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Radiation protection programmes for the transport of radioactive material

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Radiation protection programmes for the transport of radioactive material

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Foreword

Annex A of this standard is an informative annex.

This standard is proposed by China National Nuclear Corporation.

This standard was prepared by Institute for Standardization of Nuclear Industry.

Radiation protection programmes for the transport of radioactive material

1 Scope

This standard specifies the general requirements for the radiation protection programmes for the transport of radioactive materials, and provides guidance for the preparation of radiation protection programmes for the transport of radioactive materials and the compliance with the optimization requirements for the radiation protection for the safe transport of radioactive materials.

This standard is applicable to the radiation protection for the transport of radioactive materials, but does not cover the critical safety issues that should be considered for the package of fissile materials and issues related to other possible harmful properties of radioactive materials.

2 Normative references

The following normative documents contain provisions which through reference in this text, constitute provisions of this standard. For dated references, subsequent amendments (excluding corrections), or revisions, of any of these publications do not apply to this standard. However parties to agreement based on this standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

GB 11806-2004 Regulations for the safe transport of radioactive material

GB 18871-2002 Basic standards for protection against ionizing radiation and for the safety of radiation sources

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

radiation protection programme

Systematic arrangements that provide adequate consideration of radiation protection measures

3.2

carrier

An individual or unit that undertakes the transport of radioactive materials by any means of transport

3.3

competent authority

Relevant national supervisory and regulatory agency or department designated or otherwise recognized for the management of matters related to this standard

3.4

consignor

An individual or unit that sends the goods consigned for transport

3.5

consignee

An individual or unit that receives the goods consigned

3.6

surface contamination

The radioactive material on the surface is in excess of a certain amount, i.e. 0.4 Bq/cm^2 for β and γ emitters and low toxicity emitters, or 0.04 Bq/cm^2 for all other α emitters.

Surface contamination includes non-fixed contamination and fixed contamination:

a) Non-fixed contamination refers to contamination that can be removed from a surface under normal transport conditions;
b) Fixed contamination refers to contamination other than non-fixed contamination.

3.7

dose limit

The value of the effective dose or equivalent dose to individuals from controlled practices that shall not be exceeded

3.8

dose constraint

It is a predetermined limit on the individual dose that a source may cause, which is source related and used as a constraint for the protection and safety optimization of the source considered. For occupational exposure, the dose constraint is a source-related individual dose value that is used to limit the range of choices considered for the optimization process. For public exposure, the dose constraint is the upper limit of annual doses received by public members from the planned operation of a controlled source.

3.9

conveyance

Conveyance means:

c) Various vehicles used for road or rail transport;
d) Various vessels used for water transport, or any cargo hold, compartment or defined deck area of the vessel;
e) Various aircrafts used for air transport.

3.10

radioactive contents

Radioactive material together with any contaminated or activated solids, liquids, and gases within the packaging

3.11

overpack

A enclosure, such as a box or bag, used by the consignor to facilitate the loading & unloading, stacking and carrying of one or more packages as a loading & unloading unit for consignment

3.12

package

It is a general term for the shipping package and its radioactive contents. The following types of packages involved in this standard shall comply with the radioactivity limits and material limits specified in GB 11806-2004 and meet corresponding requirements:

a) Exceptional package;
b) Type-1 industrial package (IP-1);
c) Type-2 industrial package (IP-2);
d) Type-3 industrial package (IP-3);
e) Type-A package;
f) Type-B(U) package;
g) Type-B(M) package;
h) Type-C package.

Packages containing fissile material or uranium hexafluoride shall meet corresponding additional

requirements.

3.13

packaging

It is a combination of various components necessary to completely enclose the radioactive contents. Generally, it may consist of one or more containers, absorbent materials, spacing structures, radiation shield and an auxiliary device for inflation, emptying, venting and pressure relief; parts for cooling, mechanical shock absorption, loading & unloading and tie-down, thermal insulation; and auxiliary devices integral to the package. The packaging may be a box, drum or similar container, or may also be a freight container, tank or solid bulk container.

3.14

low specific activity material (LSA)

For its nature, it is a radioactive material with a limited specific activity, or an estimated average specific activity below the limit. External shielding materials surrounding the LSA shall not be considered in determining the estimated average specific activity.

LSAs are classified into three categories: Category-I low specific activity material (LSA-I), Category-II low specific activity material (LSA-II), and Category-III low specific activity material (LSA-III)

3.15

surface contaminated object (SCO)

It is a solid object which itself is not radioactive but has radioactive material distributed on its surfaces. SCO can be divided into two categories: Category-I surface contaminated object (SCO-I) and Category-II surface contaminated object (SCO-II).

3.16

transport Index (TI)

The transport index (TI) specified for the package, overpack or cargo container, or unpackaged LSA-I or SCO-I refers to a value used to control the radiation exposure.

4 Radiation protection programme

4.1 Overview

4.1.1 The purpose for preparing the radiation protection programme for the transport of radioactive material is to:

a) fully consider radiation protection measures;
b) put forward practical measures to achieve the radiation protection goals;
c) ensure the proper implementation of the radiation protection system;
d) enhance safety culture.

4.1.2 The radiation protection programme may consist of one or several documents in the radioactive material transport management system, or may be a separate programme or a part of the operator's quality assurance programme.

4.2 Scope and requirements of radiation protection programme

4.2.1 Scope

4.2.1.1 The radiation protection programme covers all aspects of transport with focus on theactivities of transport operations that cause radiation exposure, such as packaging, preparation, loading, unloading, handling, halfway storage, movement of packages, and inspection and maintenance of packaging.

4.2.1.2 The radiation protection programme covers all aspects and related conditions of the transport, including normal transport conditions and transport accidents.

4.2.1.3 For such transport of radioactive material as that with low occupational exposure dose or is a temporary transport,a radiation protection programme shall also be established. For the transport of

heavy-duty shielding package loaded with high-activity radioactive materials, although the exposure dose of personnel is generally low, full consideration of the basic elements for radiation protection, including emergency response and training are still required.

4.2.1.4 The preparation of a radiation protection programme is not required for the transport of radioactive material with the activity and specific activity of radioactive nuclides below the exemption values specified by the State.

4.2.2 **Elements of radiation protection programme**

The radiation protection programme shall explain the main considerations of radiation protection, including the following basic elements ofprotection and safety elements. For each element, an appropriate and detailed document shall be formed:

a) Scope of the programme;
b) Responsible party for programme implementation and its duties;
c) Dose assessment;
d) Dose limits, dose constraint values and radiation protection optimization;
e) Surface contamination;
f) Isolation and other protective measures;
g) Emergency preparation and response arrangements;
h) Training;
i) A safe management system for the transport of radioactive materials.

4.2.3 **Graded requirements**

4.2.3.1 The radiation protection programme shall include the requirements in 4.1 of GB 11806-2004. The radiation control measures intended to take shall be conditioned by the level of hazard that may be caused by the transport of radioactive material. A simple programme is required if only a few packages with low potential radiation hazards are involved, and a detailed programme is needed for more important operations such as operating and shipping a variety of radioactive materials and packages in public areas, and/or operating packages by large batches and with surface dose rate at a relatively high level, and conducting similar important operations with higher likelihood of potential radiation hazards.

4.2.3.2 According to the principle that the radiation protection measures proposed to take are corresponding to the potential hazards, it is recommended to use the graded approach shown in Table 1 to prepare the radiation protection programme.

Table 1 Elements of radiation protection programme and occupational exposure dose

<table>
<tr><td rowspan="2">Elements of radiation protection programme[a]</td><td colspan="3">Occupational exposure dose[b]</td></tr>
<tr><td>Annual dose not exceeding 1mSv</td><td>Annual dose within 1mSv~6mSv</td><td>Annual dose exceeding 6mSv</td></tr>
<tr><td>Scope of the programme</td><td colspan="3">All shall be considered</td></tr>
<tr><td>Responsible party and its duties</td><td colspan="3">All shall be specified</td></tr>
<tr><td>Dose assessment</td><td>Site monitoring occasionally required</td><td>Workplace or individual monitoring</td><td>Mandatory individual monitoring</td></tr>
<tr><td>Dose limits, dose constraints and radiation protection optimization</td><td>Yes, only basic optimization</td><td colspan="2">Yes</td></tr>
<tr><td>Surface contamination</td><td colspan="3">All shall be considered</td></tr>
<tr><td>Isolation and other protective measures</td><td colspan="3">Only applicable to Level-II (yellow), Level-III (yellow) and exclusive Level-III (yellow) (and packages containing fissile material)</td></tr>
<tr><td>Emergency prepardness and response[c]</td><td colspan="3">All shall be considered</td></tr>
<tr><td>Training[c]</td><td colspan="3">All shall be considered</td></tr>
<tr><td>Management system[c]</td><td colspan="3">All shall be considered</td></tr>
<tr><td colspan="4">[a] Listed Elements
[b] For each element, depending on the circumstances, a graded approach shall be used.
[c] It cannot only be used as an element of the radiation protection programme, but also involves broader considerations. The radiation protection programme can refer to contents of relevant documents.</td></tr>
</table>

4.2.3.3 No special dose assessment and control actions are required if the occupational exposure doses that may be generated during the transport activities within in a year are unlikely to exceed 1mSv; individual monitoring shall be conducted as far as possible if such doses are likely to be between 1mSv~6mSv; individual monitoring of transport personnel shall be mandatory if the doses are likely to exceed 6mSv within a year.

5 Responsible party and its duties

5.1 Operator's duties

5.1.1 The main duties of the operators (such as consignor, carrier, port station operator, consignee) are to determine the safety and performance objectives, develop related documents, provide necessary organization and resources, and work within their respective scopes of responsibilities to ensure that the objectives of the radiation protection programme are met.

5.1.2 The radiation protection programme shall cover the interfaces between the relevant organizations.

5.1.3 A programme document should be provided when the competent authority conducts the inspections.

5.2 Duties of competent authority

The competent authority shall supervise and inspect the operator's radiation protection programme for the transport of radioactive material and its implementation in accordance with relevant national laws and regulations.

6 Dose assessment and optimization

6.1 Dose assessment principle

6.1.1 Radiation monitoring and dose pre-assessment are carried out in gradedapproach for worker (including the public if necessary) to accurately describe the possible radiation impacts of radioactive material shipment operations and to demonstrate that the transport meets all relevant standards and good practices are kept.

6.1.2 Radiation dose assessment shall consider the package type, package classification, exposure time, dose rate, operation frequency, transport volume, overpack or container used, need for halfway storage, mode of transport, conveyance and stacking in conveyance.

6.1.3 The assessment methods to be usedshould be determined in the radiation protection programme

6.2 Monitoring

6.2.1 Monitoring of package and conveyance

The routine monitoring for the radiation level and Surface contamination of packages and conveyance shall be specified in the radiation protection programme to confirm that the regulatory limit requirements are met. The nature and frequency of monitoring shall be specified in accordance with the scope of the radiation protection programme. The equipment used shall match with corresponding radiation type and meet appropriate performance standards with its scale. The consignor shall be mainly responsible for ensuring that the package dose rate and contamination level meet the regulatory requirements. The consignor, carrier and consignee shall be responsible for the packages, conveyance, workplaces and individual monitoring in accordance with their respective conditions.

6.2.2 Monitoring of workplace

6.2.2.1 The routine monitoring of the workplace is to demonstrate that working conditions are well maintained and meet the regulatory requirements, and the monitoring results can be used for dose assessment. The workplace monitoring can be performed in the storage plant or at the operation site, as well as within the vehicle. It includes monitoring of external exposure and Surface contamination, and its nature and frequency shall be determined based on the results of previous radiation assessments.

6.2.2.2 The equipment used shall match with corresponding radiation type and meet appropriate performance standards with its scale. The most representative locations shall be selected for the workplace monitoring.

6.2.3 Individual monitoring

If the individual dose monitoring is required, the individual monitoring procedure shall be an integral part of the radiation protection programme. The equipment worn by the worker can be used for individual monitoring, for example, the dosimeter can be used for the assessment of external exposure, or the personal air sampler can be used for the assessment of internal exposure (only applicable when the internal exposure becomes a focus).

6.2.4 **Dose recording and reporting**

The dose assessments shall be recorded to demonstrate that the monitoring has been performed as required and the dose assessment records shall be provided on a regular basis as needed. The annual dose shall be recorded and preserved, and the records shall also include information on the assessment method.

6.3 **Assessment method for external exposure dose**

6.3.1 **Radiation dose received by worker**

The radiation dose received by worker depends on:

a) dose rate giving by package, overpack, container or conveyance;
b) exposure time;
c) The distance from the package, overpack, container or conveyance;
d) additional shielding that can be used.

6.3.2 **Literature-based dose assessment**

6.3.2.1 The exposure dose monitoring and dose assessment results of worker during the transport and handling of the radioactive material package can be obtained from relevant references, and the relevant results can also be obtained from the calculations in the safety analysis report.

6.3.2.2 These sources of information can be used in the dose pre-assessment and assessment, but care shall be taken to ensure that these results match with the specific radiation protection programme. Special attention shall be paid to whether the operational activities are comparable.

6.3.3 **TI-based dose assessment**

6.3.3.1 **Transport index (TI)**

The transport index (TI) of the package, overpack or cargo container, or unpackaged LSA-I or SCO-I shall be the value derived according to the following steps:

a) The highest radiation level (in mSv/h) at 1m from the outer surface of the package, overpack, cargo container or unpackaged LSA-I and SCO-I shall be determined, and transport index shall be 100 times of this value. For uranium ore and strontium ore and their concentrates, the highest radiation level at any point 1m from the outer surface of the loaded object may be:
   1) 0.4mSv/h For uranium ore and strontium ore and their physical concentrates;
   2) 0.3mSv/h For thorium chemical concentrate;
   3) 0.02mSv/h For uranium chemical concentrate (except uranium hexafluoride).
b) For the transport index of tanks, cargo containers and unpackaged LSA-I and SCO-I, the value determined in a) shall be corrected by multiplying the corresponding coefficient listed in Table 2;
c) The value calculated according to the above procedures a) and b) shall be rounded to the first decimal place (for example, rounding 1.13 to 1.2), and the transport index may be considered to be zero only if the calculated result is equal to or less than 0.05.

Table 2 Magnification coefficients of tanks, cargo containers and unpackaged LSA-I and SCO-I

Loaded object size S[a]	Amplification coefficient
$S \leq 1 m^2$	1
$1m^2 < S \leq 5m^2$	2
$5m^2 < S \leq 20m^2$	3
$20m^2 < S$	10
[a]The maximum cross-sectional area of loaded object measured.	

The transport index for each overpack, cargo container or conveyance shall be determined by the sum of the transport indices (TI) of all packages loaded, and for rigid overpack, it can also be determined by directly measuring the radiation level.

6.3.3.2 The package and overpack shall be graded into Level-I (white), Level-II (yellow) or Level-III (yellow) according to the conditions specified in Table 3 and the following requirements.

Table 3 Maximum dose rate of package and corresponding transport index

Category	Maximum surface dose rate H (mSv/h)	*TI* value
Level-I – white	H≤0.005	0
Level-II – yellow	0.005<H≤0.5	*0<TI≤1*
Level-III – yellow	0.5<H≤2	*1<TI≤10*
Level-III – yellow and exclusive use[a]	2<H≤10	10≤TI
[a]Although the radiation level of the package for exclusive transport can exceed the level of the Level-III – yellow package, it shall also be subject to the limit for the external radiation level of the conveyance.		

When the transport index meets a certain level but the surface radiation level meets another, the package or overpack shall be graded into the higher level. Level-I (white) is the lowest level.

If the surface radiation level of the package or overpack exceeds 2mSv/h, the package or overpack shall be transported in an exclusive manner.

Packages transported under special arrangements and overpacks containing packages shall be graded in Level-III (yellow).

6.3.3.3 Performing transport operations of the same type under normal transport conditions can cause similar exposures, and there is a correlation between the occupational exposures and TI values in particular operations. The relationship among the package transport index, the package category, and the maximum number of packages annually operated corresponding to an occupational individual dose of not more than 1mSv/a is detailed in Table 4.

6.3.3.4 During the dose estimation with data in Table 4, it is required to prove the consistency between the operation and radiation exposure of the worker and the best practice, check the operation procedures to ensure that the transport follows good practices, and leave room for unforeseen events where the received dose is greater than the assumed one.

Table 4 Number of packages annually operated causing adose of 1mSv/a according to package categories

Package category	Maximum number of packages annually operated that cause occupational individual doses not to exceed 1mSv/a	
	Scenario: for each package, the worker shall stay at 1m away for 30min	Scenario: for each package, the worker touches the surface for 5min and stays at 1m away for 25min
Level-I – white	4000	1600
Level-II – yellow	200	40[a]
Level-III – yellow	20	6[b]
Level-II – yellow + exclusive use	0	0
[a]The transport index for 40 packages with surface average dose rate of 0.25mSv/h is TI=1. [b]The transport index for 6 packages with surface average dose rate of 1.25mSv/h is TI = 10.		

6.3.4 **Computer program dose assessment**

When the assessment cannot be performed by simple calculations, a computer program shall be used for dose assessment.

6.4 **Assessment method for internal exposure dose**

When necessary, consideration shall be given to use the data of airborne radioactivity and Surface contamination for possible assessment of internal exposure doses, and the internal exposure of workers can also be assessed on the basis of in vivo or in vitro measurements.

6.5 **Dose limits, dose constraints and radiation protection optimization**

6.5.1 The dose limits for occupational exposure and public exposure for the transport of radioactive materials shall be subject to relevant provisions of GB 18871-2002.

6.5.2 The radiation protection shall be optimized so that the likelihood of exposure to radiation, the number of people exposed, and the amount of dose received by an individual after the economic and social factors are taken into account are kept at as low as reasonably achievable.

6.5.3 Dose constraints are used along with the protection optimization to limit individual doses. Therefore, when setting the dose constraint values, the cumulative illumination effect caused by other sources shall also be considered. The dose constraint values can be determined according to particular tasks, and if only very low doses are generated in the operation, setting the dose constraint values will be unnecessary.

6.5.4 The main radiation protection arrangements for the use, operation, loading and transport of radioactive material packages are different, but shall include the following elements, for example:

a) to identify areas with possible problems, the distribution of individual and collective doses shall be reviewed and compared with the distribution of expected doses;
b) Proper distance for isolation shall be kept;
c) Adequate shielding arrangement;
d) Specific guidance on the stowing, loading, unloading, and tie-down of the high-TI package;
e) Application of operational limit;
f) Restraints on access to the high-radiation zone;
g) Work arrangement related to personal does shall be reduced (Make regulations on work shifts in accordance with the occupational exposure);
h) Routine use of package shifting, auxiliary equipment of hoisting;
i) Restrict driving and route in accordance with the road and weather conditions (maximize the potential irradiation).

6.5.5 In terms of the transport activities that only cause low occupational exposure, implementatingofbasic principle of optimization is required only.

6.5.6 Transport manipulation, radiation measurement, dose assessment and other relevant information can be collected form the documents and applied for optimization. Except the examination of normal conditions, the examination of the accident conditions and measures that prevent repetition occurrence is also required. The feedback analysis can include the investigation level of does, intake and Surface contamination. If they are above the investigation level, the examination of protection arrangement shall be carried out, so as to identify the causes of exceeding the investigation level and take corrective actions.

7 Surface contamination

7.1 Relevant requirements on contamination control

7.1.1 The contamination of transport package, conveyance and other related equipment shall be controlled. The strategy of contamination management can include the prevention and removal of contamination, and the prevention and reduction of contamination by design.

7.1.2 Containers loading the spent fuel in the water pool is more prone to get surface radiation contamination than the sealed radioactive source package. Therefore, Surface contamination monitoring of the spent fuel container is more frequent than the packages manipulating and loading most of other radioactive material.

7.1.3 Under the conditions of normal transport, the routine and regular monitoring of the Surface contamination of package, outer packing, container, components, equipment, transport means and personnel shall be carried out, so as to prevent the spread of radioactive pollutants and ensure the Surface contamination as low as reasonably and lower than the contamination limit. The Surface contamination monitoring plan contributes to identifying the contained failure and the procedure deviating from the correct manipulation, and providing the probable information about internal exposure monitoring plan. The frequency of monitoring shall match the possibility of occurring Surface contamination during the transport manipulation.

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

a) The limited value for emitters of β, γ and low-toxic α is 4Bq/cm^2;
b) The limited value for the rest of α emitters is 0.4Bq/cm^2.

The average value of non-fixed contamination on any 300cm^2 area of the surfacecould be used tojudgewhether the requirement is met.

7.1.5 The non-fixed contamination level of outer packing, freight container, tank, and solid bulk container as well as the internal and external surface of transport means shall not exceed the limiting value as regulated in 7.1.4, but except the conditions provided in 7.1.7.

7.1.6 If the contamination degree of all the transport means, equipment and component exceeds the limiting value as specified in 7.1.4 or the surface radiation level of them is above 5μSv/h during the transport process of radioactive material, they shall be decontaminated as soon as possible by the qualified personnel. If the non-fixed contamination exceeds the limiting value as specified in 7.1.4, and the radiation level resulting from surface fixed contamination after decontamination is above 5μSv/h, then they shall not be reused, but except the conditions provided in 7.1.7.

7.1.7 If the contamination of β,γ emitter and low-toxic a emitter of the tanks and solid bulk containers that have transported radioactive material is not decontaminated to lower than 0.4Bq/cm^2, or other a emitter is not decontaminated to lower than 0.04Bq/cm^2, then they shall not be used to store and transport other freight.

7.2 Contamination control

7.2.1 The radiation protection programme shall determine the applicable criteria within the transport organization for controlling Surface contamination (fixed and non-fixed) in the workplace and in packages, conveyance and equipment, and provide an overview of the type and scope of the contamination monitoring plan. The conventional method of monitoring Surface contamination is to monitor a representative portion of the surface in the site or on the package at a frequency determined by experience.

7.2.2 The specific monitoring technology depends on the type of radioactive material involved and appropriate monitoring equipment should be selected.

8 Isolation and other protective measures

8.1 Isolation

8.1.1 The dose rate of external exposure from thepackagesof radioactive materials may be high, but the exposure to workers and the public can be controlled by increase of distance between the personnel and the packages, or by other protective measures.

8.1.2 The following dose values shall be used for the purpose of calculating isolation distances or radiation levels:

The annual dose is 5mSv for staff who are often in the operating area;

The annual dose for the key group was set at 1mSv, taking into account the expected exposure to all other controlled sources or practices concerned for members of the public in areas frequented by the public.

8.1.3 Radioactive materials should be fully isolated from undeveloped photographic film. The isolation distance is determined on the basis that undeveloped photographic film of each consignment is exposed to less than 0.lmSv of total radiation during transport of radioactive materials.

8.1.4 Exposure to staff and members of the public should be limited by determining isolation distances and controlling dose rates in frequently populated areas.

8.1.5 The relevant information should be presented in an isolation table for easy use. Annex A shows two means to meet the isolation requirements.

8.2 Limit exposure time

Work procedures should be periodically evaluated and the implementation procedures should be modified or optimized to reduce the time staff spend near the packages and to reduce their exposure dose. For example, writing shipping paper in low-dose areas rather than near packages; TI measurement and measurement of package surface dose rate with automatic tools; use mechanical tools (such as applicable loaders and vehicles) to transport the packages to the conveyance rather than manually moving the packages one by one; arrange work procedures to shorten lay time.

8.3 Shielding

8.3.1 Shielding measures can be adopted depending on the situation: for example, shielding is set between the driver and the cargo area to reduce the dose of the driver, or shielding is set between the work area and the cargo storage area or loading area (or unloading area) to reduce the dose of the staff.

8.3.2 Where possible, the stacking of the packages should be designed in the storage area and within the conveyance so that the packages that produce a high dose rate are furthest away from the staff.

8.4 **Control area and supervision area**

8.4.1 The area within the conveyance may be designed as a control area. During in-transit storage, Control areas and monitoring areas may be the same areas. Some protective measures may be required for temporary stops or overnight stays during road transport.

8.4.2 Transport safety covers the design, processing, preparation of packages and other operations and conditions described in GB 11806-2004. The packages themselves form the main content, and the external areas of the packages and conveyance shall be controlled.

8.4.3 The loading of cargo containers and the storage of carriages, external packings and cargo containers shall be controlled in accordance with the following requirements:

Except in the case of exclusive use, the total number of packages, external packages and cargo containers on a single conveyance shall be limited, so that the sum of the transport index on the conveyance shall not be greater than the value shown in table 5. For the consigned class I low specific activity material, the total transport index is not restricted;

When the consignments are transported with consideration for exclusive use, the sum of the transport indices on the single conveyance is not restricted;

Under normal transport conditions, the radiation level at any point on the outer surface of the conveyance should not exceed 2mSv/h, and the radiation level at 2m from the outer surface of the vehicle should not exceed 0.1mSv/h. With the exception of consignments transported by road or rail for exclusive use, radiation levels around vehicles should be below the limits of b) and c) of 8.4.5.

8.4.4 Consignments of packages, external packings, or consignments with a transport index greater than 10 or a critical safety index greater than 50 shall be transported with consideration for exclusive use.

8.4.5 Requirements for consignments shipped in exclusive use are:

The radiation level at any point on the outer surface of the packages or external packings shall not exceed 2mSv/h but under allowable conditions, and the upper limit for it is 10mSv/h:

a) The vehicle shall take physical protection measures to prevent unauthorized persons from approaching the consignment under normal conditions of transport;
b) Fixed fittings are mounted onto the package or external packing so as to make sure that it can stay in the original position in the vehicle under normal transport conditions; and
c) There is no loading or unloading during the shipment.

The radiation level at any point on the outer surface (including the upper and lower surfaces) of the vehicle, or the radiation level at any point on the vertical plane extending from the outer edge of the vehicle, the upper surface of the loading and the outer surface of the lower part of the vehicle in the case of an open vehicle, shall not exceed 2mSv/h;

The radiation level at any point 2m away from the vertical plane extending from the outer side of the vehicle, or the radiation level at any point 2m away from the vertical plane extending from the outer edge of the vehicle in the case of an open vehicle, shall not exceed 0.1mSv/h.

8.4.6 For road vehicles, no one except the driver and his/her auxiliary personnel is allowed to ride on the vehicle carrying packages, external packing or cargo containers marked with class I(yellow) or class II(yellow) marks.

Table 5 Transport index (TI) limits for non-exclusive cargo containers and conveyance

Type of cargo container or conveyance			Limit of the sum of transport index inside cargo containers or conveyance
Small cargo container			50
Large cargo container			50
Vehicle			50
Aircraft:	a) Passenger aircraft		50
	b) Cargo aircraft		200
Inland waterway vessel:			50
Seagoing vessel[a]:	a) Hold, compartment or defined deck area:	1) Packages, external packings and small cargo containers	50
		2) Large cargo container	200
	b) Total vessel:	1) Packages, external packings and small cargo containers	200
		2) Large cargo container	Unlimited
[a]Packages or external packings carried in or on a vehicle which are in accordance with the provisions of 8.4.5 may be transported by vessels provided that they are no removed from the vehicle at any time while on board the vessel.			

8.4.7 Additional requirements relating to carriage by ship are:

Packages with a surface radiation level of more than 2mSv/h may be transported by ship only if they are installed in or on the vehicle for exclusive use in accordance with footnote a in table 5, except for ship transport under special arrangements.

When freight consignment is carried by a special vessel designed or chartered for the carriage of radioactive materials, it is not subject to the requirements specified in 6.5.4, provided that the following conditions are met:

a) The radiation protection programme shall be approved by the competent authority of the flag state of the vessel and, where required, by the competent authority of the countries of call;
b) Stacking arrangements should be made in advance for any consignment throughout the voyage (including loading at ports of call);
c) The loading, carrying and unloading of consignments shall be supervised by competent personnel during the transport of radioactive materials.

8.4.8 Additional requirements relating to transport by air are:

B (M) type packages and the goods consigned for exclusive use shall not be transported by passenger aircraft;

Vented Type B (M) packages, packages which require external cooling by an ancillary cooling system, packages subject to operational controls during transport, and packages containing liquid pyrophoric materials shall not be transported by air;

Packages or external packages with surface radiation exceeding 2mSv/h shall not be shipped by air unless otherwise arranged. Class II(yellow) or class III(yellow) packages or external packages shall not be carried in compartments for passengers, except those for escorts.

9 Emergency preparedness and response

9.1 In order to ensure timely and adequate emergency response, an emergency plan (contingency plan) shall be prepared. Emergency plans shall indicate the immediate action to be taken in a transport emergency. The consignor may provide the procedures to be followed by the carrier or assist the carrier to obtain appropriate arrangements.

9.2 There shall be a mechanism or procedure to ensure that the carrier or official responders (e.g. for road or rail accidents, traffic police or fire departments) are clearly aware of the presence of radioactive materials and other hazardous substances, of which, consignors and all relevant accident management departments shall be immediately notified. Emergency instructions to the staff of the carrier shall be simple and clear.

9.3 Emergency plan shall include mechanisms for the timely contact with experienced and trained radiological protection professionals to assess the status of radioactive materials and determine how to handle incidents (for example: approval to continue the shipment of undamaged packages, control and cleaning of

fall-outs, proper disposal of scattered or damaged packages, to ensure that doses are kept to the minimum for all personnel involved during the above activities).

9.4 Competent authorities, carriers and consignors shall be prepared to be able to respond quickly to emergency situations in the transport of radioactive materials. The potential consequences of these events shall be considered in the emergency plan, including arrangements for relevant management and reporting requirements.

9.5 The emergency plan shall stipulate the post-accident analysis of the event and its response, so as to determine the measures to be taken to minimize the possibility of similar events and improve the emergency response to such events.

9.6 Emergency response include: monitoring on accident site and personnel, appropriate medical and radiological treatment of injured and contaminated persons, proper disposal of radioactive materials and removal of radioactive materials scattered in the accident site, and restoration of the status and function of accident site. The initial emergency response shall be adopted at least to ensure adequate medical care for the injured and mitigate the damage to property and the environment.

9.7 Unless there is a risk to the lives of rescue workers, medical attention should be given immediately to those who are seriously or possibly seriously injured, regardless of the presence or absence of radioactive materials.

9.8 Emergency preparedness and response shall comply with relevant national regulations and standards of nuclear emergency.

10 Training

10.1 The carrier shall provide specialized training as required by the particular transport organization.

10.2 The training of personnel involved in the transport of radioactive materials should be tailored to their specific responsibilities and working environment. Classification method shall be adopted in which the amount, form and complexity of training shall be determined based on the nature and extent of potential hazards in the transport of radioactive materials as well as the responsibilities of personnel. The training consists of three basic levels:

a) basic knowledge training;
b) specialized skills training;
c) safety training, including emergency response training.

10.3 Training is the uninterrupted obligation of the transport personnel throughout the working period, including initial training and retraining at appropriate intervals. The training effect shall be evaluated regularly. Relevant training records shall be kept.

10.4 Some workers involved in the transport of radioactive materials (e.g. nuclear plant workers or isotope laboratory workers) may have been trained and qualified for radiation protection. In this case, it can be considered that this training partially meets the training requirements of the radiation protection programme for radioactive material transport workers.

11 Management system

11.1 A management system that is consistent with applicable standards for all planned and routine activities and accepted by competent authorities shall be established. The management systems shall be fully documented. The primary objective of the management systems is to establish the planned and organized actions required to meet all safety requirements. The specific degree and depth of the management system usually depends on the stage and type of transport operation.

11.2 A sound management system for the safe transport of radioactive materials shall cover a much wider range than that the radiation protection programme for the transport of radioactive materials does.

Annex A
(Informative)
Isolation requirements for radiation protection in marine transport

The isolation for radiation protection in maritime transport shall meet the following requirements:

Radioactive materials shall be adequately isolated from crew and passengers. The following dose values shall be used for the purpose of calculating isolation distances or radiation levels:

a) For crew who are often in the operating area, the annual dose is 5mSv;
b) For passengers in areas where passenger often go in and out, the annual dose for the key group is 1mSv.

Class II(yellow) or Class III(yellow) packages or outer packages shall not be transported in the passenger detention area except in areas specifically authorized for the persons escorting such packages or outer packages;

The isolation requirements specified in article 8.1 of this standard can be met by one of two methods below:

a) For personnel retention area or living area, follow the following isolation tables (Table A.1 and Table A.2). Table A.2 shows comprehensive provisions in common use and Table A.1 shows simplified isolation requirements for specific vessels;
b) Prove that, in given exposure time, the direct measurement results of the radiation level in personnel often staying and living area are smaller than the following values:
    1) For crew, it is 0.0070mSv/h when the exposure time is shorter than 700h per year; or 0.0018mSv/h when the exposure time is shorter than 2750h per year;
    2) For passengers, it is 0.0018mSv/h when the exposure time is shorter than 550h per year.

It shall be considered to rearrange the cargo during the voyage. In all cases, the radiation level shall be measured and recorded by appropriate qualified persons.

Table A.1 Simplified personnel isolation requirements

Transport Index Sum	Isolation distance between radioactive materials and passengers and crew			
	General cargo ship[a]		Ferryboat, etc.[b]	Offshore support vessel[c]
	In bulk m	Container TEU[d]		
Not greater than 10	6	1	Stowed in the prow or stern farthest from the working and living areas	Stowed in stern or in the middle of the deck
Greater than 10 but not greater than 20	8	1	Same as above	Same as above
Greater than 20 but not greater than 50	13	2	Same as above	Not applicable
Greater than 50 but not greater than 100	18	3	Same as above	Not applicable
Greater than 100 but not greater than 200	26	4	Same as above	Not applicable
Greater than 200 but not greater than 400	36	6	Same as above	Not applicable

[a] General cargo vessels, bulk ships with minimum length of 150m or roro container ships.
[b] Ferryboats or wherries, boats with a minimum length of 100m on coasts and inland islands.
[c] Offshore support vessels with a minimum length of 50m (the actual maximum value of TI sum under this condition is 20).
[d] TEU refers to ‘equivalent unit of 20 feet’ (equivalent to a standard container of 6m in nominal length).

Table A.2 Safe distance between personnel and undeveloped photographic films and sensitive plates

Transport Index Sum	Minimum distance m from personnel retention area or living area		Minimum distance m from undeveloped film and sensitive plate																							
			Voyage of 1 day			Voyage of 2 days			Voyage of 4 days			Voyage of 10 days			Voyage of 20 days			Voyage of 30 days			Voyage of 40 days			Voyage of 50 days		
	Cargo Equivalent Density																									
	0	1	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
0.5	2	X	2	X	X	3	X	X	4	X	X	6	2	X	8	2	X	10	3	X	11	3	X	12	3	X
1	2	X	3	X	X	4	X	X	5	2	X	8	2	X	11	3	X	13	4	X	15	4	X	17	4	X
2	3	X	4	X	X	5	2	X	7	2	X	11	3	X	15	4	X	19	5	X	22	5	X	24	6	X
3	4	X	5	X	X	6	2	X	9	2	X	13	4	X	19	5	X	23	6	X	27	7	X	30	7	X
5	4	X	6	2	X	8	2	X	11	3	X	17	4	X	24	6	X	30	7	X	34	8	X	38	9	3
10	6	2	8	2	X	11	3	X	15	4	X	24	6	X	34	8	X	42	10	3	48	12	3	54	13	3
20	8	2	11	3	X	15	4	X	22	5	X	34	8	X	48	12	3	59	14	4	68	16	4	76	18	5
30	10	3	13	4	X	19	5	X	26	7	X	42	10	3	59	14	4	72	17	4	83	20	5	93	22	6
50	13	3	17	4	X	24	6	X	34	8	X	54	13	3	76	18	5	92	23	6	110	26	7	120	29	7
100	18	5	24	6	X	34	8	X	48	12	3	76	18	5	110	25	6	130	32	8	150	36	9	170	40	10
150	22	6	30	7	X	42	10	3	59	14	4	93	22	6	130	31	8	160	39	10	185	45	11	•	50	12
200	26	6	34	8	X	48	12	3	68	16	4	110	26	7	150	36	9	185	43	11	•	51	13	•	58	14
300	32	8	42	10	3	59	14	4	83	20	5	130	32	8	185	44	11	•	55	13	•	63	15	•	70	17
400	36	9	48	12	3	68	16	4	95	23	6	150	36	9	•	50	13	•	63	15	•	73	18	•	81	20

Note 1: Cargo equivalent density: for goods stacked at the density of 1 ton per cubic meter, the equivalent density is 1. If the density is smaller than this value, the specified thickness of goods must be increased proportionally.
Note 2: X indicates that the cargo shield thickness is adequate and no additional isolation distance is required.
Note 3: • means it can not be carried unless it can be arranged in a manner otherwise permitted. Other cargo and bulkheads can be used for shielding.
Note 4: If there is a steel bulkhead or deck, the distance is multiplied by 0.8. If there are two steel bulkheads or decks, the isolation distance is multiplied by 0.64.
Note 5: “Minimum distance” means the minimum distance from the outer surface of the nearest package in any direction, no matter in vertical or horizontal direction.
Note 6: The values in the last two rows of the table above are applied where the relevant clause allows the total transport index to exceed 200.
Note 7: If there is a 2m thick non-radioactive cargo with equivalent density between the radioactive materials and personnel and a 3m non-radioactive cargo with equivalent density between the films and sensitive plates and personnel, no isolation distance is required for any specified sailing time.