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# IAEA SAFETY STANDARDS

## for protecting people and the environment

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## Regulations for the Safe Transport of Radioactive Material 20XX Edition

### DRAFT SAFETY REQUIREMENT DS437

Revision of TS-R-1

**NOTE:**

- 1) Table 2 of the Regulations is to be updated according to the revision of BSS which is in progress.
- 2) One more annexe is not attached to the documents: ANNEX IV -- Guiding Principles Underlying the IAEA Transport Regulation which is related to the BSS.
- 3) Comprehensive textual review will deal with all editorial issues before approval of the draft by Safety Standard Committees.
- 4) The table of changes to 2009 Edition of TS-R-1 could be found at <http://www-ns.iaea.org/committees/transsc/default.asp?fd=903&dt=0> in TRANSSC 20 meeting report.

IAEA

**International Atomic Energy Agency**

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## Section I

### INTRODUCTION

#### BACKGROUND

101. These Regulations establish standards of safety which provide an acceptable level of control of the radiation, criticality and thermal hazards to persons, property and the environment that are associated with the transport of *radioactive material*. These Regulations are based on the Fundamental Safety Principles, Safety Fundamentals No. SF-1 [1], jointly sponsored by the European Atomic Energy Community (EAEC), the Food and Agriculture Organization of the United Nations (FAO), the IAEA, the International Labour Organization (ILO), the International Maritime Organization (IMO), the OECD Nuclear Energy Agency (NEA), the Pan American Health Organization (PAHO), the United Nations Environment Programme (UNEP) and the World Health Organization (WHO) and on the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No. 115 [2], jointly sponsored by the FAO, the IAEA, the ILO, the NEA, the PAHO and the WHO. Thus, compliance with these Regulations is deemed to satisfy the principles of the Basic Safety Standards in respect of transport. In accordance with Ref. [1], the prime responsibility for safety must rest with the person or organization responsible for facilities and activities that give rise to radiation risks.

102. This Safety Standard is supplemented by a hierarchy of Safety Guides including Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material, IAEA Safety Standards Series No. TS-G-1.1 (Rev. 1) [3]; Planning and Preparing for Emergency Response to Transport Accidents Involving Radioactive Material, IAEA Safety Standards Series No. TS-G-1.2 (ST-3) [4]; Compliance Assurance for the Safe Transport of Radioactive Material, IAEA Safety Standards Series No. TS-G-1.5 [5]; The Management System for the Safe Transport of Radioactive Material, IAEA Safety Standards Series No. TS-G-1.4 [6]; and Radiation Protection

Programmes for the Transport of Radioactive Material, IAEA Safety Standards Series No. TS-G-1.3 [7].

103. In certain parts of these Regulations, a particular action is prescribed, but the responsibility for carrying out the action is not specifically assigned to any particular legal person. Such responsibility may vary according to the laws and customs of different countries and the international conventions into which these countries have entered. For the purpose of these Regulations, it is not necessary to make this assignment, but only to identify the action itself. It remains the prerogative of each government to assign this responsibility.

#### OBJECTIVE

104. The objective of these 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*. This protection is achieved by requiring:

- (a) Containment of the *radioactive contents*.
- (b) Control of external *radiation levels*.
- (c) Prevention of criticality.
- (d) Prevention of damage caused by heat.

These requirements are satisfied firstly 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*. Secondly, they are satisfied by imposing requirements on the *design* and operation of *packages* and on the maintenance of *packagings*, including consideration of the nature of the *radioactive contents*. Finally, they are satisfied by requiring administrative controls, including, where appropriate, approval by *competent authorities*.

105. In the transport of *radioactive material*, the safety of persons and the protection of property and the environment are assured when these Regulations are complied with. Confidence in this regard is achieved through management systems and *compliance assurance* programmes.

## SCOPE

106. These Regulations apply to the transport of *radioactive material* by all modes on land, water, or in the air, including transport which is incidental to the use of the *radioactive material*. 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*. A graded approach is applied in specifying the performance standards in these Regulations which are characterized in terms of three general severity levels:

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

107. These Regulations do not apply to any of the following:

- (a) *Radioactive material* that is an integral part of the means of transport.
- (b) *Radioactive material* moved within an establishment which is subject to appropriate safety regulations in force in the establishment and where the movement does not involve public roads or railways.
- (c) *Radioactive material* implanted or incorporated into a person or live animal for diagnosis or treatment.
- (c)bis Transport of a person for medical treatment, where the person has been subject to accidental intake of or contamination from *radioactive material*.
- (d) *Radioactive material* in consumer products which have received regulatory approval, following their sale to the end user.
- (e) Natural material and ores containing naturally occurring radionuclides which may have been processed, provided the activity concentration of the material does not exceed 10 times the values specified in Table 2, or calculated in accordance with paras 403–407.

- (f) Non-radioactive solid objects with radioactive substances present on any surface in quantities not in excess of the levels defined in para. 214.

108. These Regulations do not specify controls such as routing or physical protection which may be instituted for reasons other than radiological safety. Any such controls shall take into account radiological and non-radiological hazards, and shall not detract from the standards of safety which these Regulations are intended to provide.

109. Measures should be taken to ensure that *radioactive material* is kept secure in transport so as to prevent theft or damage and to ensure that control of the material is not relinquished inappropriately (see Annex I).

110. For *radioactive material* having subsidiary risks, and for transport of *radioactive material* with other dangerous goods, the relevant transport regulations for dangerous goods shall apply in addition to these Regulations.

## STRUCTURE

111. This publication is structured so that Section II defines the terms that are required for the purposes of these Regulations; Section III provides general provisions; Section IV provides activity limits and material restrictions used throughout these Regulations; Section V provides requirements and controls for transport; Section VI provides requirements for *radioactive material* and for *packagings* and *packages*; Section VII provides requirements for test procedures; and Section VIII provides requirements for approvals and administration.

## Section II

### DEFINITIONS

The following definitions shall apply for the purposes of these Regulations:

*A<sub>1</sub>* and *A<sub>2</sub>*

201. *A<sub>1</sub>* shall mean the activity value of *special form radioactive material* which is listed in Table 2 or derived in Section IV and is used to determine the activity limits for the requirements of these Regulations. *A<sub>2</sub>* shall mean the activity value of *radioactive material*, other than *special form radioactive material*, which is listed in Table 2 or derived in Section IV and is used to determine the activity limits for the requirements of these Regulations.

*Aircraft*

202. *Cargo aircraft* shall mean any aircraft, other than a *passenger aircraft*, which is carrying goods or property.

203. *Passenger aircraft* shall mean an aircraft that carries any person other than a crew member, a *carrier's* employee in an official capacity, an authorized representative of an appropriate national authority, or a person accompanying a *consignment* or other cargo.

*Approval*

204. *Multilateral approval* shall mean approval by the relevant *competent authority* of the country of origin of the *design* or *shipment*, as applicable, and also, where the *consignment* is to be transported *through or into* any other country, approval by the *competent authority* of that country.

205. *Unilateral approval* shall mean an approval of a *design* which is required to be given by the *competent authority* of the country of origin of the *design* only.

*Carrier*

206. *Carrier* shall mean any person, organization or government undertaking the carriage of *radioactive material* by any means of transport. The term includes both *carriers* for hire or reward (known as common or contract *carriers* in some countries) and *carriers* on own account (known as private *carriers* in some countries).

*Competent authority*

207. *Competent authority* shall mean any body or authority designated or otherwise recognized as such for any purpose in connection with these Regulations.

*Compliance assurance*

208. *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.

*Confinement system*

209. *Confinement system* shall mean the assembly of *fissile material* and *packaging* components specified by the designer and agreed to by the *competent authority* as intended to preserve criticality safety.

*Consignee*

210. *Consignee* shall mean any person, organization or government which is entitled to take delivery of a *consignment*.

*Consignment*

211. *Consignment* shall mean any *package* or *packages*, or load of *radioactive material*, presented by a *consignor* for transport.

*Consignor*

212. *Consignor* shall mean any person, organization or government which prepares a *consignment* for transport.

#### *Containment system*

213. *Containment system* shall mean the assembly of components of the *packaging* specified by the designer as intended to retain the *radioactive material* during transport.

#### *Contamination*

214. *Contamination* shall mean the presence of a radioactive substance on a surface in quantities in excess of 0.4 Bq/cm<sup>2</sup> for beta and gamma emitters and *low toxicity alpha emitters*, or 0.04 Bq/cm<sup>2</sup> for all other alpha emitters.

215. *Non-fixed contamination* shall mean *contamination* that can be removed from a surface during routine conditions of transport.

216. *Fixed contamination* shall mean *contamination* other than *non-fixed contamination*.

#### *Conveyance*

217. *Conveyance* shall mean:

- (a) For transport by road or rail: any *vehicle*.
- (b) For transport by water: any *vessel*, or any hold, compartment, or *defined deck area* of a *vessel*.
- (c) For transport by air: any *aircraft*.

#### *Criticality safety index*

218. *Criticality safety index (CSI)* assigned to a *package*, *overpack* or *freight container* containing *fissile material* shall mean a number which is used to provide control over the accumulation of *packages*, *overpacks* or *freight containers* containing *fissile material*.

#### *Defined deck area*

219. *Defined deck area* shall mean the area of the weather deck of a *vessel*, or of a *vehicle* deck of a roll-on/roll-off ship or ferry, which is allocated for the stowage of *radioactive material*.

#### *Design*

220. *Design* shall mean the description of *special form radioactive material*, *low dispersible radioactive material*, *package* or *packaging* which enables such an item to be fully identified. The description may include specifications, engineering drawings, reports demonstrating compliance with regulatory requirements, and other relevant documentation.

#### *Exclusive use*

221. *Exclusive use* shall mean the sole use, by a single *consignor*, of a *conveyance* or of a large *freight container*, in respect of which all initial, intermediate and final loading and unloading and shipment is carried out in accordance with the directions of the *consignor* or *consignee*, where so required by these Regulations.

#### *Fissile nuclides and fissile material*

222. *Fissile nuclides* shall mean uranium-233, uranium-235, plutonium-239 and plutonium-241. *Fissile material* shall mean a material containing any of the *fissile nuclides*. Excluded from the definition of *fissile material* are any of the following:

- (a) Material containing only *natural uranium* or *depleted uranium* which is unirradiated; if packaged, there shall be no other material with *fissile nuclides* in the *package*.
- (b) Material in packages containing *natural uranium* or *depleted uranium* which has been irradiated in thermal reactors only, and there shall no other *fissile nuclides* in the package.
- (c) Material in *packages* each containing up to 0.25 g of *fissile nuclides* in any form.

#### *Freight container*

223. *Freight container* shall mean an article of transport equipment that is designed to facilitate the transport of goods, either packaged or unpackaged, by one or more modes of transport

without intermediate reloading which is of a permanent enclosed character, rigid and strong enough for repeated use, and must be fitted with devices facilitating its handling, particularly in transfer between *conveyances* and from one mode of transport to another. A small freight container is that which has an internal volume of no less than 1 m<sup>3</sup> and an internal volume of not more than 3 m<sup>3</sup>. Any larger *freight container* is considered to be a large *freight container*.

#### *Intermediate bulk container*

224. *Intermediate bulk container (IBC)* shall mean a portable *packaging* that :

- (a) Has a capacity of not more than 3 m<sup>3</sup>.
- (b) Is designed for mechanical handling.
- (c) Is resistant to the stresses produced in handling and transport, as determined by tests.

#### *Low dispersible radioactive material*

225. *Low dispersible radioactive material* shall mean either a solid *radioactive material* or a solid *radioactive material* in a sealed capsule, that has limited dispersibility and is not in powder form.

#### *Low specific activity material*

226. *Low specific activity (LSA) material* shall mean *radioactive material* which by its nature has a limited *specific activity*, or *radioactive material* for which limits of estimated average *specific activity* apply. External shielding materials surrounding the *LSA material* shall not be considered in determining the estimated average *specific activity*.

#### *Low toxicity alpha emitters*

227. *Low toxicity alpha emitters* are: natural uranium, depleted uranium, natural thorium, uranium-235 or uranium-238, thorium-232, thorium-228 and thorium-230 when contained in ores or physical and chemical concentrates; or alpha emitters with a half-life of less than 10 days.

#### *Management system*

227bis. *Management system* shall mean a set of interrelated or interacting elements (system) for establishing policies and objectives and enabling the objectives to be achieved in an efficient and effective manner.

*Maximum normal operating pressure*

228. *Maximum normal operating pressure* shall mean the maximum pressure above atmospheric pressure at mean sea level that would develop in the *containment system* in a period of one year under the conditions of temperature and solar radiation corresponding to environmental conditions in the absence of venting, external cooling by an ancillary system, or operational controls during transport.

*Overpack*

229. *Overpack* shall mean an enclosure used by a single *consignor* to contain one or more *packages* and to form one unit for convenience of handling and stowage during transport.

*Package*

230. *Package* shall mean the complete product of the packing operation, consisting of the *packaging* and its contents prepared for transport. The types of *package* covered by these Regulations, which are subject to the activity limits and material restrictions of Section IV and meet the corresponding requirements, are:

- (a) *Excepted package.*
- (b) *Industrial package Type 1 (Type IP-1) .*
- (c) *Industrial package Type 2 (Type IP-2).*
- (d) *Industrial package Type 3 (Type 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 are subject to additional requirements.

#### *Packaging*

231. *Packaging* shall mean one or more receptacles and any other components or materials necessary for the receptacles to perform the containment and other safety functions.

#### *Radiation level*

233. *Radiation level* shall mean the corresponding dose rate expressed in millisieverts per hour.

#### *Radiation protection programme*

234. *Radiation protection programme* shall mean systematic arrangements which are aimed at providing adequate consideration of radiation protection measures.

#### *Radioactive contents*

235. *Radioactive contents* shall mean the *radioactive material* together with any contaminated or activated solids, liquids and gases within the *packaging*.

#### *Radioactive material*

236. *Radioactive material* shall mean any material containing radionuclides where both the activity concentration and the total activity in the *consignment* exceed the values specified in paras 402–407.

#### *Shipment*

237. *Shipment* shall mean the specific movement of a *consignment* from origin to destination.

#### *Special arrangement*

238. *Special arrangement* shall mean those provisions, approved by the *competent authority*, under which *consignments* which do not satisfy all the applicable requirements of these Regulations may be transported.

*Special form radioactive material*

239. *Special form radioactive material* shall mean either an indispersible solid *radioactive material* or a sealed capsule containing *radioactive material*.

*Specific activity*

240. *Specific activity* of a radionuclide shall mean the activity per unit mass of that nuclide. The *specific activity* of a material shall mean the activity per unit mass of the material in which the radionuclides are essentially uniformly distributed.

*Surface contaminated object*

241. *Surface contaminated object (SCO)* shall mean a solid object which is not itself radioactive but which has *radioactive material* distributed on its surface.

*Tank*

242. *Tank* shall mean a portable tank (including a tank container), a road tank *vehicle*, a rail tank wagon or a receptacle that contains solids, liquids, or gases, having a capacity of not less than 450 litres when used for the transport of gases.

*Through or into*

243. *Through or into* shall mean through or into the countries in which a *consignment* is transported but specifically excludes countries over which a *consignment* is carried by air, provided that there are no scheduled stops in those countries.

*Transport index*

244. *Transport index (TI)* assigned to a *package*, *overpack* or *freight container*, or to unpackaged LSA-I or SCO-I, shall mean a number which is used to provide control over radiation exposure.

*Unirradiated thorium*

245. *Unirradiated thorium* shall mean thorium containing not more than  $10^{-7}$  g of uranium-233 per gram of thorium-232.

*Unirradiated uranium*

246. *Unirradiated uranium* shall mean uranium containing not more than  $2 \times 10^3$  Bq of plutonium per gram of uranium-235, not more than  $9 \times 10^6$  Bq of fission products per gram of uranium-235 and not more than  $5 \times 10^{-3}$  g of uranium-236 per gram of uranium-235.

*Uranium — natural, depleted, enriched*

247. *Natural uranium* shall mean uranium (which may be chemically separated) having the naturally occurring distribution of uranium isotopes (approximately 99.28% uranium-238 and 0.72% uranium-235, by mass). *Depleted uranium* shall mean uranium containing a lesser mass percentage of uranium-235 than natural uranium. *Enriched uranium* shall mean uranium containing a greater mass percentage of uranium-235 than 0.72%. In all cases, a very small mass percentage of uranium-234 is present.

*Vehicle*

248. *Vehicle* shall mean a road *vehicle* (including an articulated vehicle, i.e. a tractor and semi-trailer combination), railroad car or railway wagon. Each trailer shall be considered as a separate *vehicle*.

*Vessel*

249. *Vessel* shall mean any seagoing *vessel* or inland waterway craft used for carrying cargo.

## Section III

### GENERAL PROVISIONS

#### RADIATION PROTECTION

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

302. A *radiation protection programme* shall be established for the transport of *radioactive material*. The nature and extent of the measures to be employed in the programme shall be related to the magnitude and likelihood of radiation exposures. The programme shall incorporate the requirements of paras 301, 303–305, 311 and 559. Programme documents shall be available, on request, for inspection by the relevant *competent authority*.

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

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

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

#### EMERGENCY RESPONSE

304. In the event of accidents or incidents during the transport of *radioactive material*, emergency provisions, as established by relevant national and/or international organizations, shall be observed to protect persons, property and the environment. Appropriate guidelines for such provisions are contained in Ref. [4].

305. Emergency procedures shall take into account the formation of other dangerous substances that may result from the reaction between the contents of a *consignment* and the environment in the event of an accident.

#### MANAGEMENT SYSTEM

306. *Management systems* based on international, national or other standards acceptable to the *competent authority* shall be established and implemented for all activities in the scope of the Regulations, as identified in para. 106, to ensure compliance with the relevant provisions of these Regulations. Certification that the *design* specification has been fully implemented shall be available to the *competent authority*. The manufacturer, *consignor* or user shall be prepared:

- (a) To provide facilities for inspection during manufacture and use.
- (b) To demonstrate compliance with these Regulations to the *competent authority*.

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

#### COMPLIANCE ASSURANCE

307. The *competent authority* shall assure 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*, *special form radioactive material* and *low dispersible radioactive material* and material approved under para. 417(f), and the preparation, documentation, handling and stowage of *packages* by *consignors* and *carriers*, to provide evidence that the provisions of these Regulations are being met in practice.

308. The relevant *competent authority* shall arrange for periodic assessments of the radiation doses to persons due to the transport of *radioactive material*, to ensure that the system of protection and safety complies with the Basic Safety Standards [2].

#### NON-COMPLIANCE

309. In the event of non-compliance with any limit in these Regulations applicable to *radiation level* or *contamination*:

- (a) The *consignor* and who may be affected shall be informed of the non-compliance either by:
  - (i) The *carrier* if the non-compliance is identified during transport; or
  - (ii) The *consignee* if the non-compliance is identified at receipt.
- (b) The *carrier, consignor* or *consignee*, as appropriate, shall:
  - (i) Take immediate steps to mitigate the consequences of the non-compliance.
  - (ii) Investigate the non-compliance and its causes, circumstances and consequences.
  - (iii) Take appropriate action to remedy the causes and circumstances that led to the non-compliance and to prevent a recurrence of circumstances similar to those that led to the non-compliance.
  - (iv) Communicate to the relevant *competent authority(ies)* on the causes of the non-compliance and on corrective or preventive actions taken or to be taken.
- (c) The communication of the non-compliance to the *consignor* and the relevant *competent authority(ies)*, respectively, shall be made as soon as practicable and it shall be immediate whenever an emergency exposure situation has developed or is developing.

#### SPECIAL ARRANGEMENT

310. *Consignments* for which conformity with the other provisions of these Regulations is impracticable shall not be transported except under *special arrangement*. Provided the *competent*

*authority* is satisfied that conformity with the other provisions of these Regulations is impracticable and that the requisite standards of safety established by these Regulations have been demonstrated through means alternative to the other provisions, the *competent authority* may approve *special arrangement* transport operations for single or a planned series of multiple *consignments*. The overall level of safety in transport shall be at least equivalent to that which would be provided if all the applicable requirements had been met. For *consignments* of this type, *multilateral approval* shall be required.

## TRAINING

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

312. Persons engaged in the transport of *radioactive material* shall receive training in the contents of these Regulations commensurate with their responsibilities.

313. Individuals such as those who classify *radioactive material*; pack *radioactive material*; mark and label *radioactive material*; prepare transport documents for *radioactive material*; offer or accept *radioactive material* for transport; carry or handle *radioactive material* in transport; mark or placard or load or unload *packages* of *radioactive material* into or from transport *vehicles*, bulk *packagings* or *freight containers*; or are otherwise directly involved in the transport of *radioactive material* as determined by the *competent authority*; shall receive the following training:

(a) General awareness/familiarization training:

- (i) Each person shall receive training designed to provide familiarity with the general provisions of these Regulations.
- (ii) Such training shall include a description of the categories of *radioactive material*; labelling, marking, placarding and *packaging* and segregation requirements; a

description of the purpose and content of the *radioactive material* transport document;  
and a description of available emergency response documents.

- (b) Function specific training: Each person shall receive detailed training concerning specific *radioactive material* transport requirements which are applicable to the function that person performs.
- (c) Safety training: Commensurate with the risk of exposure in the event of a release and the functions performed, each person shall receive training on:
  - (i) Methods and procedures for accident avoidance, such as proper use of *package* handling equipment and appropriate methods of stowage of *radioactive material*.
  - (ii) Available emergency response information and how to use it.
  - (iii) General dangers presented by the various categories of *radioactive material* and how to prevent exposure to those hazards, including, if appropriate, the use of personal protective clothing and equipment.
  - (iv) Immediate procedures to be followed in the event of an unintentional release of *radioactive material*, including any emergency response procedures for which the person is responsible and personal protection procedures to be followed.

314. Records of all safety training undertaken shall be kept by the employer and made available to the employee if requested.

315. The training required in para. 313 shall be provided or verified upon employment in a position involving *radioactive material* transport and shall be periodically supplemented with retraining as deemed appropriate by the *competent authority*.

## Section IV

### ACTIVITY LIMITS AND CLASSIFICATION

#### GENERAL PROVISIONS

401. *Radioactive material* shall be assigned to one of the UN numbers specified in Table 1 in accordance with paras 408–433.

TABLE 1. EXCERPTS FROM LIST OF UN NUMBERS, PROPER SHIPPING NAMES AND DESCRIPTIONS

Assignment of UN numbers	PROPER SHIPPING NAME and description <sup>a</sup>
<i>Excepted package</i>	
UN 2908	RADIOACTIVE MATERIAL, EXCEPTED PACKAGE – EMPTY PACKAGING
UN 2909	RADIOACTIVE MATERIAL, EXCEPTED PACKAGE – ARTICLES MANUFACTURED FROM NATURAL URANIUM or DEPLETED URANIUM or NATURAL THORIUM
UN 2910	RADIOACTIVE MATERIAL, EXCEPTED PACKAGE – LIMITED QUANTITY OF MATERIAL
UN 2911	RADIOACTIVE MATERIAL, EXCEPTED PACKAGE – INSTRUMENTS or ARTICLES
<i>Low specific activity radioactive material</i>	

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UN 2912	RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-I), non-fissile or fissile-excepted <sup>b</sup>
UN 3321	RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-II), non-fissile or fissile-excepted <sup>b</sup>
UN 3322	RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-III), non-fissile or fissile-excepted <sup>b</sup>
UN 3322bis	RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-I), FISSILE
UN 3324	RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-II), FISSILE
UN 3325	RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-III), FISSILE

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*Surface contaminated objects*

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UN 2913	RADIOACTIVE MATERIAL, SURFACE CONTAMINATED OBJECTS (SCO-I or SCO-II), non- fissile or fissile-excepted <sup>b</sup>
UN 3326	RADIOACTIVE MATERIAL, SURFACE CONTAMINATED OBJECTS (SCO-I or SCO-II), FISSILE

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*Type A package*

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UN 2915	RADIOACTIVE MATERIAL, TYPE A PACKAGE, non- special form, non-fissile or fissile-excepted <sup>b</sup>
UN 3327	RADIOACTIVE MATERIAL, TYPE A PACKAGE,

FISSILE, non-special form

UN 3332 RADIOACTIVE MATERIAL, TYPE A PACKAGE,  
SPECIAL FORM, non-fissile or fissile-excepted

UN 3333 RADIOACTIVE MATERIAL, TYPE A PACKAGE,  
SPECIAL FORM, FISSILE

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*Type B(U) package*

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UN 2916 RADIOACTIVE MATERIAL, TYPE B(U) PACKAGE,  
non-fissile or fissile-excepted<sup>b</sup>

UN 3328 RADIOACTIVE MATERIAL, TYPE B(U) PACKAGE,  
FISSILE

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*Type B(M) package*

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UN 2917 RADIOACTIVE MATERIAL, TYPE B(M) PACKAGE,  
non-fissile or fissile-excepted<sup>b</sup>

UN 3329 RADIOACTIVE MATERIAL, TYPE B(M) PACKAGE,  
FISSILE

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*Type C package*

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UN 3323 RADIOACTIVE MATERIAL, TYPE C PACKAGE, non-  
fissile or fissile-excepted<sup>b</sup>

UN 3330 RADIOACTIVE MATERIAL, TYPE C PACKAGE,  
FISSILE

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*Special arrangement*

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UN 2919 RADIOACTIVE MATERIAL, TRANSPORTED UNDER  
SPECIAL ARRANGEMENT, non-fissile or fissile-  
excepted<sup>b</sup>

UN 3331 RADIOACTIVE MATERIAL, TRANSPORTED UNDER  
SPECIAL ARRANGEMENT, FISSILE

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*Uranium hexafluoride*

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UN 2977 RADIOACTIVE MATERIAL, URANIUM  
HEXAFLUORIDE, FISSILE

UN 2978 RADIOACTIVE MATERIAL, URANIUM  
HEXAFLUORIDE, non-fissile or fissile-excepted<sup>b</sup>

UN3xxx RADIOACTIVE MATERIAL, EXCEPTED PACKAGE -  
URANIUM HEXAFLUORIDE, LESS THAN 0.1 KG PER  
PACKAGE

<sup>a</sup> The “PROPER SHIPPING NAME” is found in the column “PROPER SHIPPING NAME and description” and is restricted to that part shown in CAPITAL LETTERS. In the cases of UN 2909, UN 2911, UN 2913 and UN 3326, where alternative proper shipping names are separated by the word “or”, only the relevant proper shipping name shall be used.

<sup>b</sup> “Fissile-excepted” refers only to material excepted under para. 417.

#### BASIC RADIONUCLIDE VALUES

402. The following basic values for individual radionuclides are given in Table 2:

- (a)  $A_1$  and  $A_2$  in TBq.
- (b) Activity concentration limits for exempt material in Bq/g.
- (c) Activity limits for exempt *consignments* in Bq.

#### DETERMINATION OF BASIC RADIONUCLIDE VALUES

403. For individual radionuclides which are not listed in Table 2, the determination of the basic radionuclide values referred to in para. 402 shall require *multilateral approval*. Activity concentration for

exempt material and activity limits for exempt *consignments* shall be calculated in accordance with the principles set out in the BSS.<sup>1</sup> It is permissible to use an  $A_2$  value calculated using a dose coefficient for the appropriate lung absorption type, as recommended by the International Commission on Radiological Protection, if the chemical forms of each radionuclide under both normal and accident conditions of transport are taken into consideration. Alternatively, the radionuclide values in Table 3 may be used without obtaining *competent authority* approval.

404. In the calculations of  $A_1$  and  $A_2$  for a radionuclide not in Table 2, a single radioactive decay chain in which the radionuclides are present in their naturally occurring proportions, and in which no progeny nuclide has a half-life either longer than 10 days or longer than that of the parent nuclide, shall be considered as a single radionuclide; and the activity to be taken into account and the  $A_1$  or  $A_2$  value to be applied shall be that corresponding to the parent nuclide of that chain. In the case of radioactive decay chains in which any progeny nuclide has a half-life either longer than 10 days or longer than that of the parent nuclide, the parent and such daughter nuclides shall be considered as mixtures of different nuclides.

TABLE 2. BASIC RADIONUCLIDE VALUES

Radionuclide (atomic number)	$A_1$ (TBq)	$A_2$ (TBq)	Activity concentration limit for exempt material (Bq/g)	Activity limit for an exempt consignment (Bq)
Actinium (89)				
Ac-225 (a)	$8 \times 10^{-1}$	$6 \times 10^{-3}$	$1 \times 10^1$	$1 \times 10^4$
Ac-227 (a)	$9 \times 10^{-1}$	$9 \times 10^{-5}$	$1 \times 10^{-1}$	$1 \times 10^3$
Ac-228	$6 \times 10^{-1}$	$5 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Silver (47)				

<sup>1</sup> During the Member State comment period there will be additional work to resolve concerns over the potential for disharmony

Ag-105	$2 \times 10^0$	$2 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Ag-108m (a)	$7 \times 10^{-1}$	$7 \times 10^{-1}$	$1 \times 10^1$ (b)	$1 \times 10^6$ (b)
Ag-110m (a)	$4 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Ag-111	$2 \times 10^0$	$6 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^6$
Aluminium (13)				
Al-26	$1 \times 10^{-1}$	$1 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
Americium (95)				
Am-241	$1 \times 10^1$	$1 \times 10^{-3}$	$1 \times 10^0$	$1 \times 10^4$
Am-242m (a)	$1 \times 10^1$	$1 \times 10^{-3}$	$1 \times 10^0$ (b)	$1 \times 10^4$ (b)
Am-243 (a)	$5 \times 10^0$	$1 \times 10^{-3}$	$1 \times 10^0$ (b)	$1 \times 10^3$ (b)
Argon (18)				
Ar-37	$4 \times 10^1$	$4 \times 10^1$	$1 \times 10^6$	$1 \times 10^8$
Ar-39	$4 \times 10^1$	$2 \times 10^1$	$1 \times 10^7$	$1 \times 10^4$
Ar-41	$3 \times 10^{-1}$	$3 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^9$
Arsenic (33)				
As-72	$3 \times 10^{-1}$	$3 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
As-73	$4 \times 10^1$	$4 \times 10^1$	$1 \times 10^3$	$1 \times 10^7$
As-74	$1 \times 10^0$	$9 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
As-76	$3 \times 10^{-1}$	$3 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^5$
As-77	$2 \times 10^1$	$7 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^6$
Astatine (85)				
At-211 (a)	$2 \times 10^1$	$5 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^7$

Gold (79)

Au-193	$7 \times 10^0$	$2 \times 10^c$	$1 \times 10^2$	$1 \times 10^7$
Au-194	$1 \times 10^0$	$1 \times 10^c$	$1 \times 10^1$	$1 \times 10^6$
Au-195	$1 \times 10^1$	$6 \times 10^c$	$1 \times 10^2$	$1 \times 10^7$
Au-198	$1 \times 10^0$	$6 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$
Au-199	$1 \times 10^1$	$6 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$

Barium (56)

Ba-131 (a)	$2 \times 10^0$	$2 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Ba-133	$3 \times 10^0$	$3 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Ba-133m	$2 \times 10^1$	$6 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$
Ba-140 (a)	$5 \times 10^{-1}$	$3 \times 10^{-1}$	$1 \times 10^1$ (b)	$1 \times 10^5$ (b)

Beryllium (4)

Be-7	$2 \times 10^1$	$2 \times 10^1$	$1 \times 10^3$	$1 \times 10^7$
Be-10	$4 \times 10^1$	$6 \times 10^{-1}$	$1 \times 10^4$	$1 \times 10^6$

Bismuth (83)

Bi-205	$7 \times 10^{-1}$	$7 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Bi-206	$3 \times 10^{-1}$	$3 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
Bi-207	$7 \times 10^{-1}$	$7 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Bi-210	$1 \times 10^0$	$6 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^6$
Bi-210m (a)	$6 \times 10^{-1}$	$2 \times 10^{-2}$	$1 \times 10^1$	$1 \times 10^5$
Bi-212 (a)	$7 \times 10^{-1}$	$6 \times 10^{-1}$	$1 \times 10^1$ (b)	$1 \times 10^5$ (b)

Berkelium (97)

Bk-247	$8 \times 10^0$	$8 \times 10^{-4}$	$1 \times 10^0$	$1 \times 10^4$
Bk-249 (a)	$4 \times 10^1$	$3 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^6$
Bromine (35)				
Br-76	$4 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
Br-77	$3 \times 10^0$	$3 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Br-82	$4 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Carbon (6)				
C-11	$1 \times 10^0$	$6 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
C-14	$4 \times 10^1$	$3 \times 10^c$	$1 \times 10^4$	$1 \times 10^7$
Calcium (20)				
Ca-41	Unlimited	Unlimited	$1 \times 10^5$	$1 \times 10^7$
Ca-45	$4 \times 10^1$	$1 \times 10^c$	$1 \times 10^4$	$1 \times 10^7$
Ca-47 (a)	$3 \times 10^0$	$3 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Cadmium (48)				
Cd-109	$3 \times 10^1$	$2 \times 10^c$	$1 \times 10^4$	$1 \times 10^6$
Cd-113m	$4 \times 10^1$	$5 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^6$
Cd-115 (a)	$3 \times 10^0$	$4 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$
Cd-115m	$5 \times 10^{-1}$	$5 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^6$
Cerium (58)				
Ce-139	$7 \times 10^0$	$2 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Ce-141	$2 \times 10^1$	$6 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^7$
Ce-143	$9 \times 10^{-1}$	$6 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$

Ce-144 (a)	$2 \times 10^{-1}$	$2 \times 10^{-1}$	$1 \times 10^2$ (b)	$1 \times 10^5$ (b)
Californium (98)				
Cf-248	$4 \times 10^1$	$6 \times 10^{-3}$	$1 \times 10^1$	$1 \times 10^4$
Cf-249	$3 \times 10^0$	$8 \times 10^{-4}$	$1 \times 10^0$	$1 \times 10^3$
Cf-250	$2 \times 10^1$	$2 \times 10^{-3}$	$1 \times 10^1$	$1 \times 10^4$
Cf-251	$7 \times 10^0$	$7 \times 10^{-4}$	$1 \times 10^0$	$1 \times 10^3$
Cf-252	$1 \times 10^{-1}$	$3 \times 10^{-3}$	$1 \times 10^1$	$1 \times 10^4$
Cf-253 (a)	$4 \times 10^1$	$4 \times 10^{-2}$	$1 \times 10^2$	$1 \times 10^5$
Cf-254	$1 \times 10^{-3}$	$1 \times 10^{-3}$	$1 \times 10^0$	$1 \times 10^3$
Chlorine (17)				
Cl-36	$1 \times 10^1$	$6 \times 10^{-1}$	$1 \times 10^4$	$1 \times 10^6$
Cl-38	$2 \times 10^{-1}$	$2 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
Curium (96)				
Cm-240	$4 \times 10^1$	$2 \times 10^{-2}$	$1 \times 10^2$	$1 \times 10^5$
Cm-241	$2 \times 10^0$	$1 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Cm-242	$4 \times 10^1$	$1 \times 10^{-2}$	$1 \times 10^2$	$1 \times 10^5$
Cm-243	$9 \times 10^0$	$1 \times 10^{-3}$	$1 \times 10^0$	$1 \times 10^4$
Cm-244	$2 \times 10^1$	$2 \times 10^{-3}$	$1 \times 10^1$	$1 \times 10^4$
Cm-245	$9 \times 10^0$	$9 \times 10^{-4}$	$1 \times 10^0$	$1 \times 10^3$
Cm-246	$9 \times 10^0$	$9 \times 10^{-4}$	$1 \times 10^0$	$1 \times 10^3$
Cm-247 (a)	$3 \times 10^0$	$1 \times 10^{-3}$	$1 \times 10^0$	$1 \times 10^4$
Cm-248	$2 \times 10^{-2}$	$3 \times 10^{-4}$	$1 \times 10^0$	$1 \times 10^3$

## Cobalt (27)

Co-55	$5 \times 10^{-1}$	$5 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Co-56	$3 \times 10^{-1}$	$3 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
Co-57	$1 \times 10^1$	$1 \times 10^1$	$1 \times 10^2$	$1 \times 10^6$
Co-58	$1 \times 10^0$	$1 \times 10^c$	$1 \times 10^1$	$1 \times 10^6$
Co-58m	$4 \times 10^1$	$4 \times 10^1$	$1 \times 10^4$	$1 \times 10^7$
Co-60	$4 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$

## Chromium (24)

Cr-51	$3 \times 10^1$	$3 \times 10^1$	$1 \times 10^3$	$1 \times 10^7$
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## Caesium (55)

Cs-129	$4 \times 10^0$	$4 \times 10^c$	$1 \times 10^2$	$1 \times 10^5$
Cs-131	$3 \times 10^1$	$3 \times 10^1$	$1 \times 10^3$	$1 \times 10^6$
Cs-132	$1 \times 10^0$	$1 \times 10^c$	$1 \times 10^1$	$1 \times 10^5$
Cs-134	$7 \times 10^{-1}$	$7 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^4$
Cs-134m	$4 \times 10^1$	$6 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^5$
Cs-135	$4 \times 10^1$	$1 \times 10^c$	$1 \times 10^4$	$1 \times 10^7$
Cs-136	$5 \times 10^{-1}$	$5 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
Cs-137 (a)	$2 \times 10^0$	$6 \times 10^{-1}$	$1 \times 10^1$ (b)	$1 \times 10^4$ (b)

## Copper (29)

Cu-64	$6 \times 10^0$	$1 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Cu-67	$1 \times 10^1$	$7 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$

## Dysprosium (66)

Dy-159	$2 \times 10^1$	$2 \times 10^1$	$1 \times 10^3$	$1 \times 10^7$
Dy-165	$9 \times 10^{-1}$	$6 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^6$
Dy-166 (a)	$9 \times 10^{-1}$	$3 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^6$
Erbium (68)				
Er-169	$4 \times 10^1$	$1 \times 10^c$	$1 \times 10^4$	$1 \times 10^7$
Er-171	$8 \times 10^{-1}$	$5 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$
Europium (63)				
Eu-147	$2 \times 10^0$	$2 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Eu-148	$5 \times 10^{-1}$	$5 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Eu-149	$2 \times 10^1$	$2 \times 10^1$	$1 \times 10^2$	$1 \times 10^7$
Eu-150 (short lived)	$2 \times 10^0$	$7 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^6$
Eu-150 (long lived)	$7 \times 10^{-1}$	$7 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Eu-152	$1 \times 10^0$	$1 \times 10^c$	$1 \times 10^1$	$1 \times 10^6$
Eu-152m	$8 \times 10^{-1}$	$8 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$
Eu-154	$9 \times 10^{-1}$	$6 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Eu-155	$2 \times 10^1$	$3 \times 10^c$	$1 \times 10^2$	$1 \times 10^7$
Eu-156	$7 \times 10^{-1}$	$7 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Fluorine (9)				
F-18	$1 \times 10^0$	$6 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Iron (26)				
Fe-52 (a)	$3 \times 10^{-1}$	$3 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Fe-55	$4 \times 10^1$	$4 \times 10^1$	$1 \times 10^4$	$1 \times 10^6$

Fe-59	$9 \times 10^{-1}$	$9 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Fe-60 (a)	$4 \times 10^1$	$2 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^5$
Gallium (31)				
Ga-67	$7 \times 10^0$	$3 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Ga-68	$5 \times 10^{-1}$	$5 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
Ga-72	$4 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
Gadolinium (64)				
Gd-146 (a)	$5 \times 10^{-1}$	$5 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Gd-148	$2 \times 10^1$	$2 \times 10^{-3}$	$1 \times 10^1$	$1 \times 10^4$
Gd-153	$1 \times 10^1$	$9 \times 10^c$	$1 \times 10^2$	$1 \times 10^7$
Gd-159	$3 \times 10^0$	$6 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^6$
Germanium (32)				
Ge-68 (a)	$5 \times 10^{-1}$	$5 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
Ge-71	$4 \times 10^1$	$4 \times 10^1$	$1 \times 10^4$	$1 \times 10^8$
Ge-77	$3 \times 10^{-1}$	$3 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
Hafnium (72)				
Hf-172 (a)	$6 \times 10^{-1}$	$6 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Hf-175	$3 \times 10^0$	$3 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Hf-181	$2 \times 10^0$	$5 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Hf-182	Unlimited	Unlimited	$1 \times 10^2$	$1 \times 10^6$
Mercury (80)				
Hg-194 (a)	$1 \times 10^0$	$1 \times 10^c$	$1 \times 10^1$	$1 \times 10^6$

Hg-195m (a)	$3 \times 10^0$	$7 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$
Hg-197	$2 \times 10^1$	$1 \times 10^1$	$1 \times 10^2$	$1 \times 10^7$
Hg-197m	$1 \times 10^1$	$4 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$
Hg-203	$5 \times 10^0$	$1 \times 10^c$	$1 \times 10^2$	$1 \times 10^5$
Holmium (67)				
Ho-166	$4 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^5$
Ho-166m	$6 \times 10^{-1}$	$5 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Iodine (53)				
I-123	$6 \times 10^0$	$3 \times 10^c$	$1 \times 10^2$	$1 \times 10^7$
I-124	$1 \times 10^0$	$1 \times 10^c$	$1 \times 10^1$	$1 \times 10^6$
I-125	$2 \times 10^1$	$3 \times 10^c$	$1 \times 10^3$	$1 \times 10^6$
I-126	$2 \times 10^0$	$1 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
I-129	Unlimited	Unlimited	$1 \times 10^2$	$1 \times 10^5$
I-131	$3 \times 10^0$	$7 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$
I-132	$4 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
I-133	$7 \times 10^{-1}$	$6 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
I-134	$3 \times 10^{-1}$	$3 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
I-135 (a)	$6 \times 10^{-1}$	$6 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Indium (49)				
In-111	$3 \times 10^0$	$3 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
In-113m	$4 \times 10^0$	$2 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
In-114m (a)	$1 \times 10^1$	$5 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$

In-115m	$7 \times 10^0$	$1 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Iridium (77)				
Ir-189 (a)	$1 \times 10^1$	$1 \times 10^1$	$1 \times 10^2$	$1 \times 10^7$
Ir-190	$7 \times 10^{-1}$	$7 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Ir-192	$1 \times 10^0$ (c)	$6 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^4$
Ir-194	$3 \times 10^{-1}$	$3 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^5$
Potassium (19)				
K-40	$9 \times 10^{-1}$	$9 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$
K-42	$2 \times 10^{-1}$	$2 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$
K-43	$7 \times 10^{-1}$	$6 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Krypton (36)				
Kr-79	$4 \times 10^0$	$2 \times 10^c$	$1 \times 10^3$	$1 \times 10^5$
Kr-81	$4 \times 10^1$	$4 \times 10^1$	$1 \times 10^4$	$1 \times 10^7$
Kr-85	$1 \times 10^1$	$1 \times 10^1$	$1 \times 10^5$	$1 \times 10^4$
Kr-85m	$8 \times 10^0$	$3 \times 10^c$	$1 \times 10^3$	$1 \times 10^{10}$
Kr-87	$2 \times 10^{-1}$	$2 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^9$
Lanthanum (57)				
La-137	$3 \times 10^1$	$6 \times 10^c$	$1 \times 10^3$	$1 \times 10^7$
La-140	$4 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
Lutetium (71)				
Lu-172	$6 \times 10^{-1}$	$6 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Lu-173	$8 \times 10^0$	$8 \times 10^c$	$1 \times 10^2$	$1 \times 10^7$

Lu-174	$9 \times 10^0$	$9 \times 10^c$	$1 \times 10^2$	$1 \times 10^7$
Lu-174m	$2 \times 10^1$	$1 \times 10^1$	$1 \times 10^2$	$1 \times 10^7$
Lu-177	$3 \times 10^1$	$7 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^7$
Magnesium (12)				
Mg-28 (a)	$3 \times 10^{-1}$	$3 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
Manganese (25)				
Mn-52	$3 \times 10^{-1}$	$3 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
Mn-53	Unlimited	Unlimited	$1 \times 10^4$	$1 \times 10^9$
Mn-54	$1 \times 10^0$	$1 \times 10^c$	$1 \times 10^1$	$1 \times 10^6$
Mn-56	$3 \times 10^{-1}$	$3 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
Molybdenum (42)				
Mo-93	$4 \times 10^1$	$2 \times 10^1$	$1 \times 10^3$	$1 \times 10^8$
Mo-99 (a)	$1 \times 10^0$	$6 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$
Nitrogen (7)				
N-13	$9 \times 10^{-1}$	$6 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^9$
Sodium (11)				
Na-22	$5 \times 10^{-1}$	$5 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Na-24	$2 \times 10^{-1}$	$2 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
Niobium (41)				
Nb-93m	$4 \times 10^1$	$3 \times 10^1$	$1 \times 10^4$	$1 \times 10^7$
Nb-94	$7 \times 10^{-1}$	$7 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Nb-95	$1 \times 10^0$	$1 \times 10^c$	$1 \times 10^1$	$1 \times 10^6$

Nb-97	$9 \times 10^{-1}$	$6 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Neodymium (60)				
Nd-147	$6 \times 10^0$	$6 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$
Nd-149	$6 \times 10^{-1}$	$5 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$
Nickel (28)				
Ni-59	Unlimited	Unlimited	$1 \times 10^4$	$1 \times 10^8$
Ni-63	$4 \times 10^1$	$3 \times 10^1$	$1 \times 10^5$	$1 \times 10^8$
Ni-65	$4 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Neptunium (93)				
Np-235	$4 \times 10^1$	$4 \times 10^1$	$1 \times 10^3$	$1 \times 10^7$
Np-236 (short lived)	$2 \times 10^1$	$2 \times 10^c$	$1 \times 10^3$	$1 \times 10^7$
Np-236 (long lived)	$9 \times 10^0$	$2 \times 10^{-2}$	$1 \times 10^2$	$1 \times 10^5$
Np-237	$2 \times 10^1$	$2 \times 10^{-3}$	$1 \times 10^0$ (b)	$1 \times 10^3$ (b)
Np-239	$7 \times 10^0$	$4 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^7$
Osmium (76)				
Os-185	$1 \times 10^0$	$1 \times 10^c$	$1 \times 10^1$	$1 \times 10^6$
Os-191	$1 \times 10^1$	$2 \times 10^c$	$1 \times 10^2$	$1 \times 10^7$
Os-191m	$4 \times 10^1$	$3 \times 10^1$	$1 \times 10^3$	$1 \times 10^7$
Os-193	$2 \times 10^0$	$6 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$
Os-194 (a)	$3 \times 10^{-1}$	$3 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^5$
Phosphorus (15)				
P-32	$5 \times 10^{-1}$	$5 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^5$

P-33	$4 \times 10^1$	$1 \times 10^c$	$1 \times 10^5$	$1 \times 10^8$
Protactinium (91)				
Pa-230 (a)	$2 \times 10^0$	$7 \times 10^{-2}$	$1 \times 10^1$	$1 \times 10^6$
Pa-231	$4 \times 10^0$	$4 \times 10^{-4}$	$1 \times 10^0$	$1 \times 10^3$
Pa-233	$5 \times 10^0$	$7 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^7$
Lead (82)				
Pb-201	$1 \times 10^0$	$1 \times 10^c$	$1 \times 10^1$	$1 \times 10^6$
Pb-202	$4 \times 10^1$	$2 \times 10^1$	$1 \times 10^3$	$1 \times 10^6$
Pb-203	$4 \times 10^0$	$3 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Pb-205	Unlimited	Unlimited	$1 \times 10^4$	$1 \times 10^7$
Pb-210 (a)	$1 \times 10^0$	$5 \times 10^{-2}$	$1 \times 10^1$ (b)	$1 \times 10^4$ (b)
Pb-212 (a)	$7 \times 10^{-1}$	$2 \times 10^{-1}$	$1 \times 10^1$ (b)	$1 \times 10^5$ (b)
Palladium (46)				
Pd-103 (a)	$4 \times 10^1$	$4 \times 10^1$	$1 \times 10^3$	$1 \times 10^8$
Pd-107	Unlimited	Unlimited	$1 \times 10^5$	$1 \times 10^8$
Pd-109	$2 \times 10^0$	$5 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^6$
Promethium (61)				
Pm-143	$3 \times 10^0$	$3 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Pm-144	$7 \times 10^{-1}$	$7 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Pm-145	$3 \times 10^1$	$1 \times 10^1$	$1 \times 10^3$	$1 \times 10^7$
Pm-147	$4 \times 10^1$	$2 \times 10^c$	$1 \times 10^4$	$1 \times 10^7$
Pm-148m (a)	$8 \times 10^{-1}$	$7 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$

Pm-149	$2 \times 10^0$	$6 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^6$
Pm-151	$2 \times 10^0$	$6 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$
Polonium (84)				
Po-210	$4 \times 10^1$	$2 \times 10^{-2}$	$1 \times 10^1$	$1 \times 10^4$
Praseodymium (59)				
Pr-142	$4 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^5$
Pr-143	$3 \times 10^0$	$6 \times 10^{-1}$	$1 \times 10^4$	$1 \times 10^6$
Platinum (78)				
Pt-188 (a)	$1 \times 10^0$	$8 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Pt-191	$4 \times 10^0$	$3 \times 10^0$	$1 \times 10^2$	$1 \times 10^6$
Pt-193	$4 \times 10^1$	$4 \times 10^1$	$1 \times 10^4$	$1 \times 10^7$
Pt-193m	$4 \times 10^1$	$5 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^7$
Pt-195m	$1 \times 10^1$	$5 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$
Pt-197	$2 \times 10^1$	$6 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^6$
Pt-197m	$1 \times 10^1$	$6 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$
Plutonium (94)				
Pu-236	$3 \times 10^1$	$3 \times 10^{-3}$	$1 \times 10^1$	$1 \times 10^4$
Pu-237	$2 \times 10^1$	$2 \times 10^1$	$1 \times 10^3$	$1 \times 10^7$
Pu-238	$1 \times 10^1$	$1 \times 10^{-3}$	$1 \times 10^0$	$1 \times 10^4$
Pu-239	$1 \times 10^1$	$1 \times 10^{-3}$	$1 \times 10^0$	$1 \times 10^4$
Pu-240	$1 \times 10^1$	$1 \times 10^{-3}$	$1 \times 10^0$	$1 \times 10^3$
Pu-241 (a)	$4 \times 10^1$	$6 \times 10^{-2}$	$1 \times 10^2$	$1 \times 10^5$

Pu-242	$1 \times 10^1$	$1 \times 10^{-3}$	$1 \times 10^0$	$1 \times 10^4$
Pu-244 (a)	$4 \times 10^{-1}$	$1 \times 10^{-3}$	$1 \times 10^0$	$1 \times 10^4$
Radium (88)				
Ra-223 (a)	$4 \times 10^{-1}$	$7 \times 10^{-3}$	$1 \times 10^2$ (b)	$1 \times 10^5$ (b)
Ra-224 (a)	$4 \times 10^{-1}$	$2 \times 10^{-2}$	$1 \times 10^1$ (b)	$1 \times 10^5$ (b)
Ra-225 (a)	$2 \times 10^{-1}$	$4 \times 10^{-3}$	$1 \times 10^2$	$1 \times 10^5$
Ra-226 (a)	$2 \times 10^{-1}$	$3 \times 10^{-3}$	$1 \times 10^1$ (b)	$1 \times 10^4$ (b)
Ra-228 (a)	$6 \times 10^{-1}$	$2 \times 10^{-2}$	$1 \times 10^1$ (b)	$1 \times 10^5$ (b)
Rubidium (37)				
Rb-81	$2 \times 10^0$	$8 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Rb-83 (a)	$2 \times 10^0$	$2 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Rb-84	$1 \times 10^0$	$1 \times 10^c$	$1 \times 10^1$	$1 \times 10^6$
Rb-86	$5 \times 10^{-1}$	$5 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^5$
Rb-87	Unlimited	Unlimited	$1 \times 10^4$	$1 \times 10^7$
Rb (nat)	Unlimited	Unlimited	$1 \times 10^4$	$1 \times 10^7$
Rhenium (75)				
Re-184	$1 \times 10^0$	$1 \times 10^c$	$1 \times 10^1$	$1 \times 10^6$
Re-184m	$3 \times 10^0$	$1 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Re-186	$2 \times 10^0$	$6 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^6$
Re-187	Unlimited	Unlimited	$1 \times 10^6$	$1 \times 10^9$
Re-188	$4 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^5$
Re-189 (a)	$3 \times 10^0$	$6 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$

Re (nat)	Unlimited	Unlimited	$1 \times 10^6$	$1 \times 10^9$
Rhodium (45)				
Rh-99	$2 \times 10^0$	$2 \times 10^c$	$1 \times 10^1$	$1 \times 10^6$
Rh-101	$4 \times 10^0$	$3 \times 10^c$	$1 \times 10^2$	$1 \times 10^7$
Rh-102	$5 \times 10^{-1}$	$5 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Rh-102m	$2 \times 10^0$	$2 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Rh-103m	$4 \times 10^1$	$4 \times 10^1$	$1 \times 10^4$	$1 \times 10^8$
Rh-105	$1 \times 10^1$	$8 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^7$
Radon (86)				
Rn-222 (a)	$3 \times 10^{-1}$	$4 \times 10^{-3}$	$1 \times 10^1$ (b)	$1 \times 10^8$ (b)
Ruthenium (44)				
Ru-97	$5 \times 10^0$	$5 \times 10^c$	$1 \times 10^2$	$1 \times 10^7$
Ru-103 (a)	$2 \times 10^0$	$2 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Ru-105	$1 \times 10^0$	$6 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Ru-106 (a)	$2 \times 10^{-1}$	$2 \times 10^{-1}$	$1 \times 10^2$ (b)	$1 \times 10^5$ (b)
Sulphur (16)				
S-35	$4 \times 10^1$	$3 \times 10^c$	$1 \times 10^5$	$1 \times 10^8$
Antimony (51)				
Sb-122	$4 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^4$
Sb-124	$6 \times 10^{-1}$	$6 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Sb-125	$2 \times 10^0$	$1 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Sb-126	$4 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$

Scandium (21)

Sc-44	$5 \times 10^{-1}$	$5 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
Sc-46	$5 \times 10^{-1}$	$5 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Sc-47	$1 \times 10^1$	$7 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$
Sc-48	$3 \times 10^{-1}$	$3 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$

Selenium (34)

Se-75	$3 \times 10^0$	$3 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Se-79	$4 \times 10^1$	$2 \times 10^c$	$1 \times 10^4$	$1 \times 10^7$

Silicon (14)

Si-31	$6 \times 10^{-1}$	$6 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^6$
Si-32	$4 \times 10^1$	$5 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^6$

Samarium (62)

Sm-145	$1 \times 10^1$	$1 \times 10^1$	$1 \times 10^2$	$1 \times 10^7$
Sm-147	Unlimited	Unlimited	$1 \times 10^1$	$1 \times 10^4$
Sm-151	$4 \times 10^1$	$1 \times 10^1$	$1 \times 10^4$	$1 \times 10^8$
Sm-153	$9 \times 10^0$	$6 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$

Tin (50)

Sn-113 (a)	$4 \times 10^0$	$2 \times 10^c$	$1 \times 10^3$	$1 \times 10^7$
Sn-117m	$7 \times 10^0$	$4 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$
Sn-119m	$4 \times 10^1$	$3 \times 10^1$	$1 \times 10^3$	$1 \times 10^7$
Sn-121m (a)	$4 \times 10^1$	$9 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^7$
Sn-123	$8 \times 10^{-1}$	$6 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^6$

Sn-125	$4 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^5$
Sn-126 (a)	$6 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
Strontium (38)				
Sr-82 (a)	$2 \times 10^{-1}$	$2 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
Sr-85	$2 \times 10^0$	$2 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Sr-85m	$5 \times 10^0$	$5 \times 10^c$	$1 \times 10^2$	$1 \times 10^7$
Sr-87m	$3 \times 10^0$	$3 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Sr-89	$6 \times 10^{-1}$	$6 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^6$
Sr-90 (a)	$3 \times 10^{-1}$	$3 \times 10^{-1}$	$1 \times 10^2$ (b)	$1 \times 10^4$ (b)
Sr-91 (a)	$3 \times 10^{-1}$	$3 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
Sr-92 (a)	$1 \times 10^0$	$3 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Tritium (1)				
T(H-3)	$4 \times 10^1$	$4 \times 10^1$	$1 \times 10^6$	$1 \times 10^9$
Tantalum (73)				
Ta-178 (long lived)	$1 \times 10^0$	$8 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Ta-179	$3 \times 10^1$	$3 \times 10^1$	$1 \times 10^3$	$1 \times 10^7$
Ta-182	$9 \times 10^{-1}$	$5 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^4$
Terbium (65)				
Tb-157	$4 \times 10^1$	$4 \times 10^1$	$1 \times 10^4$	$1 \times 10^7$
Tb-158	$1 \times 10^0$	$1 \times 10^c$	$1 \times 10^1$	$1 \times 10^6$
Tb-160	$1 \times 10^0$	$6 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Technetium (43)				

Tc-95m (a)	$2 \times 10^0$	$2 \times 10^c$	$1 \times 10^1$	$1 \times 10^6$
Tc-96	$4 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Tc-96m (a)	$4 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^7$
Tc-97	Unlimited	Unlimited	$1 \times 10^3$	$1 \times 10^8$
Tc-97m	$4 \times 10^1$	$1 \times 10^c$	$1 \times 10^3$	$1 \times 10^7$
Tc-98	$8 \times 10^{-1}$	$7 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Tc-99	$4 \times 10^1$	$9 \times 10^{-1}$	$1 \times 10^4$	$1 \times 10^7$
Tc-99m	$1 \times 10^1$	$4 \times 10^c$	$1 \times 10^2$	$1 \times 10^7$
Tellurium (52)				
Te-121	$2 \times 10^0$	$2 \times 10^c$	$1 \times 10^1$	$1 \times 10^6$
Te-121m	$5 \times 10^0$	$3 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Te-123m	$8 \times 10^0$	$1 \times 10^c$	$1 \times 10^2$	$1 \times 10^7$
Te-125m	$2 \times 10^1$	$9 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^7$
Te-127	$2 \times 10^1$	$7 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^6$
Te-127m (a)	$2 \times 10^1$	$5 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^7$
Te-129	$7 \times 10^{-1}$	$6 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$
Te-129m (a)	$8 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^6$
Te-131m (a)	$7 \times 10^{-1}$	$5 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Te-132 (a)	$5 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^7$
Thorium (90)				
Th-227	$1 \times 10^1$	$5 \times 10^{-3}$	$1 \times 10^1$	$1 \times 10^4$
Th-228 (a)	$5 \times 10^{-1}$	$1 \times 10^{-3}$	$1 \times 10^0$ (b)	$1 \times 10^4$ (b)

Th-229	$5 \times 10^0$	$5 \times 10^{-4}$	$1 \times 10^0$ (b)	$1 \times 10^3$ (b)
Th-230	$1 \times 10^1$	$1 \times 10^{-3}$	$1 \times 10^0$	$1 \times 10^4$
Th-231	$4 \times 10^1$	$2 \times 10^{-2}$	$1 \times 10^3$	$1 \times 10^7$
Th-232	Unlimited	Unlimited	$1 \times 10^1$	$1 \times 10^4$
Th-234 (a)	$3 \times 10^{-1}$	$3 \times 10^{-1}$	$1 \times 10^3$ (b)	$1 \times 10^5$ (b)
Th (nat)	Unlimited	Unlimited	$1 \times 10^0$ (b)	$1 \times 10^3$ (b)
Titanium (22)				
Ti-44 (a)	$5 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
Thallium (81)				
Tl-200	$9 \times 10^{-1}$	$9 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Tl-201	$1 \times 10^1$	$4 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Tl-202	$2 \times 10^0$	$2 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Tl-204	$1 \times 10^1$	$7 \times 10^{-1}$	$1 \times 10^4$	$1 \times 10^4$
Thulium (69)				
Tm-167	$7 \times 10^0$	$8 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$
Tm-170	$3 \times 10^0$	$6 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^6$
Tm-171	$4 \times 10^1$	$4 \times 10^1$	$1 \times 10^4$	$1 \times 10^8$
Uranium (92)				
U-230 (fast lung absorption) (a)(d)	$4 \times 10^1$	$1 \times 10^{-1}$	$1 \times 10^1$ (b)	$1 \times 10^5$ (b)
U-230 (medium lung absorption)(a)(e)	$4 \times 10^1$	$4 \times 10^{-3}$	$1 \times 10^1$	$1 \times 10^4$

U-230 (slow lung absorption) (a)(f)	$3 \times 10^1$	$3 \times 10^{-3}$	$1 \times 10^1$	$1 \times 10^4$
U-232 (fast lung absorption)(d)	$4 \times 10^1$	$1 \times 10^{-2}$	$1 \times 10^0$ (b)	$1 \times 10^3$ (b)
U-232 (medium lung absorption)(e)	$4 \times 10^1$	$7 \times 10^{-3}$	$1 \times 10^1$	$1 \times 10^4$
U-232 (slow lung absorption)(f)	$1 \times 10^1$	$1 \times 10^{-3}$	$1 \times 10^1$	$1 \times 10^4$
U-233 (fast lung absorption)(d)	$4 \times 10^1$	$9 \times 10^{-2}$	$1 \times 10^1$	$1 \times 10^4$
U-233 (medium lung absorption)(e)	$4 \times 10^1$	$2 \times 10^{-2}$	$1 \times 10^2$	$1 \times 10^5$
U-233 (slow lung absorption)(f)	$4 \times 10^1$	$6 \times 10^{-3}$	$1 \times 10^1$	$1 \times 10^5$
U-234 (fast lung absorption)(d)	$4 \times 10^1$	$9 \times 10^{-2}$	$1 \times 10^1$	$1 \times 10^4$
U-234 (medium lung absorption)(e)	$4 \times 10^1$	$2 \times 10^{-2}$	$1 \times 10^2$	$1 \times 10^5$
U-234 (slow lung absorption)(f)	$4 \times 10^1$	$6 \times 10^{-3}$	$1 \times 10^1$	$1 \times 10^5$
U-235 (all lung types)(a)(d)(e)(f) absorption	Unlimited	Unlimited	$1 \times 10^1$ (b)	$1 \times 10^4$ (b)
U-236 (fast lung absorption)	Unlimited	Unlimited	$1 \times 10^1$	$1 \times 10^4$

absorption)(d)

U-236 (medium lung	$4 \times 10^1$	$2 \times 10^{-2}$	$1 \times 10^2$	$1 \times 10^5$
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absorption)(e)

U-236 (slow lung	$4 \times 10^1$	$6 \times 10^{-3}$	$1 \times 10^1$	$1 \times 10^4$
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absorption)(f)

U-238 (all lung	Unlimited	Unlimited	$1 \times 10^1$ (b)	$1 \times 10^4$ (b)
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absorption

types)(d)(e)(f)

U (nat)	Unlimited	Unlimited	$1 \times 10^0$ (b)	$1 \times 10^3$ (b)
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U (enriched to 20%	Unlimited	Unlimited	$1 \times 10^0$	$1 \times 10^3$
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or less)(g)

U (dep)	Unlimited	Unlimited	$1 \times 10^0$	$1 \times 10^3$
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Vanadium (23)

V-48	$4 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^5$
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V-49	$4 \times 10^1$	$4 \times 10^1$	$1 \times 10^4$	$1 \times 10^7$
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Tungsten (74)

W-178 (a)	$9 \times 10^0$	$5 \times 10^c$	$1 \times 10^1$	$1 \times 10^6$
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W-181	$3 \times 10^1$	$3 \times 10^1$	$1 \times 10^3$	$1 \times 10^7$
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W-185	$4 \times 10^1$	$8 \times 10^{-1}$	$1 \times 10^4$	$1 \times 10^7$
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W-187	$2 \times 10^0$	$6 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$
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W-188 (a)	$4 \times 10^{-1}$	$3 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^5$
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Xenon (54)

Xe-122 (a)	$4 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^9$
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Xe-123	$2 \times 10^0$	$7 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^9$
Xe-127	$4 \times 10^0$	$2 \times 10^c$	$1 \times 10^3$	$1 \times 10^5$
Xe-131m	$4 \times 10^1$	$4 \times 10^1$	$1 \times 10^4$	$1 \times 10^4$
Xe-133	$2 \times 10^1$	$1 \times 10^1$	$1 \times 10^3$	$1 \times 10^4$
Xe-135	$3 \times 10^0$	$2 \times 10^c$	$1 \times 10^3$	$1 \times 10^{10}$
Yttrium (39)				
Y-87 (a)	$1 \times 10^0$	$1 \times 10^c$	$1 \times 10^1$	$1 \times 10^6$
Y-88	$4 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Y-90	$3 \times 10^{-1}$	$3 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^5$
Y-91	$6 \times 10^{-1}$	$6 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^6$
Y-91m	$2 \times 10^0$	$2 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$
Y-92	$2 \times 10^{-1}$	$2 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^5$
Y-93	$3 \times 10^{-1}$	$3 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^5$
Ytterbium (70)				
Yb-169	$4 \times 10^0$	$1 \times 10^c$	$1 \times 10^2$	$1 \times 10^7$
Yb-175	$3 \times 10^1$	$9 \times 10^{-1}$	$1 \times 10^3$	$1 \times 10^7$
Zinc (30)				
Zn-65	$2 \times 10^0$	$2 \times 10^c$	$1 \times 10^1$	$1 \times 10^6$
Zn-69	$3 \times 10^0$	$6 \times 10^{-1}$	$1 \times 10^4$	$1 \times 10^6$
Zn-69m (a)	$3 \times 10^0$	$6 \times 10^{-1}$	$1 \times 10^2$	$1 \times 10^6$
Zirconium (40)				
Zr-88	$3 \times 10^0$	$3 \times 10^c$	$1 \times 10^2$	$1 \times 10^6$

Zr-93	Unlimited	Unlimited	$1 \times 10^3$ (b)	$1 \times 10^7$ (b)
Zr-95 (a)	$2 \times 10^0$	$8 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^6$
Zr-97 (a)	$4 \times 10^{-1}$	$4 \times 10^{-1}$	$1 \times 10^1$ (b)	$1 \times 10^5$ (b)

(a)  $A_1$  and/or  $A_2$  values for these parent radionuclides include contributions from daughter radionuclides with half-lives less than 10 days, as listed in the following:

Mg-28	Al-28
Ar-42	K-42
Ca-47	Sc-47
Ti-44	Sc-44
Fe-52	Mn-52m
Fe-60	Co-60m
Zn-69m	Zn-69
Ge-68	Ga-68
Rb-83	Kr-83m
Sr-82	Rb-82
Sr-90	Y-90
Sr-91	Y-91m
Sr-92	Y-92
Y-87	Sr-87m
Zr-95	Nb-95m
Zr-97	Nb-97m, Nb-97
Mo-99	Tc-99m
Tc-95m	Tc-95
Tc-96m	Tc-96

Ru-103	Rh-103m
Ru-106	Rh-106
Pd-103	Rh-103m
Ag-108m	Ag-108
Ag-110m	Ag-110
Cd-115	In-115m
In-114m	In-114
Sn-113	In-113m
Sn-121m	Sn-121
Sn-126	Sb-126m
Te-118	Sb-118
Te-127m	Te-127
Te-129m	Te-129
Te-131m	Te-131
Te-132	I-132
I-135	Xe-135m
Xe-122	I-122
Cs-137	Ba-137m
Ba-131	Cs-131
Ba-140	La-140
Ce-144	Pr-144m, Pr-144
Pm-148m	Pm-148
Gd-146	Eu-146
Dy-166	Ho-166

Hf-172	Lu-172
W-178	Ta-178
W-188	Re-188
Re-189	Os-189m
Os-194	Ir-194
Ir-189	Os-189m
Pt-188	Ir-188
Hg-194	Au-194
Hg-195m	Hg-195
Pb-210	Bi-210
Pb-212	Bi-212, Tl-208, Po-212
Bi-210m	Tl-206
Bi-212	Tl-208, Po-212
At-211	Po-211
Rn-222	Po-218, Pb-214, At-218, Bi-214, Po-214
Ra-223	Rn-219, Po-215, Pb-211, Bi-211, Po-211, Tl-207
Ra-224	Rn-220, Po-216, Pb-212, Bi-212, Tl-208, Po-212
Ra-225	Ac-225, Fr-221, At-217, Bi-213, Tl-209, Po-213, Pb-209
Ra-226	Rn-222, Po-218, Pb-214, At-218, Bi-214, Po-214
Ra-228	Ac-228
Ac-225	Fr-221, At-217, Bi-213, Tl-209, Po-213, Pb-209
Ac-227	Fr-223
Th-228	Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208, Po-212
Th-234	Pa-234m, Pa-234

Pa-230	Ac-226, Th-226, Fr-222, Ra-222, Rn-218, Po-214
U-230	Th-226, Ra-222, Rn-218, Po-214
U-235	Th-231
Pu-241	U-237
Pu-244	U-240, Np-240m
Am-242m	Am-242, Np-238
Am-243	Np-239
Cm-247	Pu-243
Bk-249	Am-245
Cf-253	Cm-249

(b) Parent nuclides and their progeny included in secular equilibrium are listed in the following:

Sr-90	Y-90
Zr-93	Nb-93m
Zr-97	Nb-97
Ru-106	Rh-106
Ag-108m	Ag-108
Cs-137	Ba-137m
Ce-144	Pr-144
Ba-140	La-140
Bi-212	Tl-208 (0.36), Po-212 (0.64)
Pb-210	Bi-210, Po-210
Pb-212	Bi-212, Tl-208 (0.36), Po-212 (0.64)
Rn-222	Po-218, Pb-214, Bi-214, Po-214
Ra-223	Rn-219, Po-215, Pb-211, Bi-211, Tl-207

Ra-224	Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)
Ra-226	Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, Po-210
Ra-228	Ac-228
Th-228	Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)
Th-229	Ra-225, Ac-225, Fr-221, At-217, Bi-213, Po-213, Pb-209
Th-nat	Ra-228, Ac-228, Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)
Th-234	Pa-234m
U-230	Th-226, Ra-222, Rn-218, Po-214
U-232	Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)
U-235	Th-231
U-238	Th-234, Pa-234m
U-nat	Th-234, Pa-234m, U-234, Th-230, Ra-226, Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, Po-210
Np-237	Pa-233
Am-242m	Am-242
Am-243	Np-239

- (c) The quantity may be determined from a measurement of the rate of decay or a measurement of the *radiation level* at a prescribed distance from the source.
- (d) These values apply only to compounds of uranium that take the chemical form of  $UF_6$ ,  $UO_2F_2$  and  $UO_2(NO_3)_2$  in both normal and accident conditions of transport.
- (e) These values apply only to compounds of uranium that take the chemical form of  $UO_3$ ,  $UF_4$ ,  $UCl_4$  and hexavalent compounds in both normal and accident conditions of transport.
- (f) These values apply to all compounds of uranium other than those specified in (d) and (e) above.
- (g) These values apply to *unirradiated uranium* only.

405. For mixtures of radionuclides, the basic radionuclide values referred to in para. 402 may be determined as follows:

$$X_m = \frac{1}{\sum_i \frac{f(i)}{X(i)}}$$

where,

f(i) is the fraction of activity or activity concentration limit of radionuclide i in the mixture.

X(i) is the appropriate value of A<sub>1</sub> or A<sub>2</sub>, or the activity concentration limit for exempt material or the activity limit for an exempt consignment as appropriate for the radionuclide i.

X<sub>m</sub> is the derived value of A<sub>1</sub> or A<sub>2</sub>, or the activity concentration for exempt material or the activity limit for an exempt consignment in the case of a mixture.

406. When the identity of each radionuclide is known but the individual activities of some of the radionuclides are not known, the radionuclides may be grouped and the lowest radionuclide value, as appropriate, for the radionuclides in each group may be used in applying the formulas in paras 405 and 429. Groups may be based on the total alpha activity and the total beta/gamma activity when these are known, using the lowest radionuclide values for the alpha emitters or beta/gamma emitters, respectively.

TABLE 3. BASIC RADIONUCLIDE VALUES FOR UNKNOWN RADIONUCLIDES OR MIXTURES

<i>Radioactive content</i>	A <sub>1</sub> (TBq)	A <sub>2</sub> (TBq)	Activity Concentration Limit for exempt material (Bq/g)	Activity limit for an exempt consignment (Bq)
Only beta or gamma emitting nuclides are known to be	0.1	0.02	1 × 10 <sup>1</sup>	1 × 10 <sup>4</sup>

present

Alpha emitting nuclides, but	0.2	$9 \times 10^{-5}$	$1 \times 10^{-1}$	$1 \times 10^3$
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no neutron emitters are

known to be present

Neutron emitting nuclides are	0.001	$9 \times 10^{-5}$	$1 \times 10^{-1}$	$1 \times 10^3$
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known to be present or no

relevant data are available

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407. For individual radionuclides or for mixtures of radionuclides for which relevant data are not available, the values shown in Table 3 shall be used.

#### CLASSIFICATION OF MATERIAL

##### **Low specific activity (LSA) material**

408. *Radioactive material* may only be classified as *LSA material* if the conditions of paras 226, 409–411 and 516–520 are met.

409. *LSA material* shall be in one of three groups:

(a) *LSA-I*

Either:

- (i) Uranium and thorium ores and concentrates of such ores, and other ores containing naturally occurring radionuclides which do not meet the applicable provision of para. 107(e);
  - (ii) Natural uranium, depleted uranium, natural thorium or their compounds or mixtures, that are unirradiated and in solid or liquid form;
  - (iii) *Radioactive material* for which the  $A_2$  value is unlimited. *Fissile material* with unlimited  $A_2$  value may be included only if at least one of the applicable paras 417(a)–(f) is met;
- or

(iv) Other *radioactive material* in which the activity is distributed throughout and the estimated average *specific activity* does not exceed 30 times the values for activity concentration specified in paras 402–407. *Fissile material* with unlimited  $A_2$  value may be included only if at least one of the applicable paras 417(a)-(f) is met.

(b) *LSA-II*

Either:

- (i) Water with a tritium concentration of up to 0.8 TBq/L; or
- (ii) Other material in which the activity is distributed throughout and the estimated average *specific activity* does not exceed  $10^{-4}A_2/g$  for solids and gases, and  $10^{-5}A_2/g$  for liquids.

(c) *LSA-III*

Solids (e.g. consolidated wastes, activated materials), excluding powders, meeting the requirements of para. 601, in which:

- (i) The *radioactive material* is distributed throughout a solid or a collection of solid objects, or is essentially uniformly distributed in a solid compact binding agent (such as concrete, bitumen, ceramic, etc.).
- (ii) The *radioactive material* is relatively insoluble, or it is intrinsically contained in a relatively insoluble matrix, so that, even under loss of *packaging*, the loss of *radioactive material* per *package* by leaching when placed in water for seven days would not exceed  $0.1A_2$ .
- (iii) The estimated average *specific activity* of the solid, excluding any shielding material, does not exceed  $2 \times 10^{-3}A_2/g$ .

410. A single *package* of non-combustible solid *LSA-II* or *LSA-III material*, if carried by air, shall not contain an activity greater than  $3 \times 10^3 A_2$ .

411. The *radioactive contents* in a single *package* of *LSA material* shall be so restricted that the

*radiation level* specified in para. 516 shall not be exceeded, and the activity in a single *package* shall also be so restricted that the activity limits for a *conveyance* specified in para. 520 shall not be exceeded.

### **Surface contaminated object (SCO)**

412. Radioactive material may be classified as SCO if the conditions of paras 241, 413, 414 and 516–520 are met.

413. SCO shall be in one of two groups:

(a) *SCO-I*: A solid object on which:

- (i) The *non-fixed contamination* on the accessible surface averaged over 300 cm<sup>2</sup> (or the area of the surface if less than 300 cm<sup>2</sup>) does not exceed 4 Bq/cm<sup>2</sup> for beta and gamma emitters and *low toxicity alpha emitters*, or 0.4 Bq/cm<sup>2</sup> for all other alpha emitters.
- (ii) The *fixed contamination* on the accessible surface averaged over 300 cm<sup>2</sup> (or the area of the surface if less than 300 cm<sup>2</sup>) does not exceed  $4 \times 10^4$  Bq/cm<sup>2</sup> for beta and gamma emitters and *low toxicity alpha emitters*, or  $4 \times 10^3$  Bq/cm<sup>2</sup> for all other alpha emitters.
- (iii) The *non-fixed contamination* plus the *fixed contamination* on the inaccessible surface averaged over 300 cm<sup>2</sup> (or the area of the surface if less than 300 cm<sup>2</sup>) does not exceed  $4 \times 10^4$  Bq/cm<sup>2</sup> for beta and gamma emitters and *low toxicity alpha emitters*, or  $4 \times 10^3$  Bq/cm<sup>2</sup> for all other alpha emitters.

(b) *SCO-II*: A solid object on which either the *fixed* or *non-fixed contamination* on the surface exceeds the applicable limits specified for *SCO-I* in (a) above and on which:

- (i) The *non-fixed contamination* on the accessible surface averaged over 300 cm<sup>2</sup> (or the area of the surface if less than 300 cm<sup>2</sup>) does not exceed 400 Bq/cm<sup>2</sup> for beta and

gamma emitters and *low toxicity alpha emitters*, or 40 Bq/cm<sup>2</sup> for all other alpha emitters.

- (ii) The *fixed contamination* on the accessible surface, averaged over 300 cm<sup>2</sup> (or the area of the surface if less than 300 cm<sup>2</sup>) does not exceed 8 × 10<sup>5</sup> Bq/cm<sup>2</sup> for beta and gamma emitters and *low toxicity alpha emitters*, or 8 × 10<sup>4</sup> Bq/cm<sup>2</sup> for all other alpha emitters.
- (iii) The *non-fixed contamination* plus the *fixed contamination* on the inaccessible surface averaged over 300 cm<sup>2</sup> (or the area of the surface if less than 300 cm<sup>2</sup>) does not exceed 8 × 10<sup>5</sup> Bq/cm<sup>2</sup> for beta and gamma emitters and *low toxicity alpha emitters*, or 8 × 10<sup>4</sup> Bq/cm<sup>2</sup> for all other alpha emitters.

414. The *radioactive contents* in a single *package* of SCO shall be so restricted that the *radiation level* specified in para. 516 shall not be exceeded, and the activity in a single *package* shall also be so restricted that the activity limits for a *conveyance* specified in para. 520 shall not be exceeded.

#### **Special form radioactive material**

415. *Radioactive material* may be classified as *special form radioactive material* only if it meets the requirements of paras 602–604 and 802.

#### **Low dispersible radioactive material**

416. *Radioactive material* may be classified as *low dispersible radioactive material* only if it meets the requirements of para. 605 taking into account the requirements of paras 663 and 802.

#### **Fissile material**

417. *Fissile material* and *packages* containing *fissile material* shall be classified under the relevant entry as FISSILE according to Table 1 unless excepted by one of the provisions of subparas (a) – (f). Only one of the provisions of (a)-(f) is allowed per *consignment*. All provisions

apply to only packaged material unless unpackaged material is specifically allowed in the provision.

- (a) Uranium enriched in uranium-235 to a maximum of 1% by mass, and with a total plutonium and uranium-233 content not exceeding 1% of the mass of uranium-235, provided that the *fissile nuclides* are distributed essentially homogeneously throughout the material. In addition, if uranium-235 is present in metallic, oxide or carbide forms, it shall not form a lattice arrangement.
- (b) Liquid solutions of uranyl nitrate enriched in uranium-235 to a maximum of 2% by mass, with a total plutonium and uranium-233 content not exceeding 0.002% of the mass of uranium, and with a minimum nitrogen to uranium atomic ratio (N/U) of 2.
- (c) Uranium in *packages* the smallest overall external dimension of which is not less than 10 cm, provided that the *consignment* is limited to 45 g of uranium-235 with a total plutonium and uranium-233 content not exceeding 1% of the mass of uranium-235 and one of the following conditions is met:
  - (i) There is no more than 3.5 g of uranium-235 per *package* where the uranium is enriched in uranium-235 up to a maximum of 5% by mass, or
  - (ii) There is no more than 2.0 g uranium-235 per *package* where the uranium is enriched in uranium-235 to a value greater than 5% by mass.
- (d) *Fissile nuclides* of plutonium and uranium with a total mass not greater than 0.5 g per *package* and 15 g per *consignment*.
- (e) Up to 45 g per *conveyance* of *fissile nuclides* under exclusive use, either packaged or unpackaged.
- (f) Other materials that meet the requirements of para 605bis subject to *multilateral approval*. Only one such material is allowed per *consignment* unless specifically subject to *multilateral approval*.

418. Unless excepted by para. 417, *packages* containing *fissile material* shall not contain:

- (a) A mass of *fissile material*, *fissile material* constituent or *fissile nuclide* (or mass of each *fissile nuclide* for mixtures when appropriate) different from that authorized allowed for the *package design*;
- (b) Any radionuclide or *fissile material* different from those authorized allowed for the *package design*; or nor
- (c) Contents in a form or physical or chemical state, or in a spatial arrangement, different from those authorized allowed for the *package design* as specified in their certificates of approval where appropriate.

The allowed specifications are given either directly in these Regulations or in certificates of approval where appropriate.

### **Uranium hexafluoride**

419. Uranium hexafluoride shall only be assigned to:

- (a) UN No's 2977, RADIOACTIVE MATERIAL, URANIUM HEXAFLUORIDE, FISSILE, or 2978, RADIOACTIVE MATERIAL, URANIUM HEXAFLUORIDE, non-fissile or fissile-excepted; or
- (b) UN No 3XXX RADIOACTIVE MATERIAL, EXCEPTED PACKAGE - URANIUM HEXAFLUORIDE, LESS THAN 0.1 KG PER PACKAGE, in the case of uranium hexafluoride in quantities of less than 0.1 kg packaged and in an *excepted package*.

420. The contents of a *package* containing uranium hexafluoride shall comply with the following requirements:

- (a) The mass of uranium hexafluoride shall not be different from that allowed for the *package design*.
- (b) The mass of uranium hexafluoride shall not be greater than a value that would lead to an ullage of less than 5% at the maximum temperature of the *package* as specified for the plant systems where the *package* may be used.

- (c) The uranium hexafluoride shall be in solid form and at the internal pressure shall not be above atmospheric pressure when presented for transport.

#### CLASSIFICATION OF PACKAGES

421. The quantity of *radioactive material* in a *package* shall not exceed the relevant limits for the *package* type as specified below.

#### Classification as excepted package

422. *Packages* may be classified as *excepted packages* if:

- (a) They are empty *packages* having contained *radioactive material*;
- (b) They contain instruments or articles in limited quantities as specified in Table 5;
- (c) They contain articles manufactured of natural uranium, *depleted uranium* or natural thorium;
- (d) They contain *radioactive material* in limited quantities as specified in Table 5; or
- (e) They are designed to contain less than 0.1 kg of uranium hexafluoride non-fissile or fissile-excepted.

TABLE 5. ACTIVITY LIMITS FOR EXCEPTED PACKAGES

Physical state of contents	Instrument or article		Materials
	Item limits <sup>a</sup>	Package limits <sup>a</sup>	Package limits <sup>a</sup>
Solids:			
<i>Special form</i>	$10^{-2} A_1$	$A_1$	$10^{-3} A_1$
Other forms	$10^{-2} A_2$	$A_2$	$10^{-3} A_2$
Liquids	$10^{-3} A_2$	$10^{-1} A_2$	$10^{-4} A_2$
Gases:			
Tritium	$2 \times 10^{-2} A_2$	$2 \times 10^{-1} A_2$	$2 \times 10^{-2} A_2$
<i>Special form</i>	$10^{-3} A_1$	$10^{-2} A_1$	$10^{-3} A_1$

Other forms

$10^{-3} A_2$

$10^{-2} A_2$

$10^{-3} A_2$

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<sup>a</sup> For mixtures of radionuclides, see paras 405–407.

423. *Radioactive material* which is enclosed in or is included as a component part of an instrument or other manufactured article, may be classified under UN 2911, RADIOACTIVE MATERIAL, EXCEPTED PACKAGE – INSTRUMENTS or ARTICLES, only if:

- (a) The *radiation level* at 10 cm from any point on the external surface of any unpackaged instrument or article is not greater than 0.1 mSv/h.
- (b) Each instrument or article bears, the marking “RADIOACTIVE”. Where the instrument or article is too small to bear the marking “RADIOACTIVE” on an internal surface in such a manner that a warning of the presence of *radioactive material* is visible on opening the *package*. Excepted that:
  - (i) Radioluminescent timepieces or devices do not require markings.
  - (ii) Consumer products that have either received regulatory approval according to para. 107(d) or do not individually exceed the activity limit for an exempt *consignment* in Table 2 (column 5) do not require markings, provided that such product are transported in a *package* that bears the marking “RADIOACTIVE” on an internal surface in such a manner that a warning of the presence of *radioactive material* is visible in opening the *package*.
- (c) The active material is completely enclosed by non-active components (a device performing the sole function of containing *radioactive material* shall not be considered to be an instrument or manufactured article).
- (d) The limits specified in columns 2 and 3 of Table 5 are met for each individual item and each *package*, respectively.
- (e) For transport by post, the total activity in each *excepted package* shall not exceed one tenth of the relevant limits specified in column 3 of Table 5.

424. *Radioactive material* in forms other than as specified in para. 423 and with an activity not exceeding the limits specified in column 4 of Table 5 may be classified under UN 2910, RADIOACTIVE MATERIAL, EXCEPTED PACKAGE – LIMITED QUANTITY OF MATERIAL, provided that:

- (a) The *package* retains its *radioactive contents* under routine conditions of transport.
- (b) The *package* bears the marking “RADIOACTIVE” either on:
  - (i) An internal surface in such a manner that a warning of the presence of *radioactive material* is visible on opening the *package*, or
  - (ii) The outside of the *package*, where impractical to mark on an internal surface.
- (c) For transport by post, the total activity in each *excepted package* shall not exceed one tenth of the relevant limits specified in column 4 of Table 5. Uranium hexafluoride (UN3XXX) is limited to 10 g per *package* for transport by post.

424bis. Uranium hexafluoride not exceeding the limits specified in column 4 of Table 5 may be classified under UN 3XXX RADIOACTIVE MATERIAL, EXCEPTED PACKAGE - URANIUM HEXAFLUORIDE, LESS THAN 0.1 KG PER PACKAGE, provided that the conditions of 424 (a)–(c) are met.

424ter. Articles manufactured of *natural uranium*, *depleted uranium* or natural thorium and articles in which the sole *radioactive material* is unirradiated *natural uranium*, unirradiated *depleted uranium* or unirradiated natural thorium may be classified under UN 2909, RADIOACTIVE MATERIAL, EXCEPTED PACKAGE – ARTICLES MANUFACTURED FROM NATURAL URANIUM or DEPLETED URANIUM or NATURAL THORIUM, only if the outer surface of the uranium or thorium is enclosed in an inactive sheath made of metal or some other substantial material.

#### **Additional requirements and controls for transport of empty packagings**

425. An empty *packaging* which had previously contained *radioactive material* may be classified under UN 2908, RADIOACTIVE MATERIAL, EXCEPTED PACKAGE – EMPTY PACKAGING, only if:

- (a) It is in a well-maintained condition and securely closed.
- (b) The outer surface of any uranium or thorium in its structure is covered with an inactive sheath made of metal or some other substantial material.
- (c) The level of internal *non-fixed contamination* does not exceed 100 times the levels specified in para. 507.
- (d) Any labels which may have been displayed on it in conformity with para. 536 are no longer visible.

#### **Classification as Type A package**

427. *Packages* containing *radioactive material* may be classified as *Type A packages* provided that the conditions of paras 428 and 429 are met.

428. *Type A packages* shall not contain activities greater than either of the following:

- (a) For *special form radioactive material* —  $A_1$ ;
- (b) For all other *radioactive material* —  $A_2$ .

429. For mixtures of radionuclides whose identities and respective activities are known, the following condition shall apply to the *radioactive contents* of a *Type A package*:

$$\sum_i \frac{B(i)}{A_1(i)} + \sum_j \frac{C(j)}{A_2(j)} \leq 1$$

where

$B(i)$  is the activity of radionuclide  $i$  as *special form radioactive material*.

$A_1(i)$  is the  $A_1$  value for radionuclide  $i$ .

$C(j)$  is the activity of radionuclide  $j$  as other than *special form radioactive material*.

$A_2(j)$  is the  $A_2$  value for radionuclide  $j$ .

### **Classification as Type B(U), Type B(M) or Type C packages**

430. *Type B(U), Type B(M) and Type C packages* shall be classified in accordance with the *competent authority* approval certificate for the *package* issued by the country of origin of *design*.

431. A *Type B(U) package* shall not contain:

- (a) Activities greater than those authorized for the *package design*;
- (b) Radionuclides different from those authorized for the *package design*; or
- (c) Contents in a form or a physical or chemical state different from those authorized for the *package design*;

as specified in the certificate of approval.

432. A *Type B(M) package* shall not contain:

- (a) Activities greater than those authorized for the *package design*;
- (b) Radionuclides different from those authorized for the *package design*; or
- (c) Contents in a form or a physical or chemical state different from those authorized for the *package design*;

as specified in the certificate of approval.

433. *Type B(U) and Type B(M) packages*, if transported by air, shall meet the requirements of para. 431 or 432 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* —  $3 \times 10^3 A_1$  or  $10^5 A_2$ , whichever is the lower; or
- (c) For all other *radioactive material* —  $3 \times 10^3 A_2$ .

434. A *Type C package* shall not contain:

- (a) Activities greater than those authorized for the *package design*;
- (b) Radionuclides different from those authorized for the *package design*; or **nor**
- (c) Contents in a form or a physical or chemical state different from those authorized for the *package design*;

as specified in the certificate of approval.

#### SPECIAL ARRANGEMENT

435. *Radioactive material* shall be classified as transported under *special arrangement* when it is intended to be carried in accordance with para. 310.

## Section V

### REQUIREMENTS AND CONTROLS FOR TRANSPORT

#### REQUIREMENTS BEFORE THE FIRST SHIPMENT

501. Before a *packaging* is first used to transport *radioactive material*, it shall be confirmed that it has been manufactured in conformity with the *design* specifications to ensure compliance with the relevant provisions of these Regulations and any applicable certificate of approval. The following requirements shall also be fulfilled, if applicable:

- (a) If the *design* pressure of the *containment system* exceeds 35 kPa (gauge), it shall be ensured that the *containment system* of each *package* conforms to the approved *design* requirements relating to the capability of that system to maintain its integrity under that pressure.
- (b) For each *packaging* belonging to *Type B(U)*, *Type B(M)* and *Type C package* and for each *package* containing *fissile material*, it shall be ensured that the effectiveness of its shielding and containment and, where necessary, the heat transfer characteristics and the effectiveness of the *confinement system*, are within the limits applicable to or specified for the approved *design*.
- (c) For each *packaging* intended to contain *fissile material*, it shall be ensured that the effectiveness of the criticality safety features are within the limits applicable to or specified for the *design*, in particular where, in order to comply with the requirements of para. 671, neutron poisons are specifically included as components of the *package*, checks shall be performed to confirm the presence and distribution of those neutron poisons.

#### REQUIREMENTS BEFORE EACH SHIPMENT

502. Before each *shipment* of any *package*, it shall be ensured that all the requirements specified in the relevant provisions of these Regulations and in the applicable approval certificates have been satisfied. The following requirements shall also be fulfilled, if applicable:

- (a) It shall be ensured that lifting attachments which do not meet the requirements of para. 607 have been removed or otherwise rendered incapable of being used for lifting the *package*, in accordance with para. 608.
- (b) Each *Type B(U)*, *Type B(M)* and *Type C package* shall be held until equilibrium conditions have been approached closely enough to demonstrate compliance with the requirements for temperature and pressure unless an exemption from these requirements has received *unilateral approval*.
- (c) For each *Type B(U)*, *Type B(M)* and *Type C package*, it shall be ensured by inspection and/or appropriate tests that all closures, valve and other openings of the *containment system* through which the *radioactive contents* might escape are properly closed and, where appropriate, sealed in the manner for which the demonstrations of compliance with the requirements of paras 657 and 669 were made.
- (d) For *packages* containing *fissile material* the measurement specified in para. 674(b) and the tests to demonstrate closure of each *package* as specified in para. 677 shall be performed.

#### TRANSPORT OF OTHER GOODS

503. A *package* shall not contain any items other than those that are necessary for the use of the *radioactive material*. The interaction between these items and the *package*, under the conditions of transport applicable to the *design*, shall not reduce the safety of the *package*.

504. *Freight containers*, *IBCs*, *overpacks* and *tanks*, as well as other *packagings* used for the transport of *radioactive material* shall not be used for the storage or transport of other goods unless decontaminated below the level of 0.4 Bq/cm<sup>2</sup> for beta and gamma emitters and *low toxicity alpha emitters* and 0.04 Bq/cm<sup>2</sup> for all other alpha emitters.

505. *Consignments* shall be segregated from other dangerous goods during transport in compliance with the relevant transport regulations for dangerous goods of each of the countries

*through or into* which the materials will be transported, and, where applicable, with the regulations of the cognizant transport organizations, as well as these Regulations.

#### OTHER DANGEROUS PROPERTIES OF CONTENTS

506. In addition to the radioactive and fissile properties, any other dangerous properties of the contents of the *package*, such as explosiveness, flammability, pyrophoricity, chemical toxicity and corrosiveness, shall be taken into account in the packing, labelling, marking, placarding, storage and transport in order to be in compliance with the relevant transport regulations for dangerous goods of each of the countries *through or into* which the materials will be transported, and, where applicable, with the regulations of the cognizant transport organizations, as well as these Regulations.

#### REQUIREMENTS AND CONTROLS FOR CONTAMINATION AND FOR LEAKING PACKAGES

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

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

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

508. Except as provided in para. 513, the level of *non-fixed contamination* on the external and internal surfaces of *overpacks, freight containers, tanks, intermediate bulk containers* and *conveyances* shall not exceed the limits specified in para. 507.

509. If it is evident that a *package* is damaged or leaking, or if it is suspected that the *package* may have leaked or been damaged, access to the *package* shall be restricted and a qualified person shall, as soon as possible, assess the extent of *contamination* and the resultant *radiation level* of the *package*. The scope of the assessment shall include the *package*, the *conveyance*, the adjacent loading and unloading areas, and, if necessary, all other material which has been carried in the *conveyance*. When necessary, additional steps for the protection of persons,

property and the environment, in accordance with provisions established by the relevant *competent authority*, shall be taken to overcome and minimize the consequences of such leakage or damage.

510. *Packages* which are damaged or leaking *radioactive contents* in excess of allowable limits for normal conditions of transport may be removed to an acceptable interim location under supervision, but shall not be forwarded until repaired or reconditioned and decontaminated.

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

512. Except as provided in para. 513, any *conveyance*, or equipment or part thereof which has become contaminated above the limits specified in para. 507 in the course of the transport of *radioactive material*, or which shows a *radiation level* in excess of 5  $\mu\text{Sv/h}$  at the surface, shall be decontaminated as soon as possible by a qualified person and shall not be reused unless the *non-fixed contamination* does not exceed the limits specified in para. 507 and the *radiation level* resulting from the *fixed contamination* on surfaces after decontamination is less than 5  $\mu\text{Sv/h}$  at the surface.

513. A *freight container, tank, IBC or conveyance* dedicated to the transport of unpackaged *radioactive material* under *exclusive use* shall be excepted from the requirements of paras 508 and 512 solely with regard to its internal surfaces and only for as long as it remains under that specific *exclusive use*.

#### REQUIREMENTS AND CONTROLS FOR TRANSPORT OF EXCEPTED PACKAGES

514. *Excepted packages* shall be subject only to the following provisions in Sections V and VI:

- (a) The requirements specified in paras 502, 503, 504, 506 - 512, 515, 528-531, 544 introductory sentence, 544 (a) and (j), 549, 558, 561, 578 and 579.

- (b) The requirements for *excepted packages* specified in para. 620.
- (c) If the *excepted package* contains *fissile material*, one of the fissile exceptions provided by para. 417 shall apply and the requirement of para. shall be met.
- (d) The requirements specified in paras 576 and 577, if transported by post.

All relevant provisions of the other sections shall also apply.

515. The *radiation level* at any point on the external surface of an *excepted package* shall not exceed 5  $\mu\text{Sv/h}$ .

#### REQUIREMENTS AND CONTROLS FOR TRANSPORT OF LSA MATERIAL AND SCO IN INDUSTRIAL PACKAGES OR UNPACKAGED

516. The quantity of *LSA material* or *SCO* in a single *Type IP-1*, *Type IP-2*, *Type IP-3 package*, or object or collection of objects, whichever is appropriate, 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.

517. For *LSA material* and *SCO* which is or contains *fissile material* that is not excepted under para. 417, the applicable requirements of paras 565, 566 and 671 shall be met.

518. *LSA material* and *SCO* in groups *LSA-I* and *SCO-I* may be transported, unpackaged, under the following conditions:

- (a) All unpackaged material other than ores containing only naturally occurring radionuclides shall be transported in such a manner that under routine conditions of transport there will be no escape of the *radioactive contents* from the *conveyance* nor will there be any loss of shielding.
- (b) Each *conveyance* shall be under *exclusive use*, except when only transporting *SCO-I* on which the *contamination* on the accessible and the inaccessible surfaces is not greater than ten times the applicable level specified in para. 214.

- (c) For *SCO-I* where it is suspected that *non-fixed contamination* exists on inaccessible surfaces in excess of the values specified in para. 413(a)(i), measures shall be taken to ensure that the *radioactive material* is not released into the *conveyance*.
- (d) Unpackaged material shall meet the requirement in paras 417(e) and 580.

TABLE 6. INDUSTRIAL PACKAGE REQUIREMENTS FOR LSA MATERIAL AND SCO

<i>Radioactive contents</i>	<i>Industrial package type</i>	
	<i>Exclusive use</i>	<i>Not under exclusive use</i>
<i>LSA-I</i>		
Solid <sup>a</sup>	<i>Type IP-1</i>	<i>Type IP-1</i>
Liquid	<i>Type IP-1</i>	<i>Type IP-2</i>
<i>LSA-II</i>		
Solid	<i>Type IP-2</i>	<i>Type IP-2</i>
Liquid and gas	<i>Type IP-2</i>	<i>Type IP-3</i>
<i>LSA-III</i>	<i>Type IP-2</i>	<i>Type IP-3</i>
<i>SCO-I<sup>a</sup></i>	<i>Type IP-1</i>	<i>Type IP-1</i>
<i>SCO-II</i>	<i>Type IP-2</i>	<i>Type IP-2</i>

<sup>a</sup> Under the conditions specified in para. 518, *LSA-I material* and *SCO-I* may be transported unpackaged.

519. *LSA material* and *SCO*, except as otherwise specified in para. 518, shall be packaged in accordance with Table 6.

520. The total activity in a single hold or compartment of an inland waterway craft, or in another *conveyance*, for carriage of *LSA material* or *SCO* in a *Type IP-1*, *Type IP-2*, *Type IP-3 package* or unpackaged, shall not exceed the limits shown in Table 7.

#### DETERMINATION OF TRANSPORT INDEX

521. The *TI* for a *package, overpack or freight container*, or for unpackaged *LSA-I* or *SCO-I*, shall be the number derived in accordance with the following procedure:

- (a) Determine the maximum *radiation level* in units of millisieverts per hour (mSv/h) at a distance of 1 m from the external surfaces of the *package, overpack, freight container* or unpackaged *LSA-I* and *SCO-I*. The value determined shall be multiplied by 100 and the resulting number is the *TI*. For uranium and thorium ores and their concentrates, the maximum *radiation level* at any point 1 m from the external surface of the load may be taken as:
- (i) 0.4 mSv/h for ores and physical concentrates of uranium and thorium.
  - (ii) 0.3 mSv/h for chemical concentrates of thorium.
  - (iii) 0.02 mSv/h for chemical concentrates of uranium, other than uranium hexafluoride.
- (b) For *tanks, freight containers*, and unpackaged *LSA-I* and *SCO-I*, the value determined in step (a) shall be multiplied by the appropriate factor from Table 8.
- (c) The value obtained in steps (a) and (b) shall be rounded up to the first decimal place (e.g. 1.13 becomes 1.2), except that a value of 0.05 or less may be considered as zero.

TABLE 7. CONVEYANCE ACTIVITY LIMITS FOR LSA MATERIAL AND SCO IN INDUSTRIAL PACKAGES OR UNPACKAGED

Nature of material	Activity limit for conveyances other than by inland waterway	Activity limit for a hold or compartment of an inland waterway craft
<i>LSA-I</i>	No limit	No limit
<i>LSA-II</i> and <i>LSA-III</i> non-combustible solids	No limit	100A <sub>2</sub>
<i>LSA-II</i> and <i>LSA-III</i>	100A <sub>2</sub>	10A <sub>2</sub>

combustible solids, and

all liquids and gases

SCO

100A<sub>2</sub>

10A<sub>2</sub>

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522. The *TI* for each *overpack*, *freight container* or *conveyance* shall be determined as either the sum of the *TIs* of all the *packages* contained, or by direct measurement of *radiation level*, except in the case of non-rigid *overpacks*, for which the *TI* shall be determined only as the sum of the *TIs* of all the *packages*.

TABLE 8. MULTIPLICATION FACTORS FOR TANKS, FREIGHT CONTAINERS, AND UNPACKAGED LSA-I AND SCO-I

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Size of load <sup>a</sup>	Multiplication factor
size of load $\leq 1 \text{ m}^2$	1
$1 \text{ m}^2 < \text{size of load} \leq 5 \text{ m}^2$	2
$5 \text{ m}^2 < \text{size of load} \leq 20 \text{ m}^2$	3
$20 \text{ m}^2 < \text{size of load}$	10

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<sup>a</sup> Largest cross-sectional area of the load being measured.

#### DETERMINATION OF CRITICALITY SAFETY INDEX FOR CONSIGNMENTS, FREIGHT CONTAINERS AND OVERPACKS

523. The *CSI* for each *overpack* or *freight container* shall be determined as the sum of the *CSIs* of all the *packages* contained. The same procedure shall be followed for determining the total sum of the *CSIs* in a *consignment* or aboard a *conveyance*.

#### LIMITS ON TRANSPORT INDEX, CRITICALITY SAFETY INDEX AND RADIATION LEVELS FOR PACKAGES AND OVERPACKS

524. Except for *consignments* under *exclusive use*, the *TI* of any *package* or *overpack* shall not exceed 10, nor shall the *CSI* of any *package* or *overpack* exceed 50.

525. Except for *packages* or *overpacks* transported under *exclusive use* by rail or by road under the conditions specified in para. 569(a), or under *exclusive use* and *special arrangement* by *vessel* or by air under the conditions specified in paras 571 or 575, respectively, the maximum *radiation level* at any point on the external surface of a *package* or *overpack* shall not exceed 2 mSv/h.

526. The maximum *radiation level* at any point on the external surface of a *package* or *overpack* under *exclusive use* shall not exceed 10 mSv/h.

## CATEGORIES

527. *Packages*, *overpacks* and *freight containers* shall be assigned to either category I-WHITE, II-YELLOW or III-YELLOW in accordance with the conditions specified in Table 9 and with the following requirements:

- (a) For a *package*, *overpack* or *freight container*, the *TI* and the surface *radiation level* conditions shall be taken into account in determining which category is appropriate. Where the *TI* satisfies the condition for one category but the surface *radiation level* satisfies the condition for a different category, the *package*, *overpack* or *freight container* shall be assigned to the higher category. For this purpose, category I-WHITE shall be regarded as the lowest category.
- (b) The *TI* shall be determined following the procedures specified in paras 521 and 522.
- (c) If the surface *radiation level* is greater than 2 mSv/h, the *package* or *overpack* shall be transported under *exclusive use* and under the provisions of paras 569(a), 571 or 575, as appropriate.
- (d) A *package* transported under a *special arrangement* shall be assigned to category III-YELLOW except under the provisions of para. 528.

- (e) An *overpack* or *freight container* which contains *packages* transported under *special arrangement* shall be assigned to category III-YELLOW except under the provisions of para. 528.

TABLE 9. CATEGORIES OF PACKAGES, OVERPACKS AND FREIGHT CONTAINERS<sup>d</sup>

	Conditions	Category <sup>d</sup>
<i>TI</i>	Maximum <i>radiation level</i> at any point on external surface	
0 <sup>a</sup>	Not more than 0,005 mSv/h	I-WHITE
More than 0 but not more than 1 <sup>a</sup>	More than 0,005 mSv/h but not more than 0,5 mSv/h	II-YELLOW
More than 1 but not more than 10 <sup>c</sup>	More than 0,5 mSv/h but not more than 2 mSv/h	III-YELLOW
More than 10 <sup>c</sup>	More than 2 mSv/h but not more than 10 mSv/h	III-YELLOW <sup>b</sup>

<sup>a</sup> If the measured *TI* is not greater than 0.05, the value quoted may be zero in accordance with para. 521(c).

<sup>b</sup> Shall also be transported under *exclusive use*.

<sup>c</sup> Where the loaded *freight container* is neither a *package* nor an *overpack* the limit is 50.

<sup>d</sup> If a *package* or an *overpack* requiring *exclusive use shipment* is contained in a *freight container*, the conveyance which carries the *freight container* must also be under *exclusive use*.

## MARKING, LABELLING AND PLACARDING

528. For each *package* or *overpack* the UN number and proper shipping name shall be determined (see Table 1). In all cases of international transport of *packages* requiring *competent authority design* or *shipment* approval, for which different approval types apply in the different countries concerned by the *shipment*, the UN number, proper shipping name, categorization, labelling and marking shall be in accordance with the certificate of the country of origin of *design*.

### Marking

529. Each *package* shall be legibly and durably marked on the outside of the *packaging* with an identification of either the *consignor* or *consignee*, or both. Each *overpack* shall be legibly and

durably marked on the outside of the *overpack* with an identification of either the *consignor* or *consignee*, or both unless these markings of all the *packages* within the *overpack* are clearly visible.

530. Each *package* shall be legibly and durably marked on the outside with the UN marking as specified in Table 10. Additionally, each *overpack* shall be legibly and durably marked with the word "OVERPACK" and the UN marking as specified in Table 10 unless all markings of the *packages* are clearly visible.

TABLE 10. UN MARKING FOR PACKAGES AND OVERPACKS

Item	UN marking <sup>a</sup>
<i>Package</i> (other than an <i>excepted package</i> )	UN number, preceded by the letters "UN", and the proper shipping name
<i>Excepted package</i> (other than those in <i>consignments</i> accepted for international movement by post or for <i>packages</i> which are classified as another Class)	UN number, preceded by the letters "UN"
<i>Overpack</i> (other than an <i>overpack</i> containing only <i>excepted packages</i> )	UN number, preceded by the letters "UN" for each applicable UN number in the <i>overpack</i> , followed by the proper shipping name in the case of a <i>non-excepted package</i>
<i>Overpack</i> containing only <i>excepted packages</i> (other than <i>consignments</i> accepted for international movement by post)	UN number, preceded by the letters "UN".  UN number, preceded by the letters "UN" for each applicable UN number in the <i>overpack</i>

*Consignment* accepted for international  
movement by post

The requirement of para. 577

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<sup>a</sup> See Table 1 for listing of UN number and proper shipping name.

531. Each *package* of gross mass exceeding 50 kg shall have its permissible gross mass legibly and durably marked on the outside of the *packaging*.

532. Each *package* which conforms to:

- (a) An *IP-1*, *IP-2* or *IP-3 design* shall be legibly and durably marked on the outside of the *packaging* with “TYPE IP-1”, “TYPE IP-2” or “TYPE IP-3” as appropriate.
- (b) A *Type A package design* shall be legibly and durably marked on the outside of the *packaging* with “TYPE A”.
- (c) An *IP-2*, *IP-3* or a *Type A package design* shall be legibly and durably marked on the outside of the *packaging* with the international vehicle registration code (VRI code) of the country of origin of *design* and either the name of the manufacturer or other identification of the *packaging* specified by the *competent authority* of the country of origin of *design*.

533. Each *package* which conforms to a *design* approved under one of the paras 805–814, 816 and 817 shall be legibly and durably marked on the outside of the *packaging* with:

- (a) The identification mark allocated to that *design* by the *competent authority*.
- (b) A serial number to uniquely identify each *packaging* which conforms to that *design*.
- (c) In the case of a *Type B(U)* or *Type B(M) package design*, with “TYPE B(U)” or “TYPE B(M)”.
- (d) In the case of a *Type C package design*, with “TYPE C”.

534. Each *package* which conforms to a *Type B(U)*, *Type B(M)* or *Type C package design* shall have the outside of the outermost receptacle, which is resistant to the effects of fire and water,

plainly marked by embossing, stamping or other means resistant to the effects of fire and water with the trefoil symbol shown in Fig. 1.

535. Where *LSA-I* or *SCO-I* material is contained in receptacles or wrapping materials and is transported under *exclusive use* as permitted by para. 518, the outer surface of these receptacles or wrapping materials may bear the marking “RADIOACTIVE LSA-I” or “RADIOACTIVE SCO-I” as appropriate.

Existing Fig. 1 to be placed here

*FIG. 1. Basic trefoil symbol with proportions based on a central circle of radius X. The minimum allowable size of X shall be 4 mm.*

### **Labelling**

536. Each *package*, *overpack* and *freight container* shall bear the labels conforming to the applicable models in Figs 2-4, except as allowed under the alternative provisions of para. 541 for large *freight containers* and *tanks*, according to the appropriate category. In addition, each *package*, *overpack* and *freight container* containing *fissile material*, other than *fissile material* excepted under the provisions of para. 417, shall bear labels conforming to the model in Fig. 5. Any labels which do not relate to the contents shall be removed or covered. For *radioactive material* having other dangerous properties see para. 506.

537. The labels conforming to the applicable models in Figs 2-4 shall be affixed to two opposite sides of the outside of a *package* or *overpack* or on the outside of all four sides of a *freight container* or *tank*. The labels conforming to the model in Fig. 5, where applicable, shall be affixed adjacent to the labels conforming to the applicable models in Figs 2-4. The labels shall not cover the markings specified in paras 529–534.

Existing Fig. 2 to be placed here

*FIG. 2. Category I-WHITE label. The background colour of the label shall be white, the colour of the trefoil and the printing shall be black, and the colour of the category bar shall be red.*

Existing Fig. 3 to be placed here

*FIG. 3. Category II-YELLOW label. The background colour of the upper half of the label shall be yellow and the lower half white, the colour of the trefoil and the printing shall be black, and the colour of the category bars shall be red.*

Existing Fig. 4 to be placed here

*FIG. 4. Category III-YELLOW label. The background colour of the upper half of the label shall be yellow and the lower half white, the colour of the trefoil and the printing shall be black, and the colour of the category bars shall be red.*

### **Labelling fo rradioactive contents**

538. Each label conforming to the applicable models in Figs 2-4 shall be completed with the following information:

(a) Contents:

- (i) Except for *LSA-I* material, the name(s) of the radionuclide(s) as taken from Table 2, using the symbols prescribed therein. For mixtures of radionuclides, the most restrictive nuclides must be listed to the extent the space on the line permits. The group of *LSA* or *SCO* shall be shown following the name(s) of the radionuclide(s). The terms "*LSA-I*", "*LSA-III*", "*SCO-I*" and "*SCO-II*" shall be used for this purpose.
- (ii) For *LSA-I* material, the term "*LSA-I*" is all that is necessary; the name of the radionuclide is not necessary.

- (b) **Activity:** The maximum activity of the *radioactive contents* during transport expressed in units of becquerels (Bq) with the appropriate SI prefix symbol (see Annex II). For *fissile material*, the total mass of *fissile nuclides* in units of grams (g), or multiples thereof, may be used in place of activity.
- (c) For *overpacks* and *freight containers* the “contents” and “activity” entries on the label shall bear the information required in paras 538(a) and (b), respectively, totalled together for the entire contents of the *overpack* or *freight container* except that on labels for *overpacks* or *freight containers* containing mixed loads of *packages* containing different radionuclides, such entries may read “See Transport Documents”.
- (d) *TI*: The number determined in accordance with paras 521 and 522 (no *TI* entry is required for Category I-WHITE).

### Labelling for criticality safety

539. Each label conforming to the model in Fig. 5 shall be completed with the *CSI* as stated in the applicable certificate of approval issued by the *competent authority* or as specified in paras 672 or 672bis.

540. For *overpacks* and *freight containers*, the label conforming to the model in Fig. 5 shall bear the sum of the *CSIs* of all the *packages* contained.

Existing Fig. 5 to be placed here

*FIG. 5. CSI label. The background colour of the label shall be white, the colour of the printing shall be black.*

### Placarding

541. Large *freight containers* carrying *packages* other than *excepted packages*, and *tanks*, shall bear four placards which conform to the model given in Fig. 6. The placards shall be affixed in a vertical orientation to each side wall and to each end wall of the large *freight container* or *tank*.

Any placards which do not relate to the contents shall be removed. Instead of using both labels and placards, it is permitted as an alternative to use enlarged labels only, where appropriate, as shown in Figs 2-4, except having the minimum size shown in Fig. 6.

542. Where the *consignment* in the *freight container* or *tank* is unpackaged *LSA-I* or *SCO-I* or where a *consignment* in a *freight container* is required to be shipped under *exclusive use* and is packaged *radioactive material* with a single UN number, the appropriate UN number for the *consignment* (see Table 1) shall also be displayed, in black digits not less than 65 mm high, either:

- (a) In the lower half of the placard shown in Fig. 6 and against the white background; or
- (b) On the placard shown in Fig. 7.

When the alternative given in (b) is used, the subsidiary placard shall be affixed immediately adjacent to the main placard, on all four sides of the *freight container* or *tank*.

Existing Fig. 6 to be placed here

*FIG. 6. Placard. Except as permitted by para. 567, minimum dimensions shall be as shown; when different dimensions are used, the relative proportions must be maintained. The number '7' shall not be less than 25 mm high. The background colour of the upper half of the placard shall be yellow and of the lower half white, the colour of the trefoil and the printing shall be black. The use of the word "RADIOACTIVE" in the bottom half is optional, to allow the alternative use of this placard to display the appropriate UN number for the consignment.*

Existing Fig. 7 to be placed here

*FIG. 7. Placard for separate display of UN number. The background colour of the placard shall be orange and the border and UN number shall be black. The symbol "\*\*\*\*\*" denotes the space in which the appropriate UN number for radioactive material, as specified in Table 1, shall be*

*displayed.*

## CONSIGNOR'S RESPONSIBILITIES

543. Except as otherwise provided in these Regulations, no person may offer *radioactive material* for transport unless it is properly marked, labelled, placarded, described and certified on a transport document, and otherwise in a condition for transport as required by these Regulations.

### **Particulars of consignment**

544. The *consignor* shall include in the transport documents with each *consignment* the identification of the *consignor* and *consignee*, including their names and addresses and the following information, as applicable, in the order given:

- (a) The UN number assigned to the material as specified in accordance with the provisions of paras 401 and 528, preceded by the letters "UN".
- (b) The proper shipping name, as specified in accordance with the provisions of paras 401 and 528.
- (c) The UN class number "7".
- (d) The name or symbol of each radionuclide or, for mixtures of radionuclides, an appropriate general description or a list of the most restrictive nuclides.
- (d)bis Subsidiary hazard class or division number(s) corresponding to the subsidiary risk label(s) required to be applied, when assigned, shall be entered following the primary hazard class or division and shall be enclosed in parenthesis.
- (e) A description of the physical and chemical form of the material, or a notation that the material is *special form radioactive material* or *low dispersible radioactive material*. A generic chemical description is acceptable for chemical form.
- (f) The maximum activity of the *radioactive contents* during transport expressed in units of becquerels (Bq) with the appropriate SI prefix symbol (see Annex II). For fissile material, the mass

of the *fissile material*, *fissile material* constituent and/or *fissile nuclide* (or mass of each *fissile material* constituent or *fissile nuclide* for mixtures when appropriate) in units of grams (g), or multiples thereof, may be used in place of activity.

- (g) The category of the *package*, i.e. I-WHITE, II-YELLOW, III-YELLOW.
- (h) The *TI* (categories II-YELLOW and III-YELLOW only).
- (i) For fissile material:
  - (i) Shipped under one of the exceptions of paras 417(a)-(f), reference to that para.
  - (ii) Shipped under para. 417(c)-(e), the total mass of *fissile nuclides*.
  - (iii) Contained in a *package* for which one of paras 672(a)-(c) and 672bis is applied, reference to that para.
  - (iv) The *CSI*, where applicable.
- (j) The identification mark for each *competent authority* approval certificate (*special form radioactive material*, *low dispersible radioactive material*, material excepted under para. 417(f), *special arrangement*, *package design* or *shipment*) applicable to the *consignment*.
- (k) For *consignments* of more than one *package*, the information contained in paras 544(a)-(j) shall be given for each *package*. For *packages* in an *overpack*, *freight container* or *conveyance*, a detailed statement of the contents of each *package* within the *overpack*, *freight container* or *conveyance* and, where appropriate, of each *overpack*, *freight container* or *conveyance* shall be included. If *packages* are to be removed from the *overpack*, *freight container* or *conveyance* at a point of intermediate unloading, appropriate transport documents shall be made available.
- (l) Where a *consignment* is required to be shipped under *exclusive use*, the statement "EXCLUSIVE USE SHIPMENT".
- (m) For *LSA-II*, *LSA-III*, *SCO-I* and *SCO-II*, the total activity of the *consignment* as a multiple of  $A_2$ . For *radioactive material* for which the  $A_2$  value is unlimited, the multiple of  $A_2$  shall be zero.

## Consignor's certification or declaration

545. The *consignor* shall include in the transport documents a certification or declaration in the following terms:

"I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name and are classified, packaged, marked and labelled/placarded, and are in all respects in proper condition for transport according to the applicable international and national governmental regulations."

546. If the intent of the declaration is already a condition of transport within a particular international convention, the *consignor* need not provide such a declaration for that part of the transport covered by the convention.

547. The declaration shall be signed and dated by the *consignor*. Facsimile signatures are acceptable where applicable laws and regulations recognize the legal validity of facsimile signatures.

548. If the dangerous goods documentation is presented to the *carrier* by means of electronic data processing (EDP) or electronic data interchange (EDI) transmission techniques, the signature(s) may be replaced by the name(s) (in capitals) of the person authorized to sign.

549. When *radioactive material*, other than when carried in *tanks*, is packed or loaded into any *freight container* or *vehicle* which will be transported by sea, those responsible for packing the container or *vehicle* shall provide a container/*vehicle* packing certificate specifying the container/*vehicle* identification number(s) and certifying that the operation has been carried out in accordance with the applicable conditions of the IMDG Code [8].

550. The information required in the transport document and the container/*vehicle* packing certificate may be incorporated into a single document, if not, these documents shall be attached one to the other. If the information is incorporated into a single document, the document shall include a signed declaration such as:

“It is declared that the packing of the goods into the container/*vehicle* has been carried out in accordance with the applicable provisions”.

This declaration shall be dated and the person signing it shall be identified on the document. Facsimile signatures are acceptable where applicable laws and regulations recognize the legal validity of facsimile signatures.

551. The declaration shall be made on the same transport document which contains the particulars of *consignment* listed in para. 544.

### **Information for carriers**

552. The *consignor* shall provide in the transport documents a statement regarding actions, if any that are required to be taken by the *carrier*. The statement shall be in the languages deemed necessary by the *carrier* or the authorities concerned, and shall include at least the following points:

- (a) Supplementary requirements for loading, stowage, carriage, handling and unloading of the *package, overpack or freight container*, including any special stowage provisions for the safe dissipation of heat (see para. 562), or a statement that no such requirements are necessary.
- (b) Restrictions on the mode of transport or *conveyance* and any necessary routing instructions.
- (c) Emergency arrangements appropriate to the *consignment*.

552bis The *consignor* shall retain copies of dangerous goods transport information as follows:

- (a) a copy of the dangerous goods transport document and additional information and documentation as specified in these Regulations shall be retained for a minimum period of three months.

- (b) When the documents are kept electronically or in a computer system, the *consignor* shall be able to reproduce them in a printed form.

553. The applicable *competent authority* certificates need not necessarily accompany the *consignment*. The *consignor* shall make them available to the *carrier(s)* before loading and unloading.

#### **Notification of competent authorities**

554. Before the first *shipment* of any *package* requiring *competent authority* approval, the *consignor* shall ensure that copies of each applicable *competent authority* certificate applying to that *package design* have been submitted to the *competent authority* of the country of origin of the *shipment* and to the *competent authority* of each country *through or into* which the *consignment* is to be transported. The *consignor* is not required to await an acknowledgement from the *competent authority*, nor is the *competent authority* required to make such acknowledgement of receipt of the certificate.

555. For each *shipment* listed in (a), (b), (c) or (d) below, the *consignor* shall notify the *competent authority* of the country of origin of the *shipment* and the *competent authority* of each country *through or into* which the *consignment* is to be transported. This notification shall be in the hands of each *competent authority* prior to the commencement of the *shipment*, and preferably at least 7 days in advance.

- (a) *Type C packages* containing *radioactive material* with an activity greater than  $3 \times 10^3 A_1$  or  $3 \times 10^3 A_2$ , as appropriate, or  $10^3$  TBq, whichever is the lower.
- (b) *Type B(U) packages* containing *radioactive material* with an activity greater than  $3 \times 10^3 A_1$  or  $3 \times 10^3 A_2$ , as appropriate, or  $10^3$  TBq, whichever is the lower.
- (c) *Type B(M) packages*.
- (d) *Shipments under special arrangement*.

556. The *consignment* notification shall include:

- (a) Sufficient information to enable the identification of the *package* or *packages*, including all applicable certificate numbers and identification marks.
- (b) Information on the date of *shipment*, the expected date of arrival and proposed routing.
- (c) The names of the *radioactive materials* or nuclides.
- (d) Descriptions of the physical and chemical forms of the *radioactive material*, or whether it is *special form radioactive material* or *low dispersible radioactive material*.
- (e) The maximum activity of the *radioactive contents* during transport expressed in units of becquerels (Bq) with the appropriate SI prefix symbol (see Annex II). For *fissile material*, the mass of *fissile material* (or the mass of each *fissile nuclide* for a mixture, when appropriate) in units of grams (g), or multiples thereof, may be used in place of activity.

557. The *consignor* is not required to send a separate notification if the required information has been included in the application for *shipment* approval (see para. 822).

#### **Possession of certificates and instructions**

558. The *consignor* shall have in his or her possession a copy of each certificate required under Section VIII of these Regulations and a copy of the instructions with regard to the proper closing of the *package* and other preparations for *shipment* before making any *shipment* under the terms of the certificates.

#### **TRANSPORT AND STORAGE IN TRANSIT**

##### **Segregation during transport and storage in transit**

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

- (a) From workers in regularly occupied working areas by distances calculated using a dose criterion of 5 mSv in a year and conservative model parameters.

- (b) From members of the critical group of the public, in areas where the public has regular access, by distances calculated using a dose criterion of 1 mSv in a year and conservative model parameters.
- (c) From undeveloped photographic film by distances calculated using a radiation exposure criterion for undeveloped photographic film due to the transport of *radioactive material* of 0.1 mSv per *consignment* of such film.
- (d) From other dangerous goods in accordance with para. 505.

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

#### **Stowage during transport and storage in transit**

561. *Consignments* shall be securely stowed.

562. Provided that its average surface heat flux does not exceed  $15 \text{ W/m}^2$  and that the immediate surrounding cargo is not in sacks or bags, a *package* or *overpack* may be carried or stored among packaged general cargo without any special stowage provisions except as may be specifically required by the *competent authority* in an applicable approval certificate.

563. Loading of *freight containers* and accumulation of *packages*, *overpacks* and *freight containers* shall be controlled as follows:

- (a) Except under the condition of *exclusive use*, and for *consignments* of *LSA-I* material, the total number of *packages*, *overpacks* and *freight containers* aboard a single *conveyance* shall be so limited that the sum of the *TIs* aboard the *conveyance* does not exceed the values shown in Table 11.
- (b) The *radiation level* under routine conditions of transport shall not exceed 2 mSv/h at any point on, and 0.1 mSv/h at 2 m from, the external surface of the *conveyance*, except for

*consignments* transported under *exclusive use* by road or rail, for which the radiation limits around the *vehicle* are set forth in para. 569(b) and (c).

- (c) The sum of the *CSIs* in a *freight container* and aboard a *conveyance* shall not exceed the values shown in Table 12.

TABLE 11. TRANSPORT INDEX LIMITS FOR FREIGHT CONTAINERS AND CONVEYANCES NOT UNDER EXCLUSIVE USE

Type of <i>freight container</i> or <i>conveyance</i>	Limit on sum of <i>TIs</i> in a <i>freight container</i> or aboard a <i>conveyance</i>
<i>Freight container</i> — Small	50
<i>Freight container</i> — Large	50
<i>Vehicle</i>	50
<i>Aircraft</i> :	
<i>Passenger</i>	50
<i>Cargo</i>	200
Inland waterway craft	50
Seagoing vessel <sup>a</sup> :	
(i) Hold, compartment or <i>defined deck area</i> :	
<i>Packages, overpacks, small freight containers</i>	50
Large <i>freight containers</i>	200
(ii) Total vessel:	
<i>Packages, overpacks, small freight containers</i>	200
Large <i>freight containers</i>	No limit

<sup>a</sup> *Packages* or *overpacks* carried in or on a *vehicle* which are in accordance with the provisions of para. 569 may be transported by *vessels* provided that they are not removed from the *vehicle* at any time while on board the *vessel*.

564. Any *package* or *overpack* having a *TI* greater than 10, or any *consignment* having a *CSI* greater than 50, shall be transported only under *exclusive use*.

#### **Additional requirements relating to transport and storage in transit of fissile material**

565. Any group of *packages*, *overpacks* and *freight containers* containing *fissile material* stored in transit in any one storage area shall be so limited that the sum of the *CSIs* in the group does not exceed 50. Each group shall be stored so as to maintain a spacing of at least 6 m from other such groups.

TABLE 12. CRITICALITY SAFETY INDEX LIMITS FOR FREIGHT CONTAINERS AND CONVEYANCES CONTAINING FISSILE MATERIAL

Type of <i>freight container</i> or <i>conveyance</i>	Limit on sum of <i>CSIs</i> in a <i>freight container</i> or aboard a <i>conveyance</i>	
	Not under <i>exclusive use</i>	Under <i>exclusive use</i>
<i>Freight container</i> — Small	50	Not applicable
<i>Freight container</i> — Large	50	100
<i>Vehicle</i>	50	100
<i>Aircraft</i> :		
<i>Passenger</i>	50	Not applicable
<i>Cargo</i>	50	100
Inland waterway craft	50	100
Seagoing vessel <sup>a</sup> :		
(i) Hold, compartment or <i>defined deck area</i> :		
<i>Packages, overpacks, small freight containers</i>	50	100
Large <i>freight containers</i>	50	100
(ii) Total vessel:		

*Packages, overpacks, small freight*

<i>containers</i>	200 <sup>b</sup>	200 <sup>c</sup>
<i>Large freight containers</i>	No limit <sup>b</sup>	No limit <sup>c</sup>

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- <sup>a</sup> *Packages* or *overpacks* carried in or on a *vehicle* which are in accordance with the provisions of para. 569 may be transported by *vessels* provided that they are not removed from the *vehicle* at anytime while on board the *vessel*. In this case the entries under the heading 'under *exclusive use*' apply.
- <sup>b</sup> The *consignment* shall be so handled and stowed that the sum of *CS/s* in any group does not exceed 50, and that each group is handled and stowed so that the groups are separated from each other by at least 6 m.
- <sup>c</sup> The *consignment* shall be so handled and stowed that the sum of *CS/s* in any group does not exceed 100, and that each group is handled and stowed so that the groups are separated from each other by at least 6 m. The intervening space between groups may be occupied by other cargo in accordance with para. 505.

566. Where the sum of the *CS/s* on board a *conveyance* or in a *freight container* exceeds 50, as permitted in Table 12, storage shall be such as to maintain a spacing of at least 6 m from other groups of *packages, overpacks* or *freight containers* containing *fissile material* or other *conveyances* carrying *radioactive material*.

566bis. Unpackaged or packaged *fissile material* applying para. 417(e) shall be transported under *exclusive use* and there shall not be more than 45 g of *fissile nuclides* on the *conveyance*.

**Additional requirements relating to transport by rail and by road**

567. Rail and road *vehicles* carrying *packages, overpacks* or *freight containers* labelled with any of the labels shown in Figs 2–5, or carrying *consignments* under *exclusive use*, shall display the placard shown in Fig. 6 on each of:

- (a) The two external lateral walls in the case of a rail *vehicle*.
- (b) The two external lateral walls and the external rear wall in the case of a road *vehicle*.

In the case of a *vehicle* without sides, the placards may be affixed directly on the cargo carrying unit provided that they are readily visible; in the case of large *tanks* or *freight containers*, the placards on the *tanks* or *freight containers* shall suffice. In the case of *vehicles* which have insufficient area to allow the fixing of larger placards, the dimensions of the placard described in Fig. 6 may be reduced to 100 mm. Any placards which do not relate to the contents shall be removed.

568. Where the *consignment* in or on the *vehicle* is unpackaged *LSA-I* material or *SCO-I* or where a consignment is required to be shipped under *exclusive use* and is packaged *radioactive material* with a single UN number, the appropriate UN number (see Table 1) shall also be displayed, in black digits not less than 65 mm high, either:

- (a) In the lower half of the placard shown in Fig. 6, against the white background; or
- (b) On the placard shown in Fig. 7.

When the alternative given in (b) is used, the subsidiary placard shall be affixed immediately adjacent to the main placard, either on the two external lateral walls in the case of a rail *vehicle* or on the two external lateral walls and the external rear wall in the case of a road *vehicle*.

569. For *consignments* under *exclusive use*, the *radiation level* shall not exceed:

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

- (b) 2 mSv/h at any point on the outer surfaces of the *vehicle*, including the upper and lower surfaces, or, in the case of an open *vehicle*, at any point on the vertical planes projected from the outer edges of the *vehicle*, on the upper surface of the load, and on the lower external surface of the *vehicle*.
- (c) 0.1 mSv/h at any point 2 m from the vertical planes represented by the outer lateral surfaces of the *vehicle*, or, if the load is transported in an open *vehicle*, at any point 2 m from the vertical planes projected from the outer edges of the *vehicle*.

570. In the case of road *vehicles*, no persons other than the driver and assistants shall be permitted in *vehicles* carrying *packages*, *overpacks* or *freight containers* bearing category II-YELLOW or III-YELLOW labels.

#### **Additional requirements relating to transport by vessels**

571. *Packages* or *overpacks* having a surface *radiation level* greater than 2 mSv/h, unless being carried in or on a *vehicle* under *exclusive use* in accordance with Table 11, footnote (a), shall not be transported by *vessel* except under *special arrangement*.

572. The transport of *consignments* by means of a special use *vessel* which, by virtue of its *design*, or by reason of its being chartered, is dedicated to the purpose of carrying *radioactive material*, shall be excepted from the requirements specified in para. 563 provided that the following conditions are met:

- (a) A *radiation protection programme* for the *shipment* shall be approved by the *competent authority* of the flag state of the *vessel* and, when requested, by the *competent authority* at each port of call.
- (b) Stowage arrangements shall be predetermined for the whole voyage, including any *consignments* to be loaded at ports of call en route.
- (c) The loading, carriage and unloading of the *consignments* shall be supervised by persons qualified in the transport of *radioactive material*.

**Additional requirements relating to transport by air**

573. *Type B(M) packages and consignments under exclusive use* shall not be transported on *passenger aircraft*.

574. *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.

575. *Packages or overpacks having a surface radiation level greater than 2 mSv/h* shall not be transported by air except by *special arrangement*.

**Additional requirements relating to transport by post**

576. A *consignment* that conforms with the requirements of para. 514, and in which the activity of the *radioactive contents* does not exceed one tenth of the limits prescribed in Table 5, may be accepted for domestic movement by national postal authorities, subject to such additional requirements as those authorities may prescribe. Uranium hexafluoride (UN3XXX) is limited to 10 g per *package* for transport by post.

577. A *consignment* that conforms with the requirements of para. 514, and in which the activity of the *radioactive contents* does not exceed one tenth of the limits prescribed in Table 5, may be accepted for international movement by post, subject in particular to the following additional requirements as prescribed by the Acts of the Universal Postal Union:

- (a) It shall be deposited with the postal service only by *consignors* authorized by the national authority.
- (b) It shall be dispatched by the quickest route, normally by air.
- (c) It shall be plainly and durably marked on the outside with the words "RADIOACTIVE MATERIAL — QUANTITIES PERMITTED FOR MOVEMENT BY POST". These words shall be crossed out if the *packaging* is returned empty.

- (d) It shall carry on the outside the name and address of the *consignor* with the request that the *consignment* be returned in the case of non-delivery.
- (e) The name and address of the *consignor* and the contents of the *consignment* shall be indicated on the internal *packaging*.

#### CUSTOMS OPERATIONS

578. Customs operations involving the inspection of the *radioactive contents* of a *package* shall be carried out only in a place where adequate means of controlling radiation exposure are provided and in the presence of qualified persons. Any *package* opened on customs instructions shall, before being forwarded to the *consignee*, be restored to its original condition.

#### UNDELIVERABLE CONSIGNMENTS

579. Where a *consignment* is undeliverable, it shall be placed in a safe location and the appropriate *competent authority* shall be informed as soon as possible and a request made for instructions on further action.

## Section VI

### REQUIREMENTS FOR RADIOACTIVE MATERIALS AND FOR PACKAGINGS AND PACKAGES

#### REQUIREMENTS FOR RADIOACTIVE MATERIALS

##### Requirements for LSA-III material

601. *LSA-III material* shall be a solid of such a nature that if the entire contents of a *package* were subjected to the test specified in para. 703, the activity in the water would not exceed  $0.1A_2$ .

##### Requirements for special form radioactive material

602. *Special form radioactive material* shall have at least one dimension of not less than 5 mm.

603. *Special form radioactive material* shall be of such a nature or shall be so designed that if it is subjected to the tests specified in paras 704–711, it shall meet the following requirements:

- (a) It would not break or shatter under the impact, percussion and bending tests in paras 705–707 and 709(a), as applicable.
- (b) It would not melt or disperse in the heat test in para. 708 or para. 709(b), as applicable.
- (c) The activity in the water from the leaching tests specified in paras 710 and 711 would not exceed 2 kBq; or alternatively, for sealed sources, the leakage rate for the volumetric leakage assessment test specified in the International Organization for Standardization document ISO 9978: Radiation Protection — Sealed Radioactive Sources — Leakage Test Methods [9], would not exceed the applicable acceptance threshold acceptable to the *competent authority*.

604. When a sealed capsule constitutes part of the *special form radioactive material*, the capsule shall be so manufactured that it can be opened only by destroying it.

##### Requirements for low dispersible radioactive material

605. *Low dispersible radioactive material* shall be such that the total amount of this *radioactive material* in a *package* shall meet the following requirements:

- (a) The *radiation level* at 3 m from the unshielded *radioactive material* does not exceed 10 mSv/h.
- (b) If subjected to the tests specified in paras 736 and 737, the airborne release in gaseous and particulate forms of up to 100 µm aerodynamic equivalent diameter would not exceed 100A<sub>2</sub>. A separate specimen may be used for each test.
- (c) If subjected to the test specified in para. 703 the activity in the water would not exceed 100A<sub>2</sub>. In the application of this test, the damaging effects of the tests specified in (b) shall be taken into account.

#### REQUIREMENTS FOR FISSILE MATERIAL EXCEPTED BY COMPETENT AUTHORITY.

605bis. A *fissile material* excepted from classification as FISSILE under para. 417(f) shall be subcritical without the need for accumulation control and subject to the following:

- (a) Conditions of para. 671(a) and water inleakage that result in maximum neutron multiplication.
- (b) Conditions consistent with the assessment provisions under paras 681(b) and 682(b) for packages.
- (c) Conditions specified in para. 680(a) if transported by air.

#### GENERAL REQUIREMENTS FOR ALL PACKAGINGS AND PACKAGES

606. The *package* shall be so designed in relation to its mass, volume and shape that it can be easily and safely transported. In addition, the *package* shall be so designed that it can be properly secured in or on the *conveyance* during transport.

606 bis. *Packages* shall contain neither:

- (a) Radionuclides different from those assessed for the *package design*; nor
- (b) Contents in a form, or physical or chemical state different from those assessed for the

*package design.*

607. The *design* shall be such that any lifting attachments on the *package* will not fail when used in the intended manner and that if failure of the attachments should occur, the ability of the *package* to meet other requirements of these Regulations would not be impaired. The *design* shall take account of appropriate safety factors to cover snatch lifting.

608. Attachments and any other features on the outer surface of the *package* which could be used to lift it shall be designed either to support its mass in accordance with the requirements of para. 607, or shall be removable or otherwise rendered incapable of being used during transport.

609. As far as practicable, the *packaging* shall be so designed and finished that the external surfaces are free from protruding features and can be easily decontaminated.

610. As far as practicable, the outer layer of the *package* shall be so designed as to prevent the collection and the retention of water.

611. Any features added to the *package* at the time of transport which are not part of the *package* shall not reduce its safety.

612. The *package* shall be capable of withstanding the effects of any acceleration, vibration or vibration resonance which may arise under routine conditions of transport without any deterioration in the effectiveness of the closing devices on the various receptacles or in the integrity of the *package* as a whole. In particular, nuts, bolts and other securing devices shall be so designed as to prevent them from becoming loose or being released unintentionally, even after repeated use.

613. The materials of the *packaging* and any components or structures shall be physically and chemically compatible with each other and with the radioactive contents. Account shall be taken of their behaviour under irradiation.

614. All valves through which the *radioactive contents* could escape shall be protected against unauthorized operation.

615. The *design* of the *package* shall take into account ambient temperatures and pressures that are likely to be encountered in routine conditions of transport.

615 bis. A *package* shall be so designed that it provides sufficient shielding to ensure that, under routine conditions of transport and with the maximum *radioactive contents* which the *package* is designed to contain, the *radiation level* at any point on the external surface of the *package* would not exceed the values specified in paras 525, 526, as applicable taking into account paras 563(b) and 569.

616. For *radioactive material* having other dangerous properties, the *package design* shall take into account those properties (see paras 110 and 506).

#### ADDITIONAL REQUIREMENTS FOR PACKAGES TRANSPORTED BY AIR

617. For *packages* to be transported by air, the temperature of the accessible surfaces shall not exceed 50°C at an ambient temperature of 38°C with no account taken for insolation.

618. *Packages* to be transported by air shall be so designed that if they were exposed to ambient temperatures ranging from –40°C to +55°C, the integrity of containment would not be impaired.

619 *Packages* containing *radioactive material* to be transported by air shall be capable of withstanding, without loss or dispersal of *radioactive contents* from the *containment system*, an internal pressure which produces a pressure differential of not less than *maximum normal operating pressure* plus 95kPa.

#### REQUIREMENTS FOR EXCEPTED PACKAGES

620. An *excepted package* shall be designed to meet the requirements specified in paras 606–616 and, in addition, the requirements of paras 617–619 if carried by air.

#### REQUIREMENTS FOR INDUSTRIAL PACKAGES

##### **Requirements for Type IP-1**

621. A *Type IP-1 package* shall be designed to meet the requirements specified in paras 606–616 and 634, and, in addition, the requirements of paras 617–619 if carried by air.

### **Requirements for Type IP-2**

622. A *package* to be qualified as a *Type IP-2* shall be designed to meet the requirements for *Type IP-1* as specified in para. 621 and, in addition, if it were subjected to the tests specified in paras 722 and 723, it would prevent:

- (a) Loss or dispersal of the *radioactive contents*.
- (b) More than a 20% increase in the maximum *radiation level* at any external surface of the *package*.

### **Requirements for Type IP-3**

623. A *package* to be qualified as a *Type IP-3* shall be designed to meet the requirements for *Type IP-1* as specified in para. 621 and, in addition, the requirements specified in paras 634–647.

### **Alternative requirements for Type IP-2 and Type IP-3**

624. *Packages* may be used as *Type IP-2*, provided that:

- (a) They satisfy the requirements for *Type IP-1* specified in para. 621.
- (b) They are designed to satisfy the requirements prescribed for UN Packing Group I or II in Chapter 6.1 of the United Nations Recommendations on the Transport of Dangerous Goods, Model Regulations [10].
- (c) When subjected to the tests required for UN Packing Group I or II, they would prevent:
  - (i) Loss or dispersal of the *radioactive contents*.
  - (ii) More than a 20% increase in the maximum *radiation level* at any external surface of the *package*.

625. Portable *tanks* may also be used as *Type IP-2* or *Type IP-3*, provided that:

- (a) They satisfy the requirements for *Type IP-1* specified in para. 621.
- (b) They are designed to satisfy the requirements prescribed in Chapter 6.7 of the United Nations Recommendations on the Transport of Dangerous Goods, Model Regulations [10], or other requirements at least equivalent, and are capable of withstanding a test pressure of 265 kPa.
- (c) They are designed so that any additional shielding which is provided shall be capable of withstanding the static and dynamic stresses resulting from handling and routine conditions of transport and of preventing more than a 20% increase in the maximum *radiation level* at any external surface of the portable *tanks*.

626. *Tanks*, other than portable *tanks*, may also be used as *Type IP-2* or *Type IP-3* for transporting *LSA-I* and *LSA-II* liquids and gases as prescribed in Table 6, provided that:

- (a) They satisfy the requirements for *Type IP-1* specified in para. 621.
- (b) They are designed to satisfy the requirements prescribed in regional or national regulations for the transport of dangerous goods and are capable of withstanding a test pressure of 265 kPa.
- (c) They are designed so that any additional shielding which is provided shall be capable of withstanding the static and dynamic stresses resulting from handling and routine conditions of transport and of preventing more than a 20% increase in the maximum *radiation level* at any external surface of the *tanks*.

627. *Freight containers* with the characteristics of a permanent enclosure may also be used as *Type IP-2* or *Type IP-3*, provided that:

- (a) The *radioactive contents* are restricted to solid materials.
- (b) They satisfy the requirements for *Type IP-1* specified in para. 621.
- (c) They are designed to conform to the International Organization for Standardization document ISO 1496/1: Series 1 *Freight Containers* — Specifications and Testing — Part 1:

General Cargo Containers for General Purposes [11], excluding dimensions and ratings. They shall be designed such that if subjected to the tests prescribed in that document and to the accelerations occurring during routine conditions of transport they would prevent:

- (i) Loss or dispersal of the *radioactive contents*.
- (ii) More than a 20% increase in the maximum *radiation level* at any external surface of the *freight containers*.

628. Metal *IBCs* may also be used as *Type IP-2* or *Type IP-3*, provided that:

- (a) They satisfy the requirements for *Type IP-1* specified in para. 621.
- (b) They are designed to satisfy the requirements prescribed for UN Packing Group I or II in Chapter 6.5 of the United Nations Recommendations on the Transport of Dangerous Goods, Model Regulations [10], and if they were subjected to the tests prescribed in that document, but with the drop test conducted in the most damaging orientation, they would prevent:
  - (i) Loss or dispersal of the *radioactive contents*.
  - (ii) More than a 20% increase in the maximum *radiation level* at any external surface of the *IBC*.

#### REQUIREMENTS FOR PACKAGES CONTAINING URANIUM HEXAFLUORIDE

629. *Packages* designed to contain uranium hexafluoride shall meet the requirements prescribed elsewhere in these Regulations which pertain to the radioactive and fissile properties of the material. Except as allowed in para. 632, uranium hexafluoride in quantities of 0.1 kg or more shall also be packaged and transported in accordance with the provisions of the International Organization for Standardization document ISO 7195: Packaging of Uranium Hexafluoride (UF<sub>6</sub>) for Transport [12], and the requirements of paras 630 and 631.

630. Each *package* designed to contain 0.1 kg or more of uranium hexafluoride shall be designed so that it will meet the following requirements:

- (a) Withstand without leakage and without unacceptable stress, as specified in the International Organization for Standardization document ISO 7195 [12], the structural test as specified in para. 718.
- (b) Withstand, without loss or dispersal of the uranium hexafluoride, the free drop test specified in para. 722.
- (c) Withstand, without rupture of the *containment system*, the thermal test specified in para. 728.

631. *Packages* designed to contain 0.1 kg or more of uranium hexafluoride shall not be provided with pressure relief devices.

632. Subject to the approval of the *competent authority*, *packages* designed to contain 0.1 kg or more of uranium hexafluoride may be transported either if:

- (a) The *packages* are designed to international or national standards other than ISO 7195 [12], provided an equivalent level of safety is maintained;
- (b) The *packages* are designed to withstand, without leakage and without unacceptable stress, a test pressure of less than 2.76 MPa as specified in para. 718; or
- (c) For *packages* designed to contain 9000 kg or more of uranium hexafluoride, the *packages* do not meet the requirement of para. 630(c).

In all other respects, the requirements specified in paras 629–631 shall be satisfied.

#### REQUIREMENTS FOR TYPE A PACKAGES

633. *Type A packages* shall be designed to meet the requirements specified in paras 606–616 and, in addition, the requirements of paras 617–619 if carried by air, and of paras 634–649.

634. The smallest overall external dimension of the *package* shall not be less than 10 cm.

635. The outside of the *package* shall incorporate a feature such as a seal which is not readily breakable and which, while intact, will be evidence that the *package* has not been opened.

636. Any tie-down attachments on the *package* shall be so designed that, under normal and accident conditions of transport, the forces in those attachments shall not impair the ability of the *package* to meet the requirements of these Regulations.

637. The *design* of the *package* shall take into account temperatures ranging from  $-40^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$  for the components of the *packaging*. Attention shall be given to freezing temperatures for liquids and to the potential degradation of *packaging* materials within the given temperature range.

638. The *design* and manufacturing techniques shall be in accordance with national or international standards, or other requirements, acceptable to the *competent authority*.

639. The *design* shall include a *containment system* securely closed by a positive fastening device which cannot be opened unintentionally or by a pressure which may arise within the *package*.

640. *Special form radioactive material* may be considered as a component of the *containment system*.

641. If the *containment system* forms a separate unit of the *package*, it shall be capable of being securely closed by a positive fastening device which is independent of any other part of the *packaging*.

642. The *design* of any component of the *containment system* shall take into account, where applicable, the radiolytic decomposition of liquids and other vulnerable materials and the generation of gas by chemical reaction and radiolysis.

643. The *containment system* shall retain its *radioactive contents* under a reduction of ambient pressure to 60 kPa.

644. All valves, other than pressure relief valves, shall be provided with an enclosure to retain any leakage from the valve.

645. A radiation shield which encloses a component of the *package* specified as a part of the *containment system* shall be so designed as to prevent the unintentional release of that component from the shield. Where the radiation shield and such component within it form a separate unit, the radiation shield shall be capable of being securely closed by a positive fastening device which is independent of any other *packaging* structure.

646. A *package* shall be so designed that if it were subjected to the tests specified in paras 719–724, it would prevent:

- (a) Loss or dispersal of the *radioactive contents*.
- (b) More than a 20% increase in the maximum *radiation level* at any external surface of the *package*.

647. The *design* of a *package* intended for liquid *radioactive material* shall make provision for ullage to accommodate variations in the temperature of the contents, dynamic effects and filling dynamics.

648. A *Type A package* designed to contain liquid *radioactive material* shall, in addition:

- (a) Be adequate to meet the conditions specified in para. 646(a) if the *package* is subjected to the tests specified in para. 725.
- (b) Either:
  - (i) Be provided with sufficient absorbent material to absorb twice the volume of the liquid contents. Such absorbent material must be suitably positioned so as to contact the liquid in the event of leakage; or
  - (ii) Be provided with a *containment system* composed of primary inner and secondary outer containment components designed to enclose the liquid contents completely

and to ensure their retention within the secondary outer containment components, even if the primary inner components leak.

649. A *package* designed for gases shall prevent loss or dispersal of the *radioactive contents* if the *package* were subjected to the tests specified in para. 725. A *Type A package* designed for tritium gas or for noble gases shall be excepted from this requirement.

#### REQUIREMENTS FOR TYPE B(U) PACKAGES

650. *Type B(U) packages* shall be designed to meet the requirements specified in paras 606–616, the requirements specified in paras 617–619 if carried by air, and in paras 634–647, except as specified in para. 646(a), and, in addition, the requirements specified in paras 651–664.

651. A *package* shall be so designed that, under the ambient conditions specified in paras 654 and 655, heat generated within the *package* by the *radioactive contents* shall not, under normal conditions of transport, as demonstrated by the tests in paras 719–724, adversely affect the *package* in such a way that it would fail to meet the applicable requirements for containment and shielding if left unattended for a period of one week. Particular attention shall be paid to the effects of heat, either of which may:

- (a) Alter the arrangement, the geometrical form or the physical state of the *radioactive contents* or, if the *radioactive material* is enclosed in a can or receptacle (for example, clad fuel elements), cause the can, receptacle or *radioactive material* to deform or melt;
- (b) Lessen the efficiency of the *packaging* through differential thermal expansion, or cracking or melting of the radiation shielding material; or
- (c) In combination with moisture, accelerate corrosion.

652. A *package* shall be so designed that, under the ambient condition specified in para. 654 and in the absence of insolation, the temperature of the accessible surfaces of a *package* shall not exceed 50°C, unless the *package* is transported under *exclusive use*.

653. Except as required in para. 617 for a *package* transported by air, the maximum temperature of any surface readily accessible during transport of a *package* under *exclusive use* shall not exceed 85°C in the absence of insolation under the ambient conditions specified in para. 654. Account may be taken of barriers or screens intended to give protection to persons without the need for the barriers or screens being subject to any test.

654. The ambient temperature shall be assumed to be 38°C.

655. The solar insolation conditions shall be assumed to be as specified in Table 13.

656. A *package* which includes thermal protection for the purpose of satisfying the requirements of the thermal test specified in para. 728 shall be so designed that such protection will remain effective if the *package* is subjected to the tests specified in paras 719–724 and 727(a) and (b) or 727(b) and (c), as appropriate. Any such protection on the exterior of the *package* shall not be rendered ineffective by ripping, cutting, skidding, abrading or rough handling.

TABLE 13. INSOLATION DATA

Case	Form and location of surface	Insolation for 12 hours per day (W/m <sup>2</sup> )
1	Flat surfaces transported horizontally — downward facing	0
2	Flat surfaces transported horizontally — upward facing	800
3	Surfaces transported vertically	200 <sup>a</sup>
4	Other downward facing (not horizontal) surfaces	200 <sup>a</sup>
5	All other surfaces	400 <sup>a</sup>

<sup>a</sup> Alternatively, a sine function may be used, with an absorption coefficient adopted and the effects of possible reflection from neighbouring objects neglected.

657. A *package* shall be so designed that if it were subjected to:

- (a) The tests specified in paras 719–724, it would restrict the loss of *radioactive contents* to not more than  $10^{-6}A_2$  per hour.
- (b) The tests specified in paras 726, 727(b), 728 and 729 and either the tests in paras:
  - (i) 727(c), when the *package* has a mass not greater than 500 kg, an overall density not greater than  $10^3 \text{ kg/m}^3$  based on the external dimensions, and *radioactive contents* greater than  $10^3 A_2$  not as *special form radioactive material*, or
  - (ii) 727(a), for all other *packages*:
    - It would retain sufficient shielding to ensure that the *radiation level* 1 m from the surface of the *package* would not exceed 10 mSv/h with the maximum *radioactive contents* which the *package* is designed to contain.
    - It would restrict the accumulated loss of *radioactive contents* in a period of one week to not more than  $10A_2$  for krypton-85 and not more than  $A_2$  for all other radionuclides.

Where mixtures of different radionuclides are present, the provisions of paras 405–407 shall apply, except that for krypton-85 an effective  $A_2(i)$  value equal to  $10A_2$  may be used. For case (a), the assessment shall take into account the external *contamination* limits of para. 507.

658. A *package* for *radioactive contents* with activity greater than  $10^5 A_2$  shall be so designed that, if it were subjected to the enhanced water immersion test specified in para. 730, there would be no rupture of the *containment system*.

659. Compliance with the permitted activity release limits shall depend neither upon filters nor upon a mechanical cooling system.

660. A *package* shall not include a pressure relief system from the *containment system* which would allow the release of *radioactive material* to the environment under the conditions of the tests specified in paras 719–724 and 726–729.

661. A *package* shall be so designed that if it were at the *maximum normal operating pressure* and it were subjected to the tests specified in paras 719–724 and 726–729, the levels of strains in the *containment system* would not attain values which would adversely affect the *package* in such a way that it would fail to meet the applicable requirements.

662. A *package* shall not have a *maximum normal operating pressure* in excess of a gauge pressure of 700 kPa.

663. A *package* containing *low dispersible radioactive material* shall be so designed that any features added to the *low dispersible radioactive material* that are not part of it, or any internal components of the *packaging*, shall not adversely affect the performance of the *low dispersible radioactive material*.

664. A *package* shall be designed for an ambient temperature range from –40°C to +38°C.

#### REQUIREMENTS FOR TYPE B(M) PACKAGES

665. *Type B(M) packages* shall meet the requirements for *Type B(U) packages* specified in para. 650, except that for *packages* to be transported solely within a specified country or solely between specified countries, conditions other than those given in paras 637, 653–655 and 658–664 may be assumed with the approval of the *competent authorities* of these countries. Notwithstanding, the requirements for *Type B(U) packages* specified in paras 653 and 658–664 shall be met as far as practicable.

666. Intermittent venting of *Type B(M) packages* may be permitted during transport, provided that the operational controls for venting are acceptable to the relevant *competent authorities*.

#### REQUIREMENTS FOR TYPE C PACKAGES

667. *Type C packages* shall be designed to meet the requirements specified in paras 606–619 and 634–647, except as specified in para. 646(a), and the requirements specified in paras 651–655, 659–664 and 668–670.

668. A *package* shall be capable of meeting the assessment criteria prescribed for tests in paras 657(b) and 661 after burial in an environment defined by a thermal conductivity of 0.33 W/(m·K) and a temperature of 38°C in the steady state. Initial conditions for the assessment shall assume that any thermal insulation of the *package* remains intact, the *package* is at the *maximum normal operating pressure* and the ambient temperature is 38°C.

669. A *package* shall be so designed that if it were at the *maximum normal operating pressure* and subjected to:

- (a) The tests specified in paras 719–724, it would restrict the loss of *radioactive contents* to not more than  $10^{-6}A_2$  per hour.
- (b) The test sequences in para. 734, it would meet the following requirements:
  - (i) It would retain sufficient shielding to ensure that the *radiation level* 1 m from the surface of the *package* would not exceed 10 mSv/h with the maximum *radioactive contents* which the *package* is designed to contain.
  - (ii) It would restrict the accumulated loss of *radioactive contents* in a period of one week to not more than  $10A_2$  for krypton-85 and not more than  $A_2$  for all other radionuclides.

Where mixtures of different radionuclides are present, the provisions of paras 405–407 shall apply, except that for krypton-85 an effective  $A_2(i)$  value equal to  $10A_2$  may be used. For case (a), the assessment shall take into account the external *contamination* limits of para. 507.

670. A *package* shall be so designed that there will be no rupture of the *containment system* following performance of the enhanced water immersion test specified in para. 730.

## REQUIREMENTS FOR PACKAGES CONTAINING FISSILE MATERIAL

671. *Fissile material* shall be transported so as to:

- (a) Maintain subcriticality during normal and accident conditions of transport; in particular, the following contingencies shall be considered:
  - (i) Leakage of water into or out of *packages*.
  - (ii) Loss of efficiency of built-in neutron absorbers or moderators.
  - (iii) Rearrangement of the contents either within the *package* or as a result of loss from the *package*.
  - (iv) Reduction of spaces within or between *packages*.
  - (v) *Packages* becoming immersed in water or buried in snow.
  - (vi) Temperature changes.
- (b) Meet the requirements:
  - (i) Of para. 634.
  - (ii) Prescribed elsewhere in these Regulations which pertain to the radioactive properties of the material.
  - (iii) Of para. 635, unless excepted by para. 417.
  - (iv) Of paras 673–683, unless excepted by paras 417, 672 or 672bis.

#### GENERAL PACKAGE DESIGNS CONTAINING FISSILE MATERIAL

672. *Packages* containing *fissile material* that meet one of the provisions of subparas (a)–(c) are excepted from the application of paras 673–683. The total mass of beryllium, hydrogenous material enriched in deuterium, graphite and other allotropic forms of carbon in an individual *package* shall not be greater than the mass of *fissile nuclides* in the *package* except where their total concentration does not exceed 1 g in any  $10^3$  g of material. Beryllium incorporated in copper alloys up to 4% in weight of the alloy does not need to be considered.

(a) *Packages containing fissile material* in any form provided that:

- (i) The smallest external dimension of the *package* is not less than 10 cm.
- (ii) The *CSI* of the package is calculated using the following formula:

$$CSI = 50 \times 5 \times \{[\text{mass of U-235 in } \textit{package} \text{ (g)}] / Z +$$

$$[\text{mass of other } \textit{fissile nuclides} \text{ in } \textit{package} \text{ (g)}] / Y\}$$

Where the values of Z and Y are taken from Table M.

- (iii) The *CSI* of any package shall not exceed 10.

(b) *Packages containing fissile material* in any form provided that:

- (i) The smallest external dimension of the *package* is not less than 30 cm.
- (ii) The *package*, after being subjected to the tests specified in paras 719–724, shall;
  - retain its *fissile material* contents.
  - preserve the minimum overall outside dimensions of the *package* to at least 30 cm.
  - prevent the entry of a 10 cm cube.
- (iii) The *CSI* of the package is calculated using the following formula:

$$CSI = 50 \times 2 \times \{[\text{mass of U-235 in } \textit{package} \text{ (g)}] / Z +$$

$$[\text{mass of other } \textit{fissile nuclides} \text{ in } \textit{package} \text{ (g)}] / Y\}$$

Where the values of Z and Y are taken from Table M.

- (iv) The *CSI* of any *package* shall not exceed 10.

(c) *Packages containing fissile material* in any form provided that:

- (i) The smallest external dimension of the *package* is not less than 10 cm.
- (ii) The *package*, after being subjected to the tests specified in paras 719–724, shall;
  - retain its *fissile material* contents.
  - preserve the minimum overall outside dimensions of the *package* to at least 10 cm.
  - prevent the entry of a 10 cm cube.
- (iii) The *CSI* of the *package* is calculated using the following formula:

$$CSI = 50 \times 2 \times \{[\text{mass of U-235 in } \textit{package} \text{ (g)}] / Z +$$

$$[\text{mass of other fissile nuclides in package (g)}] / Y\}$$

Where the values of Z and Y are taken from Table M.

(iv) The maximum mass of *fissile nuclides* in any *package* shall not exceed 15 g

TABLE M. VALUES OF Y AND Z FOR CALCULATION OF CSI ACCORDING TO PARA. 672

	General use	Limited use <sup>c</sup>
Uranium enriched to 1.5 % or less (Z) <sup>a</sup>	2000	2400
Uranium enriched to 5 % or less (Z) <sup>a</sup>	770	1000
Uranium enriched to 10 % or less (Z) <sup>a</sup>	550	810
Uranium enriched to 20 % or less (Z) <sup>a</sup>	470	700
Uranium enriched to 100 % or less (Z) <sup>a</sup>	360	540
Other <i>fissile nuclides</i> (Y) <sup>b</sup>	230	350

<sup>a</sup> If a *package* contains uranium with varying enrichments of U-235, then the mass corresponding to the highest enrichment value shall be used for Z.

<sup>b</sup> Plutonium may be of any isotopic composition provided that Pu-241 < Pu-240.

<sup>c</sup> Limited use is only allowed when there is no more than 20 grams of material with a hydrogen density greater than water in a *package*.

672bis *Packages* containing not more than 10<sup>3</sup> g of plutonium are excepted from the application of paras 673-683 provided that:

- (a) Not more than 20% of the plutonium by mass are *fissile nuclides*.
- (b) The *CSI* of the *package* is calculated using the following formula:

$$CSI = 50 \times 2 \times [\text{mass of plutonium (g)} / 10^3]$$

### Contents specification for assessments of package designs containing fissile material

673. Where the chemical or physical form, isotopic composition, mass or concentration, moderation ratio or density, or geometric configuration is not known, the assessments of paras 677–682 shall be performed assuming that each parameter that is not known has the value which

gives the maximum neutron multiplication consistent with the known conditions and parameters in these assessments.

674. For irradiated nuclear fuel, the assessments of paras 677–682 shall be based on an isotopic composition demonstrated either to provide either:

- (a) The maximum neutron multiplication during the irradiation history, or
- (b) A conservative estimate of the neutron multiplication for the *package* assessments. After irradiation but prior to *shipment*, a measurement shall be performed to confirm the conservatism of the isotopic composition.

### **Geometry and temperature requirements**

675. The *package*, after being subjected to the tests specified in paras 719–724, shall:

- (a) Preserve the minimum overall outside dimensions of the *package* to at least 10 cm.
- (b) Prevent the entry of a 10 cm cube.

676. The *package* shall be designed for an ambient temperature range of  $-40^{\circ}\text{C}$  to  $+38^{\circ}\text{C}$  unless the *competent authority* specifies otherwise in the certificate of approval for the *package design*.

### **Assessment of an individual package in isolation**

677. For a *package* in isolation, it shall be assumed that water can leak into or out of all void spaces of the *package*, including those within the *containment system*. However, if the *design* incorporates special features to prevent such leakage of water into or out of certain void spaces, even as a result of error, absence of leakage may be assumed in respect of those void spaces. Special features shall include either of the following:

- (a) Multiple high standard water barriers, not less than two of which would remain watertight if the *package* were subject to the tests prescribed in para. 682(b), a high degree of quality

control in the manufacture, maintenance and repair of *packagings*, and tests to demonstrate the closure of each *package* before each *shipment*; or

- (b) For *packages* containing uranium hexafluoride only, with a maximum uranium enrichment of 5 mass per cent uranium-235:
  - (i) *Packages* where, following the tests prescribed in para. 682(b), there is no physical contact between the valve and any other component of the *packaging* other than at its original point of attachment and where, in addition, following the test prescribed in para. 728, the valves remain leaktight.
  - (ii) A high degree of quality control in the manufacture, maintenance and repair of *packagings*, coupled with tests to demonstrate closure of each *package* before each *shipment*.

678. It shall be assumed that the *confinement system* shall be closely reflected by at least 20 cm of water or such greater reflection as may additionally be provided by the surrounding material of the *packaging*. However, when it can be demonstrated that the *confinement system* remains within the *packaging* following the tests prescribed in para. 682(b), close reflection of the *package* by at least 20 cm of water may be assumed in para. 679(c).

679. The *package* shall be subcritical under the conditions of paras 677 and 678, assuming close reflection by at least 20 cm of water, and with the *package* conditions that result in the maximum neutron multiplication consistent with:

- (a) Routine conditions of transport (incident free).
- (b) The tests specified in para. 681(b).
- (c) The tests specified in para. 682(b).

680. For *packages* to be transported by air:

- (a) The *package* shall be subcritical under conditions consistent with the *Type C package* tests specified in para. 734, assuming reflection by at least 20 cm of water but no water in-leakage.
- (b) In the assessment of para. 679, allowance shall not be made for special features of para. 677 unless, following the *Type C package* tests specified in para. 734 and, subsequently, the water in-leakage test of para. 733, leakage of water into or out of the void spaces is prevented.

#### **Assessment of package arrays under normal conditions of transport**

681. A number  $N$  shall be derived, such that five times  $N$  *packages*, shall be subcritical for the arrangement and *package* conditions that provide the maximum neutron multiplication consistent with the following:

- (a) There shall not be anything between the *packages* and the *package* arrangement shall be reflected on all sides by at least 20 cm of water.
- (b) The state of the *packages* shall be their assessed or demonstrated condition if they had been subjected to the tests specified in paras 719–724.

#### **Assessment of package arrays under accident conditions of transport**

682. A number  $N$  shall be derived, such that two times  $N$  *packages* shall be subcritical for the arrangement and *package* conditions that provide the maximum neutron multiplication consistent with the following:

- (a) Hydrogenous moderation between the *packages* and the *package* arrangement reflected on all sides by at least 20 cm of water.
- (b) The tests specified in paras 719–724, followed by whichever of the following is the more limiting:

- (i) The tests specified in para. 727(b), and either para. 727(c) for *packages* having a mass not greater than 500 kg and an overall density not greater than  $10^3 \text{ kg/m}^3$  based on the external dimensions, or para. 727(a) for all other *packages*; followed by the test specified in para. 728 and completed by the tests specified in paras 731–733; or
- (ii) The test specified in para. 729; and
- (c) Where any part of the *fissile material* escapes from the *containment system* following the tests specified in para. 682(b), it shall be assumed that *fissile material* escapes from each *package* in the array, and all of the *fissile material* shall be arranged in the configuration and moderation that results in the maximum neutron multiplication with close reflection by at least 20 cm of water.

#### **Determination of criticality safety index for packages**

683. The *CSI* for *packages* containing *fissile material* shall be obtained by dividing the number 50 by the smaller of the two values of *N* derived in paras 681 and 682 (i.e.  $CSI = 50/N$ ). The value of the *CSI* may be zero, provided that an unlimited number of *packages* are subcritical (i.e. *N* is effectively equal to infinity in both cases).

## Section VII

### TEST PROCEDURES

#### DEMONSTRATION OF COMPLIANCE

701. Demonstration of compliance with the performance standards required in Section VI shall be accomplished by any of the following methods listed below or by a combination thereof:

- (a) Performance of tests with specimens representing *LSA-III* material, or *special form radioactive material*, or *low dispersible radioactive material*, or with prototypes or samples of the *packaging*, where the contents of the specimen or the *packaging* for the tests shall simulate as closely as practicable the expected range of *radioactive contents* and the specimen or *packaging* to be tested shall be prepared as presented for transport.
- (b) Reference to previous satisfactory demonstrations of a sufficiently similar nature.
- (c) Performance of tests with models of appropriate scale, incorporating those features which are significant with respect to the item under investigation when engineering experience has shown the results of such tests to be suitable for *design* purposes. When a scale model is used, the need for adjusting certain test parameters, such as penetrator diameter or compressive load, shall be taken into account.
- (d) Calculation, or reasoned argument, when the calculation procedures and parameters are generally agreed to be reliable or conservative.

702. After the specimen, prototype or sample has been subjected to the tests, appropriate methods of assessment shall be used to ensure that the requirements of this section have been fulfilled in compliance with the performance and acceptance standards prescribed in Section VI.

#### LEACHING TEST FOR LSA-III MATERIAL AND LOW DISPERSIBLE RADIOACTIVE MATERIAL

703. A solid material sample representing the entire contents of the *package* shall be immersed for 7 days in water at ambient temperature. The volume of water to be used in the test shall be sufficient to ensure that at the end of the 7 day test period, the free volume of the unabsorbed and unreacted water remaining shall be at least 10% of the volume of the solid test sample itself. The water shall have an initial pH of 6–8 and a maximum conductivity of 1 mS/m at 20°C. The total activity of the free volume of water shall be measured following the 7 day immersion of the test sample.

## TESTS FOR SPECIAL FORM RADIOACTIVE MATERIAL

### General

704. Specimens that comprise or simulate *special form radioactive material* shall be subjected to the impact test, the percussion test, the bending test and the heat test specified in paras 705–708. A different specimen may be used for each of the tests. Following each test, a leaching assessment or volumetric leakage test shall be performed on the specimen by a method no less sensitive than the methods given in para. 710 for indispersible solid material or in para. 711 for encapsulated material.

### Test methods

705. Impact test: The specimen shall drop onto the target from a height of 9 m. The target shall be as defined in para. 717.

706. Percussion test: The specimen shall be placed on a sheet of lead which is supported by a smooth solid surface and struck by the flat face of a mild steel bar so as to cause an impact equivalent to that resulting from a free drop of 1.4 kg through 1 m. The lower part of the bar shall be 25 mm in diameter with the edges rounded off to a radius of  $3.0 \pm 0.3$  mm. The lead, of hardness number 3.5–4.5 on the Vickers scale and not more than 25 mm thick, shall cover an area greater than that covered by the specimen. A fresh surface of lead shall be used for each impact. The bar shall strike the specimen so as to cause maximum damage.

707. Bending test: The test shall apply only to long, slender sources with both a minimum length of 10 cm and a length to minimum width ratio of not less than 10. The specimen shall be rigidly clamped in a horizontal position so that one half of its length protrudes from the face of the clamp. The orientation of the specimen shall be such that the specimen will suffer maximum damage when its free end is struck by the flat face of a steel bar. The bar shall strike the specimen so as to cause an impact equivalent to that resulting from a free vertical drop of 1.4 kg through 1 m. The lower part of the bar shall be 25 mm in diameter with the edges rounded off to a radius of  $(3.0 \pm 0.3)$  mm.

708. Heat test: The specimen shall be heated in air to a temperature of 800°C and held at that temperature for a period of 10 minutes and shall then be allowed to cool.

709. Specimens that comprise or simulate *radioactive material* enclosed in a sealed capsule may be excepted from:

- (a) The tests prescribed in paras 705 and 706 provided either of the mass of the *special form radioactive material*:
  - (i) Is less than 200 g and the specimens are alternatively subjected to the Class 4 impact test prescribed in the International Organization for Standardization document ISO 2919: Sealed Radioactive Sources — Classification [13], or
  - (ii) Is less than 500 g and the specimens are alternatively subjected to the Class 5 impact test prescribed in the International Organization for Standardization document ISO 2919: Sealed Radioactive Sources — Classification [13].
- (b) The test prescribed in para. 708 provided the specimens are alternatively subjected to the Class 6 temperature test specified in the International Organization for Standardization document ISO 2919: Sealed Radioactive Sources — Classification [13].

#### **Leaching and volumetric leakage assessment methods**

710. For specimens which comprise or simulate indispersible solid material, a leaching assessment shall be performed as follows:

- (a) The specimen shall be immersed for 7 days in water at ambient temperature. The volume of water to be used in the test shall be sufficient to ensure that at the end of the 7 day test period the free volume of the unabsorbed and unreacted water remaining shall be at least 10% of the volume of the solid test sample itself. The water shall have an initial pH of 6–8 and a maximum conductivity of 1 mS/m at 20°C.
- (b) The water with the specimen shall then be heated to a temperature of  $(50 \pm 5)^\circ\text{C}$  and maintained at this temperature for 4 hours.
- (c) The activity of the water shall then be determined.
- (d) The specimen shall then be kept for at least 7 days in still air at not less than 30°C and with a relative humidity of not less than 90%.
- (e) The specimen shall then be immersed in water of the same specification as in (a) and the water with the specimen heated to  $(50 \pm 5)^\circ\text{C}$  and maintained at this temperature for 4 hours.
- (f) The activity of the water shall then be determined.

711. For specimens which comprise or simulate *radioactive material* enclosed in a sealed capsule, either a leaching assessment or a volumetric leakage assessment shall be performed as follows:

- (a) The leaching assessment shall consist of the following steps:
  - (i) The specimen shall be immersed in water at ambient temperature. The water shall have an initial pH of 6–8 with a maximum conductivity of 1 mS/m at 20°C.
  - (ii) The water and the specimen shall be heated to a temperature of  $50 \pm 5^\circ\text{C}$  and maintained at this temperature for 4 hours.

- (iii) The activity of the water shall then be determined.
  - (iv) The specimen shall then be kept for at least 7 days in still air at not less than 30°C and with a relative humidity of not less than 90%.
  - (v) The process in (i), (ii) and (iii) shall be repeated.
- (b) The alternative volumetric leakage assessment shall comprise any of the tests prescribed in the International Organization for Standardization document ISO 9978: Radiation Protection — Sealed Radioactive Sources — Leakage Test Methods [9] which are acceptable to the *competent authority*.

#### TESTS FOR LOW DISPERSIBLE RADIOACTIVE MATERIAL

712. A specimen that comprises or simulates *low dispersible radioactive material* shall be subjected to the enhanced thermal test specified in para. 736 and the impact test specified in para. 737. A different specimen may be used for each of the tests. Following each test, the specimen shall be subjected to the leach test specified in para. 703. After each test it shall be determined if the applicable requirements of para. 605 have been met.

#### TESTS FOR PACKAGES

##### **Preparation of a specimen for testing**

713. All specimens shall be inspected before testing in order to identify and record faults or damage, including the following:

- (a) Divergence from the *design*.
- (b) Defects in manufacture.
- (c) Corrosion or other deterioration.
- (d) Distortion of features.

714. The *containment system* of the *package* shall be clearly specified.

715. The external features of the specimen shall be clearly identified so that reference may be made simply and clearly to any part of such a specimen.

### **Testing the integrity of the containment system and shielding and assessing criticality safety**

716. After each of the applicable tests specified in paras 718–737:

- (a) Faults and damage shall be identified and recorded.
- (b) It shall be determined whether the integrity of the *containment system* and shielding has been retained to the extent required in Section VI for the *package* under test.
- (c) For *packages* containing *fissile material*, it shall be determined whether the assumptions and conditions used in the assessments required by paras 671–683 for one or more *packages* are valid.

### **Target for drop tests**

717. The target for the drop test specified in paras 705, 722, 725(a), 727 and 735 shall be a flat, horizontal surface of such a character that any increase in its resistance to displacement or deformation upon impact by the specimen would not significantly increase damage to the specimen.

### **Test for packagings designed to contain uranium hexafluoride**

718. Specimens that comprise or simulate *packagings* designed to contain 0.1 kg or more of uranium hexafluoride shall be tested hydraulically at an internal pressure of at least 1.38 MPa, but when the test pressure is less than 2.76 MPa, the *design* shall require *multilateral approval*. For retesting *packagings*, any other equivalent non-destructive testing may be applied, subject to *multilateral approval*.

### **Tests for demonstrating ability to withstand normal conditions of transport**

719. The tests are: the water spray test, the free drop test, the stacking test and the penetration test. Specimens of the *package* shall be subjected to the free drop test, the stacking test and the penetration test, preceded in each case by the water spray test. One specimen may be used for all the tests, provided that the requirements of para. 720 are fulfilled.

720. The time interval between the conclusion of the water spray test and the succeeding test shall be such that the water has soaked in to the maximum extent, without appreciable drying of the exterior of the specimen. In the absence of any evidence to the contrary, this interval shall be taken to be two hours if the water spray is applied from four directions simultaneously. No time interval shall elapse, however, if the water spray is applied from each of the four directions consecutively.

721. Water spray test: The specimen shall be subjected to a water spray test that simulates exposure to rainfall of approximately 5 cm per hour for at least one hour.

722. Free drop test: The specimen shall drop onto the target so as to suffer maximum damage in respect of the safety features to be tested:

- (a) The height of drop measured from the lowest point of the specimen to the upper surface of the target shall be not less than the distance specified in Table 14 for the applicable mass. The target shall be as defined in para. 717.
- (b) For rectangular fibreboard or wood *packages* not exceeding a mass of 50 kg, a separate specimen shall be subjected to a free drop onto each corner from a height of 0.3 m.
- (c) For cylindrical fibreboard *packages* not exceeding a mass of 100 kg, a separate specimen shall be subjected to a free drop onto each of the quarters of each rim from a height of 0.3 m.

723. Stacking test: Unless the shape of the *packaging* effectively prevents stacking, the specimen shall be subjected, for a period of 24 h, to a compressive load equal to the greater of the following:

- (a) The equivalent of 5 times the maximum weight of the package.
- (b) The equivalent of 13 kPa multiplied by the vertically projected area of the *package*.

The load shall be applied uniformly to two opposite sides of the specimen, one of which shall be the base on which the *package* would typically rest.

724. Penetration test: The specimen shall be placed on a rigid, flat, horizontal surface which will not move significantly while the test is being carried out:

- (a) A bar 3.2 cm in diameter with a hemispherical end and a mass of 6 kg shall be dropped and directed to fall, with its longitudinal axis vertical, onto the centre of the weakest part of the specimen, so that, if it penetrates sufficiently far, it will hit the *containment system*. The bar shall not be significantly deformed by the test performance.
- (b) The height of drop of the bar measured from its lower end to the intended point of impact on the upper surface of the specimen shall be 1 m.

**Additional tests for Type A packages designed for liquids and gases**

725. A specimen, or separate specimens, shall be subjected to each of the following tests unless it can be demonstrated that one test is more severe for the specimen in question than the other, in which case one specimen shall be subjected to the more severe test:

- (a) Free drop test: The specimen shall drop onto the target so as to suffer the maximum damage in respect of containment. The height of the drop measured from the lowest part of the specimen to the upper surface of the target shall be 9 m. The target shall be as defined in para. 717.
- (b) Penetration test: The specimen shall be subjected to the test specified in para. 724, except that the height of the drop shall be increased to 1.7 m from the 1 m specified in para. 724(b).

TABLE 14. FREE DROP DISTANCE FOR TESTING PACKAGES TO NORMAL CONDITIONS

## OF TRANSPORT

<i>Package</i> mass (kg)	Free drop distance (m)
<i>Package</i> mass < 5 000	1.2
5 000 ≤ <i>Package</i> mass < 10 000	0.9
10 000 ≤ <i>Package</i> mass < 15 000	0.6
15 000 ≤ <i>Package</i> mass	0.3

**Tests for demonstrating ability to withstand accident conditions of transport**

726. The specimen shall be subjected to the cumulative effects of the tests specified in paras 727 and 728, in that order. Following these tests, either this specimen or a separate specimen shall be subjected to the effect(s) of the water immersion test(s) as specified in para. 729 and, if applicable, para. 730.

727. Mechanical test: The mechanical test consists of three different drop tests. Each specimen shall be subjected to the applicable drops as specified in para. 657 or para. 682. The order in which the specimen is subjected to the drops shall be such that, on completion of the mechanical test, the specimen shall have suffered such damage as will lead to maximum damage in the thermal test which follows:

- (a) For drop I, the specimen shall drop onto the target so as to suffer maximum damage, and the height of the drop measured from the lowest point of the specimen to the upper surface of the target shall be 9 m. The target shall be as defined in para. 717.
- (b) For drop II, the specimen shall drop onto a bar rigidly mounted perpendicularly on the target so as to suffer maximum damage. The height of the drop measured from the intended point of impact of the specimen to the upper surface of the bar shall be 1 m. The bar shall be of solid mild steel of circular section,  $15.0 \pm 0.5$  cm in diameter and 20 cm long unless a longer bar would cause greater damage, in which case a bar of sufficient length to cause maximum

damage shall be used. The upper end of the bar shall be flat and horizontal with its edge rounded off to a radius of not more than 6 mm. The target on which the bar is mounted shall be as described in para. 717.

- (c) For drop III, the specimen shall be subjected to a dynamic crush test by positioning the specimen on the target so as to suffer maximum damage by the drop of a 500kg mass from 9 m onto the specimen. The mass shall consist of a solid mild steel plate 1 m by 1 m and shall fall in a horizontal attitude. The lower face of the steel plate shall have its edges and corners rounded off to a radius of not more than 6 mm. The height of the drop shall be measured from the underside of the plate to the highest point of the specimen. The target on which the specimen rests shall be as defined in para. 717.

728. Thermal test: The specimen shall be in thermal equilibrium under conditions of an ambient temperature of 38°C, subject to the solar insolation conditions specified in Table 13 and subject to the *design* maximum rate of internal heat generation within the *package* from the radioactive contents. Alternatively, any of these parameters are allowed to have different values prior to and during the test, provided due account is taken of them in the subsequent assessment of *package* response. The thermal test shall then consist of (a) followed by (b).

- (a) Exposure of a specimen for a period of 30 minutes to a thermal environment which provides a heat flux at least equivalent to that of a hydrocarbon fuel–air fire in sufficiently quiescent ambient conditions to give a minimum average flame emissivity coefficient of 0.9 and an average temperature of at least 800°C, fully engulfing the specimen, with a surface absorptivity coefficient of 0.8 or that value which the *package* may be demonstrated to possess if exposed to the fire specified.
- (b) Exposure of the specimen to an ambient temperature of 38°C, subject to the solar insolation conditions specified in Table 13 and subject to the *design* maximum rate of internal heat generation within the *package* by the *radioactive contents* for a sufficient period to ensure that temperatures in the specimen are everywhere decreasing and/or are approaching initial

steady state conditions. Alternatively, any of these parameters are allowed to have different values following cessation of heating, provided due account is taken of them in the subsequent assessment of *package* response. During and following the test, the specimen shall not be artificially cooled and any combustion of materials of the specimen shall be permitted to proceed naturally.

729. Water immersion test: The specimen shall be immersed under a head of water of at least 15 m for a period of not less than 8 h hours in the attitude which will lead to maximum damage. For demonstration purposes, an external gauge pressure of at least 150 kPa shall be considered to meet these conditions.

**Enhanced water immersion test for Type B(U) and Type B(M) packages containing more than  $10^5 A_2$  and Type C packages**

730. Enhanced water immersion test: The specimen shall be immersed under a head of water of at least 200 m for a period of not less than 1 hour. For demonstration purposes, an external gauge pressure of at least 2 MPa shall be considered to meet these conditions.

**Water leakage test for packages containing fissile material**

731. *Packages* for which water in-leakage or out-leakage to the extent which results in greatest reactivity has been assumed for purposes of assessment under paras 677–682 shall be excepted from the test.

732. Before the specimen is subjected to the water leakage test specified below, it shall be subjected to the tests in para. 727(b), and either para. 727(a) or 727(c), as required by para. 682 and the test specified in para. 728.

733. The specimen shall be immersed under a head of water of at least 0.9 m for a period of not less than 8 h and in the attitude for which maximum leakage is expected.

**Tests for Type C packages**

734. Specimens shall be subjected to the effects of each of the following test sequences in the orders specified:

- (a) The tests specified in paras 727(a), 727(c), 735 and 736.
- (b) The test specified in para. 737.

Separate specimens are allowed to be used for each of the sequences (a) and (b).

735. Puncture-tearing test: The specimen shall be subjected to the damaging effects of a vertical solid probe made of mild steel. The orientation of the *package* specimen and the impact point on the *package* surface shall be such as to cause maximum damage at the conclusion of the test sequence specified in para. 734(a):

- (a) The specimen, representing a *package* having a mass of less than 250 kg, shall be placed on a target and subjected to a probe having a mass of 250 kg falling from a height of 3 m above the intended impact point. For this test the probe shall be a 20 cm diameter cylindrical bar with the striking end forming the frustum of a right circular cone with the following dimensions: 30 cm height and 2.5 cm diameter at the top with its edge rounded off to a radius of not more than 6 mm. The target on which the specimen is placed shall be as specified in para. 717.
- (b) For *packages* having a mass of 250 kg or more, the base of the probe shall be placed on a target and the specimen dropped onto the probe. The height of the drop, measured from the point of impact with the specimen to the upper surface of the probe, shall be 3 m. For this test the probe shall have the same properties and dimensions as specified in (a), except that the length and mass of the probe shall be such as to cause maximum damage to the specimen. The target on which the base of the probe is placed shall be as specified in para. 717.

736. Enhanced thermal test: The conditions for this test shall be as specified in para. 728, except that the exposure to the thermal environment shall be for a period of 60 minutes.

737. Impact test: The specimen shall be subject to an impact on a target at a velocity of not less than 90 m/s, at such an orientation as to suffer maximum damage. The target shall be as defined in para. 717, except that the target surface may be at any orientation as long as the surface is normal to the specimen path.

DRAFT

## Section VIII <sup>[1]</sup>

### APPROVAL AND ADMINISTRATIVE REQUIREMENTS

#### GENERAL

801. For *package designs* where it is not required that a *competent authority* issue an approval certificate, the *consignor* shall, on request, make available for inspection by the relevant *competent authority*, documentary evidence of the compliance of the *package design* with all the applicable requirements.

802. *Competent authority* approval shall be required for the following:

- (a) *Designs* for:
  - (i) *Special form radioactive material* (see paras 803, 804 and 818).
  - (ii) *Low dispersible radioactive material* (see paras 803 and 804).
  - (iii) *Fissile material* to be excepted under para. 417(f) (see paras 804bis and 804ter).
  - (iv) *Packages* containing 0.1 kg or more of uranium hexafluoride (see para. 805).
  - (v) *Packages* containing *fissile material* unless excepted by para. 417, 672 or 672bis (see paras 812–814, 816 and 817).
  - (vi) *Type B(U) packages* and *Type B(M) packages* (see paras 806–811, 816).
  - (vii) *Type C packages* (see paras 806–808).
- (b) *Special arrangements* (see paras 824–826).
- (c) Certain *shipments* (see paras 820–823).
- (d) *Radiation protection programme* for special use *vessels* (see para. 572(a)).
- (e) Calculation of radionuclide values that are not listed in Table 2 (see para. 403).

The *package design* and *shipment approval* certificates may be combined into a single certificate.

#### APPROVAL OF SPECIAL FORM RADIOACTIVE MATERIAL AND LOW DISPERSIBLE RADIOACTIVE MATERIAL

803. The *design* for *special form radioactive material* shall require *unilateral approval*. The *design* for *low dispersible radioactive material* shall require *multilateral approval*. In both cases, an application for approval shall include:

- (a) A detailed description of the *radioactive material* or, if a capsule, the contents; particular reference shall be made to both physical and chemical states.
- (b) A detailed statement of the *design* of any capsule to be used.
- (c) A statement of the tests which have been done and their results, or evidence based on calculative methods to show that the *radioactive material* is capable of meeting the performance standards, or other evidence that the *special form radioactive material* or *low dispersible radioactive material* meets the applicable requirements of these Regulations.
- (d) A specification of the applicable *management system* as required in para. 306.
- (e) Any proposed pre-*shipment* actions for use in the *consignment* of *special form radioactive material* or *low dispersible radioactive material*.

804. The *competent authority* shall establish an approval certificate stating that the approved *design* meets the requirements for *special form radioactive material* or *low dispersible radioactive material* and shall attribute to that *design* an identification mark.

#### APPROVALS FOR FISSILE MATERIAL EXCEPTED BY COMPETENT AUTHORITY

804bis. A *fissile material to be excepted*, under para. 417(f) shall require *multilateral approval*. An application for *approval* shall include:

- (a) A detailed description of the material; particular reference shall be made to both physical and chemical states.
- (b) A statement of the tests which have been done and their results, or evidence based on

calculative methods to show that the material is capable of meeting the requirements specified in para. 605bis.

- (c) A specification of the applicable *management system* as required in para. 306.
- (d) Any proposed pre-*shipment* actions.

804ter. The *competent authority* shall establish an *approval* certificate stating that the approved material meets the requirements for *fissile material* according to para. 605bis and shall attribute to that *design* an identification mark.

#### APPROVAL OF PACKAGE DESIGNS

##### **Approval of package designs to contain uranium hexafluoride**

805. The approval of *designs* for *packages* containing 0.1 kg or more of uranium hexafluoride requires that:

- (a) Each *design* that meets the requirements of para. 632 shall require *multilateral approval*.
- (b) Each *design* that meets the requirements of paras 629–631 shall require *unilateral approval* by the *competent authority* of the country of origin of the *design*, unless *multilateral approval* is otherwise required by these Regulations.
- (c) The application for approval shall include all information necessary to satisfy the *competent authority* that the *design* meets the requirements of para. 629, and a specification of the applicable *management system* as required in para. 306.
- (d) The *competent authority* shall establish an approval certificate stating that the approved *design* meets the requirements of para. 629 and shall attribute to that *design* an identification mark.

##### **Approval of Type B(U) and Type C package designs**

806. Each *Type B(U)* and *Type C package design* shall require *unilateral approval*, except that:

- (a) A *package design* for *fissile material*, which is also subject to paras 812–814, shall require *multilateral approval*.
- (b) A *Type B(U) package design* for *low dispersible radioactive material* shall require *multilateral approval*.

807. An application for approval shall include:

- (a) A detailed description of the proposed *radioactive contents* with reference to their physical and chemical states and the nature of the radiation emitted.
- (b) A detailed statement of the *design*, including complete engineering drawings and schedules of materials and methods of manufacture.
- (c) A statement of the tests which have been carried out and their results, or evidence based on calculative methods or other evidence that the *design* is adequate to meet the applicable requirements.
- (d) The proposed operating and maintenance instructions for the use of the *packaging*.
- (e) If the *package* is designed to have a *maximum normal operating pressure* in excess of 100 kPa gauge, a specification of the materials of manufacture of the *containment system*, the samples to be taken and the tests to be made.
- (f) Where the proposed *radioactive contents* are irradiated nuclear fuel, the applicant shall state and justify any assumption in the safety analysis relating to the characteristics of the fuel and describe any *pre-shipment* measurement required by para. 674(b).
- (g) Any special stowage provisions necessary to ensure the safe dissipation of heat from the *package*, considering the various modes of transport to be used and the type of *conveyance* or *freight container*.
- (h) A reproducible illustration, not larger than 21 cm × 30 cm, showing the make-up of the *package*.

- (i) A specification of the applicable *management system* as required in para. 306.

808. The *competent authority* shall establish an approval certificate stating that the approved *design* meets the requirements for *Type B(U)* or *Type C packages* and shall attribute to that *design* an identification mark.

### **Approval of Type B(M) package designs**

809. Each *Type B(M) package design*, including those for *fissile material* which are also subject to paras 812–814 and those for *low dispersible radioactive material*, shall require *multilateral approval*.

810. An application for approval of a *Type B(M) package design* shall include, in addition to the information required in para. 807 for *Type B(U) packages*:

- (a) A list of the requirements specified in paras 637, 653–655 and 658–664 with which the *package* does not conform.
- (b) Any proposed supplementary operational controls to be applied during transport not regularly provided for in these Regulations, but which are necessary to ensure the safety of the *package* or to compensate for the deficiencies listed in (a).
- (c) A statement relative to any restrictions on the mode of transport and to any special loading, carriage, unloading or handling procedures.
- (d) The range of ambient conditions (temperature, solar radiation) which are expected to be encountered during transport and which have been taken into account in the *design*.

811. The *competent authority* shall establish an approval certificate stating that the approved *design* meets the applicable requirements for *Type B(M) packages* and shall attribute to that *design* an identification mark.

### **Approval of package designs to contain fissile material**

812. Each *package design* for *fissile material*, unless excepted by any of paras 417, 672 and 672bis, shall require *multilateral approval*.

813. An application for approval shall include all information necessary to satisfy the *competent authority* that the *design* meets the requirements of para. 671, and a specification of the applicable *management system* as required in para. 306.

814. The *competent authority* shall establish an approval certificate stating that the approved *design* meets the requirements of para. 671 and shall attribute to that *design* an identification mark.

#### TRANSITIONAL ARRANGEMENTS

#### **Packages not requiring competent authority approval of design under the 1985 and 1985 (As Amended 1990) Editions of these Regulations**

815. Use of *excepted package*, *Type IP-1*, *Type IP-2*, *Type IP-3* and *Type A package* that were not designed to contain uranium hexafluoride and that did not require approval of *design* by the *competent authority* and which meet the requirements of the 1985 or 1985 (As Amended 1990) Editions of these Regulations shall be subject to:

- (a) The *management system* in accordance with the applicable requirements of para. 306
- (b) The activity limits and classification material restrictions of Section IV.
- (c) The requirements and controls for transport in Section V.

Any *packaging* modified or manufactured after 31 December 2003 shall meet this Edition of these Regulations in full.

*Packages* prepared for transport shall meet this Edition of these Regulations in full, except for *packages* prepared for transport prior to 31 December 2003 under the 1985 or 1985 (As Amended 1990) Editions of these Regulations, which may continue in transport.

**Packages approved under the 1973, 1973 (As Amended), 1985 and 1985 (As Amended 1990) Editions of these Regulations**

816. *Packages* requiring *competent authority approval of design* shall meet this Edition of these Regulations in full unless the following conditions are met:

(a)(bis) *Packagings* were manufactured to a *package design* approved by the *competent authority* under the provisions of the 1973 or 1973 (As Amended) or the 1985 or 1985 (As Amended 1990) Editions of these Regulations.

- (a) The *packages design* is subject to *multilateral approval*.
- (b) The applicable requirements of para. 306 of this Edition of these Regulations are applied.
- (c) The activity limits and classification in Section IV of this Edition of these Regulations are applied.
- (d) The requirements and controls for transport in Section V of this Edition of these Regulations are applied.
- (e) For a *package* containing *fissile material* and transported by air, the requirement of para. 680 is met.
- (f) For *packages* which meet the requirements of the 1973 or 1973 (As Amended) Editions of these Regulations:
  - (i) The *packages* retain sufficient shielding to ensure that the *radiation level* at 1 m from the surface of the *package* would not exceed 10 mSv/h in the accident conditions of transport defined in the 1973 Revised or 1973 Revised (As Amended) Editions of these Regulations with the maximum *radioactive contents* which the *package* is authorized to contain.
  - (ii) The *packages* do not utilize continuous venting.

817 Packages designed to meet the provisions of the 1973, 1973 (As Amended), 1985, and 1985 (as Amended 1990) Editions of these Regulations shall no longer be manufactured.

**Special form radioactive material approved under the 1973, 1973 (As Amended), 1985 and 1985 (As Amended 1990) Editions of these Regulations**

818. Special form *radioactive material* manufactured to a *design* which had received *unilateral approval* by the *competent authority* under the 1973, 1973 (As Amended), 1985 or 1985 (As Amended 1990) Editions of these Regulations may continue to be used when in compliance with the mandatory *management system* in accordance with the applicable requirements of para. 306. No new manufacture of such *special form radioactive material* shall be permitted to commence.

**NOTIFICATION AND REGISTRATION OF SERIAL NUMBERS**

819. The *competent authority* shall be informed of the serial number of each *packaging* manufactured to a *design* approved under paras 806, 809, 812 and 816.

**APPROVAL OF SHIPMENTS**

820. *Multilateral approval* shall be required for:

- (a) The *shipment* of *Type B(M) packages* not conforming with the requirements of para. 637 or designed to allow controlled intermittent venting.
- (b) The *shipment* of *Type B(M) packages* containing *radioactive material* with an activity greater than  $3 \times 10^3 A_1$  or  $3 \times 10^3 A_2$ , as appropriate, or  $10^3$  TBq, whichever is the lower.
- (c) The *shipment* of *packages* containing *fissile materials* if the sum of the *CSIs* of the *packages* in a single *freight container* or in a single *conveyance* exceeds 50. Excluded from this requirement shall be *shipments* by seagoing *vessels*, if the sum of the *CSIs* does not exceed 50 for any hold, compartment or *defined deck area* and the distance of 6 m between groups of *packages* or *overpacks* as required in Table 12 is met.

(d) *Radiation protection programmes for shipments by special use vessels* according to para. 572(a).

821. A *competent authority* may authorize transport into or through its country without *shipment* approval, by a specific provision in its *design* approval (see para. 827).

822. An application for *shipment* approval shall include:

- (a) The period of time, related to the *shipment*, for which the approval is sought.
- (b) The actual *radioactive contents*, the expected modes of transport, the type of *conveyance* and the probable or proposed route.
- (c) The details of how the precautions and administrative or operational controls, referred to in the *package design* approval certificates issued under paras 808, 811 and 814, are to be put into effect.

823. Upon approval of the *shipment*, the *competent authority* shall issue an approval certificate.

#### APPROVAL OF SHIPMENTS UNDER SPECIAL ARRANGEMENT

824. Each *consignment* transported under *special arrangement* shall require *multilateral approval*.

825. An application for approval of *shipments* under *special arrangement* shall include all the information necessary to satisfy the *competent authority* that the overall level of safety in transport is at least equivalent to that which would be provided if all the applicable requirements of these Regulations had been met. The application shall also include:

- (a) A statement of the respects in which, and of the reasons why, the *shipment* cannot be made in full accordance with the applicable requirements.
- (b) A statement of any special precautions or special administrative or operational controls which are to be employed during transport to compensate for the failure to meet the applicable requirements.

826. Upon approval of *shipments* under *special arrangement*, the *competent authority* shall issue an approval certificate.

## COMPETENT AUTHORITY APPROVAL CERTIFICATES

### Competent authority identification marks

828. Each approval certificate issued by a *competent authority* shall be assigned an identification mark. The mark shall be of the following generalized type:

VRI/Number/Type Code

- (a) Except as provided in para. 829(b), VRI represents the international vehicle registration identification code of the country issuing the certificate.
- (b) The number shall be assigned by the *competent authority* and shall be unique and specific with regard to the particular *design* or *shipment*. The *shipment* approval identification mark shall be clearly related to the *design* approval identification mark.
- (c) The following type codes shall be used in the order listed to indicate the types of approval certificate issued:

- AF *TYPE A package design for fissile material*
- B(U) *Type B(U) package design (B(U)F if for fissile material)*
- B(M) *Type B(M) package design (B(M)F if for fissile material)*
- C *Type C package design (CF if for fissile material)*
- IF *Industrial package design for fissile material*
- S *Special form radioactive material*
- LD *Low dispersible radioactive material*
- FE Fissile excepted material meeting requirements in para. 417(f)
- T *Shipment*
- X *Special arrangement.*

In the case of *package designs* for non-fissile or *fissile-excepted* uranium hexafluoride, where none of the above codes apply, the following type codes shall be used:

H(U) *Unilateral approval*

H(M) *Multilateral approval.*

(d) For *package design* and *special form radioactive material* approval certificates, other than those issued under the provisions of paras 816–818, and for *low dispersible radioactive material* approval certificates, the symbol “-96” shall be added to the type code.

829. These identification marks shall be applied as follows:

(a) Each certificate and each *package* shall bear the appropriate identification mark, comprising the symbols prescribed in paras 828(a)–(d), except that, for *packages*, only the applicable *design* type codes, including, if applicable, the symbol “-96” shall appear following the second stroke, that is, the “T” or “X” shall not appear in the identification marking on the *package*. Where the *design* approval and *shipment* approval are combined, the applicable type codes do not need to be repeated. For example:

A/132/B(M)F-96: A *Type B(M) package design* approved for *fissile material*, requiring *multilateral approval*, for which the *competent authority* of Austria has assigned the *design* number 132 (to be marked both on the *package* and on the *package design* approval certificate).

A/132/B(M)F-96T: The *shipment* approval issued for a *package* bearing the identification mark elaborated above (to be marked on the certificate only).

A/137/X: A *special arrangement* approval issued by the *competent authority* of Austria, to which the number 137 has been assigned (to be marked on the certificate only).

A/139/IF-96: An *industrial package design* for *fissile material* approved by the *competent authority* of Austria, to which *package design* number 139 has

been assigned (to be marked both on the *package* and on the *package design* approval certificate).

A/145/H(U)-96: A *package design* for fissile excepted uranium hexafluoride approved by the *competent authority* of Austria, to which *package design* number 145 has been assigned (to be marked both on the *package* and on the *package design* approval certificate).

- (b) Where *multilateral approval* is effected by validation according to para. 834, only the identification mark issued by the country of origin of the *design* or *shipment* shall be used. Where *multilateral approval* is effected by issue of certificates by successive countries, each certificate shall bear the appropriate identification mark and the *package* whose *design* was so approved shall bear all appropriate identification marks.

For example:

A/132/B(M)F-96

CH/28/B(M)F-96

would be the identification mark of a *package* which was originally approved by Austria and was subsequently approved, by separate certificate, by Switzerland. Additional identification marks would be tabulated in a similar manner on the *package*.

- (c) The revision of a certificate shall be indicated by a parenthetical expression following the identification mark on the certificate. For example, A/132/B(M)F-96(Rev.2) would indicate revision 2 of the Austrian *package design* approval certificate; or A/132/B(M)F-96(Rev.0) would indicate the original issuance of the Austrian *package design* approval certificate. For original issuances, the parenthetical entry is optional and other words such as “original issuance” may also be used in place of “Rev.0”. Certificate revision numbers may only be issued by the country issuing the original approval certificate.

- (d) Additional symbols (as may be necessitated by national requirements) may be added in brackets to the end of the identification mark, for example, A/132/B(M)F-96(SP503).
- (e) It is not necessary to alter the identification mark on the *packaging* each time that a revision to the *design* certificate is made. Such re-marking shall be required only in those cases where the revision to the *package design* certificate involves a change in the letter type codes for the *package design* following the second stroke.

## CONTENTS OF APPROVAL CERTIFICATES

### **Special form radioactive material and low dispersible radioactive material approval certificates**

830. Each approval certificate issued by a *competent authority* for *special form radioactive material* or *low dispersible radioactive material* shall include the following information:

- (a) Type of certificate.
- (b) The *competent authority* identification mark.
- (c) The issue date and an expiry date.
- (d) List of applicable national and international regulations, including the edition of the IAEA Regulations for the Safe Transport of Radioactive Material under which the *special form radioactive material* or *low dispersible radioactive material* is approved.
- (e) The identification of the *special form radioactive material* or *low dispersible radioactive material*.
- (f) A description of the *special form radioactive material* or *low dispersible radioactive material*.
- (g) *Design* specifications for the *special form radioactive material* or *low dispersible radioactive material*, which may include references to drawings.

- (h) A specification of the *radioactive contents* which includes the activities involved and which may include the physical and chemical forms.
- (i) A specification of the applicable *management system* as required in para. 306.
- (j) Reference to information provided by the applicant relating to specific actions to be taken prior to *shipment*.
- (k) If deemed appropriate by the *competent authority*, reference to the identity of the applicant.
- (l) Signature and identification of the certifying official.

#### Certificates for fissile material excepted by competent authority

830bis. Each approval certificate issued by a *competent authority* for exception of *fissile material* shall include the following information:

- (a) Type of certificate.
- (b) The *competent authority* identification mark.
- (c) The issue date and an expiry date.
- (d) List of applicable national and international regulations, including the edition of the IAEA Regulations for the Safe Transport of Radioactive Material under which the exception is approved.
- (e) A description of the excepted material.
- (f) Limiting specifications for the excepted material.
- (g) A specification of the applicable *management system* as required in para. 306.
- (h) Specific actions to be taken prior to shipment.
- (i) If deemed appropriate by the competent authority, reference to the identity of the applicant.
- (j) Signature and identification of the certifying official.
- (k) Reference to documentation that demonstrates compliance with para 605bis.

#### **Special arrangement approval certificates**

831. Each approval certificate issued by a *competent authority* for a *special arrangement* shall include the following information:

- (a) Type of certificate.
- (b) The *competent authority* identification mark.
- (c) The issue date and an expiry date.
- (d) Mode(s) of transport.
- (e) Any restrictions on the modes of transport, type of *conveyance*, *freight container*, and any necessary routing instructions.
- (f) List of applicable national and international regulations, including the edition of the IAEA Regulations for the Safe Transport of Radioactive Material under which the *special arrangement* is approved.
- (g) The following statement: "This certificate does not relieve the consignor from compliance with any requirement of the government of any country through or into which the package will be transported."
- (h) References to certificates for alternative *radioactive contents*, other *competent authority* validation, or additional technical data or information, as deemed appropriate by the *competent authority*.
- (i) Description of the *packaging* by reference to the drawings or a specification of the *design*. If deemed appropriate by the *competent authority*, a reproducible illustration not larger than 21 cm × 30 cm, showing the make-up of the *package*, should also be provided, accompanied by a brief description of the *packaging*, including materials of manufacture, gross mass, general external dimensions and appearance.
- (j) A specification of the authorized *radioactive contents*, including any restrictions on the *radioactive contents* which might not be obvious from the nature of the *packaging*. This shall

include the physical and chemical forms, the activities involved (including those of the various isotopes, if appropriate), mass in grams (for *fissile material* or for each *fissile nuclide*, when appropriate) and whether *special form radioactive material*, *low dispersible radioactive material*, or *fissile material* excepted under para. 417(f), if applicable.

- (k) Additionally, for *packages* containing *fissile material*:
- (i) A detailed description of the authorized *radioactive contents*.
  - (ii) The value of the *CSI*.
  - (iii) Reference to the documentation that demonstrates the criticality safety of the contents.
  - (iv) Any special features on the basis of which the absence of water from certain void spaces has been assumed in the criticality assessment.
  - (v) Any allowance (based on para. 674(b)) for a change in neutron multiplication assumed in the criticality assessment as a result of actual irradiation experience.
  - (vi) the ambient temperature range for which the *special arrangement* has been approved.
- (l) A detailed listing of any supplementary operational controls required for preparation, loading, carriage, unloading and handling of the *consignment*, including any special stowage provisions for the safe dissipation of heat.
- (m) If deemed appropriate by the *competent authority*, reasons for the *special arrangement*.
- (n) Description of the compensatory measures to be applied as a result of the *shipment* being under *special arrangement*.
- (o) Reference to information provided by the applicant relating to the use of the *packaging* or specific actions to be taken prior to the *shipment*.
- (p) A statement regarding the ambient conditions assumed for purposes of *design* if these are not in accordance with those specified in paras 654, 655 and 664, as applicable.

- (q) Any emergency arrangements deemed necessary by the *competent authority*.
- (r) A specification of the applicable *management system* as required in para. 306.
- (s) If deemed appropriate by the *competent authority*, reference to the identity of the applicant and to the identity of the *carrier*.
- (t) Signature and identification of the certifying official.

### **Shipment approval certificates**

832. Each approval certificate for a *shipment* issued by a *competent authority* shall include the following information:

- (a) Type of certificate.
- (b) The *competent authority* identification mark(s).
- (c) The issue date and an expiry date.
- (d) List of applicable national and international regulations, including the edition of the IAEA Regulations for the Safe Transport of Radioactive Material under which the *shipment* is approved.
- (e) Any restrictions on the modes of transport, type of *conveyance*, *freight container*, and any necessary routing instructions.
- (f) The following statement: "This certificate does not relieve the consignor from compliance with any requirement of the government of any country through or into which the package will be transported."
- (g) A detailed listing of any supplementary operational controls required for preparation, loading, carriage, unloading and handling of the *consignment*, including any special stowage provisions for the safe dissipation of heat or maintenance of criticality safety.

- (h) Reference to information provided by the applicant relating to specific actions to be taken prior to *shipment*.
- (i) Reference to the applicable *design* approval certificate(s).
- (j) A specification of the actual *radioactive contents*, including any restrictions on the *radioactive contents* which might not be obvious from the nature of the *packaging*. This shall include the physical and chemical forms, the total activities involved (including those of the various isotopes, if appropriate), mass in grams (for *fissile material* or for each *fissile nuclide*, when appropriate), and whether *special form radioactive material*, *low dispersible radioactive material* or *fissile material* excepted under para. 417(f), if applicable.
- (k) Any emergency arrangements deemed necessary by the *competent authority*.
- (l) A specification of the applicable *management system* as required in para. 306.
- (m) If deemed appropriate by the *competent authority*, reference to the identity of the applicant.
- (n) Signature and identification of the certifying official.

### **Package design approval certificates**

833. Each approval certificate of the *design* of a *package* issued by a *competent authority* shall include the following information:

- (a) Type of certificate.
- (b) The *competent authority* identification mark.
- (c) The issue date and an expiry date.
- (d) Any restriction on the modes of transport, if appropriate.
- (e) List of applicable national and international regulations, including the edition of the IAEA Regulations for the Safe Transport of Radioactive Material under which the *design* is approved.

- (f) The following statement: "This certificate does not relieve the consignor from compliance with any requirement of the government of any country through or into which the package will be transported."
- (g) References to certificates for alternative *radioactive contents*, other *competent authority* validation, or additional technical data or information, as deemed appropriate by the *competent authority*.
- (h) A statement authorizing *shipment* where *shipment* approval is required under para. 820, if deemed appropriate.
- (i) Identification of the *packaging*.
- (j) Description of the *packaging* by reference to the drawings or specification of the *design*. If deemed appropriate by the *competent authority*, a reproducible illustration not larger than 21 cm × 30 cm, showing the make-up of the *package*, should also be provided, accompanied by a brief description of the *packaging*, including materials of manufacture, gross mass, general external dimensions and appearance.
- (k) Specification of the *design* by reference to the drawings.
- (l) A specification of the authorized *radioactive contents*, including any restrictions on the *radioactive contents* which might not be obvious from the nature of the *packaging*. This shall include the physical and chemical forms, the activities involved (including those of the various isotopes, if appropriate), mass in grams (for *fissile material*, total mass of *fissile nuclides* or the mass for each *fissile nuclide*, when appropriate), and whether *special form radioactive material*, *low dispersible radioactive material* or *fissile material* excepted under para. 417(f), if applicable.
- (m) A description of the *containment system*.
- (n) For *package designs* containing *fissile material* that require *multilateral package design approval* according to para. 812.

- (i) A detailed description of the authorized *radioactive contents*.
- (ii) A description of the *confinement system*.
- (iii) The value of the *CSI*.
- (iv) Reference to the documentation that demonstrates the criticality safety of the contents.
- (v) Any special features on the basis of which the absence of water from certain void spaces has been assumed in the criticality assessment.
- (vi) Any allowance (based on para. 674(b)) for a change in neutron multiplication assumed in the criticality assessment as a result of actual irradiation experience.
- (vii) The ambient temperature range for which the *package design* has been approved.
- (o) For *Type B(M) packages*, a statement specifying those prescriptions of paras 637, 653–655 and 658–664 with which the *package* does not conform and any amplifying information which may be useful to other *competent authorities*.
- (p) For *packages* containing more than 0.1 kg of uranium hexafluoride, a statement specifying those prescriptions of para. 632 that apply, if any, and any amplifying information which may be useful to other *competent authorities*.
- (q) A detailed listing of any supplementary operational controls required for preparation, loading, carriage, unloading and handling of the *consignment*, including any special stowage provisions for the safe dissipation of heat.
- (r) Reference to information provided by the applicant relating to the use of the *packaging* or to specific actions to be taken prior to *shipment*.
- (s) A statement regarding the ambient conditions assumed for purposes of *design* if these are not in accordance with those specified in paras 654, 655 and 664, as applicable.
- (t) A specification of the applicable *management system* as required in para. 306.

- (u) Any emergency arrangements deemed necessary by the *competent authority*.
- (v) If deemed appropriate by the *competent authority*, reference to the identity of the applicant.
- (w) Signature and identification of the certifying official.

#### VALIDATION OF CERTIFICATES

834. *Multilateral approval* may be by validation of the original certificate issued by the *competent authority* of the country of origin of the *design* or *shipment*. Such validation may take the form of an endorsement on the original certificate or the issuance of a separate endorsement, annex, supplement, etc., by the *competent authority* of the country *through or into* which the *shipment* is made.

## REFERENCES

*References are to editions that are current as of the time of publication of these Regulations.*

*Editions that supersede these may be adopted under national legislation.*

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- [10] UNITED NATIONS, Recommendations on the Transport of Dangerous Goods, Fifteenth Revised Edition (ST/SG/AC.10/1/Rev.15), UN, New York and Geneva (2007).
- [11] INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, Series 1 Freight Containers – Specifications and Testing – Part 1: General Cargo Containers for General Purposes, ISO 1496-1:1990(E), ISO, Geneva (1990); and subsequent Amendments 1:1993, 2:1998, 3:2005, 4:2006 and 5:2006.
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## Annex I

### SUMMARY OF APPROVAL AND PRIOR NOTIFICATION REQUIREMENTS

This summary reflects the contents of the Regulations for the Safe Transport of Radioactive Material (2009 Edition). The user's attention is called to the fact that there may be deviations (exceptions, additions, etc.) relative to:

- (a) National regulations relating to safety;
- (b) *Carrier* restrictions; and
- (c) National regulations relating to security, physical protection, liability, insurance, pre-notification and/or routeing and import/export/transit licensing.<sup>1</sup>

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<sup>1</sup> In particular, additional measures are taken to provide appropriate physical protection in the transport of nuclear material and to prevent acts without lawful authority which constitute the receipt, possession, use, transfer, alteration, disposal or dispersal of nuclear material and which cause or are likely to cause death or serious injury to any person or substantial damage to property (see Refs I-1 to I-6).

ANNEX I: SUMMARY OF APPROVAL AND PRIOR NOTIFICATION REQUIREMENTS (Part 1)

Key paragraphs in the Regulations	Class of <i>package</i> or material	<i>Competent authority</i> approval required		<i>Consignor</i> required to notify country of origin and countries en route <sup>a</sup> of each <i>shipment</i>
		Country of origin	Countries en route <sup>a</sup>	
577	Excepted <i>package</i> <sup>b</sup> by domestic post	No	Not applicable	No
	Excepted <i>package</i> <sup>b</sup> by international post	Yes, of consignor	No	No
	– <i>Package</i> design	No	No	No
	– <i>Shipment</i>	No	No	No
	– <i>Consignor</i>	Yes	Not applicable	No
	Excepted <i>package</i> <sup>b</sup> other than by post	No	No	No
	<i>LSA material</i> <sup>b,c</sup> and <i>SCO</i> <sup>c</sup>	No	No	No
	– <i>Type IP-1</i> , – <i>Type IP-2</i> or – <i>Type IP-3</i> <i>Type A</i> <sup>b,c</sup>	No	No	No

<sup>a</sup> Countries *through or into* which (but not over which) the *consignment* is transported (see para. 204 of the Regulations).

<sup>b</sup> If the *radioactive contents* are uranium hexafluoride in quantities of 0.1 kg or more, the approval requirements for *packages* containing it shall additionally apply (see paras 802 and 805 of the Regulations).

<sup>c</sup> If the *radioactive contents* are *fissile material* which is not excepted from the requirements for *packages* containing *fissile material*, then the approval requirements in paras 812 and 820 of the Regulations shall additionally apply.

## ANNEX I: SUMMARY OF APPROVAL AND PRIOR NOTIFICATION REQUIREMENTS (Part 2)

Key paragraphs in the Regulations	Class of package or material	Competent authority approval required		Consignor required to notify country of origin and countries en route <sup>a</sup> of each shipment
	<i>Type B(U)</i> <sup>b,c</sup>			
806, 820	– <i>Package design</i>	Yes	No <sup>d</sup>	
554, 555	– <i>Shipment</i>	No	No	(see Notes 1 and 2)
	<i>Type B(M)</i> <sup>b,c</sup>			
809, 820	– <i>Package design</i>	Yes	Yes	Yes
554, 555	– <i>Shipment</i>	(see Note 3)	(see Note 3)	(see Note 1)
	<i>Type C</i> <sup>b,c</sup>			
806, 820	– <i>Package design</i>	Yes	No	
554, 555	– <i>Shipment</i>	No	No	(see Notes 1 and 2)

<sup>a</sup> Countries *through or into* which (but not over which) the *consignment* is transported (see para. 204 of the Regulations).

<sup>b</sup> If the *radioactive contents* are *fissile material* which is not excepted from the requirements for *packages* containing *fissile material*, then the approval requirements in paras 812 and 820 of the Regulations shall additionally apply.

<sup>c</sup> If the *radioactive contents* are uranium hexafluoride in quantities of 0.1 kg or more, the approval requirements for *packages* containing it shall additionally apply (see paras 802 and 805 of the Regulations).

<sup>d</sup> If the *radioactive contents* are *low dispersible radioactive material* and the *package* is to be shipped by air, *multilateral approval* of the *package design* is required (see para. 806(b) of the Regulations).

**Note 1:** Before the first *shipment* of any *package* requiring *competent authority* approval of the *design*, the *consignor* shall ensure that a copy of the approval certificate for that *design* has been submitted to the *competent authority* of each country (see para. 554 of the Regulations).

**Note 2:** Notification required if the *radioactive contents* exceed  $3 \times 10^3 A_1$ , or  $3 \times 10^3 A_2$ , or 1000 TBq, whichever is the lower (see para. 555 of the Regulations).

**Note 3:** *Multilateral approval* of *shipment* required if the *radioactive contents* exceed  $3 \times 10^3 A_1$ , or  $3 \times 10^3 A_2$ , or 1000 TBq, whichever is the lower, or if controlled intermittent venting is allowed (see para. 820 of the Regulations).

ANNEX I: SUMMARY OF APPROVAL AND PRIOR NOTIFICATION REQUIREMENTS (Part 3)

Key paragraphs in the Regulations	Class of package or material	Competent authority approval required		Consignor required
		Country of origin	Countries en route <sup>a</sup>	to notify country of origin and countries en route <sup>a</sup> of each <i>shipment</i>
	<i>Packages for Fissile material</i>			
812	- <i>Package design</i>	Yes <sup>b</sup>	Yes <sup>b</sup>	
820	- <i>Shipment</i>			
	$\Sigma$ CSI $\leq$ 50	No <sup>c</sup>	No <sup>c</sup>	(see Notes 1 and 2)
	$\Sigma$ CSI > 50	Yes	Yes	(see Notes 1 and 2)
	<i>Packages containing 0.1 kg or more of uranium hexafluoride</i>			
805	- <i>Package design</i>	No <sup>d</sup>	No <sup>d</sup>	
820	- <i>Shipment</i>	No <sup>c</sup>	No <sup>c</sup>	(see Notes 1 and 2)

<sup>a</sup> Countries *through or into* which (but not over which) the *consignment* is transported (see para. 204 of the Regulations).

<sup>b</sup> *Designs* of packages containing *fissile material* may also require approval in respect of one of the other items in Annex I.

<sup>c</sup> *Shipments* may, however, require approval in respect of one of the other items in Annex I.

<sup>d</sup> Except that, after 31 December 2000, designs that only meet the requirement of para. 632 require *multilateral approval*, and after 31 December 2003, designs that meet the requirements of paras 629–631 require *unilateral approval* by the *competent authority* of the country of origin of the *design* (para. 805).

**Note 1:** The *multilateral approval* requirement for *fissile packages* and some uranium hexafluoride *packages* automatically satisfies the requirement of para. 554 of the Regulations.

**Note 2:** Notification required if the *radioactive contents* exceed  $3 \times 10^3 A_1$ , or  $3 \times 10^3 A_2$ , or 1000 TBq, whichever is the lower (see para. 555 of the Regulations).

## ANNEX I: SUMMARY OF APPROVAL AND PRIOR NOTIFICATION REQUIREMENTS (Part 4)

Key paragraphs in the Regulations	Class of <i>package</i> or material	<i>Competent authority</i> approval required		<i>Consignor</i> required to notify country of origin and countries en route <sup>a</sup> of each <i>shipment</i>
	<i>Special form radioactive material</i>	Country of origin	Countries en route <sup>a</sup>	
803	– <i>Design</i>	Yes	Yes	No
820	– <i>Shipment</i>	(see Note 1)	(see Note 1)	(see Note 1)
	<i>Low dispersible radioactive material</i>			
803	– <i>Design</i>	Yes	Yes	No
820	– <i>Shipment</i>	(see Note 1)	(see Note 1)	(see Note 1)
	<i>Special arrangement</i>			
802, 824, 555	– <i>Shipment</i>	Yes	Yes	Yes
	<i>Type B (U) packages for which design is approved under</i>			
816	1973 Regulations	Yes	Yes	(see Note 2)
817	1985 Regulations	Yes	Not until 31 December 2003 Yes thereafter	(see Note 2)

<sup>a</sup> Countries *through or into* which (but not over which) the *consignment* is transported (see para. 204 of the Regulations).

**Note 1:** See approval and prior notification requirements for applicable *package*.

**Note 2:** Before the first *shipment* of any *package* requiring *competent authority* approval of the *design*, the *consignor* shall ensure that a copy of the approval certificate for that *design* has been submitted to the *competent authority* of each country (see para. 554 of the Regulations).

## REFERENCES TO ANNEX I

[I-1] INTERNATIONAL ATOMIC ENERGY AGENCY, The Convention on the Physical Protection of Nuclear Material, INFCIRC/274/Rev.1, IAEA, Vienna (1980).

[I-2] INTERNATIONAL ATOMIC ENERGY AGENCY, The Physical Protection of Nuclear Material and Nuclear Facilities, INFCIRC/225/Rev.4(Corrected), IAEA, Vienna (1999).

[I-3] INTERNATIONAL ATOMIC ENERGY AGENCY, Guidance and Considerations for the Implementation of INFCIRC/225/Rev.4, The Physical Protection of Nuclear Material and Nuclear Facilities, IAEA-TECDOC-967(Rev.1), IAEA, Vienna (2000).

[I-4] INTERNATIONAL ATOMIC ENERGY AGENCY, Security in the Transport of Radioactive Material, IAEA Nuclear Security Series No. 9, IAEA, Vienna (2008).

[I-5] INTERNATIONAL ATOMIC ENERGY AGENCY, Code of Conduct on the Safety and Security of Radioactive Sources, IAEA, Vienna (2004).

[I-6] INTERNATIONAL ATOMIC ENERGY AGENCY, Guidance on the Import and Export of Radioactive Sources, IAEA, Vienna (2005).

Annex 1 needs to be modified to add a new section covering approval of exceptions for fissile material as well as approval of radionuclides.(CS-167, meeting report, P.23)

**Annex II****CONVERSION FACTORS AND PREFIXES**

This edition of the Regulations for the Safe Transport of Radioactive Material uses the International System of Units (SI). The conversion factors for non-SI units are:

**RADIATION UNITS**

Activity in becquerel (Bq) or curie (Ci)

$$1 \text{ Ci} = 3.7 \times 10^{10} \text{ Bq}$$

$$1 \text{ Bq} = 2.7 \times 10^{-11} \text{ Ci}$$

Dose equivalent in sievert (Sv) or rem

$$1 \text{ rem} = 1.0 \times 10^{-2} \text{ Sv}$$

$$1 \text{ Sv} = 100 \text{ rem}$$

**PRESSURE**

Pressure in pascal (Pa) or (kgf/cm<sup>2</sup>)

$$1 \text{ kgf/cm}^2 = 9.806 \times 10^4 \text{ Pa}$$

$$1 \text{ Pa} = 1.020 \times 10^{-5} \text{ kgf/cm}^2$$

**CONDUCTIVITY**

Conductivity in siemens per metre (S/m) or (mho/cm)

$$10 \text{ } \mu\text{mho/cm} = 1 \text{ mS/m}$$

or

$$1 \text{ mho/cm} = 100 \text{ S/m}$$

$$1 \text{ S/m} = 10^{-2} \text{ mho/cm}$$

## SI PREFIXES AND SYMBOLS

The decimal multiples and submultiples of a unit may be formed by prefixes or symbols, having the following meanings, placed before the name or symbol of the unit:

<b>MULTIPLYING FACTOR</b>	<b>PREFIX</b>	<b>SYMBOL</b>
1 000 000 000 000 000 000 = $10^{18}$	EXA	E
1 000 000 000 000 000 = $10^{15}$	PETA	P
1 000 000 000 000 = $10^{12}$	TERA	T
1 000 000 000 = $10^9$	GIGA	G
1 000 000 = $10^6$	MEGA	M
1 000 = $10^3$	KILO	k
100 = $10^2$	HECTO	h
10 = $10^1$	DECA	da
0.1 = $10^{-1}$	DECI	d
0.01 = $10^{-2}$	CENTI	c
0.001 = $10^{-3}$	MILLI	m
0.000 001 = $10^{-6}$	MICRO	$\mu$
0.000 000 001 = $10^{-9}$	NANO	n
0.000 000 000 001 = $10^{-12}$	PICO	p
0.000 000 000 000 001 = $10^{-15}$	FEMTO	f
0.000 000 000 000 000 001 = $10^{-18}$	ATTO	a

**Annex III****SUMMARY OF REQUIREMENTS FOR EXCLUSIVE USE**

*Exclusive use* applies for shipments of the following:

- (a) Unpackaged *LSA-I* material and *SCO-I* (see para. 518).
- (b) Liquid *LSA-I* material in *Type IP-1 package* (see para. 519 and Table 6).
- (c) Gaseous and/or liquid *LSA-II* material in *Type IP-2 package* (see 519 and Table 6).
- (d) *LSA-III* material in *Type IP-2 package* (see 519 and Table 6).
- (e) *Package* or *overpack* having an individual *TI* greater than 10 or an individual *CSI* greater than 50 (see paras 524 and 564).
- (f) *Package* or *overpack* having a *radiation level* at the contact of external surfaces that exceed 2 mSv/h (see para. 525).
- (g) Loaded *conveyance* or large *freight container* with a total sum of *TI* exceeding the values given in Table 11 (see subpara. 563 (a));
- (h) Loaded *conveyance* or large *freight container* with a total sum of *CSI* exceeding the values given in Table 12 for “not under *exclusive use*” (see para. 566).
- (i) *Type B(U)*, *Type B(M)* or *Type C package* which temperature of accessible surfaces higher than 50°C when subject to the ambient temperature of 38°C in absence of insolation (see para. 652).
- (j) Up to 45 g of *fissile nuclides* on a *conveyance* shipped as *exclusive use*, either packaged or unpackaged, per the provisions of 417(e), 518(d) and 580.

**CONTRIBUTORS TO DRAFTING AND REVIEW**

DRAFT

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(by paragraph number)

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