Technical Basis for the IAEA Regulations for the Safe Transport of Radioactive Material (TS-R-1)

Support for the IAEA project “Progress and Justification of the Technical Basis TS-R-1”

This draft addresses all but the Criticality Chapter and its associated appendixes

February 2013 extended draft by R.B. Pope

10 February 2013

DRAFT
NOTES PERTAINING TO THIS DRAFT

All citations to references are done on a chapter by chapter basis, as recommended by TRANSSC. Each citation in the text is highlighted in gray, e.g. [12].

It is noted that the reference citations are frequently not in sequence in each chapter because of the way in which the text was developed and then moved around. As a result, the references will ultimately need to be identified sequentially as they appear in the text. However, this task should only be undertaken when the text of the document is deemed by the Secretariat to be “final”.

The call-out of appendixes in the text is in **bold with yellow highlighting**.

In the lists of references in this draft, the availability of these documents is shown in brackets (i.e. ... { } ), in red. All efforts have been made to have as many as possible references included in electronic format, which will make them available on an IAEA “Sharepoint” website. When the document is available on Sharepoint, it is designated in this draft based on the individual who place that document on Sharepoint. For example, those documents identified with “RPXXX” were placed on the sharepoint site by R Pope; whereas “CBXXX” were placed on the sharepoint site by Chris Bajwa, and “DMXXX” were placed on the sharepoint site by Dennis Mennerdahl). Thus, the first reference cited in Chapter 1 is shown as {RP001}.

**Where references (e.g. TS-G-1.1, the 3rd reference in Chapter 1) are currently available on the IAEA website, their availability is not shown.**

Notes where additional attention is needed in the text is provided with **red text, bold, with yellow highlighting.**
FOREWORD

This report contains February 2013 draft version of a compilation of information with respect to the technical bases for the International Atomic Energy Agency (IAEA) “Regulations for the Safe Transport of Radioactive Material – 2012 Edition”, Specific Safety Standards No. SSR-6*. {{NOTE: it does not, at this time, include the chapter and associated appendixes and annexes relating to Prevention of Criticality.}}

The report is the culmination of an effort undertaken by the IAEA in the latter part of the first decade of the twenty-first century to develop comprehensive documentation on the bases for the technical requirements in the Regulations. In the opening remarks of TM-41001 (one of the meetings working on the development of the technical basis, which was convened in Vienna 14-18 March 2011), the following was noted:

“The Regulations for the safe transport of radioactive materials have been revised more than 10 times since its first publication in 1961. Member States and International Organizations have put lots of efforts, time and resources including human and financial resources. These efforts contribute to excellent safety record of transport of radioactive material over 50 years.

“Technical bases obtained from research, feedback, experience are the foundation of the regulations. They are of great value not only to the users but also to developers. Some approaches used in the early editions of the Transport Regulations have remained virtually unchanged up to the present day. They have proved to be sound.

“Currently these technical bases are stored in decentralized ways among Member States and international organizations. When long-serving experts retire, young professionals come or governments are reorganized, this valuable knowledge will face risk of loss. One of the purposes of this meeting is to collect, sort, transfer, and store these valuable knowledge for future use.

“In addition, easy access to technical bases could lead to better understanding of the regulations. That will facilitate the implementation of the Regulations."

This compilation is structured essentially to the format of the chapters in the Transport Regulations.

Finally, an extensive set of references were used in developing this technical basis. References are cited within each chapter and listed at the end of each chapter. The listing of references includes (at least in this draft version) the source of each reference (in red bracketed text) as available to the compiler when assembling this interim draft. This extensive use and listing of references, along with making as many of them available on a Share Point site at the Agency, goes a considerable way in satisfying the desire as noted in the opening comments to TM-41001 of providing “easy access to technical bases could lead to better understanding of the regulations. That will facilitate the implementation of the Regulations.” However, as can be seen, some of the referenced documents are only available to individual experts in hardcopy. To have them readily available to future generations, scanning of the documents and storing them electronically may be necessary.

* The IAEA Transport Regulations are under continuous review and are periodically revised. The Transport Regulations were first issued in 1961, and have been re-issued multiple times since. The latest edition is dated 2012. The various editions of the Transport Regulations (and similar various editions of supportive guidance documents) are cited, as appropriate, throughout this document.
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1. INTRODUCTION

1.1. Background

Beginning in 1957, the International Atomic Energy Agency (IAEA) was assigned the tasks of formulating regulations governing the transport of radioactive materials. As summarized in Appendix 1, since that time, the IAEA has vigorously pursued the development and maintenance of the Regulations for the Safe Transport of Radioactive Material, including cooperation and coordination with relevant international bodies responsible for ensuring safety of dangerous in transport.

The first edition of the Transport Regulations was issued in 1961 [1], and updates reflecting added knowledge, experience and technology have been issued periodically. The history of issuing the regulations and the supporting guidance and explanatory documents is shown in Table 1-1.

Beginning in 2002, the advisory and explanatory documents were combined into a single document.

The IAEA works closely with Member States, involved international organizations and interested non-governmental organizations with a view to having the resulting Regulations reflect a worldwide view which has led to a generally consistent application of the requirements by the States and international modal organizations. By periodically issuing the Transport Regulations, the IAEA is providing a comprehensive, internationally agreed, consensus set of recommended safety provisions for the transport of radioactive material. The provisions focus in part on a detailed set of criteria for ensuring safety during all phases of transport by all modes and during interim storage during transport.

The Transport Regulations are developed and maintained through a cooperative process involving Member States, international governmental organizations, and international non-governmental organizations. Currently (2012) this process involves at the IAEA the Secretariat, led specifically by the Transport Safety Unit; four IAEA safety standards committees, where focus for transport safety lies specifically with the Transport Safety Standards Committee (TRANSSC); and an oversight commission, known as the Commission on Safety Standards (CSS). Through this process, all Member States and the relevant governmental organizations have the opportunity to be actively involved in advancing the Transport Regulations. A similar but less robust oversight and advisory structure preceded the formation of TRANSSC, starting in 1977 with the IAEA Standing Advisory Group for the Safe Transport of Radioactive Material (SAGSTRAM).

Each edition of the Regulations is approved for publication by the IAEA Board of Governors.

This effort is now in its seventh decade. As shown in Table 1-1, fifteen revisions, amended editions, or supplements of the Regulations have been issued, and this effort is expected to continue beyond 2012. These revisions have been taking into account the world-wide experiences, new issues, new technologies, best practices, lessons-learned from their application, the demand for safer transport, and the need for harmonization. Problems, challenges and the demand for improvements drive the transport community to continuously review and revise the Regulations.

In the early part of the second decade of the Twenty-first Century, TRANSSC recognized that the scientific and technical heritage of these past several decades of development in transport safety needs to be assessed with a view to preserving the valuable knowledge involved in this extensive, long-term effort. This document represents the results of an effort undertaken by the IAEA to preserve the knowledge of the technical basis.
Table 1-1. History of issuing transport safety regulatory documents*

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** Notes on Certain Aspects of the Regulations

The development of this document involved a large number of experts, most of which had decades of experience in the development of the international Transport Regulations. Supporting this effort, the experts developed an extensive table that considered each paragraph in the Regulations and assessed whether they represented a requirement and how the technical basis for the requirement was (or maybe was not) established; and also developed a second table that lists a number of issues related to paragraph-related requirements, options and specifications. These two tables are not part of this document, but are available for use by and from the Secretariat.

The information and discussion contained in this document is based upon the 2012 edition of the Transport Regulations [2]. However, consideration was given to other features of earlier editions of the Regulations; where such considerations were deemed to be significant, those earlier regulatory recommendations are identified.
Generally every requirement in the Transport Regulations was developed on a technical basis, though often the basis was not adequately documented, and/or the basis exists in a decentralized manner in many Member States with mature programmes. This limits the access of users to the technical basis for the requirements. It was recognized by TRANSSC that broad access to the technical basis could lead to a better understanding of the Regulations; where sharing and pooling of knowledge can contribute, in many cases, to the development and innovation of methods for ensuring transport safety and could, concurrently, prevent unnecessary efforts by newly-involved personnel attempting to “re-invent the wheel”.

The 2012 edition of the Transport Regulations [2] is in the safety requirements category of the IAEA safety standards. Thus, the Regulations have to be consistent with the IAEA Safety Fundamentals [4] and with relevant general safety requirements, in particular the International Basic Safety Standards (BSS) [5]. A schematic view of the 2012 structure of the safety requirements is given in Appendix 2.

It is noted that, according to the 2012 edition of the Transport Regulations that the “These Regulations apply to the transport of radioactive material by all modes on land, water, or in the air, including transport that is incidental to the use of the radioactive material”. It further specifies that transport “comprises all operations and conditions associated with, and involved in, the movement of radioactive material; 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”. Thus, the Transport Regulations do not cover the physical movement of radioactive material from one place to another within a fixed facility.

1.2. Purpose

This purpose of this document is to provide a single, comprehensive source of information relative to preserving, as best as could be done in the 2011 / 2012 time frame, knowledge concerning the technical basis for the requirements set forth in the Transport Regulations. To the extent possible, the document looks back into historical documents to define the logic behind the requirements that were initially introduced into the Regulations, and how these requirements have changed with time.

1.3. Scope

To be developed.

1.4. Structure

To be developed.

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1 The Transport Regulations [2] are supplemented by a number of safety guides on how to comply with them. The most relevant safety guide with respect to the technical basis is IAEA-TS-G-1.1, Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material [3].
References for Chapter 1


2. GENERAL HISTORY

The Transport Regulations [1] are an IAEA safety standard, in the category specific safety requirements. The IAEA Transport Regulations serve as the basis for regulations for consistent regulatory actions at both the international and domestic level through application by international modal organizations, and by individual member states. As a result, they therefore have to be consistent with the Safety Fundamentals [3] and with the general safety requirements.

It must be noted that, according to the Transport Regulations, transport comprises all operations and conditions associated with, and involved in, the movement of radioactive material; 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.\(^3\)

The development of the Transport Regulations began as early as the 1940s; while the international effort began in the 1950s. The following summary of the general historical background is based, in part, on documents that were produced by Pope in 2004 [4, 5].

2.1. Early Efforts in the Development of International Regulations

In 1957, the Preparatory Commission of the IAEA [6] noted that the Agency might be able to obtain information on the work which has been done in, and consider the formulation of regulations governing the transport of radioactive materials, and discussed how the Agency might staff and organize this effort. It also suggested that an advisory panel might be appointed, ‘which might later be transformed into a standing committee’.

In response to this, the United Nations Economic and Social Council (ECOSOC) passed, in 1959, a resolution [7] that, among other things, requested the ‘Secretary General, in light of the relevant recommendations contained in the report of the Committee of Experts’, to continue the Committee of Experts, to explore ‘the possibility of finding mutually acceptable performance tests for outer packages for certain classes or groups of dangerous substances’, and—significantly—to "inform the International Atomic Energy Agency of the desire of the Council that the Agency be entrusted with the drafting of recommendations on the transport of radio-active substances”.

These recommendations have guided the IAEA throughout the development and maintenance of the Transport Regulations. Specifically, the IAEA has:

- formulated and periodically updates regulations governing the transport of radioactive material;
- formed a transport safety committee, which it transformed in the late 1970s into a standing committee. It was initially identified as the Standing Advisory Group on the Safe Transport of Radioactive Material (SAGSTRAM), which later transitioned into the Transport Safety Standards Advisory Committee (TRANSSAC), and was more recently renamed the Transport Safety Standards Committee (TRANSSC);
- developed performance tests for packages for radioactive materials; and

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\(^2\) The Transport Regulations are supplemented by a number of safety guides providing insight on how to comply with them. The most relevant safety guide with respect to the technical basis is IAEA-TS-G.1.1, Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material [2]. It is noted that, as of early 2012 when this chapter was developed, TS-G.1.1 was under review, and an updated revision is anticipated to be issued by the IAEA later in 2012 or early in 2013.

\(^3\) The definition used in the BSS is slightly different: the deliberate physical movement of radioactive material (other than that forming part of the means of propulsion) from one place to another.

\(^4\) Radioactive materials constitute one of nine classes of dangerous goods as defined by the United Nations Committee of Experts in the UN Model Regulations [8]. Radioactive materials are denoted as “Class 7”.

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• worked, and continues to work, in undertaking these tasks in consultation with other
concerned UN bodies, other international bodies and its own Member States.

Gibson and Messenger [9] provide an overview of what transpired at the IAEA in developing
the first Regulations for the Safe Transport of Radioactive Material [10]. Two panels of experts were
convened at the IAEA in 1959 for which the "recommendations made the two Panels were woven
into a single set of regulations and these were approved by the Agency Board of Governors at their
meeting on the 13th September 1960". The Board of Governors "recommended them to Member
States and other international organisations as a basis for their own regulations"; and also
propose to have the UN Committee of Experts include the recommendations in their future
efforts on the transport of dangerous goods.

The previous efforts by a number of Member States in understanding the risks posed by
radioactive materials in transport and in developing guidelines and requirements at the
domestic level were instrumental in guiding the development of the 1961 edition of the
Transport Regulations. Three examples of these efforts follow.

2.1.1. Early Efforts in the United States (US)

George [11] provides insight into the formation of the United States (US) Bureau of Explosive
(BofE) in the early 1900’s, the initial efforts to control the transport of radioactive materials in
the US, and the early efforts to develop regulations for packaging of radioactive materials by the
US Interstate Commerce Commission (ICC). All of this served as one of the precursors to the
international regulations.

As early as 1944, the ICC was undertaking the establishment of regulations for the transport of
radioactive materials, and issued regulations as early as about 1946. In part, these regulations
initially required that shipments consisting of large quantities of radioactive materials be
shipped in containers approved by the BofE.

George included in his paper two examples of the early BofE permits. One of the permits [12],
which was for spent (irradiated) fuel elements, was issued in 1959. The other permit [13],
which was for other radioactive materials, was issued in 1962. Thus, these actions were
occurring concurrently with the international deliberations that were underway, leading to the
issuing of the IAEA Transport Regulations in 1961. Although some regulations had been
established, the focus was in part on protecting property in general and film specifically. George
noted that approvals of packagings would need to continue since "special types, sizes, and shapes
of containers" will be required for "to provide for larger quantity shipments than are presently
authorized". Thus, the permits that were used for providing safe transport of radioactive
materials in the US in these early days were very prescriptive (specifying how to design a
package rather than what must be accomplished in designing a package).

2.1.2. Early Efforts in the United Kingdom (UK)

Gibson and Messenger [9] reported that the carriage "of dangerous goods by sea in U.K.
registered ships, or in other ships which load or discharge in U.K. waters" was governed by a
general set of rules specified under the U.K Merchant Shipping Act of 1949; and guidance was
issued in the application of these general rules, including the addition of radioactive substances,
in 1957.

Experts from the U.K participated in the panels convened by the IAEA in 1959, and were
supportive of the provisions included in the 1961 edition of the IAEA Transport Regulations. In
June of 1961, the U.K. Radioactive Substances Advisory Committee recommended that the 1961
edition of the Transport Regulations [10] "be used as the basis for all U.K. regulations on this
subject, and the appropriate government departments were asked to proceed accordingly".
Gibson and Messenger reported that by December 1962, practical "regulations on the I.A.E.A. model thus exist in the U.K. for the carriage of radioactive materials by sea and by rail"; that compatible regulations were being produced for road transport; and that the IATA regulations were being used.

2.1.3. Early Efforts in Canada

Martin [14] reported that the Canadian Board of Transport Commissioners requirements for radioactive material packaging for rail transport was at that time the most comprehensive in Canada. Requirements for road transport were then controlled at a provincial level, and none of the provinces prescribed any packaging requirements; whereas the requirements for air transport were the regulations prescribed by IATA; and requirements for transport by ship were established by the Department of Transport. In addition, he reported that the Canadian Atomic Energy Control Board (CAECB) had, at that time, certain powers pertaining to radioactive material packaging. He illustrated that they had a “multitude of regulatory bodies that are concerned with the transportation of radioactive materials”.

The CAECB had issued a circular in 1960 that established requirements similar to the initial, i.e. 1961, edition of the IAEA Transport Regulations [10]. For example, he noted that (a) the “maximum credible accident” concept was employed, but (b) this limited container design to no more than a 20 ft (6.1 m) drop “on a solid floor”. However, the circular did not provide any specific requirement for resisting a fire environment, it simply specified that the “shell shall be fabricated from steel or other material equivalent in strength and fire resistance”.

Martin further reported that Canada had formed a committee to address a standardized set of package design requirements. This committee had concluded that “the general criteria of IAEA's Pamphlet Nos. 6 and 7 are satisfactory bases for drafting of uniform regulations”. Martin the elaborated on inadequacies the Committee has identified with the 1961 edition of the Transport Regulations, which included (a) the need to modify requirements for approvals of Type A and Type B package designs, and (b) the need to strengthen requirements for fissile materials. He concluded by stating that “...although our accident record is a favorable one, we cannot afford to relax our standards”.

2.2. Specific early efforts to improve the Transport Regulations

As work progressed in improving the Transport Regulations during those early years, many changes occurred. These changes included five key issues:

1. clearly specifying package design requirements;
2. developing the concept of different types of packages (e.g. Type A, and Type B packages);
3. eliminating the early provisions for applying the concept of a “maximum credible accident” to the package design requirements;
4. emphasizing that the Regulations address “what” was required to satisfy the regulatory requirements, not “how” those requirements were to be satisfied; and
5. establishing clarity in the Regulations and the interpretation thereof by specifying a set of definitions.

Each of these five changes, how they have developed over the years that have strengthened the understanding and application of the Transport Regulations, and the technical bases thereof, are summarized in the following.

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5 The two documents referred to here, “pamphlets Nos. 6 and 7” are the first editions of IAEA Safety Series No. 6 [8] and Safety Series No. 7 [15], respectively.
2.2.1. Clearly specifying package design requirements

With regard to the package design requirements in these early permits, they typically described the packaging as a 'container', but didn’t explicitly establish quantified containment requirements nor did they establish specific design, testing and acceptance requirements. They typically established:

a) established requirements for containing the radioactive materials being carried;
b) defined constraints on how radiation shielding should behave under ordinary conditions and under severe fire and impact conditions;
c) specified that it was to protect against criticality in the presence of other shipping containers of fissionable materials during transportation;
d) simple requirements for managing generated heat, and
e) specified how to design a package, not what requirements must be satisfied in the design.

Thus, in these early attempts at regulating the packaging of radioactive material, the four parameters currently deemed necessary to provide protection as specified in para. 104 of the 2012 edition of the Transport Regulations [1] (i.e. containment, radiation control, prevention of criticality and managing heat) were covered in these early domestic permits.

Rogers [16] elaborated on actions that were taken as a result of concerns that packaging controls needed to be codified. Rogers quoted Gibson of the UK as follows:

"We can no longer expect competent authorities, port authorities and others to be content that a shipment is safe because we in the industry are satisfied that it is safe—safety not only has to be achieved but must be seen to be achieved”.

It was noted that, in 1957, a US domestic interagency committee was formed to coordinate the Federal Agency activities in this area and to support the ECOSOC guidance [7]. Rogers [16] further indicated that the IAEA convened two panels shortly thereafter (in 1959) to develop international transport regulations. The result of these initial efforts was the IAEA 1961 edition of the Transport Regulations [10].

2.2.2. Developing the concept of Type A and Type B packages

With respect to package test standards established in this first edition of the Transport Regulations, it identified (in Section 5 of the 1961 edition [10]) two types of packages – Type A and Type B packages – and specified packaging requirements as follows:

- The Type A package must be leakproof, securely closed by a positive fastening device, shielded adequately to prevent an external dose rate in excess of the values prescribed in the regulations and must prevent loss or dispersal of radioactive contents and retain shielding efficiency under conditions normally incident to transport (such as minor drops and spills) and under minor accident conditions.
- The Type B package must be designed so as to maintain its integrity under conditions normally incident to transport without loss or dispersal of radioactive contents and the package must retain shielding efficiency under conditions normally incident to transport and in the most severe accident which is considered credible for the mode of transport involved.

Thus the general concepts that exist today in the Regulations for Type A and Type B packages and the other package types that now exist – following a graded approach – were established through these early efforts; namely that:

- Type A packages must be designed to withstand normal conditions of transport (NCT), whereas
- Type B packages must be designed to withstand both NCT and also severe accident conditions of transport (ACT).
However, this first edition of the Transport Regulations specified that Type B packages must adequately survive “the most severe accident which is considered credible for the mode of transport involved”. This concept of specifying a ‘maximum credible accident’ for Type B packages became a significant driver for modifying package design requirements in the second edition (i.e. the 1967 edition) of the Transport Regulations [17].

2.2.3. Eliminating the provision for applying the concept of a ‘maximum credible accident’

The first edition of the Transport Regulations established:

- test and acceptance criteria that were described generically. These criteria for Type A packages have not changed significantly since first conceived although the specification of ‘conditions normally incident to transport’ has since been quantified;
- accident test criteria for Type B packages were initially specified qualitatively as essentially the ‘maximum credible conditions’. These were very quickly modified to ‘accident conditions of transport’ and were quantified in later editions of the Transport Regulations; and
- acceptance requirements for Type B packages following exposure to both the test conditions ‘normally incident to transport and in the most severe accident’ were initially only specified qualitatively, but were also very quickly quantified in later editions of the Transport Regulations.

Steps were taken immediately following the publication of the first international Transport Regulations [10] to evaluate their adequacy and to elaborate on the international test and acceptance requirements for packages containing radioactive material. Much of this effort was documented in 1962 by Gibson and Messenger [9] and in 1963 by Messenger and Fairbairn [18].

One of the issues that was very quickly addressed was the requirement that Type B packages be able to withstand “the most severe accident which is considered credible for the mode of transport involved”, more frequently identified as the ‘maximum credible accident’ concept. Messenger and Fairbairn noted that:

“The requirement for the packaging to be able to withstand the ‘maximum credible accident’ is novel in the transport field; it has not been applied as a mandatory requirement to the carriage of non-radioactive dangerous goods, some of which, for example, cyanides, may be far more hazardous than many radioactive materials”.

This statement still holds true today; the package test requirements for Type B radioactive materials packages are more demanding than any of the packing group tests currently specified for Classes 1–6, 8, and 9 in the UN Model Regulations [8].

They further elaborated on the situation as perceived in 1963 as follows:

“In the absence of a reasonable borderline between ‘credible’ and ‘incredible’ accidents, some accident can always be postulated sufficiently severe or elaborate to defeat any packaging design. No accident, however extraordinary, can be ruled out as completely impossible. In fact many major accidents that have occurred had been thought incredible. On the other hand, no transport package can be designed to withstand every conceivable accident including combinations of both natural and man-made forces. Indeed, if such a package could be constructed, it would not be transportable.”

Appleton and Servant [19] addressed in 1965 the early requirement for applying the ‘maximum credible accident’ criteria to Type B packages, stating that:

“The conditions defined are somewhat vague and the concept of the maximum credible accident appeared particularly objectionable and so unpracticable that it was discarded. On the basis of experience and work done in the interim period in Member States a major
effort was made during the recent revision of the Agency transport regulations to make such conditions more objective in terms of testing procedures.”

This thinking by those imminently involved in the early development and enhancement of the Transport Regulations led to an effort that would establish reasonable, yet meaningful, test requirements initially for both the Type A and Type B radioactive material packages and later for other package types as they were defined in the Regulations.

To accomplish this, specifically for Type B packages, Messenger and Fairbairn [18] discussed considerations that underlay their proposed quantitative tests. These considerations included:

- mishandling and tampering;
- impacts due to large drops when loading or to collision during transport;
- fire and damage by fire-fighting materials,
- immersion in water, and ‘smothering’ by debris or by other goods as a result of one of the above –

where it was judged that "impact and fire are the most likely to cause serious immediate damage”.

From these philosophical considerations arose the extensive efforts on the part of many Member States to define quantitatively various tests that represent a large portion of the severe accident environments that a Type B package might be exposed to during transport. As a result, the Transport Regulations follow a graded approach to the performance standards, characterized by (see para 106 of SSR-6 [1]):

- routine conditions of transport (incident free),
- normal conditions of transport (minor mishaps), and
- accident conditions of transport.

The full suite of these three conditions are applied in the Regulations to Type B packages as elaborated in Chapter 11 of this document, and to other packages such as fissile material packages as elaborated in Chapter 13 of this document. The "Tests for demonstrating ability to withstand accident conditions of transport" which are specified in paras 726 through 729 of SSR-6.

2.2.4. Emphasizing ‘what’ is required not ‘how’ a requirement is to be satisfied

Gibson and Messenger [9] further elaborated on another issue relative to the development of the package design standards, noting the following:

“I.A.E.A. regulations confine themselves to specifying the objects to be attained by the packaging standards. They state what is to be achieved, but only suggest how it is to be achieved. Thus the designer is allowed the greatest possible freedom to develop new techniques for improving both safety and economy. The packaging standards are in fact defined in terms of transport conditions of differing severity under which the four radioactivity hazards must be so controlled as to afford the same high degree of safety.”

Fairbairn [20], in addressing that the Regulations prescribe “what” not “how”, commented that:

“In prescribing ‘what’ has to be achieved rather than ‘how’, the regulations encourage packaging/package design effort, especially regarding the use of new materials and improved constructional techniques. Also the fact that the transport of any specific radioactive material is not prohibited results largely from this basic principle.”

In this regard, Fairbairn noted that:

“...it is important that guidance be available as to ‘how’ certain regulatory requirements may be met, such guidance being given as ‘a way’ not ‘the way’. Also, in order to promote understanding of the technical basis of any regulatory prescription and to help those concerned with further reviews, comprehensive information of a ‘why’ nature is required.”
The philosophy of emphasizing “what” has to be achieved has continued from 1961 to the present. The 2012 edition of the Transport Regulations [1] specifies “what” must be accomplished. In contrast, TS-G-1.1 [2] couples specific guidance to the relevant paragraphs of SSR-1, specifying “how” the specific provision in the Regulations may be satisfied (i.e. providing “a way” or “ways” that the provision can be accomplished), and/or “why” the provision was introduced.

2.2.5. Establishing Clarity through Definitions

Gibson and Messenger [9] introduced the need to be specific about the use of terminology in the Transport Regulations, including ‘receptacle’, ‘container’, ‘packaging’ and ‘package’; and they then proposed specific definitions for ‘packaging’ and ‘package’ following which they noted that:

“The indiscriminate use of these terms in the past, both in regulations and in U.K.A.E.A. domestic documents, has led to difficulties of interpretation and to some confusion. Transport regulations should be primarily concerned with complete packages, loads and consignments, and only to a minor extent with the constituent containers and packaging details. There is a need, we believe, for definitions of these terms to be embodied in regulations.”

Fairbairn [21] commented after the 1973 edition of the Transport Regulations was published, as follows:

“Many regulatory prescriptions relate to the packages in which radioactive materials are carried. During the formulation of such prescriptions it is necessary to be quite clear as to whether it applies to the package itself or to the packaging in which the radioactive material is carried.”

He further elaborated, noting that:

“To help a user comprehend “what” is required, any regulation must be clear and concise. This is especially important in the case of the Agency’s transport regulations as besides being translated into various languages, they need to be converted by transport organizations into the form of the regulations used for dangerous goods as a whole.”

As a result of these discussions, the concepts for ‘packaging’ and ‘package’ were incorporated into the Regulations in the 1967 edition of the Transport Regulations [17], with specific definitions as currently in paras. 231 and 232 of the 2012 edition of SSR-1 [1].

The term ‘container’ is not used as a stand-alone term in the Regulations, but is always used as either ‘freight container’ or ‘intermediate bulk container’, which are also now defined in TS-R-1 in paras 223 and 224. Also, the term receptacle is used in the Regulations to describe one or more components of a packaging (see para. 232 of the 2012 edition of SSR-1) [1].

References for Chapter 2


{RP002}

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6 At the time this discussion was prepared, the latest version of TS-G-1.1 [2] reflected the 2005 edition of TS-R-1[22]. Because of changes that have occurred in the Transport Regulations since that time, the paragraph cross-referencing used between the Regulations and the Guidance does not always match. Thus a user of the 2012 edition of SSR-6 and the 2008 edition of TS-G-1.1 will need to check paragraph numberings between the 2005 and 2012 editions of the Transport Regulations when striving to apply the guidance in TS-G-1.1. A revision of TS-G-1.1 is underway which will properly reflect the paragraph structure of the 2012 edition of the Transport Regulations.


3. THE FUNDAMENTAL SAFETY PRINCIPLES

As the IAEA's involvement matured in striving to provide world-wide safety in the use of radioactive materials, the preface by the nine sponsoring organizations of the current Fundamental Safety Principles [1] notes that it three separate documents were issued in the mid-1990s addressing fundamental principles and objectives of safety. These three documents dealt with (a) the safety of nuclear installations, (b) the principles of radioactive waste management, and (c) the radiation protection and safety of radiation sources.

In 1995, the IAEA Board of Governors "requested the IAEA Secretariat to consider, at an appropriate time, the revision of the three Safety Fundamentals texts with the aim of combining them in a unified set of principles representing a common safety philosophy across all areas of application of the IAEA safety standards". This request was satisfied by the issuance of the Fundamental Safety Principles [1] in 2006. The following addresses each of ten safety principles set forth in the latest Safety Principles document, and discusses how each relates to and is satisfied by the 2012 edition of the IAEA Transport Regulations SSR-6 [2].

As stated in Ref. [1], the fundamental safety objective is to protect people and the environment from harmful effects of ionizing radiation, without unduly limiting the operation of facilities or the conduct of activities (such as the transport of radioactive material) that give rise to radiation risks. Measures have to be taken:

- to control the radiation exposure of people and the release of radioactive material to the environment;
- to restrict the likelihood of events that might lead to a loss of control over a radioactive source;
- to mitigate the consequences of such events if they were to occur.

Ten safety principles have been formulated, on the basis of which safety requirements are developed. In this context, the term 'safety' means the protection of people and the environment against radiation risks, and the safety of facilities and activities that give rise to radiation risks. Safety is concerned with both radiation risks under normal circumstances and radiation risks as a consequence of incidents; safety measures include actions to prevent incidents and arrangements put in place to mitigate their consequences if they were to occur.

The fundamental safety principles are listed below, together with some comments related to their applicability to the transport of radioactive material.

1. **The prime responsibility for safety must rest with the person or organization responsible for facilities and activities that give rise to radiation risks.**

   Since transport comprises 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, there are a number of responsible parties. It is not evident to designate the person who has the prime responsibility for safety.

2. **An effective legal and governmental framework for safety, including an independent regulatory body, must be established and sustained.**

   The transport regulations are drafted on the presumption that a national framework is in place that enables the government to discharge its responsibilities for transport safety.

   It must be noted that the transport of radioactive material is also regulated through international agreements for the different modes of transport (road, rail, air, sea, inland waterways). All these agreements are based on SSR-6.

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Note: In the IAEA transport regulations the term 'competent authority' is used instead of the term 'regulatory body'.
3. **Effective leadership and management for safety must be established and sustained in organizations concerned with, and facilities and activities that give rise to, radiation risks.**

Section III of the Transport Regulations comprises provisions regarding management systems and compliance assurance. Additionally guidance on these subjects is given in TS-G-1.4 [3] and TS-G-1.5 [4].

4. **Facilities and activities that give rise to radiation risks must yield an overall benefit (justification principle).**

The principle of justification has to be applied at different levels. At the generic level, transport has not to be justified as a practice in its own. It is the practice that gives rise to transport activities that has to be justified, taking into account that transport activities may be needed.

This principle has also to be applied to the each individual shipment, mainly by the consignor.

5. **Protection must be optimized to provide the highest level of safety that can reasonably be achieved (optimization principle).**

Both normal and potential exposure are considered.

The principle of optimization of protection also has to be applied at different levels. It is applied in a generic way in many provisions of the transport regulations, although not in a mathematically rigorous way.

This principle has to be implemented by the different actors in the transport of radioactive material: consignor, carrier, receiver.

6. **Measures for controlling radiation risks must ensure that no individual bears an unacceptable risk of harm.**

The BSS [5] set individual dose limits for workers and for members of the public. They are applicable to the transport of radioactive material.

Limits for radiation levels at the surface of and at certain distances from packages and conveyances have been set, although not in a mathematically rigorous way (using models and scenarios). Several surveys have confirmed that the dose limits are complied with [6] and [7].

7. **People and the environment, present and future, must be protected against radiation risks.**

The objective of the Transport Regulations is to establish requirements that must be satisfied to ensure safety and to protect persons, property and the environment from the effects of radiation in the transport of radioactive material.

8. **All practical efforts must be made to prevent and mitigate nuclear or radiation accidents.**

The Transport Regulations comprise requirements dealing with the design of packages and on the accumulation of packages. There are also provisions dealing with operational controls (administrative, radiation protection, criticality).

9. **Arrangements must be made for emergency preparedness and response for nuclear or radiation incidents.**

Emergency preparedness and response is dealt with in Section III of the Transport Regulations. Additional guidance is given in TS-G-1.2 [8].

10. **Protective actions to reduce existing or unregulated radiation risks must be justified and optimized.**

This principle is not relevant for transport of radioactive material.
Most of the safety principles are reflected in the provisions of section III of the transport regulations (general provisions).

References for Chapter 3


4. SAFETY OBJECTIVES AND PRINCIPLES FOR TRANSPORT

NOTE: only the graded approach is so far addressed here.

The experts working on this document have, as yet, been unsuccessful in identifying where the principle of defence in depth has been specifically addressed in the development of the regulations.

This section may also need to also address:

(a) Safety Culture (which is not mentioned in the Regulations), and
(b) Management systems (which was only mentioned once in the 2009 edition, but now in the 2012 edition, is addressed more completely – e.g. paras 102, 105, 228, 306, and in multiple places in Section VIII). Para 228.2 of the draft replacement document for TS-G-1.1 discusses briefly why management system has been introduced.

4.1. Safety Objectives for Transport

The objective of the Transport Regulations is to establish requirements that must be satisfied to ensure safety and to protect persons, property, and the environment from the effects of radiation in the transport of radioactive material, without undue restriction of movement of radioactive material. This protection is achieved by requiring:

- containment of the radioactive contents;
- control of external radiation levels;
- prevention of criticality;
- prevention of damage caused by heat.

These requirements are satisfied by:

- applying a graded approach to contents limits for packages and conveyances and to performance standards applied to package designs, depending upon the hazard of the radioactive contents; the graded approach is also reflected in the application of the exemption concept and in the administrative arrangements (approvals);
- imposing requirements on the design and operation of packages and on the maintenance of packagings, including consideration of the nature of the radioactive contents;
- requiring administrative controls, including, where appropriate, approval by competent authorities.

The Regulations note that “the protection of property and the environment are assured when these Regulations are complied with.” [1]

4.2. Safety Principles for Transport

The application of key safety principles in order to satisfy the safety objectives is fundamental to the success of the Transport Regulations. One such principle is the application of a graded approach, where the greater the hazard posed by the contents of a package should shielding or containment be lost or criticality control be degraded, then a greater number of design, operational and administrative controls are imposed by the Regulations.

One example of the application of the graded approach is, in particular, applied in specifying performance standards for packages (i.e. the packaging plus its radioactive content) in different conditions of transport:

- excepted packages are to be designed to withstand routine conditions of transport (incident free);

[1] It must be noted that protection of property is not included in the fundamental safety objective.
- Type A packages are to be designed to withstand both routine and normal conditions of transport (including minor mishaps);
- Type B packages are to be designed to withstand routine, normal and accident conditions of transport; whereas
- Type C packages are to be designed to withstand severe accident conditions for air transport, beyond the accident conditions of transport which Type B packages are designed to withstand. [1]

This categorization of packages is elaborated in Chapters 9, with respect to the design and testing requirements, and also in Chapter 11. With regards to the categorisation of packages, it is noted that the transport regulations have also introduced three categories of industrial packages (IPs) to accommodate the transport of low specific activity (LSA) material and surface contaminated objects (SCOs). A graded approach has been applied to the ability of IPs to withstand a given category of transport conditions. IP-1 packages are identical to excepted packages except for the minimum dimension and marking and labelling requirements, and are therefore designed to withstand routine conditions of transport; whereas IP-3 packages are like type A packages for solid material, and therefore are designed to withstand both routine and accident conditions of transport.

A basic principle is that the content of packages is limited such that the radiological consequences of an accident are limited, in particular the exposure of persons in the vicinity of an accident (external exposure and internal exposure due to the intake of radioactive material). This is explained in detail in the section on the derivation of A1 and A2 values.

The transport regulations define different categories of material (special form, low specific activity material, low dispersible material), the characteristics of which are taken into account to derive contents limits for packages containing that kind of material.

In normal operation, the control of radiation is ensured by setting limits to radiation levels for packages and conveyances, the application of segregation distances, the use of warning labels and other operational provisions (e.g. exclusive use, application of radiation protection programmes). These are intended to ensure that the dose to members of the public resulting from transport of radioactive material does not exceed a fraction of the applicable dose limits.

When defining the scope of the transport regulations the graded approach is applied. Transport of radioactive material (a) that is not controllable (e.g. radioactive material in a person or an animal for the purpose of diagnosis or treatment, radioactive material that forms an integral part of a means of transport such as depleted uranium counterweights); or (b) that gives rise to negligible radiological risks are excluded from the field of application (e.g. objects with surface contamination below a certain level, consumer goods that are exempted from regulatory control, material with an activity concentration below the corresponding exemption level, consignments with a total activity lower than the corresponding exemption level).

The scope of the Transport Regulations includes consideration of those natural materials or ores which form part of the nuclear fuel cycle or which will be processed in order to use their radioactive properties. The Transport Regulations do not apply to other ores which may contain naturally occurring radionuclides, but whose usefulness does not lie in the fissile, fertile or radioactive properties of those nuclides, provided that the activity concentration does not exceed ten times the exempt activity concentration values.

In addition, the Transport Regulations do not apply to natural materials and ores containing naturally occurring radionuclides which have been processed (up to ten times the exemption

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9 These levels are set in the definition of contamination: the presence of a radioactive substance on a surface in quantities in excess of 0.4 Bq/cm² for beta and gamma emitters and low toxicity alpha emitters, or 0.04 Bq/cm² for all other alpha emitters.
10 Exemption levels as in Table I-1 of the BSS (moderate quantities) [2].
levels in terms of activity concentration) where the physical and/or chemical processing was not undertaken for the purpose of extracting radionuclides (e.g. washed sands and tailings from alumina refining). However, such processed materials should not be intended for further processing for the removal of their radionuclides. Were this not the case, the Transport Regulations would have to be applied to enormous quantities of material that present a very low hazard. However, there are ores in nature where the activity concentration is much higher than the exemption values. The regular transport of these ores may require consideration of radiation protection measures. Hence, a factor of ten times the exemption values for activity concentration was chosen as providing an appropriate balance between the radiological protection concerns and the practical inconvenience of regulating large quantities of material with low activity concentrations of naturally occurring radionuclides.

The application of the basic graded approach principle is found in many aspects of the Transport Regulations where, for example, the content of packages is limited such that the radiological consequences of an accident are limited, in particular the exposure of persons in the vicinity of an accident (external exposure and internal exposure due to the intake of radioactive material). In addition, the transport regulations define different categories of material (special form, low specific activity material, low dispersible material), the characteristics of which are taken into account to derive contents limits for packages containing that kind of material. This classification of materials is elaborated in Chapter 8.

Specific applications of the graded approach used in establishing the regulatory requirements are elaborated in detail in Appendix 3. Five specific areas are addressed therein, illustrating the application of applying the graded approach to:

1. package contents activity limits,
2. types of package designs,
3. package design performance standards,
4. package performance standards, and
5. package design approval requirements.

References for Chapter 4


5. GENERAL SAFETY REQUIREMENTS

Section III of the Transport Regulations comprises general provisions that find their justification in the General Safety Requirements that are applicable to all facilities and activities and that are specifically relevant for transport. These provisions are structured to follow the principles set forth in the following series of the General Safety Requirements series on Safety Standards:

- GSR Part 1, Governmental, legal and regulatory framework for safety (2010) [1];
- GSR-R-2, Preparedness and Response for a Nuclear or Radiological Emergency (2002) [2];
- GSR Part 3 (Interim), Radiation protection and safety of radiation sources: international basic safety standards, interim edition 2011 [4]; which replaces SS 115 (1996) [5]; and
- GSR Part 4, Safety assessment for facilities and activities (2009) [6];

In addition, the following two documents in this series are under development:

- GSR Part 2, Leadership and management for safety, under development; to replace GS-R-3 (2006);

5.1. General Requirement for Compliance Assurance

The Transport Regulations have been drafted on the presumption that a national framework is in place which enables the government to discharge its responsibilities for transport safety; in particular that a regulatory body (called competent authority in the Transport Regulations) has been set up to deal with transport safety (requirement 2 of GSR Part 3 [4]), and to ensure compliance with the established regulatory requirements.

The 2012 edition of the Transport Regulations specify, e.g. in para. 208 of SSR-6 [7] that “Compliance assurance shall mean a systematic programme of measures applied by a competent authority that is aimed at ensuring that the provisions of these Regulations are met in practice”.

Thus, it is the responsibility of the competent authority to ensure compliance. The establishment of this responsibility was initially specified in the 1985 Edition of the Transport Regulations [8].

Guidance on compliance assurance was provided as early as 1973, where para. 1.09 of the first edition of Safety Series No. 37 [9] read “The IAEA Regulations define ‘competent authority’ and assign to him the responsibility for receiving applications for approval, evaluating compliance,...”.

This same comment was carried forward in 1982 into the second edition of Safety Series No. 37 [10].


Further detailed guidance on this was provided in Safety Series No. 112 [12], published in 1994. This document dealt entirely with compliance assurance. It stated that:

“105. According to para. 117 of the Regulations, “Compliance assurance shall mean a systematic programme of measures applied by a competent authority which is aimed at ensuring that the provisions of these Regulations are met in practice”. Paragraph 210 states: “The competent authority is responsible for assuring compliance with these Regulations. Means to discharge this responsibility include the establishment and execution of a programme for monitoring the design, manufacture, testing, inspection and maintenance of packaging, and the preparation, documentation, handling and stowage of...”

date: February 2013
packages by consignors and carriers, to provide evidence that the provisions of these Regulations are being met in practice.”

“106. While competent authorities are responsible for assuring compliance with the Regulations (which must include oversight and enforcement of all regulations), the prime responsibility for ensuring safety in transport rests with consignors and carriers, who must take account of all relevant safety regulations. Thus, consignors, carriers and any other users of the Regulations must comply with the actual regulations, and the competent authority should assure compliance with these regulations. The competent authority itself should comply with the IAEA Regulations, for example in such matters as issuance of approvals and the allocation of design identification marks for packagings.”

In retrospect, attributing the responsibility for compliance assurance to the competent authority as part of the regulatory functions is consistent with GSR Part 1 [1], and requirement 2 of GSR Part 3 [4]. It is also to be considered as an element of the management system of the competent authority (requirement 5 of GSR Part 3).

The handling of non-compliance with provisions of the Transport Regulations is also part of the regulatory functions.

5.2. General Requirement for Radiation Protection
The general provisions on radiation protection recall two of the basic principles of radiation protection, namely optimisation of protection and individual dose limits. The provisions for monitoring of compliance with the dose limits for workers are similar to those that are normally applied for workers in supervised and controlled areas in facilities.

A radiation protection programme is an element of the management system, the basis of which can be found in requirement 5 of GSR Part 3 [4] and in GS-R-3 [3]. Guidance on how to set up a radiation protection programme is contained in TS-G-1.3 [13].

The need to establish a radiation protection programme was first established in the Foreword of the 1985 edition of the Transport Regulations [8]. It noted that “the radiation exposure to transport workers and to the general public is subject to the limitations stated in the 'Basic Safety Standards for Radiation Protection, 1982 Edition'”. It further stated that “This revision of the Transport Regulations implements the 1982 Edition of the Basic Safety Standards for Radiation Protection which sets forth a new system of dose limitation, the components of which are: (1) justification of the practice, (2) optimization of protection for sources of exposure, and (3) individual dose limitation.” Each of these components were then elaborated upon. This text was developed through a consultants services meeting convened in Vienna in 1984 [14].

In the next revision of the Transport Regulations, the requirement for a radiation protection programme was embedded into the document itself (e.g. see paras 233 and 301 through 307 of ST-1 (1996)) [15].

Para. 302 of the 2012 edition of the Transport Regulations [7] comprises the provisions for the establishment of a radiation protection programme. It is not stipulated which actors have to comply with it. The radiation protection programme shall incorporate the provisions of para. 562, which text needs to be revised in order to correctly apply the concept of ‘dose constraint’in subpara.(b) in order to satisfy the requirement that a dose constraint shall be a fraction of the dose limit (i.e. a fraction of 1 mSv for members of the public).

5.3. General Requirement for Emergency Response
The provisions on emergency response have been drafted on the presumption that the government has set up an integrated and coordinated emergency management system (requirement 43 in GSR Part 3 [4]), TS-G-1.2 [16], developed during the 2000-2002 time period, provides guidance on emergency planning and preparedness, and contains guidelines on
planning and preparing for emergency response to transport accidents involving radioactive material.

5.4. The General Requirements from the Basic Safety Standards

The Basic Safety Standards (BSS), which were revised in 2011 [4] and issued as an interim edition, establishes 52 general requirements to be fulfilled in all facilities and activities giving rise to radiation risks. Activities include transport, which is defined in the BSS as “the deliberate physical movement of radioactive material (other than that forming part of the means of propulsion) from one place to another”.

For certain facilities and activities, such as nuclear installations, radioactive waste management facilities and the transport of radioactive material, other safety requirements, complementary to these Standards, also apply.

Of the 52 general requirements in the interim 2011 edition of the BSS [4], all but one of the first 33 apply to the transport of radioactive material, as summarized in Table 5-1 below.

<table>
<thead>
<tr>
<th>Requirement Number</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Application of the principles of radiation protection. Parties with responsibilities for protection and safety shall ensure that the principles of radiation protection are applied for all exposure situations.</td>
</tr>
<tr>
<td>2</td>
<td>Establishment of a legal and regulatory framework. The government shall establish and maintain a legal and regulatory framework for protection and safety and shall establish an effectively independent regulatory body with specified responsibilities and functions.</td>
</tr>
<tr>
<td>3</td>
<td>Responsibilities of the regulatory body. The regulatory body shall establish or adopt regulations and guides for protection and safety and shall establish a system to ensure their implementation.</td>
</tr>
<tr>
<td>4</td>
<td>Responsibilities for protection and safety. The person or organization responsible for facilities and activities that give rise to radiation risks shall have the prime responsibility for protection and safety. Other parties shall have specified responsibilities for protection and safety.</td>
</tr>
<tr>
<td>5</td>
<td>Management for protection and safety. The principal parties shall ensure that protection and safety is effectively integrated into the overall management system of the organizations for which they are responsible.</td>
</tr>
<tr>
<td>6</td>
<td>Graded approach. The application of the requirements of these Standards in planned exposure situations shall be commensurate with the characteristics of the practice or the source within a practice, and with the magnitude and likelihood of the exposures.</td>
</tr>
<tr>
<td>7</td>
<td>Notification and authorization. Any person or organization intending to operate a facility or to conduct an activity shall submit to the regulatory body, as appropriate, a notification or an application for authorization.</td>
</tr>
<tr>
<td>8</td>
<td>Exemption and clearance. The government or the regulatory body shall determine which practices or sources within practices are to be exempted from some or all of the requirements of these Standards. The regulatory body shall approve which sources, including materials and objects, within notified practices or authorized practices may be cleared from regulatory control.</td>
</tr>
<tr>
<td>9</td>
<td>Responsibilities of registrants and licensees in planned exposure situations. Registrants and licensees shall be responsible for protection and safety in planned exposure situations.</td>
</tr>
</tbody>
</table>
**Table 5-1. General Basic Safety Standards Requirements applicable to Transport.**

<table>
<thead>
<tr>
<th>Requirement Number</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td><strong>Justification of practices.</strong> The government or the regulatory body shall ensure that only justified practices are authorized.</td>
</tr>
<tr>
<td>11</td>
<td><strong>Optimization of protection and safety.</strong> The government or regulatory body shall establish and enforce requirements for the optimization of protection and safety, and registrants and licensees shall ensure that protection and safety is optimized.</td>
</tr>
<tr>
<td>12</td>
<td><strong>Dose limits.</strong> The government or the regulatory body shall establish dose limits for occupational exposure and public exposure, and registrants and licensees shall apply these limits.</td>
</tr>
<tr>
<td>13</td>
<td><strong>Safety assessment.</strong> The regulatory body shall establish and enforce requirements for safety assessment, and the person or organization responsible for a facility or activity that gives rise to radiation risks shall conduct an appropriate safety assessment of this facility or activity.</td>
</tr>
<tr>
<td>14</td>
<td><strong>Monitoring for verification of compliance.</strong> Registrants and licensees and employers shall conduct monitoring to verify compliance with the requirements for protection and safety.</td>
</tr>
<tr>
<td>15</td>
<td><strong>Prevention and mitigation of accidents.</strong> Registrants and licensees shall apply good engineering practice and shall take all practicable measures to prevent accidents and to mitigate the consequences of those accidents that do occur.</td>
</tr>
<tr>
<td>16</td>
<td><strong>Investigations and feedback of information on operating experience.</strong> Registrants and licensees shall conduct formal investigations of abnormal conditions arising in the operation of facilities or the conduct of activities, and shall disseminate information that is significant for protection and safety.</td>
</tr>
<tr>
<td>17</td>
<td><strong>Radiation generators and radioactive sources.</strong> Registrants and licensees shall ensure the safety of radiation generators and radioactive sources.</td>
</tr>
<tr>
<td>18</td>
<td>Not applicable</td>
</tr>
<tr>
<td>19</td>
<td><strong>Responsibilities of the regulatory body specific to occupational exposure.</strong> The government or regulatory body shall establish and enforce requirements to ensure that protection and safety is optimized, and the regulatory body shall enforce compliance with dose limits for occupational exposure.</td>
</tr>
<tr>
<td>20</td>
<td><strong>Requirements for monitoring and recording of occupational exposure.</strong> The regulatory body shall establish and enforce requirements for the monitoring and recording of occupational exposures in planned exposure situations.</td>
</tr>
<tr>
<td>21</td>
<td><strong>Responsibilities of employers, registrants and licensees for the protection of workers.</strong> Employers, registrants and licensees shall be responsible for the protection of workers against occupational exposure. Employers, registrants and licensees shall ensure that protection and safety is optimized and that the dose limits for occupational exposure are not exceeded.</td>
</tr>
<tr>
<td>22</td>
<td><strong>Compliance by workers.</strong> Workers shall fulfil their obligations and carry out their duties for protection and safety.</td>
</tr>
<tr>
<td>23</td>
<td><strong>Cooperation between employers and registrants and licensees.</strong> Employers and registrants and licensees shall cooperate to the extent necessary for compliance by all responsible parties with the requirements for protection and safety.</td>
</tr>
<tr>
<td>24</td>
<td><strong>Arrangements under the radiation protection programme.</strong> Employers, registrants and licensees shall establish and maintain organizational, procedural and technical arrangements for the designation of controlled areas and supervised areas, for local rules and for monitoring of the workplace, in a radiation protection programme for occupational exposure.</td>
</tr>
</tbody>
</table>
Table 5-1. General Basic Safety Standards Requirements applicable to Transport.

<table>
<thead>
<tr>
<th>Requirement Number</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>Assessment of occupational exposure and workers’ health surveillance. Employers, registrants and licensees shall be responsible for making arrangements for assessment and recording of the occupational exposure and for workers’ health surveillance.</td>
</tr>
<tr>
<td>26</td>
<td>Information, instruction and training. Employers, registrants and licensees shall provide workers with adequate information, instruction and training for protection and safety.</td>
</tr>
<tr>
<td>27</td>
<td>Conditions of service. Employers, registrants and licensees shall not offer benefits as substitutes for measures for protection and safety.</td>
</tr>
<tr>
<td>28</td>
<td>Special arrangements. Employers, registrants and licensees shall make special arrangements for female workers, as necessary, for protection of the embryo or fetus and of breast-fed infants. Employers, registrants and licensees shall make special arrangements for protection and safety for persons under 18 years of age who are undergoing training.</td>
</tr>
<tr>
<td>29</td>
<td>Responsibilities of the government and the regulatory body specific to public exposure. The government or the regulatory body shall establish the responsibilities of relevant parties that are specific to public exposure, shall establish and enforce requirements for optimization, and shall establish, and the regulatory body shall enforce compliance with, dose limits for public exposure.</td>
</tr>
<tr>
<td>30</td>
<td>Responsibilities of relevant parties specific to public exposure. Relevant parties shall apply the system of protection and safety to protect members of the public against exposure.</td>
</tr>
<tr>
<td>31</td>
<td>Radioactive waste and discharges. Relevant parties shall ensure that radioactive waste and discharges of radioactive material to the environment are managed in accordance with the authorization.</td>
</tr>
<tr>
<td>32</td>
<td>Monitoring and reporting. The regulatory body and relevant parties shall ensure that programmes for source monitoring and environmental monitoring are in place and that the results from the monitoring are recorded and are made available.</td>
</tr>
<tr>
<td>33</td>
<td>Consumer products. Providers of consumer products shall ensure that such products are not made available to the public unless their use by members of the public has been justified, and either their use has been exempted or their provision to the public has been authorized.</td>
</tr>
</tbody>
</table>

A review of these safety standards requirements shows that the extensive efforts that have led to the current Transport Regulations [7] address most, if not all, of the above listed requirements. Examples include:

- Requirements 2 and 3: the establishment of a legal and regulatory framework and specifying the responsibilities of a regulatory body is established by specifying the need for competent authorities (para. 207 of SSR-6), where detailed guidance has been provided with References [11], [12], and [17];
- Requirement 6: the use of the graded approach is discussed in detail in Section 2.2, Chapter 4 and Appendix 3 of this document;
- Requirement 7: notification of competent authorities is required, following a graded approach, in paras 557 through 560 of SSR-6 [7], hence the requirements of the interim edition of the BSS for notification and authorization are fulfilled by means of compliance with the Transport Regulations; and
- Requirements 10, 11, and 12: justification, optimization, and dose limitations were addressed specifically in the forward to the 1985 edition of the Transport Regulations.
and requirements and guidance have significantly expanded since then as discussed in Section 5.2 above.

Furthermore, specific application of the interim edition of the BSS requires that no person or organization shall transport a source other than in accordance with the requirements of the BSS. Schedule I of the interim edition of the BSS stipulates that the exemption values (in terms of total activity and in terms of activity concentration) used in the Transport Regulations are, usually, numerically equal to the levels for exemption for moderate amounts that are given in Table I-1 in the 2011 interim edition of the BSS [4] (see also, General Basic Safety Standards Requirement 8).

Special arrangement, as specified in the Transport Regulations, is intended to give flexibility to consignors to propose alternative (and more practicable) safety measures effectively equivalent to those prescribed in the Transport Regulations. It is based on the requirement that the overall level of safety resulting from additional operational control must be shown to be at least equivalent to that which would be provided had all applicable provisions been met. It does not relate to General Basic Safety Standards Requirement 28.

In addition, this makes possible both the development of new controls and techniques to satisfy the existing and changing needs of industry in a longer term sense and the use of special operational measures for particular consignments where there may be only a short term interest. Such new safety techniques may later be assimilated into specific regulatory provisions and therefore the application of this concept is useful for the further development of the Transport Regulations.

5.5. General Requirements for Quality Assurance and Management Systems

The provisions on quality assurance are consistent with the requirements in GS-R-3, except that in more recent IAEA safety standards the term ‘quality assurance’ is no longer used. Para. 306 of the Transport Regulations has been revised in the 2012 edition of the Transport Regulations [7] to take this change in terminology into account, specifying the use of a management system (see General Basic Safety Standards Requirement 5).

As stipulated in GS-R-3 [3], the term ‘management system’ reflects and includes the initial concept of ‘quality control’ (controlling the quality of products) and its evolution through quality assurance (the system to ensure the quality of products) and ‘quality management’ (the system to manage quality). The management system is a set of interrelated or interacting elements that establishes policies and objectives and which enables those objectives to be achieved in a safe, efficient and effective manner.

Further guidance has been developed in TS-G-1.4 [18] to assist those involved in transport in applying the management system concept is given.

The Transport Regulation provisions on training address the General Basic Safety Standards Requirements 26 and 28, and also find their basis in the general safety requirements on management systems [3].

References for Chapter 5


6. RADIATION PROTECTION

Radiation protection is provided by the Transport Regulations, in part, through specification of activity limits and classification of materials and of packages. The classification of materials is briefly discussed in this chapter and is further elaborated in Chapter 8, and the classification of packages is elaborated in Chapter 9.

6.1. Exemption values

The exemption levels are those given in Table I-1 of the 2011 edition of the BSS [1] for moderate quantities. The criteria for exemption are given in schedule I of the BBS; the derivation of the exemption levels is detailed in EC-RP 6511 [2]. However, the exposure scenarios that were used for the derivation of the exemption levels did not explicitly address the transport of radioactive material. Additional calculations were performed for transport specific scenarios. These transport specific exemption values were then compared with the values in the BSS. It was concluded that the relatively small differences between both sets did not justify the incorporation into the Transport Regulations of a set of exemption values different from that in the BSS, given that the use of different exemption values in various practices may give rise to problems at interfaces and may cause legal and procedural complications [4].

6.2. A1 and A2 values

The radioactive content of type A packages are limited based on activity limits for special form radioactive material (A1), and other than special form radioactive material (A2) values using the Q system, which is elaborated in detail in Appendix I of TS-G-1.1 (Rev. 1) [6].

The history and methodology of the development of the A1 and A2 values is elaborated in Appendix 3, Section A.3.1. This appendix describes the initial development of the Q-system leading to the content limit values in the 1985 edition of the Transport Regulations [7], and the updates that were made that led to the content limit values in the 1996 edition of the Transport Regulations [8]13. The Q system is more extensively documented in Appendix I of TS-G-1.1 [4]; which provides the best documentation of the efforts involved in the updates [14].

In addition to controlling the quantity of radioactive material in a Type A package, the content limit values A1 and A2 are also used as a reference for establishing contents limits of excepted packages, release limits for Type B packages, to characterise low specific activity material, and to establish thresholds for requiring added tests such as the deep water immersion test.

The Type A package contents limits are constrained such that the radiological consequences of an accident involving a Type A package are limited as follows:


11 An update may be needed, to be consistent with dose conversion factors given in the BSS. See also the derivation of exemption levels for additional radionuclides [3]; a complete list of which is in Table I-1 of the BSS [1].

12 The list of radionuclides in table I-1 of the BSS [1], taken from [3] is not the same as in table 2 of the Transport Regulations [5]. Moreover, for some radionuclides different progenies have been used in the calculations, sometimes leading to different exemption levels.

13 Following the lessons learnt from the Fukushima accident, the Q system may need to be reviewed with a view to assessing the need to consider additional exposure pathways.

14 Since the BSS was updated in 2011 [1], the list of radionuclides in the 2012 edition of the Transport Regulations [5] is now outdated. Many of the radionuclides in the 2011 edition of the BSS are not covered in the Regulations. An update is needed to make the activity limits in the Transport Regulations consistent with those in the current BSS, both in terms of radionuclides addressed and dose conversion factors. Otherwise, a user of the Regulations will need to calculate activity limit values for any of the radionuclides listed in the BSS that are not listed in the Regulations.
• the effective or committed effective dose to a person exposed in the vicinity of a transport package following an accident should not exceed 50 mSv; and
• the equivalent dose or committed equivalent dose received by individual organs, including the skin, of a person involved in the accident should not exceed 0.5 Sv, or in the special case of the eye 0.15 Sv.  

It is assumed that a person is unlikely to remain at 1 m from the damaged package (shielding completely lost) for more than 30 minutes. The dose rate at 1 m from the unshielded material is therefore to be limited to 100 mSv/h.

It is further assumed that about one thousandth of the content would be released and that a person would take up about one thousandth of the released content (i.e. about one millionth of the content would be taken up).

In the case of special form material only external radiation has been taken into account.

6.3. Low specific activity (LSA) material
Low specific activity (LSA) material is classified into three groups (LSA-1, LSA-2 and LSA-3). These groups were developed with a consideration of the radiation dose hazard presented by the material.

LSA material may be transported in limited quantities in one of three types of industrial packages (i.e. IP-1, IP-2 and IP-3), and in some limited cases unpackaged depending on the specific radiological and physical characteristics of the material. The restrictions are such that in case of an accident the radiological consequences are comparable to those of a type A package involved in an accident: dose rate of 10 mSv/h at a distance of 3 m from the unshielded material; intake of about one millionth of the content (assumed uptake of 10 mg).

Materials containing radionuclides in concentrations above the exemption levels have to be regulated. It is reasonable, following a graded approach to radiation protection, that materials containing radionuclides up to 30 times the exemption level may be exempted from parts of the transport regulatory requirements and may be associated with the category of LSA-1 material. The factor of 30 was selected to take account of the rounding procedure used in the derivation of the BSS exemption levels and to give a reasonable assurance that the transport of such material does not give rise to unacceptable doses.

6.4. Surface contaminated objects (SCOs)
Similar to LSA material, surface contaminated objects (SCOs) may be transported in two types of industrial packages (i.e. IP-1 or IP-2), and in some limited cases unpackaged depending on the specific radiological and physical characteristics of the objects.

A differentiation is made between the two categories of SCOs in terms of their contamination level. This differentiation defines the type of packaging to be used to transport these objects. As with the transport of LSA material, the level of radiological protection is equivalent to that of type A packages.

6.5. Classification as excepted package
The limits for radioactive material contents of excepted packages are such that the radiological hazard associated with a total release of contents is consistent with the hazard from a Type A

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15 Which is compared with the dose limits for occupational exposure of workers over the age of 18 years:
(a) An effective dose of 20 mSv per year averaged over five consecutive years (100 mSv in 5 years), and of 50 mSv in any single year;
(b) An equivalent dose to the lens of the eye of 20 mSv per year averaged over 5 consecutive years (100 mSv in 5 years) and of 50 mSv in any single year;
(c) An equivalent dose to the extremities (hands and feet) or the skin of 500 mSv in a year.
package releasing part of its contents (see Appendix 3, section A.3.1).

References for Chapter 6


7. CONTROLS FOR TRANSPORT

When preparing a transport, and during the course of a transport, requirements and controls set up by the Regulations have to be met.

To the extent feasible, safety features are required to be built into the design of the package. By placing primary reliance on the package design and preparation, the need for any special actions during carriage (i.e. by the carrier) is minimized. Nevertheless, some operational controls are required for safety purposes and they are an important component for safety as they complement the requirements for package design and preparation.

The controls for transport are found primarily in Section V of the Transport Regulations [1], which specifies requirements for the following topics:

[[Note: the listing with bullets below needs to be verified against SSR-6.]]

- Requirements before the first shipment and before each shipment (paras 501–503);
- Transport of other goods and other dangerous properties of contents (paras 504–507);
- Requirements and controls for contamination and for leaking packages (paras 508–514);
- Requirements and controls for transport of excepted packages and for transport of LSA material and SCO in industrial packages or unpackaged (paras 515–522);
- Determination of and limits on the transport index and the criticality index (paras 523–526);
- Limits on radiation levels and controls on transport for
  (a) packages and overpacks (paras 527–528),
  (b) consignments transported under exclusive use transported by road and rail (paras 573–574),
  (c) consignments transported by vessels (paras 575–576),
  (d) consignments transported by air (para. 579), and
  (e) consignments transported by post (paras 580–581);
- Assigning categories to packages (529);
- Requirements for marking and labelling of packages (paras 530–542);
- Requirements for placarding of
  (a) freight containers and tanks (paras 543–544), and
  (b) road and rail vehicles (paras 571–572);
- Consignor’s responsibilities (paras 545–561);
- Requirements for transport and for storage in transit (paras 562–570, and 577–578);
- Customs operations and undeliverable consignments (paras 582–583); and
- Retention and availability of transport documents by carriers (paras 584–588).

As appropriate, the following sections of the chapter address the technical basis of these controls.

[[Note: In assembling this chapter pursuant to the TRANSSC guidance, the administrative controls have not been addressed in this chapter, though such was included in Appendix 16 of the March 2012 version of the draft. Where, if at all, should this be addressed? The following paragraph introduces the concept of administrative controls.]]

Although not included in the “Controls” section of the Transport Regulations, administrative requirements (contained in Section VIII) are mostly linked to the approval of packages and shipments. The Regulations distinguish between cases where the transport can be made without competent authority package design or shipment approval and cases where some kind of approval is required. Whilst, in both cases, the Regulations place primary responsibility for compliance on the consignor and the carrier, the approval provides a vehicle to the competent authorities to ensure that the design or shipment meets the relevant requirements and that the
controls required for safety are adequate for the country and for the circumstances of the shipment.

7.1. Requirements and controls for contamination and for leaking packages

The Transport Regulations apply the optimisation principle to non-fixed contamination and also prescribe limits for non-fixed contamination on the surfaces of packages and conveyances under routine conditions of transport. The limits for the surfaces of packages derive from a radiological model developed by Fairbairn for the 1961 Edition of the Transport Regulations [2]. In summary, the pathways of exposure were external beta irradiation of the skin, ingestion and the inhalation of resuspended material. Consideration of radionuclides was limited to the most hazardous radionuclides in common use, namely Pu-239 and Ra-226 in the case of alpha emitters and Sr-90 in the case of beta emitters. These derived limits correspond to values that were generally accepted for laboratory and plant working areas and were thus conservative in the context of transport packages for which exposure time and handling time for workers were expected to be very much less than for workers in laboratories or active plants. Since this derivation, although there have been changes in radiological protection parameters, the transport contamination limits have not been changed.

Due to the spent fuel packages and conveyances contamination issue that was raised in Europe in 1998–1999, the IAEA initiated a co-ordinated research project (CRP) on non-fixed surface contamination, and its results were issued as TECDOC-1449 [3]. The CRP developed the Basic Model to evaluate annual doses to workers and public from the non-fixed surface contamination of packages.

One of the conclusions states that the contamination limits in the transport regulations are conservative, especially for irradiated nuclear fuel package shipments; however, it was decided to retain the existing conservative limits for non-fixed contamination on the external surface of any package.

7.2. Determination of and limits on the transport index (TI) and the criticality index (CSI)

[[Note: additional effort for the background / technical basis for both TI and CSI is needed here.]]

7.2.1. Determination of and limits on the TI

Limits on the transport index (TI), which is a measure for the radiation level at a distance of 1 m from the surface of a package, are set to ensure the compliance with dose limits set in the BSS.

7.2.2. Determination of and limits on the CSI

[[Note: The text below on CSI needs to be coordinated with what Dennis Mennerdahl ultimately produces for Chapter 11.]]

Fissile material and packages containing fissile material shall be classified under the relevant UN number as FISSILE, unless excepted by one of the provisions set up in the Regulations.

Typically, one or more of these provisions include consignment limits, regarding the mass of fissile nuclide to be transported in a consignment or on a conveyance.

More information about the history and the technical background of these limits is provided in Chapter 11 (Prevention of Criticality).

The Criticality Safety Index (CSI) is a number assigned to a package, overpack or freight container containing fissile material that is used to provide control over the accumulation of packages, overpacks or freight containers containing fissile material.

In order to comply with the general requirements for nuclear criticality control, limits are set for the maximum CSI in any one group of packages. In addition, a minimum spacing distance
between groups of packages is specified. Prevention of nuclear criticality is then achieved by limiting neutron interaction between packages containing fissile material.

In the case of transport under exclusive use, the limits about the CSI may be exceeded because of the additional operational controls. In some instances, a multilateral approval of the shipment can also be needed, in order to enable the competent authorities concerned to judge the need for any special controls to be applied during transport.

More information about the history and the technical background of these limits is provided in Chapter 11 (Prevention of Criticality)

**Criticality Safety Index (CSI) and Transport Index (TI)**

The Criticality Safety Index (CSI) is a new concept defined for the first time in the 1996 edition of the Regulations. The 1967, 1973 and 1985 Editions of the Regulations used the “transport index” for both radiological control and control of criticality safety of packages containing fissile material. These editions of the Regulations defined the transport index (TI) so that a single number accommodated both radiological safety and criticality safety considerations (the Transport Index (in the 1985 Edition) was the lower value of the TI (as defined in the 1996 Edition and those which came later) and the CSI (as defined in the 1996 Edition and those which came later)). As the operational controls needed for radiological protection and for criticality safety are essentially independent, the 1996 Edition of the Regulations has separated the CSI from the TI, which is now defined for radiological control only. This separation into two indices enables a clear recognition of the basis for operational control of a fissile package and eliminates potential unnecessary restrictions caused by the use of one index.

**Criticality Safety Index (CSI) and “allowable number”**

In the 1967 and 1973 Editions of the Regulations, a so-called “allowable number” was defined for Fissile Class II packages and Fissile Class III packages and was the basis for the contribution of the prevention of criticality to the calculation of the Transport Index (TI).

### 7.3. Limits on radiation levels and controls on transport

**7.3.1. Limits on radiation levels**

The requirement that the radiation level at the surface of an excepted package should not exceed 5 µSv/h was established in order to ensure that sensitive photographic material will not be damaged and that any radiation dose to members of the public will be insignificant.

The radiation level limits inherent in the definition of the categories (and associated labels) have been derived on the basis of assumed package/cargo handling procedures, exposure times for transport workers and exposure times for photographic film. Historically these were derived as follows [4]:

(a) 0.005 mSv/h at surface – This surface limit was derived, not from consideration of radiation effects on persons, but from the more limiting effect on undeveloped photographic film. Evaluation of the effect of radiation on sensitive X ray film in 1947 showed that threshold fogging would occur at an exposure of 0.15 mSv and a limit was set in the 1961 Edition of the Transport Regulations of 0.1 mSv linked to a nominal maximum exposure time of 24 h. In later editions of the Transport Regulations (1964, 1967, 1973 and 1973 (As Amended)), the 24 hour period was rounded to 20 hours and the limiting dose rate of 0.005 mSv/h was taken as a rounded-down value to provide protection to undeveloped film for such periods of transport. This dose rate was applied as a surface limit for category I-WHITE packages, which would ensure there being little likelihood of radiation damage to film or unacceptable doses to transport personnel, without need for segregation requirements.

(b) 0.1 mSv/h at 1 m – For the purposes of limiting the radiation dose to film and to persons the dose of 0.1 mSv discussed in (a) above was combined with the exposure rate at 1 m
from the package and an exposure time of 1 hour to give the 10 times TI limitation of the 1964, 1967 and 1973 Editions of the Transport Regulations (10 ‘radiation units’ in the 1961 Edition). This was based upon an assumed transit time of 24 hours and the conventional separation distance of 4.5 m (15 feet) between parcels containing radium in use by the US Railway Express Company in 1947. The above limitation would yield a dose of approximately 0.1 mSv at 4.5 m (15 feet) in 24 h.

(c) 2.0 mSv/h at surface – A separate limit of 2.0 mSv/h at the surface was applied in addition to the limit explained in (b) above on the basis that a transport worker carrying such packages for 30 minutes a day, held close to the body, would not exceed the then permissible dose of 1 mSv per 8 hour working day. While such doses would no longer be acceptable, the adequacy of the current radiation level limits, in terms of radiological safety, has been confirmed by a number of surveys where radiation exposure of transport workers has been determined [5-14] and by an assessment performed by the IAEA in 1985 [15].

However, it must be recognized that the permitted radiation levels around packages and conveyances do not alone ensure acceptably low doses and the Transport Regulations also require the establishment of RPPs (para. 302) and the periodic assessment of radiation doses to persons due to the transport of radioactive material (para. 308).

7.3.2. Radiation controls on transport by road and rail

In most cases the radiation level at any point on the external surface of a package is limited to 2 mSv/h. For road and rail transport, when transported under exclusive use, packages and overpacks are allowed to exceed 2 mSv/h if access to the enclosed areas in the vehicle is restricted. The restrictions are to prevent unnecessary or uncontrolled exposures of persons.

It is essential to secure a package or overpack to prevent movement during transport which could cause the radiation level to exceed relevant limits or to increase the dose to the vehicle driver.

In establishing the dose rate for a conveyance, account may be taken of additional shielding within the conveyance. However, the integrity of the shielding should be maintained during routine transport; otherwise compliance with the conveyance radiation limit may not be maintained.

7.3.3. Radiation controls on transport by vessel

Each mode of transport has its own unique features. In the case of transport by sea the possibility of journey times of weeks or months and the need for continued routine inspection throughout the journey might lead to significant exposures during the carriage of the radioactive material. Simply having the exclusive use of a hold, compartment or defined deck area, particularly the latter, was not felt to provide sufficient radiological control for high radiation level packages. Two further restrictions were therefore introduced for packages having a surface radiation level greater than 2 mSv/h: either they must be in (or on) a vehicle or they must be transported under special arrangement. Access and radiation levels are therefore controlled by the additional requirements relating to transport by rail and road or by controls relevant to particular circumstances prescribed by the competent authority under the terms of the special arrangement.

The simple controls on the accumulation of packages as a means of limiting radiation exposure or preventing criticality may not be appropriate for ships dedicated to the transport of radioactive material. Since the vessel itself may be transporting consignments from more than one consignor, it could not be considered as being under exclusive use, and the usual limits for the transport index for conveyances and for the criticality safety index for conveyances containing fissile material might therefore be unnecessarily restrictive. Special use vessels employed for the transport by sea of radioactive material have been adapted and/or dedicated specifically for that purpose.
7.3.4. Radiation controls on transport by air

The Regulations prohibits the transport by air of vented Type B(M) packages, packages that require external cooling by an ancillary cooling system, packages subject to operational controls during transport and packages containing liquid pyrophoric materials. If venting were permitted, it would be difficult to design this to occur safely. Ancillary cooling and other operational controls would be difficult to ensure within an aircraft under normal and accident conditions. Any liquid pyrophoric material poses a special hazard to an aircraft in flight: where a radioactive substance which has the subsidiary hazard of pyrophoricity is also a liquid, there is a greater probability of a spill occurring, and it is therefore absolutely forbidden to transport such a substance by air.

Packages or overpacks having a surface radiation level greater than 2 mSv/h shall not be transported by air except by special arrangement. Because of the higher radiation levels than would normally be allowed, greater care is necessary in loading and handling. The requirement for such consignments to be transported by special arrangement ensures the involvement of the competent authority and allows special handling precautions to be specified, either during loading, in flight or at any intermediate transfer points.

7.3.5. Radiation controls on transport by post

For movement by post, the allowed levels of activity are only one tenth of the levels allowed for excepted packages by other modes of transport, for the following reasons:

- The possibility exists of contaminating a large number of letters, etc., which would subsequently be widely distributed, thus increasing the number of persons exposed to the contamination.
- This further reduction would result in a concurrent reduction in the maximum radiation level of a source which has lost its shielding, and this is considered to be suitably conservative in the postal environment in comparison with other modes of transport.
- A single mailbag might contain a large number of such packages.

7.4. Determining categories of packages

The radiation level limits inherent in the definition of the categories (and associated labels) have been derived on the basis of assumed package/cargo handling procedures, exposure times for transport workers and exposure times for photographic film. Historically these were derived as follows [4]:

(a) 0.005 mSv/h at surface – This surface limit was derived, not from consideration of radiation effects on persons, but from the more limiting effect on undeveloped photographic film. Evaluation of the effect of radiation on sensitive X-ray film in 1947 showed that threshold fogging would occur at an exposure of 0.15 mSv and a limit was set in the 1961 Edition of the Transport Regulations of 0.1 mSv linked to a nominal maximum exposure time of 24 h. In later editions of the Transport Regulations (1964, 1967, 1973 and 1975 (As Amended)), the 24 hour period was rounded to 20 hours and the limiting dose rate of 0.005 mSv/h was taken as a rounded-down value to provide protection to undeveloped film for such periods of transport. This dose rate was applied as a surface limit for category I-WHITE packages, which would ensure there being little likelihood of radiation damage to film or unacceptable doses to transport personnel, without need for segregation requirements.

(b) 0.1 mSv/h at 1 m – For the purposes of limiting the radiation dose to film and to persons the dose of 0.1 mSv discussed in (a) above was combined with the exposure rate at 1 m from the package and an exposure time of 1 hour to give the 10 times TI limitation of the 1964, 1967 and 1973 Editions of the Transport Regulations (10 ‘radiation units’ in the 1961 Edition). This was based upon an assumed transit time of 24 hours and the conventional separation distance of 4.5 m (15 feet) between parcels containing radium in use by the US Railway Express Company in 1947. The above limitation would yield a dose of approximately 0.1 mSv at 4.5 m (15 feet) in 24 h.
(c) 2.0 mSv/h at surface – A separate limit of 2.0 mSv/h at the surface was applied in addition to the limit explained in (b) above on the basis that a transport worker carrying such packages for 30 minutes a day, held close to the body, would not exceed the then permissible dose of 1 mSv per 8 hour working day. While such doses would no longer be acceptable, the adequacy of the current radiation level limits, in terms of radiological safety, has been confirmed by a number of surveys of radiation exposure of transport workers as discussed in Section 7.3.1 above.

However, it must be recognised that the permitted radiation levels around packages and conveyances do not alone ensure acceptably low doses and the Regulations also require the establishment of Radiation Protection Programmes (RPPs) and the periodic assessment of radiation doses to persons due to the transport of radioactive material.

7.5. Assigning and use of UN Numbers

[[NOTE: This section needs to be developed to address UN Numbers, noting that

1. the assignment of the UN Number to the radioactive material being shipped according to requirements in the 2012 edition of the Regulations (para. 401 and Table 1); and
2. the use of the UN Numbers is then specified in Section V of the Regulations.

The history and purpose of the UN Numbers should then be elaborated, including pointing out that the UN Numbers were first introduced in the 1985 edition of the regulations, and that one primary use of them is to guide emergency responders on the hazards posed by the shipment and the means for properly responding – consistent with the approach taken by modal authorities in developing emergency response guides.]]

7.6. Requirements for marking and labelling of packages

Markings are placed on each packaging, part of which are unique to each packaging (e.g. serial number); whereas the labels are placed on packages when prepared for transport and provide information on the actual radioactive contents and the external radiation levels.

7.6.1. Marking of packages

Identification of the consignor or consignee

To retain the possibility of identifying the consignee or consignor of a package for which normal control is lost (e.g. lost in transit or misplaced), an identification marking is required on outside of the packaging. This marking may consist of the name or address of either the consignor or consignee, or may be a number identifying a way-bill or transport document which contains this information. Each overpack should be so marked unless the markings on all the inner packages are clearly visible within the overpack.

UN number

The UN number marked on the package and the overpack, when appropriate, and indicated in the documents is important information in the event of incidents and accidents. The UN number corresponding to the approval certificate issued by the competent authority of the country of origin of design gives the information about package type that is needed for emergency management.

UN numbers can also be used for compliance situations, performance checks and controls, data collection and other statistical purposes should the competent authority find merit in this application.

The UN numbers 2977 and 2978 should be used instead of LSA material shipping numbers, to help the emergency response team to address the specific hazards raised by uranium hexafluoride in the event of an accident involving a severe fire; a fire on a uranium hexafluoride cylinder raises more severe hazards than a fire on other LSA material [16]. It is also considered that when an accident occurs involving uranium hexafluoride transported under special
arrangement, it is better that the emergency response teams are quickly informed that uranium hexafluoride is involved in the accident.

The implementation of the 1996 Edition of the Transport Regulations could lead to multiple labelling and marking as a consequence of divergence between approvals issued by different competent authorities. To avoid having to change the marking and labelling at border crossings, only one single set of information should be applied. The 2005 Edition of the Regulations (and those which came later) specifies that the marking shall be in accordance with the certificate of the country of origin of design.

**Gross mass**

Packages exceeding 50 kg gross mass are likely to be handled by mechanical rather than manual means and require marking of the gross mass to indicate the possible need for mechanical handling and observance of floor loading and vehicle loading limits. To be useful in this respect, the marking is required to be legible and durable.

**Durability of marking**

Markings should be durable in the sense of being at least resistant to the rigours of normal transport, including the effects of open weather exposure and abrasion, without substantial reduction in effectiveness.

**Type of package**

All Type B(U), Type B(M), Type C and fissile material package designs require competent authority approval. Markings on such packages provide a link between the individual package and the corresponding national competent authority design approval (via the identification mark), as well as information on the kind of competent authority design approval.

Although no competent authority approval is required for industrial or Type A packages whose contents are not fissile material, the designer and/or consignor should be in a position to demonstrate compliance with any cognizant competent authority. The package marking therefore should identify the organization responsible for designing the package. This marking assists in the inspection and enforcement activities of the competent authorities. Where the designer is also the consignor, the mark may also provide, to the knowledgeable observer, valuable information in the event of an accident.

The 1996 Edition of the Transport Regulations introduces the requirement to identify industrial packages with a mark. The design of the mark is consistent with other similar marks in that it includes the word 'Type' together with the appropriate industrial package description (e.g. Type IP-2). The design of the mark also avoids potential confusion where, in other transport regulations, the abbreviation IP may be used for a different purpose. For example, the ICAO Technical Instructions use IP to mean Inner Packaging; for example 'IP.3' to denote one out of ten particular kinds of inner packagings.

**Serial number**

The marking with a serial number is required because operational management system and maintenance activities are oriented towards each packaging and the corresponding need to perform and verify these activities on an individual packaging basis. The serial number is also necessary for the competent authority's compliance assurance activities and for application of the provisions dealing with transitional arrangements.

**Trefoil**

The marking of a Type B(U), Type B(M) or Type C package with a trefoil symbol resistant to the effects of fire and water is needed to ensure that such a type of package can be positively identified after a severe accident as carrying radioactive material.
7.6.2. Labelling of packages

Packages, overpacks and freight containers can be characterized as handling or cargo units. Transport workers need to be made aware of the contents when such units carry radioactive material and need to know that potential radiological and criticality hazards exist. The labels provide that information by the trefoil symbol, the colour and the category (I-WHITE, II-YELLOW or III-YELLOW), and the fissile label. Through the labels it is possible to identify (a) the radiological or criticality hazards associated with the radioactive content of the cargo unit and (b) the storage and stowage provisions which may be applicable to such units.

The radioactive material labels used form part of a set of labels used internationally to identify the various classes of dangerous goods. This set of labels has been established with the aim of making dangerous goods easily recognizable from a distance by means of symbols. The specific symbol chosen to identify cargo units carrying radioactive material is the trefoil.

The content of a cargo unit may, in addition to its radioactive properties, also be dangerous in other respects, for example corrosive or flammable. In these cases the regulations pertaining to this additional hazard must be adhered to. This means that, in addition to the radioactive material label, other relevant labels need to be displayed on the cargo unit.

**Labelling for radioactive contents**

In addition to identifying the radioactive properties of the contents, the labels also carry more specific information regarding the contents (i.e. the name of the nuclide and the activity). In the case of fissile contents, the total mass of fissile nuclides may be used in place of activity. This information is important in the event of an incident or accident where content information may be needed to evaluate the hazard. The more specific information regarding the contents is not required for LSA-I material, because of the low radiation hazard associated with such material.

Yellow labels also show the TI of the cargo unit (i.e. package, overpack, tank and freight container). The TI information is essential in terms of storage and stowage in that it is used to control the accumulation and ensure proper separation of cargo units. The Transport Regulations prescribe limits on the total sum of TIs in such groups of cargo units.

**Labelling for criticality safety**

The Criticality Safety Index (CSI) is a value used for accumulation control of packages needed for criticality safety purposes (see section A.16.1.16). The control is provided by limiting the sum of the CSIs.

To facilitate such control, the CSI is required to be displayed on a label which is specifically designed to indicate the presence of fissile material in the case of packages, overpacks or freight containers where contents consist of fissile material not excepted.

The CSI label is additional to the category labels (categories I-WHITE, II-YELLOW and III-YELLOW), because its purpose is to provide information on the CSI, whereas the category label provides information on the TI and the contents. The CSI label, in its own right, also identifies the package as containing fissile material.

Like the TI, the CSI provides essential information relevant to storage and stowage arrangements in that it is used to control the accumulation and ensure proper separation of cargo units with fissile material contents.

7.7. Requirements for placarding

Placards, which are used on road and rail vehicles, large freight containers and tanks, are designed in order to clearly identify the hazards of the dangerous goods. Displaying the placards on all four sides of the freight containers and tanks ensures ready recognition from all directions. The size of the placard is intended to make it easy to read, even at a distance. To prevent the need for an excessive number of placards and labels, an enlarged label only may be
used on large freight containers and tanks where the enlarged label also serves the function of a placard.

The display of the UN number can provide information on the type of the radioactive material transported, including whether or not it is fissile, and information on the package type. This information is important in the case of incidents or accidents resulting in leakage of the radioactive material in that it assists those responsible for emergency response to determine proper response actions.

7.8. Requirements for transport and for storage in transit

7.8.1 Controls on segregation

Operational controls that are applied in the transport of radioactive material can include the use of segregation distances.

The history of the parameters used in the derivation of segregation tables is that originally a fraction of the dose limit was chosen in each case (for workers and for members of the public) and what was considered to be a realistic model was used to derive the tables of segregation distances for each mode of transport. It was noted that real data were sparse and that these data should be reviewed. With the production of more realistic data [9, 14] it has become apparent that the models are very conservative. So conservative, in fact, that as the dose limits have been reduced the model and dose criteria have, on several re-examinations, been considered to provide adequate segregation [17]. By comparing all aspects of the practice (not simply segregation) with appropriate dose constraints for transport (as a whole — not just for one transport operation) the use of the current tables has been deemed to provide an adequate level of safety.

An example of such a review was carried out during the preparation of the 1996 Edition of the Transport Regulations. The model and dose criteria were examined in light of the developing philosophy of dose constraints as amplified in Ref. [18]. A dose constraint of 0.7 mSv was considered appropriate for exposure of a critical group of the public to direct radiation from sources such as radioactive material in transport. This constraint was envisaged as being applicable to global transport operations in general rather than the operations of one particular consignor. Over a series of three technical meetings information on assessed exposures to members of the public was actively collected and evaluated. The assessment of this information demonstrated that exposures being received by members of the public from these operations were far below the dose criterion used in the modelling and the appropriate dose constraint. The conclusion of these studies was that the existing segregation tables and the other provisions of the Transport Regulations together provide for an appropriate level of radiological safety. However, these evaluations were not adequately reflected in the associated guidance publication. It is considered that the current segregation tables are consistent with the use of appropriate dose constraints. For example, the postulated public dose presented in the tables relate to a 1 mSv dose with a very pessimistic model (exposures are actually estimated to be of the order of tens of µSv), not (as was intimated in the 1996 guidance publication) a realistic model. [[[NOTE: further research is needed for the basis for this text. The reference citation in TS-G-1.1 (2008) is incorrect.]]]

Although not a radiation protection issue, an evaluation of the effect of radiation on fast X ray films in 1947 [4] determined that they may show slight fogging after development when exposed to doses exceeding 0.15 mSv of gamma radiation. This could interfere with the proper use of the film and provide incorrect diagnostic interpretation. Other types of film are also susceptible to fogging, although the doses required are much higher. Since it would be impracticable to introduce segregation procedures which vary with the type of film, the provisions of the Transport Regulations are designed to restrict the exposure of undeveloped films of all kinds to a level of not more than 0.1 mSv during any journey from consignor to consignee.
The different time durations involved for sea transport (in terms of days or weeks) and air or land transport (in terms of hours or days) mean that different tables of segregation distances are used, so that the total film exposure during transit is the same for each mode. More than one mode of transport and more than one shipment may be involved in the distribution and ultimate use of photographic film. Thus, when segregation distance tables are being established for a specific transport mode, only a fraction of the limit prescribed in para. 562 should be committed to that mode. In road transport a driver may ensure sufficient segregation from photographic film carried in other vehicles by leaving a clear space of at least 2 m all around the vehicle when parking.

Since mail bags often contain undeveloped film and will not be identified as such, it is prudent to protect mail bags in the same way as identified undeveloped film.

### 7.8.2. Controls on Stowage

One of the reasons for limiting the accumulation of packages in groups, or in conveyances and freight containers is to prevent the creation of higher than acceptable radiation levels as a result of the additive effects of radiation from the individual packages. For consignments not carried under exclusive use, this is done by placing a limit on TI. The theoretical maximum dose rate at 2 m from the surface of a vehicle carrying a TI of 50 was historically calculated as 0.125 mSv/h, and considered to be equivalent to 0.1 mSv/h since the maximum was unlikely to be reached. Experience has confirmed the acceptability of these values.

### References for Chapter 7


8. CLASSIFICATION OF MATERIALS

The classification of materials has significantly changed and matured since the first edition of the Transport Regulations [1]. For example, in the early editions of the Regulations (i.e. the 1961, 1965 and 1967 editions) the individual radionuclides were classified into groups based on radioactivity as well as classifications based on physical properties. Between that time and the issuing of the 2009 edition of the Regulations, the terms “classify” and “classification” were not used significantly, but the materials were still ordered according to radioactivity and physical properties. However, with the 2009 edition [2], and also the 2012 edition of the Regulations [3], classification was imposed in detail according to specific physical characteristics of the radioactive material.

The following subsections provides a summary of how the concept of classification of materials evolved through the various editions of the transport regulations, illustrating how these classifications changed, and providing some insight into why the changes were made.

8.1. Classification of material in the 1961 edition of the Transport Regulations

In that first edition, the materials were classified as follows:

- Group I – very high radioactivity
- Group II – high radioactivity
- Group III moderate radioactivity
- Large radioactive sources
- Non-friable massive solids that are non-soluble in water and non-reactive with air or water
- Pyrophoric radioactive material
- Explosive radioactive material
- Radioactive materials of low specific activity
- Fissile materials

From the radiological perspective, each radionuclide was assigned a group (i.e. Group I, II or III), where the quantity allowed in a package was limited except, if that quantity was exceeded, then it was to be treated as a “large radioactive source”. These materials were required to be transported in Type B packagings, the design of which was to be approved by the competent authority in which the shipment originated.

From the physical characteristics perspective:

- small quantities of the non-friable solids could be transported in Type A packagings; however if a specified activity limit was exceeded, they were required to be transported in Type B packagings;
- pyrophoric radioactive materials were required to be transported in Type B packagings; and
- explosive radioactive materials were only permitted to be transported under special arrangements.

In addition, characteristics of materials with low specific activity were specified. When a material satisfied those characteristics, their transport was allowed in strong, leak-proof packages or in vehicle compartment specially designed to prevent leakage under normal conditions of transport. The low specific activity material classification was developed with a consideration of the radiation dose hazard presented by the material.

Materials containing radionuclides in concentrations above the exemption levels must be regulated. However, it is reasonable that materials containing radionuclides slightly above exemption levels may themselves be exempted from parts of the transport regulatory requirements; these may be associated with the low end of the low specific activity material spectrum, or with the exemptions noted in the next paragraph. This approach is intended to allow packaging and transport flexibility while concurrently giving reasonable assurance that the transport of such materials does not give rise to unacceptable doses.
Exemptions from parts of the regulatory requirements were specified for Groups I, II and III materials based on the maximum activity in a package and other features of the package; while the transport of instruments with radioactive materials as components and the transport of empty packages were further exempted from many of the regulatory requirements.

The technical basis for the classifying of the materials in summarized in Section A.3.1 of Appendix 3. Additional information on the basis of the initial classification of material can be found in References [4], [5].

8.2 Classification of material in the 1964 edition of the Transport Regulations

As elaborated in Appendix 3, the grouping and limits changed to a larger number of groups in the 1964 edition of the Transport Regulations [6] to eight groups. Section A.3.1 of Appendix 3, shows that Aikens [7] provided a summary of the activity limits for the eight different groups as they applied to the three package types that then existed in the Regulations (i.e. Exempt from Requirements, Type A Packaging, and Type B Packaging).

Concurrently, the 1964 edition retained the concept of large radioactive sources and low specific activity materials; however, the concept of special form radioactive material was introduced in place of the concept of 'massive non-friable solid' with a different set of limits [8].

The concept of exemptions from parts of the regulatory requirements was expanded to include not only instruments but also of manufactured articles with radioactive materials.

8.3 Classification of material in the 1967 edition of the Transport Regulations

In the 1967 edition [9], the number of groups was changed from eight to seven. Fairbairn [8] noted, discussed the work of various panels convened to address the Regulations, that the panels convened for the 1964 and 1967 editions of the Regulations. As already illustrated in the last subsection, the 1964 "Panel listed radionuclides within Groups I – VIII"; whereas "in the 1967 issue of the regulations this was changed to Groups I – VII, the previous Groups VII and VIII having a common contents limit".

8.4 Classification of material in the 1973 edition of the Transport Regulations

The 1973 edition of the Transport Regulations [10] first introduced the concept of $A_1$ and $A_2$ values for specifying the contents limits in packages. Fairbairn [8] noted that with this $A_1/A_2$ system "...each nuclide has two Type a package limits, $A_1$ curies when in special form and $A_2$ curies when not in special form". As elaborated in Section A.3.1 of Appendix 3, Fairbairn discussed how the $A_1$ values were derived using a rather limited, but conservative model where it was assumed that the source was intact but had completely released from its packaging and associated shielding; whereas, the $A_2$ values were derived assuming that the material was completely released from its packaging where the value was calculated using the then most recent ICRP guidance [11], while imposing the assumption that internal exposure from intake would be $10^{-6}$ of the package contents. A detailed summary of the basis for the 1973 values of $A_1$ and $A_2$ was provided in the First Edition of Safety Series No. 37 [12]. This process established a more rigorous technical basis for classifying the radioactive materials for shipment.

The introduction of the $A_1$ and $A_2$ values for each radionuclide in the 1973 edition of the Regulations "enabled the panel responsible for the 1973 revision to dispense with the artificial concept of the 'large radioactive source'"[8]. Paras 401 – 421 of the 1973 edition of Safety Series No. 37 [12] elaborates extensively on the technical basis for establishing the $A_1$ and $A_2$ values. It states that the "replacement of the 20-Ci Type A package limit for special form, ..., by an $A_1$ curie limit for each nuclide represents an increase in safety with regard to emitters of gamma photons in excess of 1 MeV and also with regard to alpha, beta and neutron emitters for which assessments based on specified models were made". Because of the advanced sophistication of the model used, a number of limits increased from what they were in the 1967 edition while others decreased.
Furthermore, for the $A_2$ values, the limits were previously established based on the "most toxic member of the Group (......), the resulting $A_2$ values represent a relaxation of Type A package limits for most nuclides".

The 1973 edition of the Regulations also introduced for the first time the concept of low-level solid radioactive material. This included (a) solids where evenly distributed throughout a solid, the activity was insoluble to a measurable level of $0.1A_2$ when exposed to specified weathering effects for one week, and the specific activity in the solid did not exceed $2 \times 10^{-3} A_2$/g; and (b) non-radioactive solids contaminated with limited quantities of radioactivity.

Paras 354 - 356 of the 1973 edition of Safety Series No. 37 [12] elaborates on the motivation for establishing the classification of low level solids, noting that "this category extends the concept of non-inherently safe low specific activity materials in Section I of the Regulations, para. 121 (d) and (g), to materials with a distributed activity of up to twenty times the levels specified there, liquids and solids being specifically excluded". It then discusses the basis for the non-radioactive material contaminated with radioactive materials, noting that (a) this allows a twenty-fold increase in the maximum surface contamination levels over what was then specified for low specific activity materials; (b) this increase means these "materials are therefore potentially very hazardous, which is why packaging specification must be laid down"; and (c) "the contamination must be in a 'non-readily dispersible form'".

8.5. Classification of material in the 1973 Revised Edition (As Amended), 1979, of the Transport Regulations

Essentially no changes were made in the classification of materials in the 1973 Revised Edition (As Amended), which was issued in 1979 [13]. As noted in the Foreword to this document, only minor amendments, mainly of an editorial nature, plus a number of changes of detail were implemented. However, it is noted that paras 4.12 - 4.16 of the Second Edition of Safety Series No. 37 [14] provides additional insight into the manner by which the original $A_1$ and $A_2$ values were derived.

8.6. Classification of material in the 1985 edition of the Transport Regulations

The specification of $A_1$ and $A_2$ values for radionuclides continued in the 1985 edition of the Transport Regulations [15]. However, an extensive effort produced a much more solid basis for the values using what is known as the Q system. Appendix I of the 1990 edition of Safety Series No. 7 [16] provides a detailed discussion of the technical basis for the $A_1$ and $A_2$ values derived using the initial Q system. In addition, Section 6.2 above, and Appendix 3 further address the basis of the Q system.

In the 1985 edition, extensive changes were made to what were formerly classified as low specific activity material and low-level solid radioactive material. These classification were replaced by (a) low specific activity (LSA) material, defined into three groups (LSA-I, LSA-II and LSA-III); and surface contaminated objects (SCO-I and SCO-II). A brief explanation of the basis for these changes is provided in paras. E-131.1 – E-131.10 for LSA material, and in paras. E-144.1 – E-144.4 for SCOs.

Coupled with the above requirements is a limit on the quantity of LSA material or SCO that can be carried in a single IP package such that it shall be "so restricted that the external radiation level at 3 m from the unshielded material or object or collection of objects does not exceed 10 mSv/h (1 rem/h)" (see para. 422 of the 1985 Edition [15]). The basis for this restriction is that, since "industrial packages used for transporting LSA material and SCOs are not required to withstand transport accidents, a provision was initiated in the 1985 edition of the Regulations to limit package contents to the amount which would limit the external radiation level at 3 m from
the unshielded material or object to 10 mSv/h. Geometrical changes of LSA material or SCOs as a
result of an accident are not expected to lead to a significant increase of this external radiation
level. This limits accident consequences associated with LSA material and SCOs to essentially the
same level as that associated with Type A packages, where the A1 value is based on the unshielded
contents of a Type A package creating radiation levels of 100 mSv/h at a distance of 1 m." [17]
Thus, if the “unshielded material or object or collection of objects exceeds 10 mSv/h (1 rem/h)",
the material or objects must be transported in Type A or Type B packages, as appropriate, and
should not be classified as LSA material or SCO for the purposes of transport.

In order to correct minor editorial errors that occurred in the 1985 edition, and to address
changes of details that were identified and agreed to, the 1985 edition was supplemented with
change pages in 1986 and 1988; and an amended version incorporating these editorial and
minor changes was issued in 1990. However, none of the materially affected the classification of
materials.

8.7. Classification of material in the 1996 edition of the Transport Regulations

In the 1996 edition of the Regulations [18], two additional material classifications were added:
(1) low dispersible radioactive material (LDRM), and (2) uranium hexafluoride (UF6).

8.7.1. The LDRM Classification

The LDRM classification was added to allow large quantities of radioactive material that are not
prone to airborne dispersion to be carried in Type B packages transported by air. The threshold
for materials other than LDRM where transport by air is not allowed in Type B package is
specified in para. 416 of the 1996 edition, which reads as follows:

"416. Type B(U) and Type B(M) packages, if transported by air, shall meet the requirements
of para. 415 and shall not contain activities greater than the following:
(a) for low dispersible radioactive material - as authorized for the package design as
specified in the certificate of approval,
(b) for special form radioactive material - 3000 A₁ or 100 000 A₂, whichever is the lower; or
(c) for all other radioactive material - 3000 A₂."

For materials that can be demonstrated to satisfy the requirements for LDRM, they can be
transported in a single Type B package in a quantity greater than the threshold specified in para. 416(a) and para. 416(b), subject to certification approval by the relevant competent
authority(ies). However, for materials that cannot be demonstrated to satisfy the requirements
for LDRM, if they are to be transported in a single package in a quantity greater than the
threshold specified in para. 416(a) and para. 416(b), they must be transported in a package
satisfying the more robust Type C package design requirements.

The requirements that must be satisfied for a material to be accepted as LDRM are specified in
para. 605 of the 1996 edition of the Regulations [18].

As elaborated in Paras 225.2 and 225.3 of TS-G-1.1, 2008 edition [19], 225.2. the LDRM
requirements were established to ensure that the material would not give rise to significant
potential releases or exposures even when subjected to high velocity impact and severe thermal
environments such as might be expected to occur during a severe aircraft accident. Under these
conditions, only a limited fraction of the LDRM would be expected to become airborne. As a
result, the potential for radiation exposure from inhalation of airborne material by persons in
the vicinity of such an accident would be very limited. These criteria are derived so as to be
consistent with other safety criteria. [[Need to look in the archives for documentation from the
revision panels and associated CSMs and TMs leading up to the 1996 edition of the regulations.
The actual thresholds for moving to ]]]
8.7.2. The UF6 Classification

The UF6 classification was added in the 1996 edition of the Regulations in order to introduce special requirements for protecting people and the environment against the chemical, not the radiological, nature of the material. Although not specifically elaborated as a classification, requirements for testing of UF6 packages beyond what had previously been required were introduced at that time. The basis for this classification and the added package tests are elaborated in Section 10.6. [[Need to look in the archives for documentation from the revision panels and associated CSMs and TMs leading up to the 1996 edition of the regulations to see if there is additional information that can be added here.]]

8.8. Emphasis on classification of material in the 2009 and 2012 editions of the Transport Regulations

Essentially no changes were made with regard to the classification of material in the 2005 edition of the Regulations. However, in the 2009 edition of the Regulations [2], significant emphasis was placed on the classification of material. Specifically, the title of Section IV of the Regulations was changed to read “ACTIVITY LIMITS AND CLASSIFICATION”; where paras 408 through 419 elaborate the requirements for (a) LSA material, (b) SCO, (c) special form radioactive material, (d) LDRM, (e) fissile material, and (f) UF6. This change, carried forward into the 2012 edition of the Regulations [3], was introduced to clarify that materials (and also packages, see Chapter 9 of this document) are classified according to the above. It is noted that this then leads to the assignment of UN Numbers according to the classification of material and sometimes package used [see Chapter 7, Section 7.5 for more details].

8.9. Technical basis for the requirements for a material classified as a special form radioactive material

As noted in Section 8.2, the classification of "special form radioactive material" was introduced in the 1964 edition of the Regulations in place of the earlier classification of 'massive non-friable solid' with a different set of limits. The requirements for special form radioactive material are found in the 2012 edition of the Regulations, SSR-1 [3] in paras 239, 415, 602-604 and 802. Specifically, para. 239 specifies that Special form radioactive material means "either an indispersible solid radioactive material or a sealed capsule containing radioactive material". In turn, para. 415 specifies that "Radioactive material may be classified as special form radioactive material only if it meets the requirements of paras 602–604 and 802." The requirements in paras 602 – 604 were established with a view to ensuring that a Type A package containing special form radioactive material would not release or disperse its radioactive contents during a severe accident, by leakage from the sealed capsule or by dispersion/leaching of the radioactive material itself, even though the packaging may be destroyed. This minimizes the predicted hazards from inhalation or ingestion of, or from contamination by, the radioactive material.

For example, in developing the requirements for special form radioactive material, it was decided early on that the material must be of a reasonable size to enable it to be easily salvaged or found after an incident or loss; hence the restriction on minimum size. Para. 602.1 of TS-G-1.1 [19] notes that the figure of 5 mm as specified in para. 602 of SSR-1 is arbitrary but practical and reasonable, it was specified considering the type of material normally classified as special form radioactive material.

The requirement the special form radioactive material would not break or shatter and would not release or disperse its radioactive contents by leakage from the sealed capsule or by dispersion/leaching of the radioactive material itself during a severe accident, even though the packaging may be destroyed was imposed with a view to minimizing the predicted hazards from inhalation or ingestion of, or from contamination by, the radioactive material. The tests in para. 603 of the Regulations were established pragmatically to address what a special form radioactive material in a Type A package might experience in a severe accident condition.
8.10. Technical basis for the requirements for a material classified as a fissile material

See Chapter 11 of the Technical Basis Document for details on the technical basis for fissile and fissile excepted material.

References for Chapter 8


9. CLASSIFICATION OF PACKAGES

Initially, in the first editions of the Regulations, five basic types of packagings were specified. The specifications for the packages, which were graded according to the risk posed by the contents, were:

(a) **Exempt and Empty Packages**: packages that were exempt from requirements, containing small quantities of radioactive material and having a minimal set of package design requirements;

(b) **Strong, leak-proof packages**: packages for materials that were judged to be "inherently safe", e.g. low specific activity materials such as radioactive ores, where the regulations provided for their carriage in "bulk or in strong, leak-proof package";

(c) **Type A packagings**: containing larger, but limited, quantities of radioactive material while being designed to be resistant to normal conditions of transport;

(d) **Type B packagings**: containing larger quantities of radioactive material while being resistant to both normal and accident conditions; and

(e) **Large radioactive source packages**: containing large radioactive sources, where the activity exceeded the limits for Type B packages, and where additional requirements were imposed on materials compatibility, containment system pressure and pressure relief systems, protection of valves, and proper design of attachments and tiedowns [1].

As the Regulations have matured, more package types were introduced, the classification titles of some have changed and expanded, while the two categories with the highest risk contents as defined in the early regulations (i.e. Type B packagings and packages containing large radioactive sources) were coalesced in the 1973 edition of the Regulations [2] into a single category. Beginning in 1996 [3], ten different package classifications were specified.

The extension and changes to the number and classification of package types involved extensive deliberations by expert panels concerning the nature of the contents and the need to provide flexibility in the Regulations, while concurrently ensuring adequate protection by each package type. The history of specification of classes of packages, as it has grown with time, is illustrated in Table 9-1.

Of the package classifications existing in the Transport Regulations since the 1996 edition (see Table 9-1), all but the H(U) and H(M) package classifications are specified in para. 231 of SSR-6 [4], whereas the H(U) and H(M) package classifications are established by way of para. 832 of the SSR-6.

The "classifying" of packages was not detailed specifically in the early edition of the Regulations; whereas, beginning in 2009, Section IV of the Regulations specifically called for classification of packages (see paras 421-434 of TS-R-1 (2009) [5] and paras 421-433 of SSR-6 [4]). However, SSR-6 does not address all of the package type that exist; it only addresses (1) excepted packages, including empty packages; (2) Type A packages; (3) Type B(U) packages; (4) Type B(M) packages; and (5) Type C packages.

The technical bases for these classifications of packages are discussed in detail in Chapter 10 and Appendix 3 of this Technical Basis document. The technical bases for the remaining package classifications – i.e. industrial packages and packages for UF6 – are also discussed in detail in Chapter 10 and Appendix 3.
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<thead>
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<td>Exempt Package / Empty Package</td>
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<td>Type B</td>
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<td>X X X</td>
</tr>
<tr>
<td>Type C</td>
<td>X</td>
</tr>
<tr>
<td>H(U) (specific approval specified for UF₆ contents)</td>
<td>X</td>
</tr>
<tr>
<td>H(M) (specific approval specified for UF₆ contents)</td>
<td>X</td>
</tr>
</tbody>
</table>

* Note: This table does not include the specific package types that address fissile material. The types of packages for fissile material are Type AF, Type B(U)F, Type B(M)F, and Type CF. The requirements for these are discussed in Chapter 11 of this Technical Basis document.

References for Chapter 9


