, in the absence of [Name of individual], any other responsible person would be able to take these actions.

IV–15. Emergency contact details are as follows:

(a) Person responsible for this RPP ([Name of individual]): ………………..
(b) Qualified expert in radiation protection: ………………..
(c) Other contacts: ………………..

TRAINING

IV–16. The persons listed below, being employees of LMN Industrial Gamma Radiographers engaged in the preparation of packages containing gamma radiography sources for transport, have received training commensurate with their responsibilities:

(a) [Name of individual]……………………(radiographer)
(b) [Name of individual]……………………(radiographer)
(c) [Name of individual]……………………(radiographer)

IV–17. The training they have received fulfils the applicable requirements of the competent authority and the policies of LMN Industrial Gamma Radiographers. These individuals will be subject to retraining every three years or at an interval specified by the competent authority.

MANAGEMENT SYSTEM FOR PROCEDURES AND PRACTICES

IV–18. The RPP and associated procedures are part of LMN Industrial Gamma Radiographers' management system and are subject to management system processes, such as document and version control, document review, issuing and review of instructions and procedures, and follow-up of non-conformances.

IV–19. 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 OPERATORS OF PORTS

SCOPE

V–1. This radiation protection programme (RPP) is applicable to organizations operating harbours, seaports or airports. It covers the transport and storage in transit of packages containing radioactive material: excepted packages; industrial packages; Type IP-1, 2 and 3 packages; Type A packages; and Type B(U) and B(M) packages.

ROLES AND RESPONSIBILITIES

V–2. The RPP is managed by [Name of individual], who is a suitably qualified person. [Name of individual] will ensure that all the elements of the RPP are implemented, including:

(a) Training of workers and implementation of proper work procedures;
(b) Regular review of the workload to identify changes that would result in the need for a dose assessment programme for workers;
(c) Emergency procedures.

V–3. The role of workers who handle packages is to move packages within the port area, including the following tasks:

(a) Obtain information about:
    (i) Emergency procedures;
    (ii) Conditions for storage in transit;
    (iii) Loading and securing of the packages on the conveyance;
    (iv) Unloading packages from the conveyance.
(b) Unload packages from and load packages onto conveyances.
(c) Move packages within the port, including placing them in and removing them from storage in transit locations.
(d) Implement emergency procedures, if appropriate.

FACILITATING THE CARRIAGE OF RADIOACTIVE CARGO

V–4. [Name of individual] will ensure that the handling of radioactive cargo is facilitated to contribute to worker dose reduction by avoiding unnecessary stops or delays of shipments of radioactive cargo, provided that such cargo has been forwarded in compliance with the applicable regulations for the safe transport of radioactive material.

DOSE ASSESSMENT

V–5. An evaluation of the possible doses received by workers (document No. ABC) has shown that these are well below 1 mSv per year at the present workload owing to pre-established segregation of packages containing radioactive material and the limitation of access to these packages. Therefore, a dose assessment programme is not necessary. The workload is subject to regular review by [Name of individual] to identify any potential changes and the need for a dose assessment programme for workers.

SURFACE CONTAMINATION

V–6. The radioactive material is transported in appropriate packages that are in good condition and that do not have any surface contamination above allowed limits; therefore, regular surveys for contamination are not needed. If a package appears to have been damaged, checks for contamination will be performed and appropriate action taken, as directed by [Name of individual].

EMERGENCY RESPONSE

V–7. [Name of individual] will ensure that arrangements for emergency preparedness and response are:

(a) Commensurate with the hazards of the radioactive materials to be transported;
(b) In compliance with the relevant international and national emergency response requirements;
(c) Updated regularly in accordance with (a) and (b).

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

TRAINING

V–9. Workers who handle packages:

(a) Have received basic training relating to dangerous goods, including radioactive material (Class 7);
(b) Are aware of basic regulatory requirements, including those for storage in transit;
(c) Are capable of recognizing labels for different types of dangerous cargo, reporting incidents and acting in accordance with emergency instructions and as directed by experts in the event of an emergency.

These individuals will be subject to retraining every three years or at an interval specified by the competent authority.

MANAGEMENT SYSTEM FOR PROCEDURES AND PRACTICES

V–10. This RPP and associated procedures are part of the management system documents and are subject to management system processes, such as document and version control, document review, issuing and review of instructions and procedures, and follow-up of non-conformances.

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[1]

SCOPE

VI–1. This radiation protection programme (RPP) covers the transport and storage in transit of packages containing uranium oxide concentrate and packages containing sealed sources of ^{60}Co used in industrial irradiators. Vessel X transports consignments of uranium oxide concentrate and special form radioactive material containing ^{60}Co used in industrial irradiators.

VI–2. Uranium oxide concentrate: Annually, 12 consignments, each consisting of 960 steel drums that are loaded into twenty 20-foot freight containers, are transported. 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 and has a transport index (TI) of 6.0.

VI–3. Cobalt-60 sealed sources: Each year, 12 consignments are transported that consist of two Type B(U) packages containing ^{60}Co sealed sources, which 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 and has a TI of 9.0.

VI–4. 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.

[1] Guidance on radiation protection programmes for special use vessels (see paras 576 and 802(d) of IAEA Safety Standards Series No. SSR-6 (Rev. 1), Regulations for the Safe Transport of Radioactive Material, 2018 Edition, [VI–1]) is provided in paras 576.1–576.7 of IAEA Safety Standards Series No. SSG-26 (Rev. 1), Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material (2018 Edition) [VI–2].

ROLES AND RESPONSIBILITIES

VI–5. The RPP is managed by [Name of individual], who is a suitably qualified person. [Name of individual] will ensure that all 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–6. The role of the vessel's crew and captain is to:

(a) Obtain information on the following:
    (i) Actions to be taken in the event of an emergency for each consignment;
    (ii) Conditions for storage, loading and securing of each consignment.
(b) Load shipping containers onto the vessel.
(c) Segregate and secure containers.
(d) Implement actions to reduce doses to workers.
(e) Implement emergency procedures, if appropriate.

DOSE ASSESSMENT AND OPTIMIZATION OF PROTECTION

VI–7. The owners of Vessel X or the maritime shipping line operating Vessel X arranged for a qualified expert in radiation protection, who evaluated the possible levels of individual exposure and determined 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;
(c) The radionuclides in the packages;
(d) The frequency of shipment.

VI–8. The study (document No. RRR) showed that the maximum radiation dose any individual crew member of Vessel X would receive would be significantly less than 1 mSv in a year at the present workload. The qualified expert advised that a dose assessment programme (using individual monitoring or workplace monitoring) was not necessary.

VI–9. 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.

Further measures to optimize radiation protection are given in the following sections.

SURFACE CONTAMINATION

VI–10. 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 damaged as a result of an accident, checks for contamination will be performed by an appropriately qualified individual and appropriate action taken if contamination is detected.

SEGREGATION AND OTHER PROTECTIVE MEASURES

VI–11. All 20-foot shipping containers are stowed in accordance with the segregation requirements of the International Maritime Dangerous Goods Code (IMDG Code) [VI–3]. If possible, the 20-foot shipping containers will be stowed such that the minimum segregation distances are exceeded.

EMERGENCY RESPONSE

VI–12. In the event of an incident, the following actions will be taken:

(a) For dealing with fires and spills (leaks), implement the recommendations in Emergency Response Procedures for Ships Carrying Dangerous Goods ('the EmS Guide') [VI–4];
(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 (e.g. firefighting service, emergency medical service, response forces) as appropriate;
(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) 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, in accordance with the applicable rules established by the competent authority.

VI–13. These instructions are to be available to crew members and emergency responders (e.g. in documentation stored in identified locations, notices or placards) in the event of an incident.

VI–14. Emergency contact details are as follows:

(a) Person responsible for this RPP ([Name of individual]): ………………..
(b) Qualified expert in radiation protection: ………………..
(c) Other contacts: ………………..

TRAINING

VI–15. The persons listed below, being the captain and crew members of Vessel X engaged in the transport of packages containing radioactive material, have received training commensurate with their duties:

(a) [Name of individual]…………………… (captain)
(b) [Name of individual]…………………… (crew member)
(c) [Name of individual]…………………… (crew member)
(d) [Name of individual]…………………… (crew member)

VI–16. The training they have received fulfils the applicable requirements of the competent authority. These individuals will be subject to retraining every three years or at an interval specified by the competent authority.

MANAGEMENT SYSTEM FOR PROCEDURES AND PRACTICES

VI–17. The RPP and associated procedures are part of Vessel X's management system and are subject to management system processes, such as document and version control, document review, issuing and review of instructions and procedures, and follow-up of non-conformances.

VI–18. The RPP, as described in this document, is approved.

Signature: ……………….. Date: ………………..

(Name and designation)

REFERENCES TO ANNEX VI

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

[VI–2] INTERNATIONAL ATOMIC ENERGY AGENCY, Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material (2018 Edition), IAEA Safety Standards Series No. SSG-26 (Rev. 1), IAEA, Vienna (2022).

[VI–3] INTERNATIONAL MARITIME ORGANIZATION, International Maritime Dangerous Goods Code (IMDG Code) (amendment 41-22), IMO, London (2022).

[VI–4] INTERNATIONAL MARITIME ORGANIZATION, Revised Emergency Response Procedures for Ships Carrying Dangerous Goods (EmS Guide), MSC.1/Circ.1588/Rev.2, IMO, London (2022).

Annex VII

QUESTIONNAIRE FOR EVALUATING THE EFFECTIVENESS OF RADIATION PROTECTION PROGRAMMES

VII–1. The following questions may be used in evaluating the effectiveness of radiation protection programmes (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 prior radiological evaluation of the expected doses to workers in different workplaces been performed correctly? And is it still valid based on the results of workplace monitoring and individual monitoring?
(g) Are the personnel involved in different actions sufficiently and correctly trained and familiar with equipment and instruments (including those that are not routinely used)?
(h) Is the training correctly documented (e.g. certificates, expiry dates)?
(i) If applicable (e.g. to consignors): Are the decisions on classification (e.g. UN number, proper shipping name), packaging (i.e. using the correct and optimized package design) and labelling taken by sufficiently qualified personnel, and are those decisions verified and properly documented and recorded?
(j) Are the necessary approvals and certificates available and valid?
(k) Are instructions and procedures that give clear and adequate guidance implemented by the workers to ensure that protection is optimized?
(l) Are the instructions and procedures up to date and consistent with the objectives of the RPP?
(m) Do the instructions and procedures cover all aspects, including emergency plans and procedures?
(n) Is the measuring equipment (for dose rate, contamination and air monitoring, as appropriate) adequate for routine use or during an emergency, as appropriate?

(o) Are there valid calibration certificates for the monitoring equipment that are relevant to the measurements to be made?
(p) Are the user instructions for use of the monitoring equipment followed?
(q) Are the results of measurements recorded, reported and reviewed?

Annex VIII

REQUIREMENTS OF THE INTERNATIONAL MARITIME DANGEROUS GOODS CODE FOR SEGREGATION OF PACKAGES CONTAINING RADIOACTIVE MATERIAL

VIII–1. The contents of this annex have been reproduced with permission from the International Maritime Dangerous Goods Code (IMDG Code) [VIII–1].[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.

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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[1]		Ferry, etc.[2]	Offshore support vessel[3]
	Break bulk (m)	Containers (TEUs)[4]		
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

[1] General cargo, break bulk or ro-ro containership of 150 m minimum length.
[2] Ferry or cross channel, coastal and inter-island ship of 100 m minimum length.
[3] Offshore support vessel of 50 m minimum length (in this case the practical maximum sum of TIs carried is 20).
[4] TEU means “20 ft Equivalent Unit” (this is equivalent to a standard freight container of 6 m nominal length).

REFERENCE TO ANNEX VIII

[VIII–1] INTERNATIONAL MARITIME ORGANIZATION, International Maritime Dangerous Goods Code (IMDG Code) (amendment 41-22), IMO, London (2022).

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