AUTORITÉ DE SÛRETÉ NUCLÉAIRE

ASN GUIDES

Guide 29

TRANSPORT

Radiation protection in radioactive substance transport activities

Updated version of 06/07/2023

Preamble

The ASN collection of guides is intended for professionals concerned by the nuclear safety and radiation protection regulations (licensees, users or transporters of ionising radiation sources, general public, etc.). These guides can also be issued to the various stakeholders, such as the local information committees (CLIs).

Each guide sets out recommendations which aim to:

- explain the regulations and the rights and obligations of the persons concerned by the regulations;
- explain the regulatory objectives and, as applicable, describe the practices ASN considers to be satisfactory;
- give practical tips and information concerning nuclear safety and radiation protection.

Application of these guides does not in any way reduce the responsibility of a Basic Nuclear Installation licensee with regard to the safety of its installation.

ASN Guide No. 29 was adopted by the Commissioners present at the Commission session of 6 July 2023.

Contents

1. INTRODUCTION

1.1. Background

Dangerous goods that can be transported on the public highway are divided into nine "classes" by the regulations, according to the nature of the associated risk (for example: explosive, toxic, flammable materials, etc.). Class 7 concerns radioactive substances.

About 770,000 consignments of radioactive substances are transported each year in France. That corresponds to about 980,000 packages of radioactive substances. The very large majority of radioactive substance transport operations take place by road, but other modes of transport (rail, maritime, inland waterway or air) are also concerned. These transport operations concern three sectors of activity: non-nuclear industry and research, the medical sector and the nuclear industry.

In France, the largest percentage of transported packages, about 57%, is accounted for by non-nuclear industry or research (sectors referred to as "small-scale nuclear activities"), often for mobile devices containing radioactive sources (gamma radiography devices, devices for detecting lead in paint, etc.). About one third of the packages transported (31%) are used in the medical sector: they supply the healthcare centres with radioactive sources for medical purposes, such as radiopharmaceutical products. Lastly, 12% of the packages transported in France are associated with the nuclear industry, containing products necessary for the various stages of the "fuel cycle".

The workers involved in the transport of radioactive substances are potentially exposed to ionising radiation, due more specifically to their close proximity with the packages. Members of the public situated in the immediate vicinity of the transport vehicles may also be exposed, but to a lesser extent. The regulations therefore make provisions to protect the workers, the general public and the environment against ionising radiation. The transport regulations thus stipulate that companies involved in radioactive substance transport operations must establish a radiation protection programme. Without prejudice to other applicable regulations, the radiation protection programme presents all the measures taken by a company to ensure radiation protection during the transport operations it carries out or in which it is involved.

The inspections conducted by ASN (*Autorité de sûreté nucléaire*, the French nuclear regulator) from 2015 to 2021 show that prevention measures defined and implemented by some transport players still take insufficient account of the risk of exposure of workers and the public to ionising radiation, even though transport activities can represent significant radiation exposure risks, particularly for the workers. The IRSN's annual assessments show that the drivers transporting sources for medical purposes are more exposed that the average for workers involved in the other sectors of activity. In 2020, two cases of exceeding the whole-body occupational exposure limit values (20 mSv) were recorded in the sector of transport of sources for medical purposes.

Furthermore, regulatory changes have been introduced since the first version of ASN Guide No. 29 was published in early 2018, notably in the Labour Code by two decrees published in mid-2018. These decrees and their implementation texts significantly modify the provisions applicable to those involved in the transport of radioactive substances.

Furthermore, the International Atomic Energy Agency (IAEA) has updated its Guide No. TS-G-1.3 [18], which focuses on the recommended content of a radiation protection programme.

ASN has therefore updated Guide No. 29 taking into account the feedback from the use of the first version of the guide.

1.2. Scope of application

This guide is applicable to all modes of transport (road, rail, inland waterways, maritime, air) and to all radioactive substance transport operations during which people (workers or the public) could be exposed to ionising radiation: preparation of packages, handing, carriage, loading, unloading, etc. It therefore does not address:

- the design and manufacture of the packagings,
- their maintenance and repair, if these operations are performed on packagings decontaminated to below the regulatory thresholds (set for example in article 2.2.7.1.2 of document [5].

Out of concern for simplification, this guide only makes reference to the articles of the Agreement concerning the international carriage of dangerous goods by road (ADR) [5] and the Order of 29 May 2009 amended relative to the transport of dangerous goods over land (called the "TMD Order") [9], regulations governing transport by road. Unless otherwise specified, the recommendations given in this guide are valid for the other modes of transport.

This guide addresses questions relating to protection of workers and the public against the risks arising from exposure to ionising radiation, under routine or incident transport conditions. It does not however address accident or post-accident situations, which form the subject of ASN Guide No. 17 [19].

In application of the Order of 7 February 2012 [10], the on-site transport operations in the basic nuclear installations (BNI) are:

- in conformity with the regulations applicable on the public highway; or
- described in the safety baseline requirements of the BNI and taken into account in the related safety cases.

This guide can therefore also be applicable to the radioactive substances within the site of the BNI if the first option is chosen. If the second option is chosen, the guide nevertheless contains recommendations that are useful for application of the provisions of the labour code.

1.3. Purpose of the guide

This guide is intended for professionals exercising a radioactive substance transport activity. It sets out the regulatory requirements relating to radiation protection of workers and the public and details the relationships between the various applicable texts. It also includes ASN recommendations to ensure due compliance with these requirements.

1.4. Document status

This document is an ASN guide which underwent a public consultation from 23 November to 23 December 2022.

2. DEFINITIONS AND REGULATORY FRAMEWORK

2.1. Definitions

The transport operations are defined in article 1.7.1.3 of the ADR [5]. These include: the design, manufacture, maintenance and repair of packaging, and the preparation, consigning, loading, carriage, including in-transit storage, unloading and receipt at the final destination of loads of radioactive material and packages.

As indicated in chapter 1.2, this guide only concerns transport operations during which there is a risk of the workers or the public being exposed to ionising radiation.

Radiation protection consists in protecting people, whether they are workers or members of the public, and the environment against the harmful effects of ionising radiation.

Environment Code

Article L. 591-1

[...]
Radiation protection means protection against ionising radiation, in other words all the rules, procedures and means of prevention and monitoring aimed at preventing or mitigating the harmful effects of ionising radiation on people, directly or indirectly, including by their adverse environmental impact.
[...]

It is based on three broad principles: justification, optimisation and limitation. These principles are defined in article L. 1333-2 of the Public Health Code.

Public Health Code

Article L. 1333-21

Nuclear activities shall satisfy the following principles:
1° The principle of justification, whereby a nuclear activity may only be undertaken or exercised if justified by the individual or collective advantages it procures - particularly in health, social, economic or scientific terms - with respect to the risks inherent to the exposure to ionising radiation to which the individuals are likely to be subjected;
2° The principle of optimisation, whereby the level of exposure of individuals to ionising radiation resulting from one of these activities, the probability of such exposure occurring and the number of persons exposed must be maintained at a level that is as low as reasonably achievable, in view of the state of technical knowledge, economic and societal factors and, where applicable, the medical research objective;
3° The principle of limitation, whereby the exposure of a person to ionising radiation resulting from one of these activities cannot raise the sum of the doses received beyond limits set by regulations, unless this person is exposed for medical purposes or in the context of research work as stipulated in 1° of article L. 1121-1.

The glossary in Appendix 1 contains other statutory definitions relative to radiation protection and transport operations.

2.2. International texts underpinning the French regulatory framework

The texts listed below are the foundation of the French regulatory framework:

[1] Regulations for the Safe Transport of Radioactive Materials, 2018 Edition, Specific Safety Requirements No. SSR-6 (revision 1), IAEA

[2] Regulations concerning the International Carriage of Dangerous Goods by Rail (RID)

[3] International Civil Aviation Organisation Technical Instructions (ICAO-TI)

[4] International Maritime Dangerous Goods Code (IMDG Code)

[5] Agreement concerning the international carriage of dangerous goods by road (ADR)

[6] European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN)

[7] Directive 2013/59/Euratom of 5 December 2013 setting basic standards for health protection against the hazards arising from exposure to ionising radiation

2.3. French regulatory framework

A list of reference texts is provided in section 2.3.6.

2.3.1. Division of responsibilities of the transport players

The transport of radioactive substances is governed by various regulatory requirements, established in particular by the Public Health Code (see section 2.3.2 below), the Labour Code (see section 2.3.3) and the Transport Code (see section 2.3.4), which apply concomitantly and contribute to achieving common objectives.

The radiation protection provisions aim to protect the public, the workers and the environment against the harmful effects of ionising radiation. In France these provisions figure in the three Codes concerned, depending on their target. In principle:

- When they aim to protect public health, public safety and the environment, these provisions are laid down in the **Public Health Code** and the **Environment Code**. Their implementation is the responsibility of the person or entity responsible for the nuclear activities or the nuclear licensee if a Basic Nuclear Installation (BNI) or an Installation Classified for Protection of the Environment (ICPE) is concerned.
- When they aim to protect the health and safety of workers, these provisions are laid down in the **Labour code** and their implementation is the responsibility of the **employer**. These provisions apply as soon as a worker, including independent workers and employers, is likely to be exposed to a risk due to natural or artificial ionising radiation.
- As for the ADR [5], rendered applicable in the French regulatory framework by the TMD Order [9], it lays down the responsibilities of the consignor (§ 1.4.2.1 of the ADR), the carrier (§ 1.4.2.2 of the ADR) and of the consignee (§ 1.4.2.3 of the ADR), particularly with regard to radiation protection in transport operations. It underlines that the transport of radioactive substances must be governed by a radiation protection programme.

2.3.2. Public Health Code

The transport of radioactive substances is a nuclear activity within the meaning of article L. 1333-1 of the Public Health Code therefore, as such, it is subject to the provisions of this code which aim at protecting the public and the environment against the dangers arising from ionising radiation.

Public Health Code

Article L. 1333-11

The provisions of this chapter apply to:
1° Activities involving a risk of exposure of individuals to ionising radiation resulting from the use either of an artificial source, whether it is a substance or device, or a natural source, whether naturally occurring radioactive substances or materials containing natural radionuclides, hereinafter referred to as nuclear activities; […]

In application of Article R. 1333-146 of the Public Health Code, ASN resolution 2015-DC-0503 [15] introduced more specifically[1] an obligation to notify ASN of the companies performing the transport operations identified in Article 1 of the resolution, if the corresponding transport operations take place at least in part on French territory. Notification is to be made via the ASN on-line services portal[2].

[1] **Article R. 1333-13 of the Public Health Code stipulates that the use of high-activity sealed sources comes under the licensing system. The transport of such sources will soon be subject to the licensing system in application of Article R. 1333-146 of the said Code.**

[2] **https://teleservices.asn.fr/views/connexion.html**

ASN resolution 2015-DC-0503 of 12 March 2015 relative to the notification system for companies transporting radioactive substances on French territory

Article 1

An application of Articles [L. 1333-8] and [R. 1333-146 of the Public Health Code, companies that carry out the radioactive substance transport operations mentioned in this article are subject to a notification system whenever these operations are not totally exempted from the requirements of the regulations applicable to the transport of dangerous goods of class 7 mentioned below:

- Council regulation (EEC) No. 3922/91 of 16 December 1991 amended on the harmonisation of technical requirements and administrative procedures in the field of civil aviation;
- Order of 29 May 2009 amended on the land transport of dangerous goods (called the "TMD order");
- Order of 23 November 1987 amended on the safety of ships;
- Order of 18 July 2000 amended regulating the transport and handling of dangerous goods in seaports;
- Order of 22 March 2001 on postal dispatches of radioactive materials.

The following operations are concerned:

- the carriage of radioactive substance packages,
- the loading or unloading of radioactive substance packages, including on logistic platforms, in airports and ports,
- the handling of radioactive substance packages after loading a package on the dispatch site and before its unloading on the reception site,

carried out for overland carriage (road, rail, inland waterways), all or part of which take place on French territory, or by sea and including a stop in a French port, or by air and including a stop in a French airport.

The following are not concerned:

- transport operations carried out entirely within a basic nuclear installation defined in Article L. 593-2 of the Environment Code or a defence-related nuclear installation defined in Article L. 1333-15 of the Defence Code;
- transport operations carried out entirely within an installation forming the subject of the authorisation mentioned in article L. 512-1 of the Environment Code or the authorisation mentioned in Article L. 162-3 of the Mining Code, if these authorisations take into account the utilisation or the holding of radioactive sources in the installation.

Companies that only transport radioactive substances for which they have a possession or utilisation authorisation or have given notification of their possession or utilisation in application of b) of 1°) of I of article R. 1333-104 of the Public Health Code are exempted from the notification mentioned in the first paragraph.

In this respect, ASN underlines that:

- The carriage of radioactive substance packages includes parking periods during carriage and in-transit storage (that is to say storage of the package during carriage, for example while waiting for a change in means of transport or for an overnight stop).
- Radioactive substance transport operations carried out solely inside a basic nuclear installation (BNI) are considered to be part of the operation of that installation and as such are covered by its license. They are governed by the order of 7 February 2012 amended setting out the general rules for basic nuclear installations. ASN Guide No. 34 relative to the implementation of the regulatory requirements applicable to on-site transport operations [20]. Thus, a company that only loads

packages within a BNI is dispensed from notification, even if the packages are subsequently transported outside the installation.

- Notification to ASN is not required if the company transporting the radioactive substances already has a license or an existing notification to possess or use these substances under Article L. 1333-8 of the Public Health Code. It can concern a transport activity:
  - own-account transport, such as the transportation of a gamma ray projector by the industrial radiography contractor;
  - hire or reward transport, such as a radiopharmaceuticals producer which delivers the sources it has produced to a hospital.

  This transport activity does effectively have to figure in the notifications, registration or license applications to be made before exercising the nuclear activity.

2.3.3. Labour Code

In accordance with the provisions of Article L. 4121-1 of the Labour Code, the employer takes the necessary measures to protect the health and ensure the safety of workers. The risk prevention rules for the health and safety of workers liable to be exposed to ionising radiation are established taking into account the general prevention principles mentioned in Article L. 4121-2 of the Labour Code, and the three principles of radiation protection, namely justification, optimisation and limitation. It is the employer's duty, in the same way as for any other professional risk, to implement occupational radiation protection measures.

Labour Code

Article L. 4121-11

The employer takes the necessary measures to ensure the safety and to protect the physical and mental health of the workers.
These measures include:
1° Occupational risk prevention actions, including those mentioned in Article L. 4161-1;
2° Information and training measures;
3° Implementation of an appropriate organisation and resources.
The employer ensures that these measures are adapted to take account of changing circumstances and seek to improve the existing situations.

For application of the provisions concerning ionising radiation, the notion of "worker" encompasses, according to Articles L. 4111-5 and L. 4451-1, salaried employees, including temporary employees and, as specified in Article L. 4451-1, independent workers and employers. The notion of "independent worker" includes the French status of "auto-entrepreneur" (self-employed) [16].

Labour Code

Article L. 4111-51

For application of this section, the workers are the employees, including temporary employees, and trainees (interns), and any person placed under the authority of the employer in any way whatsoever.

Article L. 4451-11

The risk prevention rules for the health and safety of workers, including independent workers and employers, exposed to ionising radiation are set in compliance with the general radiation protection principles set out in Articles L. 1333-2 and L. 1333-3 of the Public Health Code, without prejudice to the general prevention principles provided for in Article L. 4121-2 of this Code.

In accordance with the provisions of Article L. 4122-1, each worker is responsible for their own radiation protection and that of other people, without prejudice to the prime responsibility of the employer.

Labour Code

Article L. 4122-11

In accordance with the instructions given to them by the employer, under the conditions stipulated in the internal regulations for companies that are obliged to have them, each worker is responsible for taking care, according to their training and possibilities, of their own health and safety and that of other people concerned by the worker's actions or omissions at work.

The employer's instructions specify, particularly when justified by the nature of the risks, the conditions of use of the work equipment, the means of protection and the hazardous substances and preparations. They are adapted to the types of tasks to accomplish.

The provisions of the first paragraph do not change the principle of employer responsibility.

The regulatory provisions set out in Chapter 1 of Title V of Book IV of the fourth part of the Labour Code "*Prevention of the risks of exposure to ionising radiation*" are applicable from the moment a worker could be exposed to a risk due to ionising radiation. These provisions concern in particular transport companies that are subject to notification to ASN on account of resolution 2015-DC-0503 [15], whether notification has been given or not.

ASN underlines that companies exempted from notification in application of article 1 of this resolution are not exempted from application of the provisions of the Labour Code, such as:

- a company that loads radioactive substance packages within the bounds of a BNI;
- a company that only carries out transport operations involving radioactive substances for which it has a license, a registration or notification to possess or use (transportation of a gamma ray projector by an industrial gamma radiography contractor, or a radiopharmaceuticals producer which delivers the sources it has produced for the treatment of patients to a hospital, etc.).

In addition, the provisions of the Labour Code relative to the prevention of risks associated with certain activities or operations, particularly those relative to loading and unloading operations, set out in articles R. 4515-1 to R. 4515-11, apply to the loading and unloading of radioactive substance packages.

Labour Code

Article R. 4515-4

The loading and unloading operations form the subject of a written document called "security protocol" which replaces the prevention plan.

Article R. 4515-5

The security protocol contains the relevant information for assessing the risks of all types created by the operation and the prevention and security measures applicable at each phase of the operation.

2.3.4. Transport Code

The TMD order [9] issued in application of articles L. 1252-1 and R. 1252-8 of the Transport Code renders applicable the international agreements specific to each mode of transport (modal regulations) and clarifies or supplements their provisions. When radioactive substances are transported by road, which accounts for the very large majority of cases, the modal regulation applicable is the ADR [5]. It governs the transportation of dangerous goods, which include radioactive substances.

ADR [5] provides for several provisions for protecting workers, the public and the environment against the hazards of ionising radiation, such as the production and implementation of a radiation protection programme (see chapter 3 of this guide).

2.3.5. Environment Code

Article L. 595-1 of the Environment Code stipulates that ASN is the competent authority for taking the requisite individual decisions and for receiving the notifications of radioactive substance transport activities. Articles L. 596-1 et seq. define the conditions of oversight of radioactive substance transport.

2.3.6. Other specific applicable texts

The texts below also set applicable regulatory requirements:

[8] Order of 1 September 2003 defining the methods of calculating effective doses and equivalent doses resulting from human exposure to ionising radiation

[9] Order of 29 May 2009 amended on the land transport of dangerous goods (known as the "TMD order")

[10] Order of 7 February 2012 setting the general rules concerning basic nuclear installations

[11] Order of 26 June 2019 on the personal monitoring of worker exposure to ionising radiation

[12] Order of 15 May 2006 amended relative to the requirements for delimiting and signalling monitored and controlled areas and specially regulated or prohibited areas in view of the exposure to ionising radiation, and the health, safety and maintenance rules imposed in them (called the "zoning order")

[13] Order of 18 December 2019 amended relative to the training conditions for the Radiation Protection Expert-Officers (RPE-Os) and the certification of the training organisations and the radiation protection organisations

[14] Order of 23 October 2020 amended on the measurements taken for the assessment of risks and checks on the effectiveness of the prevention means put into place for the protection of workers against the risks due to ionising radiation

[15] ASN resolution 2015-DC-0503 of 12 March 2015 relative to the notification system for companies transporting radioactive substances on French territory (approved by the order of 24 July 2015)

[16] Instruction No. DGT/ASN/2018/229 of 2 October 2018 relative to the prevention of risks of exposure to ionising radiation

2.4. Guides

The following guides provide explanations and good practice recommendations on the subject addressed in this document.

[17] IAEA Safety Standards Series n° SSG-86 "Radiation Protection Programmes for the Transport of Radioactive Material (2023 Edition)"

[18] IAEA Specific Safety Guide SSG-26 "Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material (2018 Edition)"

[19] ASN Guide No. 17 relative to the content of radioactive substance transport incident and accident management plans

[20] ASN Guide No. 34 relative to the implementation of the regulatory requirements applicable to on-site transport operations

3. RADIATION PROTECTION PROGRAMME

3.1. Need for a radiation protection programme

Paragraph 1.7.2 of the ADR [5] stipulates that all radioactive substance transport operations (preparation of packages, package handling, loading, unloading, carriage, in-transit storage, unpacking, receipt, etc.) on the public highway shall be governed by a radiation protection programme (RPP).

To meet this obligation, the TMD Order [9] stipulates that each company involved in a radioactive substance transport operation must draw up an RPP, whether this is a single document or a set of documents.

TMD Order

Article 12-1

[...]

1. Radiation protection programme

In application of 1.7.2, any company involved in radioactive material transport operations (packaging, filling, loading, unloading, handling, carriage, emptying, etc.) establishes and implements a radiation protection programme (RPP).

[...]

The requirement to put in place an RPP applies whatever the mode of transport (road, rail, inland waterways, air, sea) and whatever the types of substances transported (materials in excepted packages, fissile material, LSA[3] materials and SCO[4], materials in type-A packages, materials in type-B packages, etc.).

The RPP defines the radiation protection objectives and the means necessary to achieve these objectives while taking account of the nature and scale of the risks (Article 1.7.2.3 of the ADR). **The graded approach principle is applicable: the level of detail of the RPP and the extent of the provisions it contains must be proportional to the radiation risks of the transport operations performed.**

Whatever the level of risk, even low, it is mandatory for the RPP to indicate (Article 1.7.2.3 of the ADR):

- the estimations of predicted individual doses resulting from the transport operations for the workers and the individual monitoring or work place monitoring provisions adopted (Article 1.7.2.4 of ADR);
- the individual dose constraints[5] defined below the relevant dose limits for the public and workers, and the measures taken to optimise radiation protection and safety, taking into account the interfaces between carriage and any other activities (Article 1.7.2.2 of the ADR: the "relevant dose limits" to which this article makes reference must be taken as being the regulatory dose limits);
- the measures taken to ensure compliance with the minimum segregation distances between the packages of radioactive substances and the workers or the public (Article 7.5.11 CV33 (1.1) of the ADR).
- the provisions for ensuring worker training (Article 1.7.2.5 of the ADR).

These requirements converge with those that the Labour code imposes on the employer of the worker(s) concerned.

[3] ***Low Specific Activity:*** **these are materials whose specific activity is below the thresholds defined in the regulations.**

[4] ***Surface Contaminated Object:*** **these are non-radioactive objects with external contamination that does not exceed certain thresholds defined in the regulations.**

[5] **See definition given in chapter 3.4.6 of this guide.**

Extracts from the ADR

1.7.2.1

The carriage of radioactive material shall be subject to a radiation protection program which shall consist of systematic arrangements aimed at providing adequate consideration of radiation protection measures.

1.7.2.2

Doses to persons shall be below the relevant dose limits. Protection and safety shall be optimized in order that the magnitude of individual doses, the number of persons exposed and the likelihood of incurring exposure shall be kept as low as reasonably achievable, economic and social factors being taken into account with the restriction that the doses to individuals shall be subject to dose constraints. A structured and systematic approach shall be adopted and shall include consideration of the interfaces between carriage and other activities.

1.7.2.3

The nature and extent of the measures to be employed in the programme shall be related to the magnitude and likelihood of radiation exposures. The programme shall incorporate the requirements of 1.7.2.2, 1.7.2.4, 1.7.2.5 and 7.5.11 CV 33 (1.1). Programme documents shall be available, on request, for inspection by the relevant competent authority.

1.7.2.4

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

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

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

NOTE : *For occupational exposures arising from transport activities, where it is assessed that the effective dose is most unlikely to exceed 1 mSv in a year, no special work patterns, detailed monitoring, dose assessment programmes or individual record keeping need be applied.*

1.7.2.5

Workers (see 7.5.11 CV 33 Note 3) shall be appropriately trained in 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.

7.5.11 CV 33 Note 3

"Workers" are any persons who work, whether full time, part-time or temporarily, for an employer and who have recognised rights and duties in relation to occupational radiation protection.

7.5.11 CV 33 (1.1)

Packages, overpacks, containers and tanks containing radioactive material and unpacked radioactive material shall be segregated during carriage:

a) from workers in regularly occupied working areas;
   i) in accordance with table A below [see chapter 3.5.1 of this guide]; or
   ii) by distances calculated using a dose criterion of 5 mSv in a year and conservative model parameters;

   NOTE : Workers subject to individual monitoring for the purposes of radiation protection shall not be considered for the purposes of segregation

b) from members of the public, in areas where the public has regular access:
   i) in accordance with table A below [see chapter 3.5.1]; or
   ii) by distances calculated using a dose criterion of 5 mSv in a year and conservative model parameters; [...]

ASN therefore recommends that a radiation protection programme (RPP) should include the following chapters:

- **scope of the radiation protection programme;**
- **roles and responsibilities within the company and interfaces, if any, with external players;**
- **exposure of workers and the public to ionising radiation;**
- **verifications of the surface contamination and the level of external exposure of the packages and means of transport;**
- **measures taken to ensure the radiation protection of workers and the public;**
- **worker training;**
- **quality management system (quality assurance).**

Chapters 3.2 to 3.8 below detail the expected content of each of these chapters and the associated regulatory requirements.

Depending on the ionising radiation risks assessment carried out under the Labour Code (see chapter 3.4.3 of this guide), the following table lists the RPP chapters to be addressed. This table also underlines that whatever the estimated exposure of the workers, some chapters are required systematically.

<table>
<tr><th rowspan="3">Chapter of Guide No. 29</th><th colspan="3">Chapter of the RPP</th></tr>
<tr><th rowspan="2">Subject addressed in the chapter</th><th colspan="2">Need for the chapter according to worker exposure assessment</th></tr>
<tr><th>< 1 mSv/year</th><th>≥ 1 mSv/year</th></tr>
<tr><td>§ 3.2</td><td>Scope of the RPP</td><td colspan="2" rowspan="8">Yes</td></tr>
<tr><td>§ 3.3</td><td>Roles and responsibilities within the company and interfaces, if any, with external players;</td></tr>
<tr><td>§ 3.4.3</td><td>Assessment of the risks associated with ionising radiation</td></tr>
<tr><td>§ 3.4.4</td><td>Individual assessment of worker exposure to ionising radiation</td></tr>
<tr><td>§ 3.4.5</td><td>Assessment of exposure of the public to ionising radiation</td></tr>
<tr><td>§ 3.4.6</td><td>Defining the dose constraints</td></tr>
<tr><td>§ 3.5.1</td><td>Segregation distances between packages and workers and between packages and the public</td></tr>
<tr><td>§ 3.5.2</td><td>Optimisation of radiation protection of workers and the public</td></tr>
<tr><td>§ 3.5.3</td><td>Classification of workers into category A or B</td><td>Not compulsory</td><td>Yes</td></tr>
<tr><td>§ 3.5.4</td><td>Monitoring of individual exposure of the workers</td><td colspan="2">Yes</td></tr>
<tr><td>§ 3.5.5</td><td>Tightened individual monitoring of workers' health</td><td>Not compulsory</td><td>Yes</td></tr>
<tr><td>§ 3.6</td><td>Verifications of the surface contamination and the level of external exposure of the packages and means of transport</td><td colspan="2" rowspan="3">Yes</td></tr>
<tr><td>§ 3.7</td><td>Worker training</td></tr>
<tr><td>§ 3.8</td><td>Quality management system</td></tr>
</table>

The RPP shall be kept available for inspection by the competent authorities (§ 1.7.2.3 of the ADR).

Under Article R. 4121-1 of the Labour Code, the employer is obliged to inventory all the risks workers are exposed to in a "DUER" (French acronym for "unified risks assessment document"). To avoid having identical content repeated in different documents, the employer may decide to reference the DUER in the section of the RPP on occupational exposure to ionising radiation. The RPP shall nevertheless cover the other aspects, particularly exposure of the public.

This approach can be adopted in the other sections of the RPP: their content may also be found in other documents, provided that they are referenced in the RPP and kept available for examination by the competent authorities.

3.2. Scope of the radiation protection programme (RPP)

The RPP shall be tailored to the activities of the company. It shall cover all the aspects of transport: all the transport activities exercised, all the modes of transport concerned, all types of packages, and all the potentially exposed persons (workers and public). It shall take into account the interactions between carriage and other transport activities.

The objective of the "Scope of the programme" chapter of the RPP is therefore to describe the activities of the company with respect to their radiation protection implications. As is emphasised in chapter 3.1, the level of detail shall be proportional to the significance of the risks with regard to radiation protection of the workers and the public.

3.2.1. Company activities

To describe the activities of the company, the RPP should contain:

- a list of the company's transport activities (carriage, loading, unloading, handling, packaging, etc.);
- the modes of transport concerned;
- a general description of the radioactive substances concerned:
  - an estimation of the number of packages transported per year (or the number of packages loaded, unloaded, handled, packaged or not, etc.);
  - the types of packages concerned (by indicating, for example, the UN numbers of the packages or giving a more precise description of the contents), with an estimation of the proportions of the different types;
  - the package categories (labels I-white, II-yellow, III-yellow or without label), with an estimation of the proportions of the different categories;
- the number of workers (employees of the company or subcontractors) who could be exposed to ionising radiation, also indicating those that are involved in the organisation of transport activities;
- The sites or itineraries frequently used and persons of the public or third parties to the company (workers) potentially subject to frequent exposure;
- any additional information deemed necessary.

3.2.2. Interactions between several companies

Paragraph 1.7.2.2 of the ADR indicates that the RPP shall take account of the interfaces between carriage and other activities. Regarding application of this paragraph, ASN considers that if the transport operation involves several companies, each company should have its own radiation protection programme. However, one of the companies can take charge of all the risk assessments in its RPP in order to ensure better coordination of the radiation protection measures, on condition that the other companies participate and make reference to this RPP in their own RPP. In this case, this constitutes a method of conducting the risk assessment which does not relieve each employer of its responsibilities.

When loading and unloading operations take place within a facility, this obligation must be interlinked with the obligation imposed on the receiving company and the carrier company to **draw up a "security protocol"** (chapter 2.3.3. of this guide) comprising an assessment of the risks - including but not limited

to the radiological risk - and a description of the associated prevention measures under Articles R. 4515-1 et seq. of the Labour Code.

3.3. Roles and responsibilities within the company and interfaces, if any, with external players

The RPP should contain a description of the role of each of the players involved in the transport activity with regard to radiation protection. The responsibilities of each person or entity shall be clearly defined, indicating more specifically the persons responsible for drafting, updating and ensuring correct application of the RPP, the persons handling the packages, the persons taking dose rate and contamination measurements, the persons performing the inspections (including of documents) to verify compliance with the various requirements, etc. An organisation chart can help to clarify these aspects.

The transport company must, in its quality management system (see article 1.7.3.1 of the ADR and chapter 3.8 of this guide):

- designate the person(s) responsible for managing and monitoring the RPP. They shall have the necessary skills and authority to fully grasp the radiation protection implications and to check that the RPP is correctly applied within the company. This role could for example be assigned to the transport safety advisor (if there is one: see chapter 4.2) or to the radiation protection advisor (see chapter 4.1);
- define and make available the means and resources necessary for implementation of the RPP (decision-making authority, qualified personnel, equipment, training, quality assurance, etc.);
- verify that the radiation protection objectives under the applicable regulations (compliance with dose constraints and effectiveness of optimisation measures) have been achieved or, if they have not, identify and analyse the causes of the deviations from the objectives in order to implement the necessary corrective action with a view to continuous improvement.

3.4. Exposure of workers and the public to ionising radiation

The obligation to assess doses and to optimise exposure of workers and the public set by the regulations applicable to transport is also specifically laid down in the Labour Code (for workers) and in the Public Health Code (for the public).

These obligations must be fulfilled without increasing the number of procedures for as much.

3.4.1. Occupational exposure limit values

The regulations define the effective dose and equivalent dose limits over twelve consecutive months (Articles R. 4451-6 to R. 4451-9 of the Labour Code). The values concerning transport activities more specifically are set out in the table below.

	Whole Body (effective dose)	**Extremities: Hands, forearms, feet, ankles (equivalent dose)**	**Skin (equivalent dose over any surface of 1 cm² of skin)**
Workers	20 mSv over twelve consecutive months	500 mSv over twelve consecutive months	500 mSv over twelve consecutive months
Young workers (between 16 and 18 years, provided they are authorised for their training needs)	6 mSv over twelve consecutive months	150 mSv over twelve consecutive months	150 mSv over twelve consecutive months
Working pregnant women	Less than 1 mSv (exposure of the unborn child), from notification of pregnancy until childbirth.		
Working nursing mothers (Article D. 4152-7 of the Labour Code)	Prohibited to keep them working in, or to assign them to, a job leading to a risk of internal exposure.		

3.4.2. Exposure limit values for the public

The regulations define the annual effective dose and equivalent dose limits to the skin for the public (Article R. 1333-11 of the Public Health Code).

	Whole Body (effective dose)	**Skin (equivalent dose over any surface of 1 cm²)**
General public	1 mSv/year	50 mSv/year

3.4.3. Assessment of the risks associated with ionising radiation

The assessment of the risks associated with ionising radiation (particularly the assessment of the doses that could be received) constitutes a key element of the RPP because it enables the radiation protection measures to be adapted to the radiological risks.

Under Article R. 4451-13 of the Labour Code, the assessment of the risks resulting from the exposure of workers to ionising radiation is carried out by the employer assisted by the radiation protection advisor. If the company has not yet been confronted with the radiological risk and has therefore not yet appointed a radiation protection advisor, the employer relies on the competent employee to manage the occupational risks protection and prevention activities mentioned in I of Article L. 4644-1 of the Labour Code.

This first assessment is preliminary to the other prevention measures and means to be defined by the employer according to the assessment results.

The primary aim of assessing the ionising radiation risks is to identify and characterise the dangers or the risk factors: devices and sources emitting ionising radiation. The risk assessment subsequently consists in analysing the conditions of exposure of the workers to these dangers or risk factors.

The assessment must be carried out prior to any transport activity to ascertain that all the protection measures are, in principle, appropriate. It must take into account all the occupational exposures of the workers to ionising radiation associated with transport operations and other possible professional activities.

It is conducted per work unit, with a scope that extends from one to several types of jobs occupied by workers or to work situations, presenting the same characteristics. Likewise, from a geographical point of view, the work unit is not always limited to a single activity or a single place but can cover several activities or places, particularly for radioactive substance carriers [16].

As a first approach, the employer takes into account, on a documented basis, all the points mentioned in Article R. 4451-14 of the Labour Code.

Labour Code

Article R. 4451-14

When carrying out the risk assessment, the employer takes the following into consideration more specifically:

1° The inventory of ionising radiation sources mentioned in Article R. 1333-158 of the Public Health Code;

2° The nature of the ionising radiation sources, the type of radiation and the level and duration of exposure and, if applicable, any modes of radionuclide dispersion and incorporation;

3° The information on the emission levels communicated by the supplier or manufacturer or ionising radiation sources;

4° The information on the nature and emission levels of cosmic radiation reigning at the flight altitudes of aircraft and spacecraft;

5° The exposure limit values laid down in Articles R. 4451-6, R. 4451-7 and R. 4451-8;

[…]

8° The existence of collective protective equipment, notably means of biological protection, ventilation or capture systems, enabling the level of exposure to ionising radiation to be reduced or which could be used in place of the existing equipment;

9° The reasonably foreseeable incidents inherent to the work process or the work performed;

[…]

11° Any impact on the health and safety of pregnant women and unborn children or nursing mothers and workers under 18 years of age;

12° Interaction with the other physical, chemical, biological or organisational risks of the job; […]

As the targeted situations are defined by the employer beforehand, it is highly probable that collective biological protections will be implemented in the transport context (e.g. vehicles equipped with lead shields to limit exposure of the driver). The assessments of ionising radiation risks must take these

collective protection devices into account when they exist. However, the employer's risk assessment must not take into consideration personal protective equipment (such a lead apron worn by a worker).

The risk assessment must be carried out considering the usual work situations and the reasonably foreseeable incidents. It is not necessary, however, to consider accident conditions of transport as defined in the ADR.

The ADR defines "normal conditions of carriage" (using the term "carriage", not transport) which cover the incidents a package can suffer during transport and which can lead to a 20% increase in the dose rate on the surface of the package. ASN considers that an incident corresponding to normal conditions of transport could occur during transportation without always being detected immediately. Consequently, the ionising radiation risk assessment must take into account the possibility of such an incident. In concrete terms this means that the results of the dose assessment carried out using one of the methods described in chapter 3.4.7 should be increased by 20%.

The characteristics of the ionising radiation are also an integral part of the risk assessment.

With regard to spent nuclear fuel packages, the employer must take the neutron radiation into consideration in this assessment.

Where air transport is concerned, the level of exposure of workers to cosmic radiation must also be taken into account.

When the results of the risk assessment reveal exposure that could reach or exceed one of the levels set in Article R. 4451-15, the employer shall take measurements at the work place and conserve the results specified in Article R. 4451-15. The results of the risk assessment and the measurements are communicated to the health professionals mentioned in the first paragraph of Article L. 4624-1 and to the social and economic committee if there is one.

Labour Code

Article R. 4451-15

I.- The employer takes measurements at the work place when the risk assessment results reveal that exposure levels could reach or exceed one of the following values:
1° For the whole body: 1 millisievert per year;
[...]
3° For the extremities and the skin: 50 millisievert per year;
[...]

Article R. 4451-16

The risk assessment results are recorded in the "unified risks assessment document" (DUER) mentioned in Article R. 4121-1.
The results of the assessment and measurements provided for in Article R. 4451-15 are kept in a form that will enable them to be consulted for a period of at least 10 years.

The assessment of the risks relating to ionising radiation must be reviewed periodically and updated if necessary. **The obligation to periodically review the content of the exposure assessment applies even if the foreseeable dose for the workers is less than 1 mSv/year.** This can more specifically provide confirmation that the initial assessment remains valid, including in cases where the company's activity

has undergone changes (increase in the transport operations in particular). The verification frequency should be specified in the RPP.

In this respect, since the results of the ionising radiation risks assessment are recorded in the DUER, in the same way as the other risks identified in each work unit of the company or the facility, Article R. 4121-2 of the Labour Code implies that **the maximum frequency of reviewing and, if applicable, updating the ionising radiation risks assessment is one year.**

Whatever the case, the assessment shall be updated if there is a change in the company's activities that could significantly change the exposure of the workers.

Labour Code

Article R. 4121-2

The unified risks assessment document (DUER) is updated:
1° At least annually in companies with at least eleven employees;
2° Following any major development decision that changes the health and safety or work conditions;
3° When additional information concerning the assessment of a risk is made known to the employer.

[...]

When the assessment concludes that doses could exceed 1 mSv/year for the whole body or 50 mSv/year for the extremities and the skin, the employer must carry out an individual exposure assessment of each worker concerned in the company. For workers whose exposure is not likely to exceed these limits the employer may decide not to classify them (see chapter 3.5.3), but must apply the provisions of Article R. 4451-32 of the Labour Code if they access monitored or controlled zones (green or yellow in this case).

Labour Code

Article R. 4451-32

Workers who are not classified can access a blue monitored zone or green controlled zone and a radon zone provided they have their employer's authorisation based on the individual assessment of the ionising radiation risk provided for in Article R. 4451-52.

These workers can also enter a controlled yellow zone for a reason duly justified beforehand. In this case the employer applies special prevention measures, notably by providing the workers with more detailed information.

3.4.4. Individual assessment of worker exposure to ionising radiation

The previous notion of "job position analysis" or "exposure sheet" figuring in the provisions prior to 1 July 2018 is not taken up as such in the current version of the Labour Code. It is now included under the term "individual risk assessment".

When the ionising radiation risk assessment (see chapter 3.4.3) concludes that doses could exceed 1 mSv/year for the whole body or 50 mSv/year for the extremities and the skin, the employer must carry out an individual exposure assessment of each worker concerned in the company. Moreover, in application of Article R. 4451-52 of the Labour Code, **the individual assessment concerns each worker**

involved in radioactive substance transport operations or accessing delimited zones, **irrespective of the results of the risk assessment**.

The individual assessment of the equivalent or effective dose that the worker is likely to receive over the next twelve consecutive months is carried out **before the worker is assigned to the job**. All the jobs occupied by the worker are taken into account for this assessment, in the usual work conditions or under conditions associated with reasonably foreseeable incidents inherent to the job. More particularly, if a worker takes part in professional activities involving exposure to ionising radiation and involving several companies, the individual dose assessment must be the sum of the individual assessments carried out for each professional activity. In the transport context, this means that several parameters must be taken into account, such as the dose rates at the work place(s), the time spent near the packages, the number of transport operations, the use of overpacks or containers, in-transit storage, the mode of transport, the way the packages are arranged inside the vehicle, the use of collective equipment protecting against ionising radiation, etc. It can be based on the methods described in chapters 3.4.7 and 3.4.8 of this guide.

If a worker wears personal protective equipment (e.g. a lead apron) for a given operation, the individual exposure assessment of that worker can take this equipment into account.

The individual assessment is formalised under the conditions set out in Article R. 4451-53.

Labour Code

Article R. 4451-52

Before assigning workers to job positions, the employer assesses the individual exposure of the workers:
1° Accessing the zones delimited under Article R. 4451-24 and R. 4451-28;
[...]
3° Involved in radioactive substance transport operations;
[...]

Article R. 4451-53

This prior individual assessment, recorded by the employer in a form that enables it to be consulted for a period of at least ten years, comprises the following information:
1° The nature of the work;
2° The characteristics of the ionising radiation to which the worker is liable to be exposed;
3° The frequency of exposure;
4° The equivalent or effective dose the worker is likely to receive over the next twelve consecutive months, taking into account the potential exposures and the reasonably foreseeable incidents inherent to the job;
[...]
The employer updates this individual assessment as and when necessary.
Each worker has access to their assessment.

The aim of the individual assessment is to define the obligations resulting from the worker's employment conditions:

- classification (see chapter 3.5.3 of this guide),
- monitoring of individual exposure (chapter 3.5.4),
- tightened individual health monitoring (chapter 3.5.5),
- training (chapter 3.7).

If the employer concludes that the worker must be classified under Article R. 4451-57 of the Labour Code (see chapter 3.5.3 of this guide), the individual assessment of the equivalent or effective dose that the worker is likely to receive over the next twelve consecutive months is communicated to the occupational physician (Article R. 4451-54).

3.4.5. Assessment of exposure of the public to ionising radiation;

Article R. 1333-23 of the Public Health Code introduces the provisions applicable to the assessment of the doses for the public.

Public Health Code

Article R. 1333-23

Any estimation of the doses to which the public is exposed takes into account the doses resulting from external exposure to ionising radiation and the incorporation of radionuclides. It is calculated for a representative person, considering scenarios that are as realistic as possible.

3.4.6. Defining the dose constraints

By virtue of the principle of optimisation written into the Labour Code, the Public Health Code and the ADR, radiation protection must be optimised such that the exposure of persons is kept as low as reasonably achievable, given the current state of technical knowledge and the economic and social factors (ALARA[6] approach), without exceeding the regulatory limits. Consequently, it cannot be considered satisfactory to reach the exposure limit values (see chapters 3.4.1 and 3.4.2).

To apply the optimisation principle, **the RPP must set dose constraints** (Article 1.7.2.2 of the ADR). These dose constraints are required equally well for workers (Article R. 4451-33 of the Labour Code) as for the public (Article R. 1333-10 of the Public Health Code).

They are necessarily below the exposure limit values and represent the dose values that should not be exceeded in standard operations carried out in accordance with good practice. These dose constraints, comparable with reference levels specific to the company, constitute a tool for managing the radiation protection optimisation measures, for the employer and the prevention actors (radiation protection advisor, occupational physician, etc.). Exceeding the dose constraints is not an offence. However, the employer must analyse the reasons for the exceedance in order to prevent it from occurring again.

These dose constraints can be annual, quarterly, monthly, or even shorter periods when relevant in view of the risk. For example, it is worthwhile defining a dose constraint for a single operation if the estimated doses for that operation are high.

[6] *As Low As Reasonably Achievable.*

The exposure limit values for a member of the public are applicable for all the nuclear activities that can lead to the person being exposed. It therefore cannot be excluded that this member of the public exposed as a result of the radioactive substance transport operations carried out by the company may also be exposed by other nuclear activities, including by radioactive substance transport operations carried out by other companies. With the aim of optimising radiation protection of the public, ASN recommends setting a dose constraint for members of the public that is well below the regulatory annual limits.

3.4.7. External dose assessment methods

The external dose is the dose resulting from exposure to radioactive sources situated outside the organism (irradiation). In transport operations, the external dose received results from the dose emitted by the package and the ambient dose rate in the work area if other sources of ionising radiation are also present.

The dose rate values and the transport index (TI)[7] which apply to the different categories of packages, overpacks and containers are indicated in table 5.1.5.3.4 of the ADR.

ADR

Table 5.1.5.3.4: Categories of packages, overpacks and containers

Conditions		
TI	**Maximum dose rate at any point on the external surface**	**Category**
0 [a]	Not more than 0.005 mSv/h	I-WHITE
More than 0 but not more than 1 [a]	More than 0.005 mSv/h but not more than 0.5 mSv/h	II-YELLOW
More than 1 but not more than 10 [a]	More than 0.5 mSv/h but not more than 2 mSv/h	III-YELLOW
More than 10	More than 2 mSv/h but not more than 10 mSv/h	III-YELLOW [b]

[a] *If the measured TI is not greater than 0.05, the value quoted may be zero in accordance with 5.1.5.3.1 (c)*

[b] *Shall also be carried under exclusive use except for containers (see Table D in 7.5.11 CV33 (3.3)).*

The initial dose assessment can be carried out using various methods:

- by using feedback on the dosimetric results of the workers or work place radiation monitoring;

  In compliance with the conditions of utilisation of dosimetric results provided for in the Labour Code, the use of this method more specifically necessitates correct monitoring of the doses received by the workers in the past (wearing of dosimeters) and extrapolation of these data on an annual basis taking into account the ratios reflecting any changes in the activity of the company and covering the uncertainties.

- by means of a calculated estimate.

[7] **TI: Transport Index - Articles 5.1.5.3 and 5.1.5.3.2 of the ADR indicate how to calculate it.**

The dose assessment can also be carried out by calculation, particularly if the available data are not representative of the planned operations or not directly transposable to them.

For straightforward exposure situations (for example an operator remaining at a fixed distance from a package), the dose received by the workers or the public can be assessed by simple calculations (see example in appendix 3).

For more complex exposure situations, the use of calculation codes (such as those mentioned in chapter 5 of the IAEA Safety Guide TS-G-1.3 [17]) is also a possibility. These codes enable exposure situations to be modelled with varying levels of detail. The level of detail to use depends on the complexity of the situation and the associated radiation risks.

Whatever the case, if the assessment is based on a calculation - whether simple or complex - and concludes that individual or work place radiation monitoring is necessary, a retrospective verification that it is effectively reasonably conservative must be carried out on the basis of a comparison with said monitoring results.

- by using bibliographic data.

  The use of bibliographic studies for the assessment can be envisaged when data are available on exposures for activities of the same type conducted under similar conditions (see example in appendix 4). This method should however only be used for activities presenting minor radiation risks.

  Whatever the case, if the dose assessment for the workers or public is based on a bibliographic study, it shall be demonstrated that this study is relevant and conservative for the activities of the company.

For companies that have been carrying out radioactive substance transport activities for several months or even several years, the method to favour is experience feedback, provided that worker dosimetric monitoring and work place radiation monitoring are implemented in a reliable and representative manner.

Whatever the case, the chosen method shall be justified with respect to the characteristics of the company's activities.

3.4.8. Internal dose assessment methods

The internal dose results from exposure to radioactive sources situated inside the organism, most often due to the inhalation of radionuclides. Internal exposure can sometimes result from the ingestion of radionuclides or their passage through the skin (via wounds or transcutaneously). In the case of transport, the risk of internal exposure generally arises from residual contamination that may be present on the external surfaces of the packages.

On account of the checks to verify compliance with the regulatory contamination limits, the assessment of internal exposure is generally not necessary, on condition that protection measures are put in place (gloves for handling packages, etc.). The checks to verify compliance with the regulatory contamination limits and the protection measures against internal exposure may be adapted according to the result of the risk assessment, for example in cases where is its demonstrated that surface contamination is extremely improbable (transportation of sealed radioactive sources for example).

If there is a risk of dispersion of radionuclides into the ambient air, an internal dose assessment based on estimations and then measurements of activity concentration (Bq/m^3) in the air will be necessary.

3.5. Measures to ensure the radiation protection of workers and the public

3.5.1. Segregation distances between packages and workers or the public

During transport operations, the minimum segregation distances between the packages and workers who are not subject to individual dose monitoring, and between packages and the public, shall be respected (§ 7.5.11 CV 33 (1.1) and associated Table A of the ADR). These segregation distances also apply to the work areas and areas normally accessible to the public. The aim to reduce the doses received by segregating the sources of ionising radiation from persons.

Moreover, packages and overpacks in category II-YELLOW or III-YELLOW (categories with the highest transport indices) shall not be carried in compartments occupied by passengers.

Extracts from the ADR

7.5.11 CV 33 (1.1)

Packages, overpacks, containers and tanks containing radioactive material and unpacked radioactive material shall be segregated during carriage:

a) from workers in regularly in regularly occupied working areas;
   i) in accordance with Table A below; or
   ii) 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:
   i) in accordance with Table A below; or
   ii) by distances calculated using a dose criterion of 1 mSv in a year and conservative model parameters;

c) [...]

Table A: Minimum distances between packages of category II-YELLOW or category III-YELLOW and persons

	Exposure time per year (hours)			
	Areas where members of the public have regular access		Regularly occupied working areas	
Sum of transport indices not more than	**50**	**250**	**50**	**250**
	Segregation distance in metres, no shielding material intervening, from			
2	1	3	0.5	1
4	1.5	4	0.5	1.5
8	2.5	6	1.0	2.5
12	3	7.5	1.0	3
20	4	9.5	1.5	4
30	5	12	2	5
40	5.5	13.5	2.5	5.5
50	6.5	15.5	3	6.5

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 authorised to accompany such packages or overpacks.

Example: with a load whose transport index equals 1 (and therefore not exceeding 2), the packages of categories II-Yellow and III-Yellow of this load shall be placed at least 1 m from members of the public (considering the minimum exposure hypothesis of table A, namely an area to which the public has regular access but is only exposed for 50 h/year).

Specific segregation distances are applicable to maritime transport means. Their conditions, laid down in the IMDG code [4], are indicated in appendix 5 of this guide.

The carrier may also choose not to use the values of table A and calculate the minimum applicable distances itself, with a maximum dose criterion of 5 mSv/year for classified workers (see chapter 3.5.3 of this guide) and 1 mSv/year for the public and non-classified workers, using conservative assumptions (§ 7.5.11 CV 33 (1.1) a) ii) and b) ii) of the ADR). The dose constraints set for workers and the public must also be taken into account (see chapter 3.4.6).

The RPP shall indicate the applicable segregation distances when this is relevant in view of the company's activities.

Moreover, the regulations require that vehicles transporting radioactive materials:

- be parked in a supervised park;
- or be parked unsupervised in a secure depot or secure factory premises;
- or, failing this, be parked on a site separated from major public highways and dwellings, where the public does not normally pass or assemble (see article 8.4.1 of the ADR and S21 of article 8.5).

It is also to be noted that Article 2.6.3 of Appendix I of the TMD Order limits the parking durations (to 72 hours in the general case). These provisions also serve to limit the doses received by the workers and the public. The abovementioned separation distances also apply during these parking phases.

Lastly, complementary provisions relative to the delimiting and signalling of the areas, within the bounds of a site, where the workers could be exposed to levels of ionising radiation exceeding the statutory values stated in Article R. 4451-22 of the Labour Code are to be put in place by the employer (see chapter 4.3 of this guide).

TMD Order

Appendix I - Article 2.6.3

Without prejudice to the requirements of 8.4 and 8.5, the following provisions apply to the parking during carriage of vehicles transporting radioactive materials and the in-transit storage of radioactive materials, off the premises of the consigner and the consignee if they come under one of the regimes mentioned in article L. 1333-4 of the public health code. The duration of a parking period in the course of carriage or of an in-transit storage period is limited to 72 consecutive hours. This duration can be extended by 24 hours if a public holiday falls the day before or after a weekend or by 48 hours if the public holiday is separated from a weekend by a single working day.

If the parking or in-transit storage takes place in a loading, unloading and transfer centre, its duration may be extended in the event of constraints associated with the delay of a ship, or the impossibility to board an aircraft, or the formation, separation or inspection of a rail convoy.

If the parking or in-transit storage takes place within a basic nuclear installation defined in article L. 593-2 of the Environment Code or a defence-related nuclear installation defined in article L. 1333-15 of the Defence Code, its duration can be extended to one week.

If an event arises that obliges parking during carriage or in-transit storage beyond the above durations, the carrier shall inform the consigner and the consignee as soon as possible in order to determine the measures to take. The duration limitations defined above do not start running until it is once again possible to stop the parking or in-transit storage phase.

If the duration of a parking period or an in-transit storage period during carriage exceeds 72 hours, the checks stipulated in point c of Article 1.4.2.2.1 c) are carried out every 24 hours, after a period of 72 hours. These operations are recorded for purposes of traceability.

The present paragraph does not apply to:
- excepted packages under UN number 2908;
- empty cleaned tanks under UN numbers 2912, 3321 or 3322.

ADR

1.4.2.2.1

In the context of 1.4.1, where appropriate, the carrier shall in particular: [...]

c) Ascertain visually that the vehicles and loads have no obvious defects, leakages or cracks, missing equipment, etc. ; [...]

8.4.1

Vehicles carrying dangerous goods in the quantities shown in special provisions S1 (6) and S14 to S24 of chapter 8.5 for a given substance according to Column (19) of Table A of Chapter 3.2[8] shall be supervised or alternatively may be parked, unsupervised, in a secure depot or secure factory premises. If such facilities are not available, the vehicle, after having been properly secured, may be parked in an isolated position meeting the requirements of a), b) or c) below:

a) a vehicle park supervised by an attendant who has been notified of the nature of the load and the whereabouts of the driver;

b) A public or private vehicle park where the vehicle is not likely to suffer damage from other vehicles; or

c) A suitable open space separated from the public highway and from dwellings, where the public does not normally pass or assemble.

The parking facilities permitted in b) shall be used only if those described in a) are not available, and those described in c) may be used only if facilities described in a) and b) are not available.

The segregation distances indicated in table A associated with Article 7.5.11 CV 33 (1.1) of the ADR are the minimum distances to apply. Greater segregation distances than those required by the regulations can be used if an optimisation approach is adopted.

Nevertheless, the segregation distances do not constitute the only optimisation tool, given their non-conservative approach. Other complementary radiation protection measures must be implemented.

3.5.2. Optimisation of radiation protection of workers and the public

When the worker exposure assessment leads to an effective dose of 1 mSv/year or more, the employer shall determine the collective means of protection to apply to reduce the risks associated with ionising radiation to a level that is as low as reasonably achievable (Article R. 4451-18 of the Labour Code). As a last resort, the employer examines the personal protection means (Article R. 4451-56 of the Labour Code).

Whatever the case, even if the exposure assessment results in a dose below 1 mSv/year, the prevention action aiming to eliminate or reduce as far as reasonably possible the risks resulting from exposure of workers to ionising radiation constitutes a statutory obligation for the employer (Article R. 4451-5 of the Labour Code). The employer must always put in place radiation protection optimisation tools that are appropriate for the radiological risks.

[8] **Column (19) of Table A of Chapter 3.2 of the ADR indicates that the special provision S21 of Chapter 8.5 is applicable for all radioactive substances**

Prior to the carriage activity and with the aim of ensuring the radiological cleanliness of its premises, the carrier, the consignor or the consignee of the packages can design their facilities so as to avoid any contamination by radioactive substances, by means of retention trays for example, for storing unsealed sources [17].

Pursuant to Article R. 1333-15 of the Public Health Code, it is the duty of the person responsible for the nuclear activity to implement "*all the means within their competence and reasonably possible, given the current state of technical knowledge and the economic and societal factors, to achieve an optimal level of [...] protection of the public against ionising radiation associated with the exercise of their activity or a malicious act*".

The RPP must describe the measures taken to optimise the doses that could be received by workers and the public. Below are some examples of possible measures depending on the parameters that can be used for radiation protection (time, distance, shielding and general):

Time:

- automate the measuring systems to limit the time operators spend near packages;
- reduce the loading and unloading times;
- arrange the work schedules to minimise the doses for the personnel, for example by rotating the personnel so that the jobs involving the highest doses are not always carried out by the same operators;
- divide long hauls into several hauls with changes of driver and temporary storage if necessary between two hauls;
- acquire a motorway toll payment tag to reduce the stopping times at motorway tolls;
- look for the main roads with the fewest traffic jams.

Distance:

- apply appropriate segregation distances between the packages and the workers or the public (possibly greater than those imposed by the regulations);
- prepare the documents as far away from the radioactive substance packages as possible;
- use distancing means (e.g. a pole) to take the dosimetric measurements while remaining as far away from the packages as possible;
- take the measurements from a distance appropriate for the external exposure risks induced by the source, while gradually approaching the source;
- optimise the way in which the packages are arranged in the vehicle so as to maximise the distance between the packages and the driver's cab, and place the packages with the lowest transport index (TI) in front of the packages with high TI to form a shield;
- use equipment to maintain a distance between the personnel and the packages when handling them (handling cart or trolley for example, possibly with lead shields).

Shield:

- use protective devices, such as lead shields for gamma radiation, between the driver's cab and the packages (on condition that this is compatible with the regulations governing the use of road vehicles).

As a general rule:

- define specific instructions for the storage, loading, unloading and securing packages with high transport index (TI) numbers;

- restrict the access of workers and the public to package storage areas, particularly those with the highest dose rates;
- wear appropriate personal protective equipment:
    - wear gloves, for example, when handling packages presenting contamination risks (unsealed sources),
    - or lead aprons for gamma radiation, for example, if exposed to packages with high TI numbers;
- define the itineraries to minimise exposure of workers and the public (bypassing densely populated areas, minimising driving time, parking vehicles in areas away from the public and workers, delivering high TI packages in priority when making deliveries to several customers along the route, etc.).

As part of the quality management system (see chapter 3.8 of this guide), experience feedback must be taken into account to assess the effectiveness of the optimisation measures, and improve them if necessary. This should more specifically lead to deeper reflection on how to optimise the exposure of the company's most exposed workers.

3.5.3. Classification of workers

The category A or B classification of workers liable to be exposed to ionising radiation concerns above all the workers whose individual assessment (see chapter 3.4.4. of this guide) leads to exposure exceeding 1 mSv/year. The radiation protection advisor informs the employer on this subject (Article R. 4451-123 of the Labour Code).

The employer communicates the prior individual assessment to the occupational physician when proposing a worker classification.

To classify a worker in either category A or B, the individual assessment has to be compared with the limits indicated in Article R. 4451-57 of the Labour Code.

Labour Code

Article R. 4451-57

I.- In view of the dose assessed in application of 4° of Article R. 4451-53, the employer classifies:
1° In category A, any worker who is liable to receive, in the course of twelve consecutive months, an effective dose exceeding 6 millisieverts or an equivalent dose exceeding 150 millisieverts to the skin or the extremities;
2° In category B, any other worker who is liable to receive:
a) An effective dose exceeding 1 millisievert;
b) An equivalent dose exceeding 15 millisieverts for the lens of the eye or 50 millisieverts for the skin and extremities.

II.- The employer obtains the occupational physician's opinion on the classification.
The employer updates this classification as necessary in view, more specifically, of the medical fitness opinion mentioned in Article R. 4624-25, the work conditions and the results of worker exposure monitoring.

A pregnant woman may not be classified in category A (Article D. 4152-6 of the Labour Code). A young worker aged between 16 and 18 may be classified in category B by way of derogation (Article D. 4153-21).

The worker classification determines the conditions of informing and training in radiation protection (chapter 3.7), the monitoring of individual exposure (chapter 3.5.4) and the tightened individual health monitoring (chapter 3.5.5) of the workers. The following table summarises these conditions according to the worker classification. The applicable measures are set out in detail in the referenced chapters.

Worker status	Informing / Training (§ 3.7)	Monitoring individual exposure (chapter 3.5.4)	Maximum interval for tightened individual health monitoring (§ 3.5.5)
Category A	Informing and training	■ Passive dosimetry ■ Active dosimetry in controlled, extremity or operation areas	1 year
Category B			4 years 2 years for the intermediate medical check-up
Not classified	Informing	■ Active dosimetry in controlled, extremity or operation areas ■ Appropriate dosimetry in the other areas	/

3.5.4. Monitoring of individual exposure of the workers

Classified workers must be subject to appropriate individual exposure monitoring (Article R. 4451-64 of the Labour Code).

The individual dosimetric monitoring for external exposure is carried out using personal passive dosimeters.

The additional use of an active dosimeter is a good practice that ASN recommends applying when the predicted doses for a transport operation are high. An active dosimeter is an electronic device equipped with alarms which measures the level of external exposure of the worker in real time. It therefore allows the early detection of abnormally high exposure, more specifically by setting the alarm thresholds.

Article R. 4451-33 of the Labour Code stipulates that in controlled areas, extremity areas or operation areas, all workers, classified or not, must be equipped with an active dosimeter.

The active dosimeter can be supplied by a user company to the workers of an outside contractor, subject to a formalised agreement between the two companies in accordance with the provisions of Article R. 4451-35 of the Labour Code. Take the case, for example, of a driver loading or unloading packages in a controlled zone, who must be provided with an active dosimeter by either his/her employer or, if there is an agreement, by the consignor or consignee company.

In the case of a non-classified worker accessing a delimited area in accordance with Article R. 4451-64, the employer must ensure by appropriate means that the worker's exposure remains below the limits applicable to a worker classified in category B (see limits in chapter 3.5.3 of this guide):

- In a controlled area, extremity area or operation area, by means of an active dosimeter.
- In any other area, such as a monitored area, the appropriate means can be the wearing of a personal active or passive dosimeter, the wearing of a dosimeter by one worker for an entire group of people, or an ambient radiological measurement with a radiation meter for example. These means must allow the exposure of the workers to be assessed.

The individual monitoring of external exposure with passive or active dosimeters must be adapted [11] :

- to the characteristics of the ionising radiation to which the workers are liable to be exposed (X-rays, gamma, beta or neutron radiation), particularly the energy and intensity of the radiation,
- and to the conditions of exposure, as regards where they are worn:
    - on the chest or, if this is impossible, at the waist, to evaluate the "whole body" dose;
    - as close as possible to the exposed organ or tissue, to assess the equivalent doses (for example, on the wrist or using a ring dosimeter for the extremities).

In the case of internal exposure, monitoring is ensured by contamination measurements that can be direct (whole body radiation measurements) or indirect (radiotoxicological analyses).

The provisions of the Order [11] indicate in particular the conditions for wearing passive dosimeters (Appendix I of the Order) and active dosimeters (Appendix III), and for monitoring internal exposure (Appendix II).

Whatever the mode of exposure (internal or external), dosimetric monitoring is ensured by accredited organisations (Article R. 4451-65). This individual dosimetric monitoring can also be ensured by IRSN (French Institute for Radiation Protection and Nuclear Safety) in application of 2° of Article R. 4451-134.

3.5.5. Tightened individual monitoring of the health of workers

Tightened individual health monitoring is applied for workers classified in category A or B (Article R. 4451-82 of the Labour Code).

The provisions relative to health monitoring are applicable to independent workers who organise their medical monitoring under the same conditions as employees. Non-salaried workers shall therefore take the necessary measures to benefit from appropriate medical monitoring.

Before being assigned to the job, each worker, classified or not, must have undergone a medical fitness check-up giving rise to the issuing of a medical fitness notice (Article L. 4624-2 of the Labour Code).

Workers classified in category A have an annual medical fitness check-up.

After undergoing the medical fitness check-up, category B workers get a check-up renewal by the occupational physician after a period determined by the latter, but which cannot exceed four years. An intermediate check-up is performed by a health professional no later than two years after the check-up with the occupational physician.

Labour Code

Article R. 4451-82

The tightened individual monitoring of workers classified within the meaning of Article R. 4451-57 [...] is carried out under the conditions stipulated in Articles R. 4624-22 to R. 4624-28.

For a category A worker, the medical check-up mentioned in Article R. 4624-28 is renewed each year. The intermediate check-up mentioned in the same article is not required.

Articles R. 4451-85 et seq. indicate the particular conditions applicable to basic nuclear installations, and notably the monitoring of workers employed by outside contractors and temporary work agencies.

3.6. Verifications of the surface contamination and the level of external exposure of the packages and means of transport

3.6.1. Internal checks provided for in the Public Health Code

Article R. 1333-15 of the Public Health Code imposes the conducting of checks within the company. The dose rate and contamination checks performed under the Labour Code and the ADR (see following chapters, 3.6.2 and 3.6.3 respectively) on the packages and the means of transport, and the verifications of the RPP effectiveness (see chapter 3.8) satisfy the provisions of this article on condition that the measuring instruments used for these checks are periodically calibrated and verified.

Public Health Code

Extract of Article R. 1333-15

[...]S/he [the person responsible for the nuclear activity] also implements an internal check and appropriate measurement and assessment procedures to ensure compliance with the applicable measures in terms of protection against ionising radiation linked to the exercise of their activity or to a malicious act.

S/he checks the effectiveness and maintains the technical devices provided for this purpose, receives and periodically calibrates the measuring instruments and checks that they are in good condition and are used correctly. [...]

3.6.2. Periodic verifications provided for by the Labour Code

The provisions of Articles R. 4451-40 to R. 4451-51 of the Labour Code set out the conditions for carrying out the "verifications", particularly of the means of transport used for the carriage of radioactive substances.

These verifications take the form of an initial verification followed by periodic verifications performed or supervised by a radiation protection advisor.

Order 3.6.2 sets the conditions and, where appropriate, the frequency of the verifications and the content of the corresponding verification reports. Article 14 of this Order specifies the conditions of the verifications applicable to the means of transport. These verifications are planned to assess:

- the external exposure, particularly by making sure that no radioactive package has been forgotten and left inside the means of transport; and
- the surface contamination of the means of transport in order to check more specifically that the carriage of packages containing unsealed sources or effluents has not contaminated the means of transport.

The periodic verification (PV) of the means of transport required by Article 14 applies to all radioactive substance carriage operations. These provisions are complementary to the provisions specific to the transport of radioactive materials (notably ADR, class 7 and TMD Order). **They do not apply to the transported packages but only to the means of transport used on the public highway (or to the on-site transport systems in basic nuclear installations), whatever their mode (road, rail, maritime, inland waterway or air).**

A first periodic verification (PV) is carried out inside the empty means of transport, before it is first used to transport radioactive substances. The aim of this first verification is to check the radiological cleanliness of the means of transport. In practical terms, the measured values must remain limited to the background radiation.

The results of the subsequent verifications are to be compared with those obtained from this first verification.

These PVs are carried out at a frequency defined by the employer with the assistance of the radiation protection advisor, according to the frequency of the transport operations and the radiological risks. The verification frequency is to figure in the verifications programme required by Article 18 of the abovementioned Order [14].

The results of the PVs are recorded in a form that will allow them to be consulted over a period of at least ten years (Article R. 4451-49).

If the employer identifies a risk of surface contamination of the means of transport, particularly in the case of carriage of unsealed source or effluents, **the interval between two PVs must not exceed three months**. In this case, **the PV is carried out when the means transport is not carrying radioactive substances, i.e. when it contains no radioactive packages**. This allows a conclusive check that the means of transport is effectively not contaminated. If contamination is suspected, for example following a traffic incident, the verification is carried out immediately after unloading the packages.

If the transport of radioactive substances is stopped for more than three months, it is necessary to perform:

- a last verification in the means of transport immediately after the last transport operation preceding the stopping of operations, or
- a verification before resuming radioactive substance transport operations.

With regard to the external exposure risk, it is recommended to set an interval between PVs that does not exceed one year.

For all the periodic verifications, the employer provides the radiation protection advisor with the necessary means and information (Article 19 of the Order of 23 October 2020 [14]).

Order of 23 October 2020 amended [14]

Article 18

The employer, with the guidance of the radiation protection advisor, establishes a verification programme that is reassessed as and when necessary.
The employer records this verification programme in an internal document and makes it accessible to the competent inspection agents and to the social and economic committee or, failing this, to the competent employee mentioned in Article L. 4644-1 of the Labour Code.

Article 19

The employer makes the necessary means and information available to the person tasked with the verifications. The employer ensures the presence of the personnel required to perform the verifications.

Furthermore, Article 17 of the Order [14] introduces provisions regarding the calibration and verification of correct operation of the radiation protection instrumentation used for the PVs.

Order of 23 October 2020 amended [14]

Article 17

The calibration, calibration verification and functional verification of the radiation protection instrumentation provided for in Article R. 4451-48 of the Labour Code are carried out under the conditions defined in this Article.
I. – The functional verification provided for in I. of Article R. 4451-48 of the Labour Code concerns the characteristics of the measuring instrument. It comprises:
1° A verification by the employer on reception of the equipment to check that the measuring instrument is appropriate for the measurement range(s) for which it is used and, if applicable, to check the consistency of the background of the instrument;
2° A verification of the electrical power supply and the consistency of the measuring instrument's background before each use.
II. - The periodic verification of calibration provided for in II of Article R. 4451-48 of the Labour Code is carried out by the radiation protection advisor if s/he has the necessary skills and means or, failing this, by a third party organisation whose quality system is in conformity with the quality management standard and complies with the standards applicable to the calibration of ionising radiation detection devices.
The instruments are calibrated in the range(s) of quantities for which they are used.
The method and frequency of the calibration verification shall comply with the requirements defined by the employer as appropriate for the use made of the instrumentation and the recommendations of the manufacturer's instruction manual. The interval between two verifications shall not exceed one year. If a difference is observed during a verification, adjustment or calibration is carried out as required in accordance with the manufacturer's instructions.

3.6.3. Inspections provided for by the transport regulations

In order to verify that the level of contamination and the dose rates do not exceed the limits set by the regulations on the transport of radioactive substances, the ADR provides that controls be carried out on the packages, the vehicle and the equipment used for transport.

Prior to departure of the consignment, it is necessary to check compliance with the contamination and dose rate limits around the packages (see articles 4.1.9.1.2, 4.1.9.1.4 and 4.1.9.10 to 12 of the ADR) and the vehicles[9] (see article 7.5.11 CV 33 (3.3) and (3.5) of the ADR). The controls performed (radiological measurements or appropriate demonstrations) must be recorded under the quality management system required by Article 1.7.3.1 of the ADR (also see chapter 3.8).

[9] **The limits on vehicles indicated in the ADR are not applicable to transport by air or sea. Refer to the technical instructions of the ICAO [3] or to the IMDG code [4] for further information.**

Extracts from the ADR

2.2.7.2.4.1.2

A package containing radioactive materials may be classified as an excepted package provided that the dose rate at any point on its external surface does not exceed 5 µSv/h.

4.1.9.1.2

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; and
b) 0.4 Bq/cm^2 for the other alpha emitters.

These limits are applicable when averaged over any area of 300 cm^2 on any part of the surface.

4.1.9.1.4

Except as provided in 7.5.11, CV33, the level of non-fixed contamination on the external and internal surfaces of overpacks, containers and vehicles shall not exceed the limits specified in 4.1.9.1.2. This requirement does not apply to the internal surfaces of the containers used as packagings, whether loaded or empty.

4.1.9.1.10

Except for consignments under exclusive use[10], the transport index of any package or overpack shall not exceed 10 [...]

4.1.9.1.11

Except for packages and overpacks carried under exclusive use under the conditions specified in 7.5.11, CV33 (3.5) a), the maximum dose rate at any point on any external surface of a package or overpack shall not exceed 2 mSv/h.

4.1.9.1.12

The maximum dose rate at any point on any external surface of a package or overpack under exclusive use shall not exceed 10 mSv/h.

7.5.11 CV 33 (3.3)

Loading of containers and accumulation of packages, overpacks and containers shall be controlled as follows:

a) Except under the condition of exclusive use, and for consignments of LSA-I material, the total number of packages, overpacks and containers aboard a single vehicle shall be so limited that the total sum of the transport indexes aboard the vehicle does not exceed the values shown in Table D below;
b) The dose rate under routine conditions of transport shall not exceed 2 mSv/h at any point on the external surface and 0.1 mSv/h at 2 m from the external surface of the vehicle, except for consignments carried under exclusive use, for which the dose rate limits around the vehicle are set forth in (3.5) b) and c);
c) [...]

Table D: Transport Index limits for containers and vehicles not under exclusive use

Type of container or vehicle	Limit on total sum of transport indexes in a container or aboard a vehicle
Small container	50
Large container	50
Vehicle	50

7.5.11 CV 33 (3.5)

For consignments under exclusive use, the dose rate shall not exceed:

a) 10 mSv/h at any point on the external surface of any package or overpack and may only exceed 2 mSv/h provided that:
   i) the vehicle is equipped with an enclosure which, during routine conditions of carriage, prevents the access of unauthorized persons to the interior of the enclosure;
   ii) provisions are made to secure the package or overpack so that its position within the vehicle enclosure remains fixed during routine conditions of carriage, and
   iii) there is no loading or unloading during the shipment;

b) 2 mSv/h at any point on the outer surfaces of the vehicle, including the upper and lower surfaces, or, in the case of an open vehicle, at any point on the vertical planes projected from the outer edges of the vehicle, on the upper surface of the load, and on the lower external surface of the vehicle; and

c) 0.1 mSv/h at any point 2 m from the vertical planes represented by the outer lateral surfaces of the vehicle, or, if the load is carried in an open vehicle, at any point 2 m from the vertical planes projected from the outer edges of the vehicle.

Summary table of regulatory limits on dose rates					
	Limits on packages		Limits on vehicles (*valid for land transport only*)		
	In contact	At 1 m	In contact	At 2 m	Maximum transport index of load
Excepted packages	5 µSv/h	-	2 mSv/h	0.1 mSv/h	50
Packages not carried under exclusive use	2 mSv/h	0.1 mSv/h			50
Packages carried under exclusive use	10 mSv/h	No limit			No limit

(5.3) of 7.5.11 CV 33 of the ADR provides for a periodic check of the contamination of the equipment and vehicles used regularly for the carriage of radioactive substances. The frequency of these checks is determined by the company according to the probability of contamination and the consignments

[10] **Use by a single consignor of a vehicle or of a large container in respect of which all initial, intermediate and final loading and unloading is carried out in accordance with the instructions of the consignor or the consignee, when this required by the ADR.**

carried. This frequency must be indicated in the RPP. When handling or transporting spent fuel assemblies stored under water, there is a high risk of surface contamination of the equipment or vehicles used. It is recommended to set a higher verification frequency for the equipment and vehicles used for transporting these packages than for packages presenting lower radiation risks.

The ADR does not indicate precisely who must perform the checks, but they must be performed by competent persons who have received appropriate training (see section 1.3 and article 1.7.2.5 of the ADR).

The verifications carried out under the Labour Code can also serve as contamination checks on the means of transport required by the ADR, in terms of methodology and frequency (see chapter 3.6.2 of this guide). The applicable contamination thresholds are the levels indicated in the ADR.

For non-fixed contamination, the levels of vehicle surface contamination below which decontamination is not necessary are those given in article 4.1.9.1.2 of the ADR, that is to say:

- 4 Bq/cm^2 for gamma, beta and low-toxicity alpha emitters,
- 0.4 Bq/cm^2 for the other alpha emitters.

Furthermore, the dose rate due to fixed contamination shall not exceed 5 µSv/h (see Article 7.5.11 CV 33 (5.4) of the ADR).

The routine monitoring of contamination of the means of transport and the equipment is not required for sealed radioactive sources if it can be demonstrated that the risk of contamination is very low, which is the case in particular for special form[11] radioactive materials (gamma radiography devices, for example). This nevertheless assumes that no unforeseen event, incident or accident that could compromise the integrity of the source has arisen during transport operations.

Extracts from the ADR

7.5.11 CV 33 (5.3)

A vehicle and equipment used regularly for the carriage 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 carried.

7.5.11 CV 33 (5.4)

Except as provided in paragraph (5.5), any vehicle, or equipment or part thereof which has become contaminated above the limits specified in 4.1.9.1.2 in the course of carriage of radioactive material, or which shows a dose rate in excess of 5 µSv/h at the surface, shall be decontaminated as soon as possible by a qualified person and shall not be re-used unless the following conditions are fulfilled:

a) the non-fixed contamination shall not exceed the limits specified in 4.1.9.1.2;
b) the dose rate resulting from the fixed contamination shall not exceed 5 µSv/h at the surface.

Lastly, before a vehicle that has been used to transport radioactive substances can be used for other purposes, the carrier must be able to demonstrate that the contamination of the internal surfaces of the vehicle is as low as reasonably achievable under the principle of optimisation imposed by Article L. 1333-2 of the Public Health Code. ASN considers that to achieve this objective, it is necessary at least

[11] *Special form radioactive material* **(see 2.2.7.1.3 of the ADR): either an indispersible solid radioactive material, or a sealed capsule containing radioactive materials, and meeting the requirements defined in 2.2.7.2.3.3.**

to check that the internal surfaces of the vehicle are not contaminated (that is to say that the measured contamination levels must be below those set in Article 2.2.7.1.2 of the ADR, i.e. 0.4 Bq/cm2 for the gamma, beta and low-toxicity alpha emitters and 0.04 Bq/cm2 for the other alpha emitters). If the means of transport is transferred from one company to another, but always for the purpose of transporting radioactive substances, these limits can be multiplied by a factor of ten (Article 4.1.9.1.2 of the ADR) to achieve an acceptable level of radiological cleanliness.

3.7. Worker training

All workers, when they could be exposed to ionising radiation during a transport operation, shall be trained in radiation protection in order to know the characteristics of ionising radiation, the risks it presents, the ways of protecting themselves and other persons against them, and the regulatory provisions (see Article 1.7.2.5 of the ADR). This requirement also enables the radiation protection culture to be promoted within the company, which is a vital factor in keeping exposure levels as low as reasonably achievable.

The level of training must proportionate to the level of risk and the functions and responsibilities of the worker.

ADR

Article 1.7.2.5

Workers (see 7.5.11 CV 33 Note 3) shall be appropriately trained in 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.

Moreover, the measures to provide information and training in occupational health and safety provided by the Labour Code are essential for the effectiveness of the prevention of occupational risks. They are stepped up in the sectors where the risks are high, such as those exposed to ionising radiation.

On this account, the Labour Code stipulates that persons involved in transport operations and workers accessing delimited areas must receive appropriate training (Articles R. 4451-58 to R. 4451-63).

These measures supplement the training and general information on health and safety delivered to all workers (Articles L. 4141-1 et seq.).

Workers classified in category A or B receive complementary training in relation to the results of the assessment of their risk of exposure to ionising radiation, renewable whenever necessary and, whatever the case, at least every three years.

It is considered good practice for non-classified workers to have information refresher sessions at frequencies appropriate for the risks, or if there is a change in the company's activities.

The information and training sessions are organised under the responsibility of the employer. The radiation protection advisor contributes to the defining and implementation of the sessions (Article R. 4451-123).

The information or training sessions required under the Labour Code are more stringent that the training required under the ADR. **It is therefore considered that following the radiation protection**

information or training sessions under the Labour Code fulfils the obligations of Article 1.7.2.5 of the ADR.

Labour Code

Article R. 4451-58

I.- The employer makes sure that appropriate information is provided to each worker:
1° Accessing zones delimited under Article R. 4451-24 and R. 4451-28;
2° Involved in radioactive substance transport operations;
3° Belonging to air crew on board aircraft and spacecraft;
4° Working in a situation of long-term exposure resulting from a radiological emergency situation.

II.- Workers subject to personal dosimetry monitoring within the meaning of I of Article R. 4451-64 receive training as appropriate for the results of the risk assessment carried out in accordance with section 4 of this chapter.

III.– The information and training provided focus in particular on:
1° The characteristics of ionising radiation;
2° The adverse health effects that can result from exposure to ionising radiation, if applicable, the impact of smoking if exposed to radon;
3° The potentially harmful effects of exposure of the embryo to ionising radiation, particularly at the beginning of pregnancy, and on the unborn child and the need to give notification of pregnancy as early as possible;
4° The name and contact details of the radiation protection advisor;
5° The measures taken in application of this chapter with a view to eliminating or reducing the risks linked to ionising radiation;
6° The conditions of access to the delimited areas under this chapter;
7° The specific rules established for pregnant or nursing women, workers aged under 18 years, workers on limited-term contracts and temporary workers;
8° The methods of monitoring individual exposure and accessing the dosimetric results;
9° What to do in the event of an accident or incident;
10° The specific rules relating to a radiological emergency situation;
11° If applicable, the aspects relative to safety and the possible consequences of loss of adequate control of high-activity sealed sources as defined in Appendix 13.7 referred to in Article R. 1333-1 of the Public Health Code.

[…]

Article R. 4451-59

The worker training mentioned in II of Article R. 4451-58 is taken charge of by the employer and renewed at least every three years.

The regulations also provide that workers must receive training in line with their responsibilities, focusing on the regulatory requirements that concern them and safety in general, in accordance with the procedures introduced in paragraph 1.3 of the ADR. On this account they shall, among other things, be trained in the management of accident situations (see ASN Guide No. 17 [19]), and receive training or appropriate information as provided for in Article R. 4451-58 of the Labour Code.

The employer must ensure the traceability of training course attendance. This tracking can be included in the RPP [17].

3.8. Quality management system (quality assurance)

This chapter of the RPP shall indicate the way in which the requirements of the company's management system are applied to the RPP.

Implementation of the RPP shall meet the formalisation and traceability requirements of the quality management system that is required for any transport operation (see Article 1.7.3 of the ADR), which can be used to ensure compliance with the regulatory requirements. This applies in particular to the results of the various checks or assessments that must be carried out.

ADR

Article 1.7.3

A management system based on international, national or other standards acceptable to the competent authority shall be established and implemented for all activities within the scope of ADR, as identified in 1.7.1.3, to ensure compliance with the applicable provisions of the ADR. Certification that the design specification has been fully implemented shall be available to the competent authority. The manufacturer, consignor or user shall be prepared:

a) To provide facilities for inspection during manufacture and use; and

b) To demonstrate compliance with ADR to the competent authority.

Where competent authority approval is required, such approval shall take into account and be contingent upon the adequacy of the management system.

Under the quality management system, the RPP effectiveness shall be assessed more specifically on the basis of an experience feedback analysis and periodic reviews. The quality management system shall therefore provide for such reviews and specify their scope such that they cover all the areas addressed in the RPP and are held at appropriate frequencies for the risks and for the particularities of the company. This also helps to ensure compliance with the provisions of Article R. 1333-15 of the Public Health Code which provides for the implementation of controls within the company to ensure compliance with the radiation protection provisions (see chapter 3.6.1).

Whatever the case, the quality management system must guarantee the existence of continuous improvement processes based on the acquisition and analysis of experience feedback and the periodic reviews. The dates of RPP revisions, the results of the various measurements taken and the measuring instrument calibrations and verifications must be conserved.

The **quality management system** shall provide for the RPP:

- to be revised at each major change that could impact the radiation protection of the workers or the public on account of the transport activities (also see section 3.4.3 of this guide);
- to undergo a periodic review to ascertain that its content remains relevant and up to date, particularly with regard to lessons learned from experience. The frequency of this review is to be determined by the company, but should be consistent with the frequency of the review of the doses received by the workers, planned at least once a year (see section 3.4.3).

4. OTHER REGULATORY OBLIGATIONS

4.1. Radiation protection advisors

4.1.1. The radiation protection adviser appointed under the Labour Code

The employer sets up a radiation protection organisation (Article R. 4451-111 of the Labour Code) and appoints a radiation protection advisor (RPA) (Article R. 4451-112), after consulting the social and economic committee (CSE), when at least one of the following three criteria is satisfied:

- workers are classified (category A or B) within the meaning of Article R. 4451-57;
- at least one area has been delimited under the conditions laid down in Articles R. 4451-22 and R. 4451-28;
- initial or periodic verifications are required under Articles R. 4451-40 et seq.

The CSE must also be consulted if this organisation undergoes a significant change.

The appointing of a radiation protection advisor (RPA) is of major importance for the organisation of radiation protection (Articles R. 4451-111 to R. 4451-126). The RPA advises the employer on matters concerning radiation protection. Apart from their advisory duties, the RPA participates in the implementation of the provisions to protect the health and safety of the workers. The duties of the RPA are laid down in Articles R. 4451-122 to R. 4451-124 of the Labour Code.

The radiation protection adviser may be:

- either a physical person internal to the company designated "Radiation Protection Expert-Officer (RPE-O), whose competence is attested by a certificate issued by a certified organisation after completing a specific training course,
- or a "Radiation Protection Organisation" (RP Organisation), whose competence is attested by certification.

Within a given company, the duties of RPA can be divided between several RPE-Os, who in this case are grouped within an internal entity (Article R. 4451-114). The employer can also divide these duties between RPE-Os and an RP Organisation. The allocation of duties is defined by the employer as part of its organisation of radiation protection.

In accordance with Article R. 4451-118, the employer puts down in writing the conditions of exercise of the RPA's defined duties, indicating the times allocated to these duties and the means available to the RPA to fulfil them.

In the BNIs[12], an organisation based on one or more "Radiation Protection Skills Centres" fulfils the functions of radiation protection advisor (Article R. 4451-113 of the Labour code and II of Article R. 1333-18 of the Public Health Code).

[12] **With the exception of BNIs using only sealed radioactive sources, of BNIs comprising an accelerator as defined in Article R. 593-3 of the Environment Code, and the outside contractors working in BNIs.**

Labour Code

Article R. 4451-112

The employer appoints at least one radiation protection advisor to implement the prevention measures and means provided for in this chapter. This advisor is:
1° Either a physical person called "radiation protection expert-officer", who is an employee of the site or, failing this, of the company;
2° Or a legal person, called "radiation protection organisation".

Article R. 4451-113

I.- In a facility comprising a basic nuclear installation, the employer sets up a radiation protection skills centre tasked with giving advice on radiation protection.
The following are not concerned by the provisions of the first paragraph:
1° Facilities that only use sealed radioactive sources and those comprising an accelerator as defined in Article R. 593-3 of the Environment Code;
2° The outside contractors working in the facilities mentioned in the first paragraph.
[...]

Article R. 4451-123

The radiation protection adviser:
1° Gives advice concerning:
a) The design, modification or fitting out of the work places and the safety systems intended to prevent the risks associated with ionising radiation;
b) The schedules of work equipment and work place verifications provided for in section 6 of this chapter, and the methods of monitoring individual exposure of the workers;
c) The appropriate instrumentation for the verifications mentioned in b) and the active dosimeters;
d) The worker classification procedures provided for in Article R. 4451-57;
e) The delimiting methods and conditions of access to the areas mentioned in Articles R. 4451-24 and R. 4451-28;
f) The preparation for and response to radiological emergency situations provided for in section 12 of this chapter;
2° Provides their assistance with regard to:
a) The risk assessment provided for in Article R. 4451-13 et seq.;
b) The defining and implementation of the provisions relative to the prevention measures and means referred to in section 5 of this chapter, particularly those concerning the defining of the dose constraints provided for in 1° of Article R. 4451-33 and the identification and delimiting of the areas provided for in Articles R. 4451-22 and R. 4451-26;
c) The defining and implementation of the provisions concerning the conditions of employment of workers provided for in section 7 of this chapter, particularly those concerning the individual assessment of risks associated with ionising radiation provided for in Article R. 4451-52, the personal protection measures provided for in Article R. 4451-56 and the informing and training of the workers in safety provided for in Articles R. 4451-58 and R. 4451-59;
d) The defining and implementation of measures relative to the individual exposure monitoring of workers provided for in section 9 of this chapter in collaboration with the occupational physician;
e) The coordination of the prevention measures concerning radiation protection within the meaning of Article R. 4511-5;

f) The development of procedures and means for decontaminating the work places that could be contaminated;
g) Investigation and analysis of the significant events mentioned in Article R. 4451-77;
3° Carry out or supervise:
a) The measurements provided for in Article R. 4451-15;
b) The checks of the effectiveness of the prevention means provided for in section 6 of this chapter, with the exception of those provided for in Articles R. 4451-40 and R. 4451-44.

Since the Order of 18 December 2019 [13] came into effect, any **RPE-O in the transport sector wishing to continue their duties must obtain an initial training certificate as a level-2 "industry" sector RPE-O, with the sealed or unsealed sources option, depending on the sources transported**.

There is no obligation for all the members of an RP Organisation to be RPE-Os. However, those working for a third party must have a RPE-O certificate. Article 17 of the abovementioned Order [13] indicates that the RP Organisation identifies and lists among the radiation protection advisors covered by its certification:

- the person(s) holding RPE-O certificates with advanced training working for a third party as specifically appointed radiation protection advisor(s) and who is/are in charge of all the RPE-O duties;
- the person(s) holding the appropriate RPE-O certificate for the level, sector and option concerned, working occasionally for a third party and in charge of certain RPE-O duties;
- but also the person(s) who coordinate(s) all the actions undertaken by the organisation and the specialised operators.

In a BNI, the members of the radiation protection skills centres do not need to hold an RPE-O certificate.

As of 1 January 2022, the employer can no longer call upon an external RPE-O to carry out the duties of the RPA, and the periodic verification of the means of transport in particular. The employer must appoint an RPE-O or an RP Organisation within its facility. For example, in the case of a loading or unloading operation, the head of the carrier company can no longer designate the RPE-O of the destination company on its own behalf through a formalised agreement between the two companies.

Article R. 4451-125 of the Labour Code defines the methods of certificating the advisor depending on whether it is an RPE-O, an RP Organisation or a radiation protection skills centre.

For the RP Organisation, a certification delivered by an accredited certificating organisation (OCA), accredited by the French accreditation committee (Cofrac), or by any other organisation mentioned in Article R. 4724-1 of the Labour Code is required. The list of RP Organisations is available on the website of each OCA. Each OCA draws up a table, consultable on line, of the certifications it has delivered, indicating the names and addresses of the RP Organisations with their dates of certification or certification withdrawal. The list of OCAs can be consulted on the "ionising radiation / radiation protection" page of the Ministry for Labour's website[13].

[13] **https://travail-emploi.gouv.fr/sante-au-travail/prevention-des-risques-pour-la-sante-au-travail/article/rayonnements-ionisants-ri-et-radioprotection-rp-des-travailleurs**

4.1.2. The radiation protection adviser appointed under the Labour Code

Under Article R. 1333-18 of the Public Health Code, the person/entity responsible for a nuclear activity must appoint an RPA. The duties of one or more RPE-O(s) internal to the facility, the RP Organisation or the radiation protection skills centre in the BNIs, apply to the questions concerning the protection of the public and the environment against ionising radiation, which forms the subject of provisions introduced in Article R. 1333-19 of the Public Health Code.

The RPA appointed by the employer under the Labour Code may be appointed by the person responsible for the nuclear activity under the Public Health Code or the licensee of installations classified for protection of the environment (ICPE) under the Environment Code. If they concern the same subject, the advice given by the RPA under the Public Health Code can be considered as advice under the Labour Code (Article R. 1333-19 of the Public Health Code).

Public Health Code

Article R. 1333-18

I. – The person/entity responsible for a nuclear activity appoints at least one radiation protection advisor to assist and advise them in all matters relating to radiation protection of the public and the environment, and in questions relating to the collective protection measures for workers with respect to ionising radiation mentioned in Article L. 1333-27.
This advisor is:
1° Either a physical person, called: "radiation protection expert-officer" (RPE-O) chosen from the personnel of the facility or facilities in which the nuclear activity is exercised;
2° Or a legal person, called: "radiation protection organisation".
II.– For the basic nuclear installations defined in Article L. 593-2 of the Environment Code, the function of radiation protection advisor is entrusted to the organisation mentioned in Article 63-6 of Decree 2007- 1557 of 2 November 2007 relative to basic nuclear installations and oversight of the transport of radioactive substances with regard to nuclear safety.
III.– The person/entity responsible for the nuclear activity provides the RPA with the means necessary for the exercise of their duties. If several RPAs are appointed, their respective duties are specified by the person/entity responsible for the nuclear activity.

Article R. 1333-19

I.-Depending on the nature of the activity exercised, the RPA:
1° Gives advice concerning:
a) The prior examination of the plans of the facilities, from the radiation protection aspect, particularly with regard to the interests mentioned in Article L. 1333-7;
b) The periodic verification of the effectiveness of the internal check of the procedures and technical devices mentioned in Article R. 1333-15;
c) Reception and inspection, from the radiation protection aspect, of new or modified sources of ionising radiation;
d) Reception and periodic calibration of the measuring instruments and the periodic check of their operation and correct use;
e) Optimising radiation protection and establishing appropriate dose constraints;
f) Defining the quality assurance system put in place;
g) Defining of the programme of radiological monitoring of effluents and the environment;
h) Defining the radioactive waste management procedures;
i) Defining the measures relative to the prevention of the significant events mentioned in Article R. 1333-21, the investigations and analyses concerning these events and defining corrective actions;
j) Preparation for the radiological emergency situations mentioned in Article L. 1333-3 and the emergency response;
k) Preparation of appropriate documentation, particularly regarding the prior risks assessment, and written procedures;
2° Carries out or supervises implementation of the radiation protection measures mentioned in 1°.
II.-The radiation protection advisor records the advice mentioned in 1° of I in a form allowing its consultation for a period of at least ten years. […]

The training and certification requirements for an RPE-O or an RP Organisation under the Public Health Code are identical to those required under the Labour Code (Article R. 1333-20 of the Public Health Code).

4.2. The transport safety advisor (TSA)

In application of Article 1.8.3.1 of the ADR, of the RID and of the ADN, companies involved in land transport (by road, rail or inland waterways) as packer, loader, carrier or unloader, must also appoint a transport safety advisor (TSA).

ADR

Article 1.8.3.1

Each undertaking, the activities of which include the consigning or the carriage of dangerous goods by road, or the related packing, loading, filling or unloading shall appoint one or more safety advisers for the carriage of dangerous goods, responsible for helping to prevent the risks inherent in such activities with regard to persons, property and the environment.

Article 6 of the "TMD" Order [9] indicates the exemptions. Companies that only carry out transport operations by air or sea[14] are not subject to this obligation.

The TSA must hold a certificate covering class 7 (radioactive materials) and the modes of land transport used (road, rail and inland waterways), delivered by an approved body. The function of TSA can be fulfilled by any person in the company (including the head of the company) or by a person external to the company, provided that this person is effectively capable of fulfilling the tasks of advisor.

The TSA - the company's expert in the safety of transport operations, and the RPE-O - the expert in occupational radiation protection reporting to the employer, have specific and separate skills. Their training and their appointment meet different requirements. Consequently, one cannot substitute for the other. Collaboration between the RPE-O and the TSA is nevertheless essential. Furthermore, the two functions can be fulfilled by the same person.

4.3. Delimitation and signalling of monitored and controlled areas given the exposure to ionising radiation (zoning)

Any area in which the workers are liable to be exposed to levels of ionising radiation exceeding an effective whole body dose of 80 µSv per month or, for the extremities or the skin, an equivalent dose of 4 mSv per month, must be set up as delimited zones with appropriate signalling (Article R. 4451-22 et seq. of the Labour Code). This procedure is called "zoning".

Instruction DGT/ASN/2018/229

The provisions concerning the delimiting of zones are applicable to the carriage of radioactive substances within a facility, its annexes or worksites.

[14] **Air transport is taken as meaning any transport operation on an airport platform and any carriage operation by air. Maritime transport is taken as meaning only the carriage operation that is actually by sea.**

Thus, the phases of package loading onto or unloading from a conveyance, modification of a shipment, transhipment or temporary parking within the perimeter of a facility or its annexes can lead to the creation of a zone, depending on the characteristics of the packages carried.

If such phases are carried out on an occasional basis, the package can be considered to be a mobile device and be subject to the corresponding delimitation.

On the other hand, all the radioactive substance transport operations carried out on the public highway, which come under the Order of 29 May 2009 amended on the land transport of dangerous goods, remain exempted from the radiological zoning obligation within the meaning of the Labour Code.

Appendix 1

GLOSSARY

Public Health Code (Appendix 13-7)

Absorbed, equivalent and effective doses

Absorbed dose (D): energy absorbed per unit mass:

$D = dE/dm$

where:

- dE is the average energy communicated by the ionising radiation to the matter in a specified volume;
- dm is the mass of matter contained in this specified volume.

The term "absorbed dose" designates the average dose received by a tissue or organ. The absorbed dose unit is the gray (Gy).

Equivalent dose (H_T)**:** dose absorbed by the tissue or organ T, weighted according to the type and energy of the radiation R. It is given by the formula:

$H_{T,R} = w_R D_{T,R}$

where:

- $D_{T,R}$ is the average dose of radiation R absorbed by the organ or tissue T;
- w_R is the weighting factor for the radiation R.

When the radiation field comprises radiations of types and energies corresponding to different values of w_R the total equivalent dose H_T is given by the formula:

H_T = Sum of $w_R D_{T,R}$

The appropriate values of w_R are laid down in the order mentioned in Article R. 1333-24 (see Order of 1 September 2003 defining the methods of calculating the effective doses and equivalent doses resulting from the exposure of persons to ionising radiation [8]). The equivalent dose unit is the sievert (Sv).

Effective dose (**E**)**:** sum of the weighted equivalent doses delivered to the various tissues and organs of the body further to internal and external exposure. It is defined by the formula:

E = Sum $w_T H_T$ = Sum w_T Sum $w_R D_{T,R}$ where:

$D_{T,R}$ is the average dose of radiation R absorbed by the organ or tissue T;
– w_R is the weighting factor for the radiation R;
– w_T is the weighting factor for the tissue or organ T.

The appropriate values of w_T and w_R are set in the order mentioned in Article R. 1333-24 [8]. The effective dose unit is the sievert (Sv)

Exposure

Exposure: the fact of being exposed to ionising radiation.

Terms used:

- **External** exposure: exposure resulting from ionising radiation sources situated outside the organism;
- **Internal** exposure: exposure resulting from ionising radiation sources situated inside the organism;
- **Total** exposure: sum of the external and internal exposure.

Source of ionising radiation

Source of ionising radiation: entity liable to cause exposure, for example by emitting ionising radiation or releasing radioactive substances.

Note: With regard to the definition of the terms "radioactive substance", "radioactive material" and "radioactive waste", Appendix 13-7 of the Public Health Code refers to Article L. 542-1-1 of the Environment Code.

Environment Code

Radioactive substances

Environment Code

Article L. 542-1-11

[...]
A radioactive substance is a substance containing natural or artificial radionuclides, the activity or concentration of which justifies radiation protection monitoring.
[...]

In the "transport" regulations (ADR [5] and the TMD Order [9]), different terms are used to designate the same object. As these regulations do not distinguish materials from waste, it uses the term "radioactive materials (see below) to designate radioactive substances. In this guide we understand the term "radioactive substance" to mean "radioactive material" and vice versa.

Modal transport regulations

Radioactive materials

Article 2 of the TMD Order [9] refers to Article 2.2.7.1.1 of the ADR [5] for the definition of the term "radioactive materials".

ADR

Article 2.2.7.1.1

Radioactive material means any material containing radionuclides where both the activity concentration and the total activity in the consignment exceed the values specified in 2.2.7.2.2.1 to 2.2.7.2.2.6.

Paragraphs 2.2.7.2.2.1 to 2.2.7.2.2.6 of the ADR define the activity limits for which the unit is the becquerel (Bq) and the activity concentration limits for which the unit is the becquerel per gramme (Bq/g), beyond which the substances are subject to safety and security requirements defined in the ADR.

Means of transport / vehicle

Transport Code

Article D. 1431-1

[...]
3° "Means of transport": any motorised device used to transport people or goods by rail [...], road, inland waterway, sea or air;
[...]

In the modal regulations for road transport:

TMD Order

Article 2

[«]
"Vehicle" : any motor vehicle designed for road use, provided with at least four wheels and with a maximum design speed in excess of 25 km/h, as well as any trailer, with the exception of vehicles running on rails, mobile machines and agricultural and forestry tractors which do not exceed 40 km/h when carrying dangerous goods.
[...]

Appendix 2

ACRONYMS

ADN	European agreement concerning the international carriage of dangerous goods by inland waterways
ADR	European agreement concerning the international carriage of dangerous goods by road
IAEA	International Atomic Energy Agency
ALARA	*As low as reasonably achievable*
ASN	*Autorité de sûreté nucléaire* - French nuclear safety authority
RPA	Radiation Protection Advisor
CSE	Social and Economic Committee
TSA	Transport Safety Advisor
DUER	*Document Unique d'Evaluation des Risques* - Unified risks assessment document
IMDG	International Maritime Dangerous Goods Code
BNI	Basic Nuclear Installation
LSA	*Low Specific Activity*
ICAO	International Civil Aviation Organisation
OCA	Accredited Certificating Organisation
RP	Radiation Protection
RPE-O	Radiation Protection Expert-Officer
RPP	Radiation protection programme
RID	Regulation concerning the international carriage of dangerous goods by rail
SCO	*Surface Contaminated Object*
TI	Transport Index
PV	Periodic Verification

Appendix 3

EXAMPLES OF CALCULATIONS FOR ASSESSING THE DOSE RECEIVED BY WORKERS OR THE PUBLIC

Application of the inverse square law which states that the intensity of radiation is inversely proportional to the square of the distance from the source

In simple cases, the assessment of the dose rate for a source considered to be a point source emitting photons can for example be carried out using the law which states that the radiation intensity is inversely proportional to the square of the distance from the source:

$$I = I_0 \left(\frac{D_0}{D}\right)^2$$

I: dose rate at D metres from the source I_0: dose rate at D_0 metres from the source

This formula is valid for small-sized packages which can be likened to point sources (a source can considered a point source if the distance D between the source and the point in question is at least 5 times greater than the largest dimension of the source), and where the radiation contributing to the dose rate mainly comprises photons.

The dose rate at D_0 meters from the source can be obtained using the package transport index (a TI of 10 signifies that the dose rate I_0 equals 0.1 mSv/h at D_0= 1 m from the package).

Example 1: Administrative personnel of a freight transport company

- **Situation envisaged**

The storage area of a freight transport company is situated 10 metres from an office occupied by the administrative personnel.

The office has 20-cm thick concrete walls. This thickness reduces the dose rate by a factor of 1/50 (this is an arbitrary value taken as an example. In an RPP this value would have to be substantiated).

The packages are stored for 3 hours per day at the most and have a total transport index of 10, which corresponds to a dose rate of 0.1 mSv/h at 1 metre from the package.

- **Exposure calculation**

Considering that this is a point source (approximation that is acceptable for small packages, given the low risks), the attenuation factor due to the distance between the dose rate at d_0 = 1 m (the transport index) and the dose rate at d = 10 m (distance between the workers and the packages) can be considered to be the inversely proportional to the square of the distances, that is to say:

$$\left(\frac{d_0}{d}\right)^2 = \frac{1^2}{10^2} = \frac{1}{100}$$

Given the distance between the packages and the workers, and the thickness of the wall, the total reduction factor with respect to the dose rate at 1 m is:

1/100 ×1/50 = 1/5000

The dose rate in the office is therefore 100/5000 = 0.02 µSv/h when the packages are present, which - given the maximum duration of package presence of 3 hours per day - corresponds to 0.06 µSv/day.

If we assume a working year of 230 days, the effective dose will be 230 × 0.06 = 13.8 µSv.

Example 2: Driver transporting radiopharmaceuticals

- **Situation envisaged**

A driver transports two category III-Yellow packages at the most per journey.

The packages are loaded at the last minute in order to minimise the time they spend near the driver. Furthermore, they are loaded by another handler, not by the driver. The packages are positioned as far as possible from the driver's cab, which, given the type of vehicle, maintains a distance of 2 metres between the packages and the driver during the journey.

The carriage is not under exclusive use therefore the dose rate at 1 metre from each package is less than 0.1 mSv/h. However, to ensure a conservative approach, it is assumed that the dose rate of each package is maximal, that is to say 0.1 mSv/h at 1 m.

- **Exposure calculation**

Considering a point source and applying the inverse square law, we obtain an attenuation factor between the dose rates at 1 m and at 2 m equal to:

$\frac{1^2}{2^2} = \frac{1}{4}$.

The driver is therefore exposed to a dose of 0.1/4 = 0.025 mSv/h for each package, that is to say 2 × 0.025 = 0.05 mSv/h for the two packages together.

Assuming that the driver makes a journey of one hour per day, 230 days per year, the predicted annual dose received is 230 × 0.05 = 11.5 mSv.

Remark: In view of the predicted calculated exposure, the RPP should provide for technical or organisational means of reducing the driver's exposure. For example, placing a 3-mm thick lead shielding plate behind the driver's cab would reduce the dose by about 30% (in the case of packages containing fluorine 18), which would reduce the driver's predicted annual dose to 8 mSv.

Example 3: Dose received by a member of the public, exposure of a motorway toll attendant

- **Situation envisaged**

A carrier carries out weekly transport operations on the same given motorway section (to make deliveries to a hospital situated near that motorway, to gain access to an airport, etc.). The passage of the vehicle at the toll lasts 2 minutes on average. The toll attendant is situated 2 m from the load. It is considered that there is no shielding screen between the toll attendant and the load.

The dose rate at 2 m from the vehicle is the maximum authorised by the regulations in Article 7.5.11 CV33 (3.3) b) of ADR (0.1 mSv/h at 2 m).

- **Exposure calculation**

The employee is therefore exposed to 0.1 mSv/h x 2 min = 3.3 µSv at each passage of the vehicle.

Over one year, that employee, assuming conservatively that it is always the same person, is exposed to 174 µSv solely on account of this practice.

Remark: In view of the predicted exposure, the RPP should envisage optimising the dose received by this member of the public. Technical and organisational means for reducing the exposure of the toll attendant can still be envisaged (limitation of the activity of the packages, additional vehicle shielding, positioning the packages away from the wall of the vehicle to reduce the contact dose rate, etc.), or even using the electronic payment toll lanes to avoid exposing the toll attendant.

Appendix 4

EXAMPLE OF BIBLIOGRAPHIC STUDY

Table 2 of the IAEA Safety Guide TS-G-1.3 [17] gives the results of a study linking the doses received by workers to the transport indices of the handled packages.

	Maximum number of packages handled annually resulting in an individual occupational dose not exceeding 1 mSv/year	
Category of packages	Scenario: for each package, worker is located at 1 m for 30 min	Scenario: for each package, worker is located at contact for 5 min and at 1 m for 25 min
Category I-WHITE	4 000	1 600
Category II-YELLOW	200	40[a]
Category III-YELLOW	20	6[b]
Category III + exclusive use	0	0

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

Appendix 5

SEGREGATION DISTANCES REQUIRED BY THE MARITIME TRANSPORT REGULATIONS

IMDG Code

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 dose rates :

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 authorised to accompany such packages or overpacks.

7.1.4.5.18

The segregation requirements specified in 7.1.4.5.13 may be established in one of the following 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 dose rate 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 dose rate must be made and documented by a suitably qualified person.

Table 7.1.4.5.18 – *Class 7 – Radioactive material*

Segregation table for persons

Segregation distance of radioactive material from passengers and crew in metres				
Sum of transport indices (TI)	**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.

THE COLLECTION OF ASN GUIDES

TRANSPORT

No. 2
Transport of radioactive materials in airports

No. 7
Civil transport of radioactive packages or substances on the public highway

No. 17
Content of radioactive substance transport incident and accident management plans

No. 27
Stowage of radioactive packages, materials or objects for transportation

No. 29
Radiation protection in radioactive substance transport activities

No. 31
Notification procedures for events relating to the transport of radioactive substances

No. 34
Implementation of the regulatory requirements applicable to on-site transport operations

No. 44
Quality management system applicable to the transport of radioactive substances on public highways

List of the ASN Guides available on English on ***french-nuclear-safety.fr***

AUTORITÉ
DE SÛRETÉ
NUCLÉAIRE

15, rue Louis Lejeune
92120 Montrouge

Public Information Centre:
+33 1 46 16 40 16 • info@asn.fr

ASN regional divisions:
asn.fr/contact

french-nuclear-safety.fr