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REGULATIONS FOR THE SAFE TRANSPORT OF RADIOACTIVE MATERIALS, 1973 REVISED EDITION
IAEA, VIENNA, 1973
STI/PUB/323
FOREWORD

The Agency's Regulations for the Safe Transport of Radioactive Materials were first published in 1961, as Safety Series No. 6. Two subsequent reviews, carried out in consultation with Member States and the organizations concerned, resulted in the incorporation of additional material, relating mainly to package testing procedures and to the transport of large radioactive sources. The revised Regulations resulting from this work were published as Safety Series No. 6 (1964 Revised Edition) and Safety Series No. 6 (1967 Edition).

By 1969, the Agency's Regulations had been adopted by almost all international organizations concerned with transport and taken by many Member States as the basis of their own regulations. In that year, it was considered that the time had come to undertake a comprehensive review of the Regulations in the light of the accumulated operating experience.

This review and the subsequent revision were performed by a panel of experts which met for the first time in February 1970. The draft revision of the Regulations was sent to all Member States and to the appropriate international organizations for their comments. The panel met for the second time in October 1971 to consider the comments received, and the final revised Regulations were approved by the Board of Governors in September 1972.

In carrying out the revision, the guiding principles adopted were that the high standard of safety laid down in the Regulations should be maintained, and that a balance should be struck between the need to take account of the technical advances made and the operational experience gained over a period of almost ten years and the desirability of providing a fixed and lasting framework for the Regulations.

The new form in which the Regulations are presented is designed to make them easier both to use and to incorporate in other regulatory documents.

A set of schedules listing in abbreviated form the requirements to be met for the transport of specified types of consignment is appended to the Regulations. These schedules are intended merely as an aid to the user and do not contain any requirements in addition to those already appearing in the Regulations.

Technical material dealing with methods of meeting the regulatory requirements, for example methods of conducting certain
performance tests, has been deleted from the Regulations. This material, together with further material of an advisory character which was prepared by a panel of experts convened in November 1971, will be published as a companion volume to the Regulations. The volume, under the title 'Advisory Material for the Application of the IAEA Transport Regulations', will be published by the IAEA in 1973 as Safety Series No. 37. It is intended to review such material at intervals of about two and a half years with a view to ensuring that it adequately reflects developments in procedures and techniques.

With regard to the need for periodic reviews of the Regulations, it is foreseen at present that such reviews by a panel of experts will be required at intervals of ten years; Member States and the international organizations concerned will, however, be asked at intervals of five years whether they consider an earlier review necessary. The changes in the Regulations resulting from such reviews would be submitted to the Board for approval. The Director General can make changes of detail which do not require consideration by a panel of experts but which are needed from time to time to keep the Regulations up to date. Before such action is taken, the Governments of Member States will be given not less than 90 days' notice of the proposed changes and any comments received from the Governments will be taken into consideration.
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>VI</td>
<td>Exemptions of Fissile Materials from Fissile Class Package Prescriptions</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>General Provisions for Nuclear Safety</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Provisions Specific to Fissile Class I Packages</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>The individual package considered in isolation</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>Consignments of one or more packages</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>Examples of package designs requiring multilateral approval</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>Examples of package designs requiring unilateral approval</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>Provisions Specific to Fissile Class II Packages</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>The individual package considered in isolation</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Consignments of one or more packages</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td>Examples of package designs requiring multilateral approval</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td>Examples of package designs requiring unilateral approval</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td>Examples of package designs requiring no further competent authority approval</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>Provisions Specific to Fissile Class III Packages</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>Examples of package designs requiring multilateral approval</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>Examples of package designs requiring unilateral approval</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>Examples of package designs requiring no further competent authority approval</td>
<td>75</td>
</tr>
<tr>
<td>VII</td>
<td>Test and Inspection Procedures</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>Demonstration of Compliance with the Tests</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>Tests for Packaging</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>Number of specimens to be tested</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>Preparation of a specimen for testing</td>
<td>80</td>
</tr>
</tbody>
</table>
Testing the integrity of containment and shielding (707) ................................................................. 80

Target for the drop tests specified in paras 712, 716, 719 and 732 (708) ................................. 80

Tests for demonstrating ability to withstand normal conditions of transport (709-714) ........ 80

Additional tests for Type A packaging designed for liquids and gases (715-717) ......................... 82

Tests for demonstrating ability to withstand accident conditions in transport (718-721) ............ 83

Water in-leakage test for fissile material packages (722-724) ............................................. 84

Tests for integrity of containment and shielding (725) ................................................................. 84

TESTS FOR SPECIAL FORM RADIOACTIVE MATERIAL (726-737) .................................................. 85

General (726-731) ........................................................................................................... 85

Test methods (732-735) ................................................................................................... 85

Leaching assessment methods (736-737) ............................................................................. 86

INSPECTION REQUIREMENTS TO BE FULFILLED BEFORE FIRST SHIPMENT AND BEFORE EACH SHIPMENT OF CERTAIN TYPES OF PACKAGE (738-739) .................................................. 87

Before first shipment (738) ............................................................................................. 87

Before each shipment (739) ............................................................................................. 87

SECTION VIII - ADMINISTRATIVE REQUIREMENTS ........ 88

GENERAL (801) .................................................................................................................. 88

APPROVAL OF SPECIAL FORM RADIOACTIVE MATERIAL (802-803) ........................................... 88

APPROVAL OF PACKAGE DESIGNS (804-814) ................................................................. 88

Approval of Type B(U) package designs (including those for Fissile Class I, Class II and Class III packages which are also subject to paras 810-814) (804-806) ......................... 88

Approval of Type B(M) package designs (including those for Fissile Class I, Class II and Class III packages which are also subject to paras 810-814) (807-809) ................................................. 89

Approval of Fissile Class I, Class II and Class III package designs (810-814) ......................... 90
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# APPENDIX - SCHEDULES LISTING IN ABBREVIATED FORM THE REQUIREMENTS TO BE MET FOR THE TRANSPORT OF SPECIFIED TYPES OF CONSIGNMENT

1. **EMPTY PACKAGES** ................................................................. 99
2. **ARTICLES MANUFACTURED FROM NATURAL OR DEPLETED URANIUM OR NATURAL THORIUM** ................................................................. 102
3. **SMALL QUANTITIES OF RADIOACTIVE MATERIALS** ................................................................. 105
4. **INSTRUMENTS AND ARTICLES** ............................................. 108
5. **LOW SPECIFIC ACTIVITY MATERIALS (I)** ..................................... 111
6. **LOW SPECIFIC ACTIVITY MATERIALS (II)** .................................... 114
7. **LOW-LEVEL SOLID RADIOACTIVE MATERIALS** .......................................... 117
8. **MATERIALS IN TYPE A PACKAGES** ........................................ 120
9. **MATERIALS IN TYPE B(U) PACKAGES** .................................... 123
10. **MATERIALS IN TYPE B(M) PACKAGES** .................................... 127
11. **FISSILE MATERIALS** ................................................................. 130
12. **MATERIALS TRANSPORTED UNDER SPECIAL ARRANGEMENT** ............................................ 133

**LIST OF PARTICIPANTS OF PANELS** ............................................ 137
This publication is no longer valid
Please see http://www-ns.iaea.org/standards/
SECTION I — INTRODUCTION

PURPOSE AND SCOPE

101. The purpose of these Regulations is to establish standards of safety which provide an acceptable level of control of the radiation hazards to persons, property and the environment that are associated with the transport of radioactive material.

102. These Regulations shall apply to the transport by land, water or air, including transport on own account, of radioactive material other than that which is an integral part of the means of transport.

103. Transport shall be deemed to include any operation incidental to the whole course of carriage, such as loading, unloading and storage in transit. The term includes both normal transport and that under accident conditions.

104. These Regulations do not apply within establishments where the radioactive material is produced, used or stored, other than in the course of transport, and in respect of which other appropriate safety regulations are in force.

105. In the transport of radioactive materials, any other hazardous characteristics of these materials such as explosiveness, inflammability, pyrophoricity, chemical toxicity, and corrosiveness must be taken into account in such a manner as 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, as well as in compliance with these Regulations.

106. In certain parts of these Regulations, a particular action is required, but the responsibility for carrying out the action is not specifically assigned to any particular 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.
107. A consignment of radioactive materials which does not satisfy all the applicable requirements of these Regulations must be made only under special arrangement which requires multilateral approval. The special arrangements shall be adequate to ensure that the overall level of safety in transport is at least equivalent to that which would be provided if all the applicable requirements of the Regulations had been met.

108. The transport of explosive radioactive materials shall be permitted only under special arrangement.

DEFINITIONS FOR THE PURPOSE OF THESE REGULATIONS

$A_1$ and $A_2$

109. $A_1$ shall mean the maximum activity of special form radioactive material permitted in a Type A package. $A_2$ shall mean the maximum activity of radioactive material, other than special form radioactive material, permitted in a Type A package. These values are either listed in Table VII or may be derived in accordance with the procedure described in Section IV, paras 404-411.

Allowable number of packages

110. Allowable number$^1$ of packages shall mean the maximum number of Fissile Class II or III packages which may be grouped together in one place during transport or transit storage.

Carrier

111. Carrier shall mean any organization or private individual undertaking the conveyance of radioactive materials 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).

---

$^1$ When the group is made up of packages of different designs, the maximum number of packages shall be such that the following formula is satisfied:

$$\frac{n_1}{N_1} + \frac{n_2}{N_2} + \frac{n_3}{N_3} + \ldots \text{ shall not exceed } 1.$$  

In this formula $n_1$, $n_2$, $n_3$, ... are the numbers of packages for which the corresponding allowable numbers are $N_1$, $N_2$, $N_3$, ... respectively.
Competent authority

112. Competent authority shall mean any national or international authority designated or otherwise recognized as such for any purpose in connection with these Regulations.

Consignment

113. Consignment shall mean any package or packages or load of radioactive materials presented by a consignor for transport.

Consignor

114. Consignor shall mean any person who presents a consignment of radioactive materials for transport, and who is named as consignor in the transport documents. The term "person" includes individuals, organizations and governments.

Containment system

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

Design

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

Fissile material

117. Fissile material shall mean plutonium-238, plutonium-239, plutonium-241, uranium-233, uranium-235, or any material containing any of the foregoing. Unirradiated natural and depleted uranium do not come under this definition.

Freight container

118. Freight container shall mean an article of transport equipment designed to facilitate the carriage of goods by one or more modes of transport without intermediate reloading. Small freight
Containers are those which have either any overall outer dimension less than 1.5 m, or an internal volume of not more than 3.0 m³. All other freight containers are considered to be large freight containers. Each freight container shall meet the following requirements:

(a) It shall be of a permanent enclosed character and rigid and strong enough for repeated use.

(b) It shall be fitted with devices facilitating its handling, particularly in transfer from one mode of transport to another.

Full load

Full load shall mean any load:

(a) From a single consignor having the sole use of a vehicle, of a large freight container, or of an aircraft, or of a hold or compartment of an inland waterway craft, or of a hold, of a compartment or of a deck area of a seagoing vessel; and

(b) In respect of which all initial, intermediate and final loading and unloading is carried out by the consignor or consignee, subject to the requirements of paras 146-148.

Low-level solid radioactive material

Low-level solid radioactive material (LLS) shall mean any of the following:

(a) Solids (e.g. consolidated wastes, activated materials) in which:

(i) the activity under normal transport conditions is, and remains, distributed throughout a solid or a collection of solid objects, or is, and remains, uniformly distributed in a solid compact binding agent (such as concrete, bitumen, ceramic), and

(ii) the activity is, and remains, insoluble so that, even under loss of packaging, the loss of radioactive material per package resulting from the effects of wind, rain, etc., and from total immersion in water is limited to less than 0.1 A² in a period of one week, and

(iii) the estimated activity averaged throughout the radioactive material does not exceed $2 \times 10^{-3}$ A²/g.
(b) Objects of non-radioactive material contaminated with radioactive material, provided that the radioactive contamination is in a non-readily dispersible form and the level of contamination averaged over 1 m² (or the area of the surface if this is less than 1 m²) does not exceed

\[ 20 \mu\text{Ci/cm}^2 \]

for beta and gamma emitters and the low toxicity alpha emitters indicated in Table XI

\[ 2 \mu\text{Ci/cm}^2 \]

for other alpha emitters.

Low specific activity material

121. Low specific activity material (LSA) shall mean any of the following:

(a) Uranium or thorium ores and physical or chemical concentrates of those ores.
(b) Unirradiated natural or depleted uranium or unirradiated natural thorium.
(c) Tritium oxide in aqueous solutions, provided the concentration does not exceed 10 Ci/litre.
(d) Materials in which the activity, under normal transport conditions, is, and remains, uniformly distributed and in which the average estimated specific activity does not exceed \(10^{-4} \text{ A}_2/\text{g}\).
(e) Materials in which the activity is uniformly distributed and which, if reduced to the minimum volume under conditions likely to be encountered in transport, such as dissolution in water with subsequent recrystallization, precipitation, evaporation, combustion, abrasion, etc., would have an average estimated specific activity of no more than \(10^{-4} \text{ A}_2/\text{g}\).
(f) Objects of non-radioactive material contaminated with radioactive material, provided the non-fixed surface contamination does not exceed ten times the values given in Table XI and the contaminated object or the contamination on the object, if reduced to the minimum volume under conditions likely to be encountered in transport, such as dissolution in water with subsequent recrystallization, precipitation, evaporation, combustion, abrasion, etc., would have an average estimated specific activity of no more than \(10^{-4} \text{ A}_2/\text{g}\).
(g) Objects of non-radioactive material contaminated with radioactive material, provided that the radioactive contamination is in a non-readily dispersible form and the level of contamination averaged over 1 m² (or the area of the surface if this is less than 1 m²) does not exceed
1 μCi/cm² for beta and gamma emitters and the low toxicity alpha emitters indicated in Table XI; 0.1 μCi/cm² for other alpha emitters.

**Maximum normal operating pressure**

122. 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 of transport in the absence of venting, external cooling by an ancillary system or operational controls during transport.

**Multilateral approval**

123. Multilateral approval shall mean approval by both the relevant competent authority of the country of origin and of each country through or into which the consignment is to be transported.

**Non-fixed radioactive contamination**

124. Non-fixed radioactive contamination shall mean contamination that can be removed from a surface by wiping with a dry smear.

**Package**

125. Package shall mean the packaging together with its radioactive contents as presented for transport.

126. Type A package shall mean a Type A packaging together with its limited radioactive contents. A Type A package, since its contents are limited to $A_1$ or $A_2$, does not require competent authority approval.

127. Type B(U) package shall mean a Type B packaging, together with its radioactive contents, which, since it is designed in accordance with specified design and containment criteria, requires unilateral approval only of the package design and of any stowage provisions that may be necessary for heat dissipation.

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2 The term "through or into" specifically excludes "over"; i.e. the approval and notification requirements would not apply to a country over which radioactive materials are carried in aircraft, provided that there is no scheduled stop in that country.
128. Type B(M) package shall mean a Type B packaging, together with its radioactive contents, which, since its design fails to meet one or more of the specific additional design criteria for Type B(U) packages (see Section II, paras 234-241), requires multilateral approval of the package design and, in certain circumstances, of the conditions of shipment.

Packaging

129. Packaging shall mean the assembly of components necessary to ensure compliance with the packaging requirements of these Regulations. It may, in particular, consist of one or more receptacles, absorbent materials, spacing structures, radiation shielding and devices for cooling, for absorbing mechanical shocks and for thermal insulation. These devices may include the vehicle with a tie-down system when these are intended to form an integral part of the packaging.

130. Type A packaging shall mean a packaging that is designed to withstand the normal conditions of transport as demonstrated by the retention of the integrity of containment and shielding, to the extent required by these Regulations, after the tests specified in Section VII, paras 709-717, as appropriate.

131. Type B packaging shall mean a packaging that is designed to withstand the damaging effects of a transport accident as demonstrated by the retention of the integrity of containment and shielding, to the extent required by these Regulations, after the tests specified in Section VII, paras 709-721, as appropriate.

Radiation level

132. The radiation level shall mean the corresponding radiation dose-equivalent rate expressed in millirem per hour. Radiation levels may be determined by appropriate instruments together with any necessary conversion tables, or by calculation. Measured or calculated neutron flux densities may be converted into radiation levels by using the data provided in Table I.

Radioactive contents

133. Radioactive contents shall mean the radioactive material together with any contaminated solids, liquids and gases within the package.
SECTION I

TABLE I. NEUTRON FLUX DENSITIES TO BE REGARDED AS EQUIVALENT TO A RADIATION LEVEL OF 1 mrem/h

<table>
<thead>
<tr>
<th>Energy of neutron</th>
<th>Flux density equivalent to 1 mrem/h (n/cm² • s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal</td>
<td>268</td>
</tr>
<tr>
<td>5 keV</td>
<td>228</td>
</tr>
<tr>
<td>20 keV</td>
<td>112</td>
</tr>
<tr>
<td>100 keV</td>
<td>32</td>
</tr>
<tr>
<td>500 keV</td>
<td>12</td>
</tr>
<tr>
<td>1 MeV</td>
<td>7.2</td>
</tr>
<tr>
<td>5 MeV</td>
<td>7.2</td>
</tr>
<tr>
<td>10 MeV</td>
<td>6.8</td>
</tr>
</tbody>
</table>

Note: Flux densities equivalent for energies between those listed above should be obtained by interpolation.

Radioactive material

134. Radioactive material shall mean any material having a specific activity greater than 0.002 μCi/g.

Special form radioactive material

135. Special form radioactive material shall mean either an indispensible solid radioactive material or a sealed capsule containing radioactive material. The sealed capsule shall be so constructed that it can be opened only by destroying the capsule. Special form radioactive material shall meet the following requirements:

(a) It shall have at least one dimension not less than 5 mm
(b) It shall comply with the relevant test requirements specified in Section VII, paras 726-737.

The special form concept permits the inclusion of a greater activity in a Type A package.

Specific activity

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

**Transport index**

137. Transport index for a package shall mean:

(a) The number expressing the maximum radiation level in millirem per hour at 1 m from the external surface of the package; or

(b) For Fissile Class II and Class III packages, the larger of the following numbers:

the number expressing the maximum radiation level under (a) above; the number obtained by dividing 50 by the allowable number of such packages.

138. Transport index of a freight container shall mean the sum of the transport indices of all packages within the freight container [see, however, Section V, para. 532 (a)]. In the case of full loads, the number expressing the maximum radiation level in millirem per hour at 1 m from the external surface of the freight container may be used as an alternative, provided that, for freight containers containing Fissile Class II packages, the transport index shall be the larger of these two alternative numbers. For freight containers containing Fissile Class III packages, the transport index shall be 50 in all cases.

139. Transport index for low specific activity material or low level solid radioactive material transported as a full load, or transported by land or sea in a compact stack, or stored in a compact stack shall mean the number expressing the maximum radiation level at any point 1 m from the external surface of the load multiplied by the value in Table II appropriate to the cross-sectional area of the load. For uranium and thorium ores and concentrates, in the absence of actual measurements or calculations, the maximum radiation level at any point 1 m from the external surface of the load may be taken as:

- 40 mrem/h for ores and physical concentrates of uranium;
- 10 mrem/h for ores and physical concentrates of thorium;
- 2 mrem/h for chemical concentrates of uranium and thorium.
TABLE II. MULTIPLICATION FACTORS

<table>
<thead>
<tr>
<th>Size of full load</th>
<th>Multiplication factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement</td>
<td></td>
</tr>
<tr>
<td>(cross-sectional area measurements of the load perpendicular to the direction of interest)</td>
<td></td>
</tr>
<tr>
<td>1 m² and less</td>
<td>1</td>
</tr>
<tr>
<td>&gt; 1 m² to 5 m²</td>
<td>3</td>
</tr>
<tr>
<td>&gt; 5 m² to 20 m²</td>
<td>6</td>
</tr>
<tr>
<td>&gt; 20 m² to 100 m²</td>
<td>19</td>
</tr>
</tbody>
</table>

By multiplying the radiation level in mrem/h at 1 metre from the surface of the load or stack of packages by the multiplication factor in the above table, the number of the transport index may be obtained for a full load or a compact stack of packages of:
(a) uranium or thorium ores and physical or chemical concentrates of these ores, or
(b) unirradiated natural or depleted uranium or unirradiated natural thorium.

140. The number expressing the transport index shall be rounded up to the first decimal place.

Uncompressed gas

141. Uncompressed gas shall mean gas at a pressure not exceeding ambient atmospheric pressure at the time the containment system is closed.

Unilateral approval

142. Unilateral approval shall mean approval by the competent authority of the country of origin only.

Unirradiated uranium

143. Unirradiated uranium shall mean uranium containing not more than $10^{-6}$ g plutonium per g uranium-235 and a fission product activity of not more than 0.25 mCi of fission products per g uranium-235.

Uranium — natural, depleted, enriched

144. Natural uranium shall mean chemically separated uranium with the naturally occurring distribution of uranium isotopes (approximately 99.28% uranium-238, 0.72% uranium-235). Depleted
uranium shall mean uranium containing less than 0.72% uranium-235, with the remainder being uranium-238. Enriched uranium shall mean uranium containing more than 0.72% uranium-235, with the remainder being uranium-238. In all cases, a very small amount of uranium-234 is present.

Vehicle

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

LIMITATION OF EXPOSURE OF PERSONS TO RADIATION

146. The radiation exposure of transport and storage personnel shall be so controlled that none of them is likely to receive a radiation dose in excess of that permitted for members of the public. In special cases, arrangements may be made with the competent authority for radiological control to have such personnel classified as radiation workers and to comply with the necessary provisions.

147. The relevant competent authority shall arrange for periodic assessments to be carried out to ensure that the dose limitations for the various categories of person set down in the Basic Safety Standards for Radiation Protection of the International Atomic Energy Agency are not being exceeded. Radiation surveys shall also be undertaken when there is reason to suppose that these levels are being approached.

148. All relevant transport and storage personnel shall receive such instructions as are necessary concerning the hazards involved and the precautions to be observed.

GENERAL ACCIDENT PROVISIONS

149. In the event of accidents during the transport of radioactive material, emergency provisions3, as established by relevant national and/or international organizations, shall be observed in order to protect human health and the environment.

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3 Appropriate guidelines for such provisions are contained in Advisory Material for the Application of the IAEA Transport Regulations, Safety Series No. 37, IAEA, Vienna (1973).
SECTION II. PACKAGING AND PACKAGE DESIGN REQUIREMENTS

GENERAL DESIGN REQUIREMENTS FOR ALL PACKAGINGS AND PACKAGES

201. The packaging shall be so designed that the package can be easily handled and can be properly secured in or on the conveyance during transport.

202. A package of gross weight 10 kg or more and up to 50 kg shall be provided with means for manual handling.

203. A package of gross weight in excess of 50 kg shall be so designed as to enable safe handling to be done by mechanical means.

204. The design shall be such that any lifting attachments on the package, when used in the intended manner, do not impose unsafe stresses on the structure of the package; assessment shall take account of appropriate safety factors to cover 'snatch' lifting.

205. Attachments and any other features on the outer surface of the packaging which could be used to lift the packages shall be removable or otherwise rendered inoperable for transport or shall be designed to support the weight of the package in accordance with the requirements of para.204.

206. The outer layer of packaging shall be so designed as to avoid, as far as practicable, the collection and the retention of water.

207. The external surfaces of packaging shall, as far as practicable, be so designed and finished that they may be easily decontaminated.

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

[ADDITIONAL REQUIREMENTS FOR STRONG INDUSTRIAL PACKAGES]

ADDITIONAL REQUIREMENTS FOR TYPE A PACKAGES

210. The smallest overall external dimension of the packaging shall not be less than 10 cm.

211. The outside of every 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.

212. As far as practicable, packaging shall be designed so that the external surfaces are free from protruding features.

213. The design of the packaging shall take into account the variations in temperature to which the packaging may be subjected during transport and storage. In this respect, -40°C and 70°C shall be considered as satisfactory limits to be used in the selection of the materials; special attention, however, must be given to brittle fracture over this temperature range.

214. The design, fabrication and manufacturing techniques for welded, brazed, or other fusion joints shall be in accordance with national or international standards or with standards acceptable to the competent authority.

215. The package shall be capable of withstanding the effects of any acceleration, vibration or vibration resonance which may arise during normal 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.

216. 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.

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

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

219. The materials of the packaging and any components or structures shall be physically and chemically compatible with each other and with the package contents; account shall be taken of their behaviour under irradiation.
220. 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.

221. The containment system shall retain its radioactive contents under the reduction of ambient pressure to 0.25 kg/cm².

222. All valves, other than pressure relief valves, through which the radioactive contents could otherwise escape shall be protected against unauthorized operation and shall be provided with an enclosure to retain any leakage from the valve.

223. A radiation shield which encloses a component of the packaging 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.

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

225. Type A packaging shall be so designed that, if it were subjected to the tests specified in Section VII, paras 709-714, it would prevent:

   (a) loss or dispersal of the radioactive contents, and
   (b) any increase of the maximum radiation level recorded or calculated at the external surface for the condition before the test.

226. Type A packaging designed for liquids shall, in addition, be adequate to meet the conditions prescribed in para. 225 if the package is subjected to the tests specified in Section VII, paras 715-717. However, these tests are not required when enough absorbent material to absorb twice the volume of the liquid contents is within the containment and:

   (a) The absorbent material is within the radiation shield; or
   (b) The absorbent material is outside the radiation shield, provided that it can be shown that if the liquid contents were taken up by the absorbent material the resultant radiation level at the surface of the package would not exceed 200 mrem/h.
Type A packaging designed for compressed or uncompressed gases shall, in addition, prevent loss or dispersal of the radioactive contents if the packaging is subjected to the tests specified in Section VII, paras 715-717. Packages designed for tritium and argon-37, in gaseous form and in activities up to 200 Ci, shall be exempted from this requirement.

BASIC ADDITIONAL REQUIREMENTS FOR TYPE B(U) PACKAGES

Type B(U) packages shall be designed to meet all the additional requirements specified for Type A packages.

The packaging shall be so designed that if it were subjected to the tests in Section VII, paras 718-721, it would retain sufficient radiation shielding to ensure that the radiation level at 1 m from the surface of the package would not exceed 1 rem/h had the package contained sufficient iridium-192 to produce a radiation level of 10 mrem/h at 1 m from the surface before the tests. Where the use of the packaging is to be restricted to a particular radionuclide, that radionuclide may be used as the reference source in place of iridium-192. In addition, if the packaging is to be used for neutron emitters, an appropriate neutron reference source should also be used.

A Type B(U) package shall be so designed that, if it were subjected to the tests referred to below, it would:

(a) with regard to the tests specified in Section VII, paras 709-714, restrict the loss of radioactive contents to not more than $A_2 \times 10^{-6}$ per hour;

(b) with regard to the tests specified in Section VII, paras 718-721, restrict the accumulated loss of radioactive contents to not more than $A_2 \times 10^{-3}$ in a period of one week.

For (a) above, the evaluation shall take into account the external contamination limitations of Section V, para.502, and, for both (a), and (b) above, the $A_2$ values for noble gases shall be those for the uncompressed state.

Type B(U) packages shall be so designed, constructed, and prepared for shipment that, under the ambient conditions specified in para.232, they shall satisfy the conditions in (a) and (b) below.

(a) Heat generated within the package by the radioactive contents will not, under normal conditions encountered in transport (as demonstrated by the tests in Section VII), adversely affect
the package in such a way that it will 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 which may:

(i) alter the arrangement, the geometrical form or the physical state of the radioactive contents or, if the material is enclosed in a can or receptacle (for example, clad fuel elements), cause the can, receptacle or material to 'melt';
(ii) lessen the efficiency of the packaging through differential thermal expansion or cracking or melting of the radiation shielding material;
(iii) in combination with moisture, accelerate corrosion.

(b) The temperature of the accessible surfaces of a Type B(U) package shall not exceed 50°C in the shade unless the package is transported as a full load.

232. In applying para.231 above, the following conditions shall be assumed:

(a) ambient temperature 38°C;
(b) insolation data according to Table III.

233. Packaging which includes thermal protection for the purpose of satisfying the requirements of the thermal test specified in Section VII, para.720, shall be so designed that such protection

<table>
<thead>
<tr>
<th>TABLE III. INSOLATION DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form and location of surface</td>
</tr>
<tr>
<td>Flat surfaces transported horizontally:</td>
</tr>
<tr>
<td>- base</td>
</tr>
<tr>
<td>- other surfaces</td>
</tr>
<tr>
<td>Flat surfaces not transported horizontally:</td>
</tr>
<tr>
<td>- each surface</td>
</tr>
<tr>
<td>Curved surfaces</td>
</tr>
</tbody>
</table>

³ Alternatively, a sine function may be used, adopting an absorption coefficient and neglecting the effects of possible reflection from neighbouring objects.
will remain effective if the packaging is subjected to the tests specified in Section VII, paras 709-714 and 719. Any such protection on the exterior of the package shall not be rendered ineffective by conditions commonly encountered in normal handling or in accidents and not simulated in the tests referred to above, e.g. by ripping, cutting, skidding, abrasion or rough handling.

SPECIFIC ADDITIONAL REQUIREMENTS FOR TYPE B(U) PACKAGES

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

235. A package shall not incorporate a feature which is intended to allow continuous venting during transport.

236. The 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 Section VII, paras 709-714 and 718-721.

237. Where the maximum normal operating pressure (see Section I, para.122) of the containment system added to any differential pressure below mean sea-level atmospheric pressure to which any component of the packaging specified as part of the containment system may be subjected exceeds 0.35 kg/cm², that component shall be capable of withstanding a pressure of not less than one and a half times the sum of those pressures; the stress at this latter pressure shall not be more than 75% of the minimum yield strength and not more than 40% of the ultimate strength of that component at the maximum expected operating temperature.

238. When the package at the maximum normal operating pressure (see Section I, para.122) is subjected to the thermal test specified in Section VII, para.720, the pressure in any component of the packaging specified as a part of the containment system shall be demonstrated not to exceed the pressure which corresponds to the minimum yield strength of that component at the maximum temperature which it would be expected to reach in the test.

239. The package shall not have a maximum normal operating pressure (see Section I, para.122) in excess of 7 kg/cm² (gauge).

240. The maximum temperature of any surface readily accessible during transport of the package shall not exceed 82°C under normal conditions of transport (see also para.231(b)).
SECTION II

241. The containment system of a package containing liquid shall not be impaired if the package is subjected to a temperature of -40°C under normal conditions of transport.

ADDITIONAL REQUIREMENTS FOR TYPE B(M) PACKAGES

242. Type B(M) packages shall meet the requirements specified for Type A packages, the additional basic requirements for Type B(U) packages and, as far as practicable, the additional specific requirements for Type B(U) packages.

243. A Type B(M) package shall be so designed that, if it were subjected to the tests referred to in Section VII, paras 709-714 and 718-721, it would restrict the loss of radioactive contents to not more than the activity limits specified in Table IV. The evaluation with respect to the tests specified in Section VII, paras 709-714, shall take into account the external contamination limitations of Section V, para.502.

244. If the pressure in the containment system of a Type B(M) package could result in a stress exceeding, under the conditions of the tests in Section VII, paras 709-714 and 718-721, the minimum yield strength of any structural material of the containment system at the temperature which it would be expected to reach in the tests, the packaging shall be equipped with a pressure relief system to ensure that that minimum yield strength is not exceeded.

TABLE IV. ACTIVITY LIMITS FOR LOSS OF RADIOACTIVE CONTENTS FROM TYPE B(M) PACKAGES

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Type B(M) packages not designed for continuous venting</th>
<th>Type B(M) packages specially designed to allow continuous venting</th>
</tr>
</thead>
<tbody>
<tr>
<td>After the tests in Section VII, paras 709-714</td>
<td>$A_2 \times 10^{-5}$ per hour</td>
<td>$A_1 \times 5 \times 10^{-5}$ per hour</td>
</tr>
<tr>
<td>After the tests in Section VII, paras 718-721</td>
<td>Krypton-85: 10 000 Ci in 1 week</td>
<td>Krypton-85: 10 000 Ci in 1 week</td>
</tr>
<tr>
<td></td>
<td>Other radionuclides: $A_2$ in 1 week</td>
<td>Other radionuclides: $A_2$ in 1 week</td>
</tr>
</tbody>
</table>

The $A_2$ values used for noble gases shall be for the uncompressed state.
SECTION III - ITEMS EXEMPT FROM SPECIFIED PRESCRIPTIONS;
LOW SPECIFIC ACTIVITY MATERIAL;
LOW-LEVEL SOLID RADIOACTIVE MATERIAL

ITEMS EXEMPT FROM THE PRESCRIPTIONS

[301.1] The materials, instruments, articles and empty packages which meet the general requirements in paras 302-305 and the relevant specific requirements in paras 306-313 shall be exempt from all the provisions of Sections II to VIII, except for the general design requirements specified in Section II, paras 201-208, and Section V, paras 547-554. Explosive radioactive materials shall not be exempt. However, all materials possessing any of the hazardous characteristics mentioned in Section I, para.105, of these Regulations are subject to the transport regulations for dangerous goods that are relevant to these characteristics.

General requirements

302. The radiation level at any point on the external surface of the package shall not exceed 0.5 mrem/h.

303. The non-fixed radioactive contamination on any external surface of the package shall not exceed the levels in Table XI.

304. Except for the articles listed in para.312, packages containing uranium-235 shall not contain more than 15 g of that isotope and the smallest external dimension of such packages shall not be less than 10 cm.

305. Exempt items transported under the provisions of this Section shall be described in the transport documents as "exempt radioactive materials".

Materials

306. Radioactive materials whose activities do not exceed the relevant exemption limits listed in the column headed "Materials - package limits" in Table V shall be exempt, provided that:

(a) these materials are packaged in such a manner that, during the normal conditions of transport, there can be no leakage of radioactive material from the package; and
### TABLE V. EXEMPTION LIMITS

<table>
<thead>
<tr>
<th>Nature of contents</th>
<th>Instruments and articles</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Item limits$^a$</td>
<td>Package limits</td>
</tr>
<tr>
<td><strong>Solids</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special form</td>
<td>$10^{-2} A_1$</td>
<td>$A_1$</td>
</tr>
<tr>
<td>Other forms</td>
<td>$10^{-2} A_2$</td>
<td>$A_2$</td>
</tr>
<tr>
<td><strong>Liquids</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tritiated water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$&lt; 0.1$ Ci/1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>between</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$0.1$ Ci/1 and 1.0 Ci/1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$&gt; 1.0$ Ci/1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other liquids</td>
<td>$10^{-3} A_2$</td>
<td>$10^{-1} A_2$</td>
</tr>
<tr>
<td><strong>Gases</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tritium$^b$</td>
<td>20 Ci</td>
<td>200 Ci</td>
</tr>
<tr>
<td>Special form</td>
<td>$10^{-3} A_1$</td>
<td>$10^{-2} A_1$</td>
</tr>
<tr>
<td>Other forms</td>
<td>$10^{-3} A_2$</td>
<td>$10^{-2} A_2$</td>
</tr>
</tbody>
</table>

$^a$ For mixtures of radionuclides in items, see Section IV, paras 406-411.

$^b$ These values also apply to tritium in activated luminous paint and tritium adsorbed on solid carriers.

(b) the packaging bears the marking "Radioactive" in such a manner that a warning of the presence of radioactive material is visible on opening the package.

**Instruments and articles**

307. Instruments and manufactured articles such as clocks, electronic tubes or apparatus having radioactive material as a component part shall be exempt, provided that these instruments and articles are securely packed and the conditions stated in paras 308-311 are fulfilled.

308. The radiation level at 10 cm from any point on the external surface of any unpacked instrument or article shall not exceed 10 mrem/h.
309. The activity of an instrument or article shall not exceed the relevant exemption limit listed in the column headed "Instruments and articles — item limits" in Table V.

310. The total activity per package shall not exceed the relevant exemption limit listed in the column headed "Instruments and articles — package limits" in Table V.

311. Each instrument or article (except radioluminescent time-pieces or devices) shall bear the marking "Radioactive".

Articles manufactured from natural or depleted uranium and natural thorium

312. Manufactured articles in which the sole radioactive material is natural or depleted uranium or natural thorium shall be exempt, provided that the outer surface of the uranium or thorium is enclosed in an inactive sheath made of metal or some other substantial material.

Empty packages

313. A package which has contained radioactive materials shall be exempt provided:
   (a) it is in good condition and securely closed;
   (b) it has been decontaminated internally so that the level of non-fixed contamination does not exceed one hundred times the levels in Table XI; and
   (c) any labels which may have been on it in conformity with Section V, para.519, are no longer visible.

ALTERNATIVE TRANSPORT ARRANGEMENTS FOR LOW SPECIFIC ACTIVITY MATERIAL

314. Low specific activity material as defined in Section I, para.121(a), (b), (c), (e) and (f) shall be transported either:
   (a) in bulk as a full load when the total activity does not exceed the limits of Table VI and when loaded into a vehicle, inland waterway craft or seagoing vessel (transport by aircraft is not allowed) in such a manner that, under normal conditions of transport, there will be no leakage out of the vehicle, or out of the hold or compartment of the inland waterway craft, or out of the part of the seagoing vessel in which it is loaded; or
in packages which:

(i) meet the requirements of Section II, paras 201-208 and 210, and of Section V, paras 501-509; and
(ii) meet the requirements of Section V, paras 510-513, except that the contents shall be indicated as "Radioactive LSA"; or

(c) in packages not necessarily meeting any of the requirements of Section II and transported as a full load, provided that:

(i) in the case of air transport, the packages meet the requirements of Section V, para.502; and
(ii) the packages are stencilled or otherwise marked with the notation "Radioactive LSA"; and
(iii) the total activity of the load does not exceed the limits in Table VI.

### TABLE VI. ACTIVITY LIMITS FOR TRANSPORT OF LOW SPECIFIC ACTIVITY MATERIAL

<table>
<thead>
<tr>
<th>Nature of material</th>
<th>Vehicle, aircraft, hold, compartment or deck area of a seagoing vessel</th>
<th>Hold or compartment of an inland waterway craft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solids</td>
<td>No limit</td>
<td>$100 \times A_2$</td>
</tr>
<tr>
<td>Triated water</td>
<td>50 000 Ci</td>
<td>5 000 Ci</td>
</tr>
<tr>
<td>Other liquids and gases</td>
<td>$100 \times A_2$ (see also Section V, paras 538-541)</td>
<td>$100 \times A_2$</td>
</tr>
</tbody>
</table>

Low specific activity material defined in Section I, para.121(d) and (g) shall be transported as a full load in packages which meet the requirements of para.314(b)(i). Packages shall be stencilled or otherwise marked with the notation "Radioactive LSA".

316. The low specific activity materials defined in Section I, para.121(b), shall, in massive solid form, be packed or stowed so as to prevent movements of any kind which may cause abrasion of the material; in other solid forms, they shall be contained in an inert metal cover or other substantial sheath so that the surface of the material is not exposed.
ALTERNATIVE TRANSPORT ARRANGEMENTS FOR LOW-LEVEL SOLID RADIOACTIVE MATERIAL

317. Low-level solid radioactive material defined in Section I, para.120, shall be transported as a full load in strong industrial packagings which meet the requirements of Section II, paras 201-210. The packages must be stencilled or otherwise marked with the notation "Radioactive LLS".

ADDITIONAL REQUIREMENTS FOR FISSILE MATERIALS

318. In all cases where the low specific activity material or the low-level solid radioactive material is also a fissile material, the additional requirements for packages containing fissile materials set out in Section VI shall apply.
SECTION IV – ACTIVITY LIMITS

ACTIVITY LIMITS FOR TYPE A AND TYPE B PACKAGES

401. Type A packages shall not contain activities greater than the following:
(a) For special form radioactive material - A₁.
(b) For all other radioactive materials - A₂.

A₁ and A₂ are determined in accordance with the procedures described in paras 403-411.

402. The only limits on the activities contained in Type B(U) and Type B(M) packages are those prescribed on their approval certificates.

DETERMINATION OF A₁ AND A₂

Single radionuclides

403. For single radionuclides of known identity, the values of A₁ and A₂ are given in Table VII.

404. For any single radionuclide whose identity is known, but which is not listed in Table VII, the values of A₁ and A₂ shall be determined according to the procedure given below:
(a) If the radionuclide emits only one type of radiation, A₁ shall be determined according to the rules in (i), (ii), (iii) and (iv) below. For radionuclides emitting different kinds of radiation, A₁ shall be the most restrictive value of those determined for each individual radiation. However, in both cases A₁ shall be restricted to a maximum of 1000 Ci. If a parent nuclide decays into a shorter lived daughter, of a half-life not greater than 10 days, A₁ shall be calculated for both the parent and the daughter, and the more limiting of the two values should be assigned to the parent nuclide.

(i) For gamma emitters, A₁ is determined by the expression:

\[ A₁ = \frac{9}{\Gamma} \text{ curies} \]

where \( \Gamma \) is the gamma-ray constant, corresponding to the dose in R/h at 1 m per Ci; the number 9 results from the choice of 1 rem/h at a distance of 3 m as the reference dose-equivalent rate.
Table VII. $A_1$ and $A_2$ Values for Radionuclides

<table>
<thead>
<tr>
<th>Symbol of radionuclide</th>
<th>Element and atomic number</th>
<th>$A_1$(Ci)</th>
<th>$A_2$(Ci)</th>
<th>Specific activity (Ci/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{227}$Ac</td>
<td>Actinium (89)</td>
<td>1000</td>
<td>0.003</td>
<td>$7.2 \times 10^5$</td>
</tr>
<tr>
<td>$^{230}$Ac</td>
<td></td>
<td>10</td>
<td>4</td>
<td>$2.2 \times 10^6$</td>
</tr>
<tr>
<td>$^{105}$Ag</td>
<td>Silver (47)</td>
<td>40</td>
<td>40</td>
<td>$3.1 \times 10^4$</td>
</tr>
<tr>
<td>$^{110m}$Ag</td>
<td></td>
<td>7</td>
<td>7</td>
<td>$4.7 \times 10^3$</td>
</tr>
<tr>
<td>$^{111}$Ag</td>
<td></td>
<td>100</td>
<td>100</td>
<td>$1.6 \times 10^5$</td>
</tr>
<tr>
<td>$^{241}$Am</td>
<td>Americium (95)</td>
<td>8</td>
<td>0.008</td>
<td>$3.2 \times 10^5$</td>
</tr>
<tr>
<td>$^{243}$Am</td>
<td></td>
<td>8</td>
<td>0.008</td>
<td>$1.9 \times 10^{-1}$</td>
</tr>
<tr>
<td>$^{37}$Ar (compressed or uncompressed)</td>
<td>Argon (18)</td>
<td>1000</td>
<td>1000</td>
<td>$1.0 \times 10^5$</td>
</tr>
<tr>
<td>$^{41}$Ar (uncompressed)</td>
<td></td>
<td>20</td>
<td>20</td>
<td>$4.3 \times 10^7$</td>
</tr>
<tr>
<td>$^{41}$Ar (compressed)</td>
<td></td>
<td>1</td>
<td>1</td>
<td>$1.1 \times 10^6$</td>
</tr>
<tr>
<td>$^{73}$As</td>
<td>Arsenic (33)</td>
<td>1000</td>
<td>400</td>
<td>$2.4 \times 10^4$</td>
</tr>
<tr>
<td>$^{74}$As</td>
<td></td>
<td>20</td>
<td>20</td>
<td>$1.0 \times 10^5$</td>
</tr>
<tr>
<td>$^{75}$As</td>
<td></td>
<td>10</td>
<td>10</td>
<td>$1.6 \times 10^6$</td>
</tr>
<tr>
<td>$^{77}$As</td>
<td></td>
<td>300</td>
<td>300</td>
<td>$1.1 \times 10^6$</td>
</tr>
<tr>
<td>$^{211}$At</td>
<td>Astatine (85)</td>
<td>200</td>
<td>7</td>
<td>$2.1 \times 10^6$</td>
</tr>
<tr>
<td>$^{193}$Au</td>
<td>Gold (79)</td>
<td>200</td>
<td>200</td>
<td>$3.8 \times 10^5$</td>
</tr>
<tr>
<td>$^{196}$Au</td>
<td></td>
<td>30</td>
<td>30</td>
<td>$1.2 \times 10^5$</td>
</tr>
<tr>
<td>$^{198}$Au</td>
<td></td>
<td>40</td>
<td>40</td>
<td>$2.5 \times 10^5$</td>
</tr>
<tr>
<td>$^{209}$Au</td>
<td></td>
<td>200</td>
<td>200</td>
<td>$2.1 \times 10^5$</td>
</tr>
<tr>
<td>$^{137}$Ba</td>
<td>Barium (56)</td>
<td>40</td>
<td>40</td>
<td>$8.7 \times 10^4$</td>
</tr>
<tr>
<td>$^{133}$Ba</td>
<td></td>
<td>40</td>
<td>10</td>
<td>$4.0 \times 10^2$</td>
</tr>
<tr>
<td>$^{140}$Ba</td>
<td></td>
<td>20</td>
<td>20</td>
<td>$7.3 \times 10^4$</td>
</tr>
<tr>
<td>$^7$Be</td>
<td>Beryllium (4)</td>
<td>300</td>
<td>300</td>
<td>$3.5 \times 10^5$</td>
</tr>
<tr>
<td>$^{206}$Bi</td>
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<td>$^{197}$Mpt</td>
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### TABLE VII (cont.)

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<th>Symbol of radionuclide</th>
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<th>(A_2) (CI)</th>
<th>(\dagger) Specific activity (CI/g)</th>
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<tr>
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<td>(^{46})Sc</td>
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<td>1000</td>
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<td>T (activated luminous paint)</td>
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### TABLE VII (cont.)

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<th>( A_1(\text{Ci}) )</th>
<th>( A_2(\text{Ci}) )</th>
<th>Specific activity (Ci/g)</th>
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<td>T (tritiated water)</td>
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<td>T (other forms)</td>
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<tr>
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### TABLE VII (cont.)

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<th>Symbol of radionuclide</th>
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<th>$A_2(\text{Cl})$</th>
<th>Specific activity (Cl/g)</th>
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<td>30</td>
<td>$2.5 \times 10^4$</td>
</tr>
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</table>
(ii) For X-ray emitters, $A_1$ is determined by the atomic number of the nuclide:

$$
\begin{align*}
\text{for } Z \leq 55 & - A_1 = 1000 \text{ Ci} \\
\text{for } Z > 55 & - A_1 = 200 \text{ Ci}
\end{align*}
$$

(iii) For beta emitters, $A_1$ is determined by the maximum beta energy ($E_{\text{max}}$) according to Table IX.

(iv) For alpha emitters $A_1$ is determined by the expression:

$$
A_1 = 1000 A_3
$$

where $A_3$ is the value listed in Table X.

(b) $A_2$ shall be the more restrictive of the following two values:

(1) the corresponding $A_1$ and (2) the value $A_3$ obtained from Table X.

405. For any single radionuclide whose identity is unknown, the value of $A_1$ shall be taken to be 2 Ci and the value of $A_2$ shall be taken to be 0.002 Ci. However, if the atomic number of the radionuclide is known to be less than 82, the value of $A_1$ shall be taken to be 10 Ci and the value of $A_2$ shall be taken to be 0.4 Ci.
### TABLE VIII. ACTIVITY-MASS RELATIONSHIPS FOR URANIUM AND NATURAL THORIUM\(^a\)
(This table is referred to in Table VII)

<table>
<thead>
<tr>
<th>Radioactive material (wt% (^{235})U present)</th>
<th>Ci/g</th>
<th>g/Ci</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uranium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.45</td>
<td>(5.0 \times 10^{-7})</td>
<td>(2.0 \times 10^6)</td>
</tr>
<tr>
<td>0.72 (natural)</td>
<td>(7.06 \times 10^{-7})</td>
<td>(1.42 \times 10^6)</td>
</tr>
<tr>
<td>1.0</td>
<td>(7.6 \times 10^{-7})</td>
<td>(1.3 \times 10^6)</td>
</tr>
<tr>
<td>1.5</td>
<td>(1.0 \times 10^{-6})</td>
<td>(1.0 \times 10^6)</td>
</tr>
<tr>
<td>5.0</td>
<td>(2.7 \times 10^{-6})</td>
<td>(3.7 \times 10^5)</td>
</tr>
<tr>
<td>10.0</td>
<td>(4.8 \times 10^{-6})</td>
<td>(2.1 \times 10^5)</td>
</tr>
<tr>
<td>20.0</td>
<td>(1.0 \times 10^{-5})</td>
<td>(1.0 \times 10^5)</td>
</tr>
<tr>
<td>35.0</td>
<td>(2.0 \times 10^{-5})</td>
<td>(5.0 \times 10^4)</td>
</tr>
<tr>
<td>50.0</td>
<td>(2.5 \times 10^{-5})</td>
<td>(4.0 \times 10^4)</td>
</tr>
<tr>
<td>90.0</td>
<td>(5.8 \times 10^{-5})</td>
<td>(1.7 \times 10^4)</td>
</tr>
<tr>
<td>93.0</td>
<td>(7.0 \times 10^{-6})</td>
<td>(1.4 \times 10^4)</td>
</tr>
<tr>
<td>95.0</td>
<td>(9.1 \times 10^{-5})</td>
<td>(1.1 \times 10^4)</td>
</tr>
<tr>
<td>Natural thorium</td>
<td>(2.2 \times 10^{-7})</td>
<td>(4.6 \times 10^6)</td>
</tr>
</tbody>
</table>

\(^a\) The figures for uranium include the activity of uranium-234 which is concentrated during the enrichment process. The activity for thorium includes the equilibrium concentration of thorium-228.

### TABLE IX. RELATIONSHIP BETWEEN \(A_1\) AND \(E_{\text{max}}\) FOR BETA EMITTERS

<table>
<thead>
<tr>
<th>(E_{\text{max}}) (MeV)</th>
<th>(A_1) (Ci)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(&lt;0.5)</td>
<td>1000</td>
</tr>
<tr>
<td>(0.5 \text{ - } &lt;1.0)</td>
<td>300</td>
</tr>
<tr>
<td>(1.0 \text{ - } &lt;1.5)</td>
<td>100</td>
</tr>
<tr>
<td>(1.5 \text{ - } &lt;2.0)</td>
<td>30</td>
</tr>
<tr>
<td>(&gt;2.0)</td>
<td>10</td>
</tr>
</tbody>
</table>
TABLE X. RELATIONSHIP BETWEEN $A_3$ AND THE ATOMIC NUMBER OF THE RADIONUCLIDE

<table>
<thead>
<tr>
<th>Atomic number</th>
<th>$A_3$</th>
<th>Half-life less than 1000 days</th>
<th>Half-life 1000 days to $10^6$ years</th>
<th>Half-life greater than $10^6$ years</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 81</td>
<td>3 Ci</td>
<td>50 mCi</td>
<td>3 Ci</td>
<td></td>
</tr>
<tr>
<td>82 and above</td>
<td>2 mCi</td>
<td>2 mCi</td>
<td>3 Ci</td>
<td></td>
</tr>
</tbody>
</table>

Mixtures of radionuclides, including radioactive decay chains

406. For mixed fission products the following activity limits may be assumed, if a detailed analysis of the mixture is not carried out:

$$A_1 = 10 \text{ Ci}$$
$$A_2 = 0.4 \text{ Ci}$$

407. A single radioactive decay chain in which the radionuclides are present in their naturally occurring proportions and in which no daughter nuclide has a half-life either longer than 10 days or longer than that of the parent nuclide shall be considered a single radionuclide. The activity to be taken into account and the $A_1$ or $A_2$ value to be applied shall be those corresponding to the parent nuclide of that chain. However, in the case of radioactive decay chains in which any daughter nuclide has a half-life either longer than 10 days or greater than that of the parent nuclide, the parent and such daughter nuclides shall be considered as mixtures of different nuclides.

408. In the case of a mixture of different radionuclides, where the identity and activity of each radionuclide are known, the permissible activity of each radionuclide $R_1, R_2 \ldots R_n$ shall be such that $F_1 + F_2 + \ldots F_n$ is not greater than unity, where

$$F_1 = \frac{\text{Total activity of } R_1}{A_i(R_1)}$$
$$F_2 = \frac{\text{Total activity of } R_2}{A_i(R_2)}$$
$$F_n = \frac{\text{Total activity of } R_n}{A_i(R_n)}$$
$A_i(R_1, R_2 \cdots R_n)$ is the value of $A_1$ or $A_2$ as appropriate for the nuclide $R_1, R_2 \cdots R_n$.

409. When the identity of each radionuclide is known but the individual activities of some of the radionuclides are not known, the formula given in para. 408 shall be applied to establish the values of $A_1$ or $A_2$ as appropriate. All the radionuclides whose individual activities are not known (their total activity will, however, be known) shall be classed in a single group and the most restrictive value of $A_1$ and $A_2$ applicable to any one of them shall be used as the value of $A_1$ or $A_2$ in the denominator of the fraction.

410. Where the identity of each radionuclide is known but the individual activity of none of the radionuclides is known, the most restrictive value of $A_1$ or $A_2$ applicable to any one of the radionuclides present shall be adopted as the applicable value.

411. When the identity of none of the nuclides is known, the value of $A_1$ shall be taken to be $2 \text{ Ci}$ and the value of $A_2$ shall be taken to be $0.002 \text{ Ci}$. However, if alpha emitters are known to be absent, the value of $A_2$ shall be taken to be $0.4 \text{ Ci}$. 
SECTION V - CONTROLS FOR TRANSPORT AND STORAGE IN TRANSIT

MIXED PACKING

501. A package containing radioactive material shall not contain any other items except such articles and documents as are necessary for the use of the radioactive material. Such items may be included, provided that there is no interaction between them and the packaging or contents that would reduce the safety of the package.

NON-FIXED RADIOACTIVE CONTAMINATION

502. The non-fixed radioactive contamination on any external surface of the package shall be kept as low as practicable and, under normal conditions of transport, shall not exceed the levels laid down in Table XI. The level of non-fixed radioactive contamination shall be determined by wiping an area of 300 cm² of the surface concerned by hand with a dry filter paper, or a wad of dry cotton wool, or any other material of this nature.

TABLE XI. MAXIMUM PERMISSIBLE LEVELS OF NON-FIXED RADIOACTIVE CONTAMINATION

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Maximum permissible level (see Note 1) (µCi/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural and depleted uranium and natural thorium</td>
<td>$10^{-3}$</td>
</tr>
<tr>
<td>only</td>
<td></td>
</tr>
<tr>
<td>Beta and gamma emitters and the low toxicity</td>
<td>$10^{-4}$</td>
</tr>
<tr>
<td>alpha emitters specified in Note 2 below</td>
<td></td>
</tr>
<tr>
<td>All other alpha emitters</td>
<td>$10^{-5}$</td>
</tr>
</tbody>
</table>

Notes: (1) The above levels are permissible when averaged over any area of 300 cm² of any part of the surface.

(2) Low toxicity alpha emitters:
- uranium-235 or uranium-238; thorium-232; thorium-228 and thorium-230 when diluted to a specific activity of the same order as that of natural uranium and natural thorium; radionuclides with a half-life of less than 10 days.
CATEGORIES

Packages and freight containers (both large and small) shall be in one of the following three categories:

**Category I-WHITE**

- **Packages**: When the radiation level originating from the package at any time during normal transport does not exceed 0.5 mrem/h at any location on the external surface of the package, and the package does not belong to Fissile Class II or III.

- **Freight containers**: When the freight container contains packages of radioactive materials none of which is in a category higher than Category I-WHITE.

**Category II-YELLOW**

- **Packages**: When the radiation level limit in para.504 is exceeded, or the package belongs to Fissile Class II, provided that:
  - (a) the radiation level originating from the package at any time during normal transport does not exceed 50 mrem/h at any location on the external surface of the package; and
  - (b) the transport index at any time during normal transport does not exceed 1.0.

- **Freight containers**: When the transport index of the freight container at any time during normal transport does not exceed 1.0, and when it contains no packages of Fissile Class III.

**Category III-YELLOW**

- **Packages**: When the radiation level limit in para.506(a) is exceeded, or when the package belongs to Fissile Class II or Class III, or when the package is being transported under special arrangement, provided that:
  - (a) the radiation level originating from the package at any time during normal transport shall not exceed 200 mrem/h at any location on the external surface of the package, except that, for full load shipments under the conditions specified in paras 534(a) and 537(a), the maximum allowable level shall be 1000 mrem/h; and
  - (b) the transport index at any time during normal transport shall not exceed 10 unless the package is being transported as a full load.
Freight containers: when the transport index of the freight container, at any time during normal transport, exceeds 1.0, or when the container carries packages belonging to Fissile Class III, or when it is being transported under special arrangement. In the case of a freight container containing Fissile Class III packages, the total transport index of the container shall be assumed to be 50.

LABELLING AND MARKING

510. Each package and freight container (both large and small) shall bear at least two labels which conform to the models given in para.519, Figs 2, 3 or 4, according to the category (see paras 503-509) of that package or freight container.

511. The labels shall be affixed to two opposite sides of the outside of the package, or on the outside of all four sides of the freight container.

512. Each label shall be completed with the information required, i.e. with the content, activity, and transport index.

513. In the case of full loads, each such label on the package or freight container shall be additionally marked (by overstamp or legible writing) with the words "Full Load".

514. Each package of gross weight exceeding 50 kg shall have its gross weight plainly and durably marked on the outside of the package.

515. Each package which conforms to a Type A packaging design shall be plainly and durably marked on the outside of the package with "Type A".

516. Each package which conforms to a design approved under Section VIII, paras 804-814, shall be plainly and durably marked on the outside of the package with the identification mark allocated to that design by the competent authority and, in the case of a Type B(U) or Type B(M) package design, with "Type B(U)" or "Type B(M)".

517. Each package which conforms to a Type B(U) or Type B(M) 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.

518. Packages containing radioactive materials having additional hazardous characteristics shall be additionally labelled to indicate
these characteristics as required by the relevant transport regulations (see Section I, para. 105).

519. The labels for packages of radioactive materials and placards for vehicles carrying radioactive material shall conform to the appropriate model shown in Figs 1-5. The only inscriptions which shall be mandatory shall be those shown in these models.

![Basic trefoil symbol with proportions based on a central circle of radius 4 mm](image)

**Fig. 1**

Basic trefoil symbol with proportions based on a central circle of radius 4 mm
Fig. 2

Category I-White label
Dimensions given here are the actual ones to be used
Category II: Yellow label

Dimensions given here are the actual ones to be used.
Category III- Yellow label
Dimensions given here are the actual ones to be used
SECTION V

45

Placard for vehicles

The over-all shape of the placard may be diamond, rectangular or square as indicated by the dashed lines. Minimum dimensions are given; when larger dimensions are used the relative proportions must be maintained.

A contrasting colour other than white may be used for the background.

The lower half of the placard may be utilized for other hazard identification codes, letters, etc. as required by relevant national regulations, conventions, etc. pertaining to emergency incident information systems for all classifications of dangerous goods.
SECTION V

SEGREGATION OF RADIOACTIVE MATERIALS FROM PERSONS AND FILMS

520. To ensure that the requirements of Section I, para.146, are observed, radioactive materials, in the course of transport, except those in Category I-WHITE packages, shall be kept separated from living accommodation, from regularly occupied working spaces and from spaces that may be continually occupied by passengers or the public. They shall also be so separated from undeveloped photographic films or plates so that these are not exposed to more than 10 mR. The appropriate segregation distances shall be derived on the basis of these assumptions.

STORAGE IN TRANSIT

521. Packages of radioactive materials shall not be stored near dangerous goods with which common loading or storage is prohibited (see Section I, para.105 and Section V, para.528).

522. The number of Category II-YELLOW and Category III-YELLOW packages and freight containers stored in any one storage area, such as a transit area, terminal building, store-room or assembly yard, shall be so limited that the total sum of the transport indices in any individual group of such packages or freight containers does not exceed 50. Groups of such packages and freight containers shall be stored so as to maintain a spacing of at least 6 metres from other groups of such packages or freight containers.

523. Where control of package accumulations is not effected by reference to transport indices, there shall not be more than 50 Category II-YELLOW or 5 Category III-YELLOW packages in any one group of packages. Where packages of both categories are present, one Category III-YELLOW package shall be taken as equivalent to ten Category II-YELLOW packages.

524. Except in the case of Fissile Class II or Class III packages, the limitations in para.522 do not apply to packages marked "RADIOACTIVE LSA" and containing low specific activity material or those marked "RADIOACTIVE LLS" and containing low-level solid radioactive material when they are maintained in a compact stack or in freight containers.

525. Mixing of different kinds of packages, including Fissile Class I packages with Fissile Class II packages, is permitted.
TRANSPORT

General requirements

526. Consignments of radioactive materials shall be securely stowed.

527. Provided that its average surface heat flux does not exceed 15 W/m² and that the surrounding cargo is not in sacks or bags, a package may be carried among packaged general cargo or within freight containers without any special stowage provisions except as may be specially required by the competent authority in an appropriate certificate.

528. Packages of radioactive materials shall not be loaded in the same vehicle, aircraft or hold or compartment of an inland waterway craft, or hold, compartment or deck area of a seagoing vessel as dangerous goods which, on the basis of the relevant transport regulations, could adversely affect the integrity of the packaging of these radioactive materials under accident conditions.

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

530. Mixing of different kinds of packages, including Fissile Class I packages with Fissile Class II packages, is permitted.

531. Accumulation of packages and freight containers shall be controlled as follows:

(a) For both packages and freight containers, the number of packages and freight containers shall be so limited that the total sum of the transport indices in any vehicle, aircraft or inland waterway craft does not exceed 50. For seagoing vessels, see paras 538 and 539. Where this control of packages is not effected by reference to transport indices, see para.523.

(b) In the case of full loads, the limits under (a) above shall not apply. For Fissile Class II or III consignments, or mixtures thereof, the full load shall not include more than the allowable number of packages (see p.2, footnote 1). However, for seagoing vessels, see para.541.
The following additional requirements shall apply to large freight containers:

(a) Persons loading packages into large freight containers shall determine the transport index as provided in Section I, para. 138. The total sum of the transport indices of the packages in any one large freight container shall not exceed 50. However, if it is known that the freight container does not contain Fissile Class II or III packages, the total transport index may exceed 50, provided that the persons loading the freight containers have determined by the use of appropriate monitoring equipment that the radiation levels outside the freight container from the inside packages at any time during normal conditions of transport shall not exceed 200 mrem/h at any point on, and 10 mrem/h at any point 2 metres from, the outside surface of the freight container.

(b) The normal segregation distances as necessary to ensure compliance with Section V, para. 520, shall apply.

(c) Each large freight container shall display the placard shown in Section V, Fig. 5, on all four vertical walls.

Additional requirements relating to transport by rail

533. Railway vehicles carrying packages or freight containers labelled with any of the labels shown in Section V, Figs 2, 3 or 4, or carrying full-load consignments of any radioactive materials, shall display the placard shown in Section V, Fig. 5, on the outside of each of the two external lateral walls. In the case of a rail vehicle with no sides that is carrying large freight containers, the placards on the freight containers will suffice.

534. In the case of full loads of packages, the radiation levels shall not exceed:

(a) 1000 mrem/h at any point on the external surface of the package, provided that:

(i) the vehicle is equipped with an enclosure which, during normal transport, prevents the access of unauthorized persons to the interior of the enclosure;
(ii) provisions are made to secure the packages so that their position within the vehicle remains fixed during normal transport;
(iii) there are no loading or unloading operations between the beginning and end of the transport.
Under other conditions, the radiation level at any point on the external surface of the package shall not exceed 200 mrem/h.

(b) 200 mrem/h at any point on the outer surface of the railway vehicle, including the upper and lower surfaces, or, in the case of an open railway vehicle, at any point on the vertical planes projected from the outer edges of the railway vehicle, on the upper surface of the load, and on the lower external surface of the railway vehicle; and

(c) 10 mrem/h at any point 2 m from the vertical planes represented by the outer lateral surfaces of the railway vehicle, or, if the load is transported in an open railway vehicle, at any point 2 m from the vertical planes projected from the outer edges of the railway vehicle.

Additional requirements relating to transport by road

535. Except for the driver and assistants, no persons shall be carried in road vehicles carrying radioactive materials.

536. Road vehicles carrying packages or freight containers labelled with any of the labels shown in Figs 2, 3 or 4, or carrying full-load consignments of any radioactive materials shall display the placard shown in Fig. 5 on the outside of each of the two external lateral walls and on the external rear wall. In the case of a flat road vehicle without sides that is carrying large freight containers, the placards on the freight containers will suffice.

In the case of full loads of packages, the radiation level shall not exceed:

(a) 1000 mrem/h at any point on the external surface of the package, provided that:

(i) the vehicle is equipped with an enclosure which, during normal transport, prevents the access of unauthorized persons to the interior of the enclosure;
(ii) provisions are made to secure the packages so that their position within the vehicle remains fixed during normal transport;
(iii) there are no loading or unloading operations between the beginning and end of the transport.

Under other conditions, the radiation level at any point on the external surface of the package shall not exceed 200 mrem/h.
SECTION V

(b) 200 mrem/h at any point on the outer surface of the road vehicle, including the upper and lower surfaces, or, in the case of an open road vehicle, at any point on the vertical planes projected from the outer edges of the road vehicle, on the upper surface of the load, and on the lower external surface of the road vehicle.

(c) 10 mrem/h at any point 2 m from the vertical planes represented by the outer lateral surfaces of the road vehicle or, if the load is transported in an open road vehicle, at any point 2 m from the vertical planes projected from the outer edges of the road vehicle.

(d) 2 mrem/h in any normally occupied position of the vehicle, unless persons occupying such positions are provided with special health supervision and personnel monitoring devices.

Additional requirements relating to transport by seagoing vessels

538. The accumulation of packages not in large freight containers shall be controlled as follows:

(a) The number of packages not in large freight containers aboard a vessel shall be so limited that the total sum of the transport indices in any hold or defined deck area does not exceed 50 and the total sum aboard a single vessel does not exceed 200.

(b) Where this control is not effected by reference to transport indices, see para.523.

539. The number of large freight containers containing packages of radioactive materials shall be so limited that the total sum of the transport indices in any hold or deck area does not exceed 200, with no limitation on the total sum aboard a single vessel, provided that:

(a) the total sum of transport indices in any individual freight container, or group of freight containers, does not exceed 50;

(b) each such freight container or group of freight containers is handled and stowed in such a manner that groups are separated from each other by at least 6 metres; the intervening space may be occupied by other large freight containers not containing radioactive materials.

540. The limitations specified in para.538 shall not apply to consignments of either low specific activity material or low-level solid radioactive material described on the package labels as "RADIOACTIVE LSA" or "RADIOACTIVE LLS", respectively.
541. The limitations in paras 538 and 539 do not apply when an entire hold or deck area of a vessel, or the entire vessel, is reserved or chartered for the exclusive use of a single consignor under full load conditions, provided that the number of Fissile Class II and III packages aboard the vessel does not exceed the allowable number. Otherwise, normal segregation distances as necessary to ensure compliance with para.520 shall apply.

Additional requirements relating to transport by air

542. Type B(M) packages shall not be transported on passenger-carrying aircraft.

543. The temperature of the accessible surfaces of Type B(U) and Type B(M) packages shall not exceed 50°C even when transported as a full load.

544. Continuously vented Type B(M) packages, packages which require external cooling by an ancillary cooling system, and packages subject to operational controls during transport shall not be transported by air.

545. Liquid pyrophoric radioactive materials shall not be transported by air.

546. Packages having a surface radiation level in excess of 200 mrem/h, otherwise allowed under Section V, para.508(a), for full load conditions, shall not be transported by air except by special arrangement.

Transport by post

547. A consignment of radioactive materials that conforms with the exemption provisions of Section III, paras 301-313, of these Regulations and in which the activity content does not exceed one tenth of those listed in Table V may be accepted for domestic movement by national postal authorities, subject to such additional requirements as those authorities may prescribe.

548. A consignment of radioactive materials that conforms with the exemption provisions of Section III, paras 301-313, and in which the activity content does not exceed one tenth of those listed in Table V may be accepted for international movement by post, subject, in particular, to the following additional requirements:4

---

4 These requirements are prescribed by the convention of the Universal Postal Union.
(a) it shall be deposited with the postal service only by consignors authorized by the national competent authority;
(b) it shall be dispatched by the quickest route, normally by air;
(c) it shall carry on the outside a white label bearing the words "radioactive materials", which shall be crossed out if the package 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; and
(e) the name and address of the consignor and the content of the consignment shall be indicated on the internal packaging.

LEAKING PACKAGES AND CONTAMINATED CONVEYANCES

549. If it is evident that a package of radioactive materials may have leaked, access to the package should be restricted and a qualified person called in as soon as possible to make a survey to assess the extent of the spread of contamination. The scope of the survey should include the package, the conveyance, the adjacent loading and unloading areas, and, if necessary, all other material which has been carried in the conveyance. "Conveyance", as used here, includes all transport vehicles, aircraft, or vessels used during the suspect portion of the carriage. When necessary, additional steps for the protection of human health, in accordance with provisions established by the relevant competent authority, should be taken to overcome and minimize the consequences of such a leak.

550. Packages leaking in excess of allowable limits for normal conditions of transport must not be forwarded until repaired or reconditioned and decontaminated.

551. Conveyances and equipment used routinely for the carriage of radioactive materials 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 materials are carried.

552. Except as provided for in para.553, any conveyance, equipment, or part thereof which has become contaminated in the course of carriage of radioactive materials shall be decontaminated as soon as possible by a qualified person and shall not be re-used unless the non-fixed radioactive contamination is below the levels specified in Table XI and the conveyances, equipment or part there-
of have been declared safe in respect of residual radiation levels by a qualified person.

553. Conveyances or compartments used for the bulk transport of low specific activity materials in full load shall not be used for other goods until decontaminated as specified in para. 552.

CUSTOMS

554. Customs operations involving examination of the contents of a package in which radioactive materials are being transported 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 at its final destination, be restored to its original condition.
SECTION VI - FISSILE MATERIALS

EXEMPTIONS OF FISSILE MATERIALS FROM FISSILE CLASS PACKAGE PRESCRIPTIONS

601. Packages containing radioactive materials which are also fissile materials, except for the cases specified in (a) to (g) below, shall be designed to comply with the requirements of this Section.

(a) Packages containing individually not more than 15 g of uranium-233, uranium-235, plutonium-238, plutonium-239, plutonium-241, or 15 g of any combination of these radionuclides, provided that the smallest external dimension of the package is not less than 10 cm. When material is transported in bulk, the quantity limitations may apply to the vehicle, inland waterway craft or part of a seagoing vessel.

(b) Packages containing only natural or depleted uranium which has been irradiated in thermal reactors only.

(c) Packages containing homogeneous hydrogenous solutions or mixtures satisfying the conditions listed in Table XII. When material is transported in bulk, the quantity limitations shall apply to the vehicle, inland waterway craft or part of a seagoing vessel.

(d) Packages containing uranium enriched in uranium-235 to a maximum of 1% by weight, and with a total plutonium and uranium-233 content of up to 1% of the mass of uranium-235, provided that the fissile materials are distributed homogeneously throughout the material. In addition, if uranium-235 is present in metallic or oxide forms, it shall not form a lattice arrangement within the package.

(e) Packages containing any fissile material, provided that they do not contain more than 5 g of fissile material in any 10-litre volume. The materials must at least be packed in packages which will maintain the limitations on fissile material distribution during normal transport.

(f) Packages containing individually not more than 1 kg of total plutonium, of which not more than 20% by mass may consist of plutonium-239, plutonium-241, or any combination of those radionuclides.

(g) Packages containing liquid solutions of uranyl nitrate enriched in uranium-235 to a maximum of 2% by weight, with a tolerance for plutonium and uranium-233 of up to 0.1% of the mass of uranium-235.

The packages shall also comply with the other relevant parts of these Regulations.
TABLE XII. LIMITATIONS ON HOMOGENEOUS HYDROGENOUS SOLUTIONS OR MIXTURES

<table>
<thead>
<tr>
<th>Parameters</th>
<th>$^{235}$U only</th>
<th>Any other fissile material (including mixtures)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum $H/X^a$</td>
<td>5200</td>
<td>5200</td>
</tr>
<tr>
<td>Maximum concentration of fissile nuclide in g/l</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Maximum mass of fissile nuclide in g/package</td>
<td>800 $^b$</td>
<td>500</td>
</tr>
</tbody>
</table>

$^a$ Where $H/X$ is the ratio of the number of hydrogen atoms to the number of atoms of fissile nuclide.

$^b$ With a tolerance for Pu and $^{232}$U of not more than 1% of the mass of $^{235}$U.

GENERAL PROVISIONS FOR NUCLEAR SAFETY

602. All fissile materials shall be packed and shipped in such a manner that criticality$^5$ cannot be reached under any foreseeable circumstances of transport. In particular, the following contingencies shall be considered:

(a) water leaking into packages;
(b) the loss of efficiency of built-in neutron absorbers or moderators;
(c) possible rearrangement of contents into more reactive arrays, either within the package or as a result of loss from the package;
(d) reduction of spaces between packages or contents;
(e) packages becoming immersed in water or buried in snow;
(f) possible increase of reactivity due to temperature changes.

603. In addition, for irradiated nuclear fuel or unspecified fissile material, the following assumptions shall be made:

$^5$ In applying criticality data, obtained by either calculation or experiment, to the criticality clearance of transport packages, allowance should be made separately for any inaccuracy in the data or uncertainty concerning their validity.
(a) Irradiated nuclear fuel for which the degree of irradiation is not known and whose reactivity decreases with burn-up shall be regarded as unirradiated for criticality control. If its reactivity increases with burn-up, it shall be regarded as irradiated to the point of maximum reactivity. The reactivity of nuclear fuel for which the degree of irradiation is known may be assessed accordingly.

(b) For unspecified fissile materials such as residues or scrap whose enrichment, mass, concentration, moderation ratio or density is not known or cannot be identified, the assumption shall be that each parameter that is not known has the value which gives the maximum reactivity under credible conditions.

604. Packages of fissile materials, except as provided in para.601, (a) to (g), shall be classified as follows:

(a) Fissile Class I: packages which are nuclearly safe in any number and in any arrangement under all foreseeable circumstances of transport;

(b) Fissile Class II: packages which, in limited number, are nuclearly safe in any arrangement under all foreseeable circumstances of transport;

(c) Fissile Class III: packages which are nuclearly safe under all foreseeable circumstances of transport by reason of special precautions, or special administrative or operational controls imposed upon the transport of the consignment.

PROVISIONS SPECIFIC TO FISSILE CLASS I PACKAGES

605. Each Fissile Class I package shall be so designed that, if it were subjected to the tests specified in Section VII, paras 709-714:

(a) water would not leak into any part of the package unless water inleakage to that part, to the optimum foreseeable extent, had been assumed for the purposes of para.709; and

(b) the configuration of the contents and the geometry of the containment system would not be altered so as to increase the reactivity significantly.

606. Fissile Class I packages shall satisfy the nuclear safety criteria specified in Section VI, paras 607-610.
The individual package considered in isolation

607. The following conditions shall be assumed:

(a) the package is "damaged" (for this purpose "damaged" shall mean the evaluated or demonstrated condition of the package if it had been subjected either to the tests specified in Section VII, paras 709-714 and 718-720 followed by that in paras 722-724, or to the tests specified in Section VII, paras 709-714 and 721, whichever combination is the more limiting); and

(b) water can leak into all void spaces of the packages, including those within the containment system, except that, where the package design incorporates special features to prevent the leakage of water into certain void spaces even as a result of human error, absence of water from those void spaces may be assumed. Such special features may include either:

(i) multiple high standard water barriers, each of which would remain leaktight if the package were subjected to the combinations of tests specified in para.607(a); or

(ii) high degree of quality control in the production and maintenance of packaging, coupled with special tests to demonstrate closure of each package before shipment.

608. The package shall be sub-critical by an adequate margin\(^6\) under the conditions specified in para.607, the physical and chemical characteristics being taken into account, including any change in those characteristics which could occur under the conditions of para.607, and with the conditions of moderation and reflection as specified below:

(a) with the material within the containment system:

(i) the most reactive configuration and moderation foreseeable under the conditions of para.607;

(ii) close full water reflection of the containment system or such greater reflection of the containment system as may additionally be provided by the surrounding material of the packaging, and, in addition,

---

\(^6\) For example, if mass of fissile material is an appropriate parameter for control, an adequate margin would be represented by limiting the mass to 80% of that mass which would be critical in a similar system.
(b) if any part of the material escapes from the containment system under the conditions of para.607:

the most reactive configuration and moderation considered credible;
close full water reflection of the material.

Consignments of one or more packages

609. Any number of undamaged packages of one design in any arrangement shall be sub-critical; for this purpose "undamaged" shall mean the condition in which the packages are designed to be presented for transport.

610. 250 such packages when "damaged" shall be sub-critical if stacked together in any arrangement and closely reflected on all sides of the stack by the equivalent of water (for this purpose "damaged" shall mean the evaluated or demonstrated condition of the package if it had been subjected either to the tests specified in Section VII, paras 709-714 and 718-720, followed by that in paras 722-724, or to the tests specified in Section VII, paras 709-714 and 721, whichever combination is the more limiting). Hydrogenous moderation\(^7\) between packages, and water leakage into the package consistent with the test results shall be assumed to the extent which results in the greatest reactivity.

Examples of package designs requiring multilateral approval

Example I

611. The calculation shall be based on the following requirements:

(a) Each individual package shall comply with the criteria under paras 605 and 607 above.
(b) The package, whether damaged or undamaged, shall be such as to shield the fissile contents from thermal neutrons.
(c) When a parallel beam of neutrons having an energy spectrum as specified in Table XIII is incident at any angle on an undamaged package, the surface multiplication factor for epithermal neutrons, i.e. the ratio of the number of epithermal neutrons leaving the package to the number of epithermal neutrons entering the package,

\(^7\) The hydrogenous moderation can be considered to consist of either a uniform layer of full density water surrounding each package or water at an appropriate density homogeneously interspersed between packages.
### TABLE XIII. NEUTRON ENERGY SPECTRUM

<table>
<thead>
<tr>
<th>Neutron energy $E$</th>
<th>Fraction of neutrons with energy less than $E$</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.0 MeV</td>
<td>1.000</td>
</tr>
<tr>
<td>2.4 MeV</td>
<td>0.802</td>
</tr>
<tr>
<td>1.1 MeV</td>
<td>0.590</td>
</tr>
<tr>
<td>0.55 MeV</td>
<td>0.460</td>
</tr>
<tr>
<td>0.26 MeV</td>
<td>0.373</td>
</tr>
<tr>
<td>0.13 MeV</td>
<td>0.319</td>
</tr>
<tr>
<td>43 keV</td>
<td>0.263</td>
</tr>
<tr>
<td>10 keV</td>
<td>0.210</td>
</tr>
<tr>
<td>1.6 keV</td>
<td>0.156</td>
</tr>
<tr>
<td>0.26 keV</td>
<td>0.111</td>
</tr>
<tr>
<td>42 eV</td>
<td>0.072</td>
</tr>
<tr>
<td>5.5 eV</td>
<td>0.036</td>
</tr>
<tr>
<td>0.4 eV</td>
<td>0</td>
</tr>
</tbody>
</table>

*a* The spectrum is the epithermal portion of the equilibrium spectrum emergent from packages incorporating 5 cm thickness of wood in a critical array of such packages.

shall be less than one, and the energy spectrum of the neutrons that are emitted by the package in an infinite array shall be no harder than that of the incident neutrons.

(d) The package design shall comply with the criteria in para.610.

**Examples of package designs requiring unilateral approval**

**Example I**

612. The packaging shall be constructed so that the fissile contents are surrounded by a layer of material capable of absorbing all thermal neutrons incident on it\(^8\) and this neutron absorbent layer is

\(^8\) This layer can consist of cadmium at least 0.38 mm thick equivalent to 0.325 g cadmium per cm\(^2\).
then surrounded by a thickness of at least 10.2 cm of wood having a minimum hydrogen content of 6.5 wt%, so that the minimum external dimension over the wood is 30.5 cm.

613. The packaging shall be so constructed that when "damaged" (for this purpose "damaged" shall have the meaning assigned in para.607) the fissile contents will remain surrounded by the neutron absorbent layer, the neutron absorbent layer will remain surrounded by the wood, and wood will not be lost to an extent which would reduce the thickness of the remaining wood to less than 9.2 cm or reduce the minimum external dimension over the remaining wood to less than 28.5 cm.

614. The contents shall not exceed that permissible mass of fissile material shown in Tables XIV to XXII which is consistent with: (a) the nature of the material; (b) the maximum moderation; and (c) the maximum diameter (or volume) which could occur if the package were "damaged" (for this purpose "damaged" shall have the meaning assigned in para.607).

Note: For the values given in Tables XIV to XXII, the calculations used were based on Annex II of Regulations for the Safe Transport of Radioactive Materials, Safety Series No.6, IAEA, Vienna (1961), and are restrictive by comparison with those specified in para.611. Hence, the values can be used safely in association with packaging complying with the description in paras 612 and 613, although a detailed calculation of permissible values in accordance with para.611 may yield less restrictive values for the same packaging.

PROVISIONS SPECIFIC TO FISSILE CLASS II PACKAGES

615. Each Fissile Class II package shall be designed so that if it were subjected to the tests specified in Section VII, paras 709-714:

(a) neither the volume nor any spacing on the basis of which nuclear safety for the purpose of para.619(a) has been assessed would suffer more than 5% reduction, and the construction of the package would not permit the entry of a 10-cm cube;

(b) water would not leak into any part of the package unless water leakage to that part, to the optimum foreseeable extent, had been assumed in assessing the allowable number for the purposes of para.619(a).
## AQUEOUS SOLUTIONS OF URANYL\(^{(a)}\) FLUORIDE OR URANYL\(^{(a)}\) NITRATE

Permissible mass of uranium per package as a function of the packaging wood density

<table>
<thead>
<tr>
<th>Inner receptacle diameter not exceeding (cm)</th>
<th>Wood density not exceeding 1.25 g/cm(^3) and not less than (g/cm(^3))</th>
<th>kg uranium per package</th>
</tr>
</thead>
<tbody>
<tr>
<td>10, 16</td>
<td>No limit</td>
<td></td>
</tr>
<tr>
<td>No Limit</td>
<td>0.084, 0.120</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.157, 0.193</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.231, 0.267</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.301, 0.335</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.370, 0.400</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.429, 0.456</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.478, 0.498</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inner receptacle volume not exceeding (l)</th>
<th>Wood density not exceeding 1.25 g/cm(^3) and not less than (g/cm(^3))</th>
<th>kg uranium per package</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.152, 0.380</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.084, 0.223</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.084, 0.120</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.084, 0.120</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0.084, 0.120</td>
<td></td>
</tr>
<tr>
<td>No Limit</td>
<td>0.084, 0.120</td>
<td></td>
</tr>
</tbody>
</table>

\(\text{a)}\) Uranium which includes no \(^{233}\text{U}\) and no more than 93.15 wt. \% \(^{235}\text{U}\).
TABLE XV

NON-HYDROGENOUS URANIUM\(^{(a)}\) COMPOUNDS OR MIXTURES IN WHICH THE URANIUM-235 CONCENTRATION DOES NOT EXCEED 4.8 g/cm\(^3\)\(^{(b)}\)

(Including unmoderated uranium metal of uranium-235 enrichment not exceeding 25 wt.%)

Permissible mass of uranium per package as a function of the packaging wood density

<table>
<thead>
<tr>
<th>1</th>
<th>Limited by maximum internal diameter of inner receptacle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner receptacle diameter not exceeding (cm)</td>
<td>Wood density not exceeding 1.25 g/cm(^3) and not less than 0.6 g/cm(^3)</td>
</tr>
<tr>
<td></td>
<td>kg uranium per package</td>
</tr>
<tr>
<td>10.16</td>
<td>No limit</td>
</tr>
<tr>
<td>No limit</td>
<td>0.69</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2</th>
<th>Limited by maximum internal volume of inner receptacle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner receptacle volume not exceeding (l)</td>
<td>Wood density not exceeding 1.25 g/cm(^3) and not less than (g/cm(^2))</td>
</tr>
<tr>
<td></td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>kg uranium per package</td>
</tr>
<tr>
<td>3</td>
<td>7.0</td>
</tr>
<tr>
<td>4</td>
<td>4.8</td>
</tr>
<tr>
<td>5</td>
<td>3.63</td>
</tr>
<tr>
<td>7</td>
<td>1.41</td>
</tr>
<tr>
<td>No limit</td>
<td>0.69</td>
</tr>
</tbody>
</table>

\(^{(a)}\) Uranium which includes no \(^{233}\)U and no more than 93\(\frac{1}{2}\) wt.% \(^{235}\)U.

\(^{(b)}\) Mixtures containing beryllium or deuterium are excluded and the mass of carbon must not exceed five times the allowed mass of uranium.
### NON-HYDROGENOUS URANIUM (a) COMPOUNDS OR MIXTURES IN WHICH THE URANIUM-235 CONCENTRATION DOES NOT EXCEED 9.6 g/cm³ (b)

(INCLUDING UNMODERATED URANIUM METAL OF URANIUM-235 ENRICHMENT NOT EXCEEDING 50 wt. %)

**Permissible mass of uranium per package as a function of the packaging wood density**

<table>
<thead>
<tr>
<th>Inner receptacle diameter not exceeding (cm)</th>
<th>Wood density not exceeding 1.25 g/cm³ and not less than (g/cm³)</th>
<th>kg uranium per package</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.5</td>
<td></td>
<td>No limit</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>No limit</td>
</tr>
<tr>
<td>8.5</td>
<td></td>
<td>No limit</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No limit</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Limited by maximum internal diameter of inner receptacle

<table>
<thead>
<tr>
<th>Inner receptacle volume not exceeding (l)</th>
<th>Wood density not exceeding 1.25 g/cm³ and not less than (g/cm³)</th>
<th>kg uranium per package</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No limit</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Limited by maximum internal volume of inner receptacle

(a) Uranium which includes no ²³⁵U and no more than 93.5 wt. % ²³⁵U.
(b) Mixtures containing beryllium or deuterium are excluded and the mass of carbon must not exceed five times the allowed mass of uranium.
TABLE XVII

UNMODERATED URANIUM\(^{\text{a}}\) METAL

Permissible mass of uranium per package as a function of the packaging wood density.

<table>
<thead>
<tr>
<th>Inner receptacle diameter not exceeding (cm)</th>
<th>Wood density not exceeding 1.25 g/cm(^2) and not less than (g/cm(^2))</th>
<th>kg uranium per package</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>0.6 0.65 0.7 0.75 0.8 0.85 0.9 0.95 1.0 1.05 1.1 1.15 1.2 1.25</td>
<td>No limit</td>
</tr>
<tr>
<td>6.5</td>
<td>6 7</td>
<td>No limit</td>
</tr>
<tr>
<td>7</td>
<td>6 7 8 9.2 10 11 12 14 15 16 17 17 17 19</td>
<td>No limit</td>
</tr>
<tr>
<td>7.5</td>
<td>6 7 8 9.2 10 11 12 14 15 16 17 17 17 19</td>
<td>No limit</td>
</tr>
<tr>
<td>10</td>
<td>No limit</td>
<td>No limit</td>
</tr>
<tr>
<td>No limit(^{\text{b}})</td>
<td>0.69 0.69 0.69 0.69 0.69 0.69 0.69 0.69 0.69 0.69 0.69 0.69 0.69 0.69</td>
<td>No limit</td>
</tr>
<tr>
<td>No limit(^{\text{a}})</td>
<td>6 7 8 9.2 10 11 12 14 15 16 17 17 17 19</td>
<td>No limit</td>
</tr>
</tbody>
</table>

2. Limited by maximum internal volume of inner receptacle

<table>
<thead>
<tr>
<th>Inner receptacle volume not exceeding (l)</th>
<th>Wood density not exceeding 1.25 g/cm(^2) and not less than (g/cm(^2))</th>
<th>kg uranium per package</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.6 0.65 0.7 0.75 0.8 0.85 0.9 0.95 1.0 1.05 1.1 1.15 1.2 1.25</td>
<td>No limit</td>
</tr>
<tr>
<td>2</td>
<td>6 7 8 9.2 10 11 12 14 15 16 17 17 17 19</td>
<td>No limit</td>
</tr>
<tr>
<td>3</td>
<td>6 7 8 9.2 10 11 12 14 15 16 17 17 17 19</td>
<td>No limit</td>
</tr>
<tr>
<td>4</td>
<td>6 7 7.8 7.8 7.8 7.8 7.8 7.8 7.8 7.8 7.8 7.8 7.8</td>
<td>No limit</td>
</tr>
<tr>
<td>7</td>
<td>1.41 1.41 1.41 1.41 1.41 1.41 1.41 1.41 1.41 1.41 1.41 1.41 1.41 1.41</td>
<td>No limit</td>
</tr>
<tr>
<td>No limit(^{\text{a}})</td>
<td>0.69 0.69 0.69 0.69 0.69 0.69 0.69 0.69 0.69 0.69 0.69 0.69 0.69 0.69</td>
<td>No limit</td>
</tr>
<tr>
<td>No limit(^{\text{b}})</td>
<td>6 7 8 9.2 10 11 12 14 15 16 17 17 17 19</td>
<td>No limit</td>
</tr>
</tbody>
</table>

\(^{\text{a}}\) Uranium which includes no \(^{233}\)U and no more than 0.9\% wt. \(^{235}\)U.

\(^{\text{b}}\) These enhanced masses apply where the fissile material is in the form of massive metal pieces weighing not less than 2 kg each and free from re-entrant surfaces.
TABLE XVIII
URANIUM\textsuperscript{(a)} COMPOUNDS OR MIXTURES IN WHICH THE URANIUM CONCENTRATION DOES NOT EXCEED \( \frac{26.44}{H/U+1.41} \) \( \text{g/cm}^3 \)

Permissible mass of uranium per package as a function of the packaging wood density

<table>
<thead>
<tr>
<th>Inner receptacle diameter not exceeding (cm)</th>
<th>Wood density not exceeding 1.25 ( \text{g/cm}^3 ) and not less than (( \text{g/cm}^3 ))</th>
<th>Permissible mass of uranium per package</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.6    0.65 0.7 0.75 0.8 0.85 0.9 0.95 1.0 1.05 1.1 1.15 1.2 1.25</td>
<td>No limit 2.80 6.0 6.0 6.0 6.0 6.0 6.0 6.0 14 15 15.2 15.2 15.2 15.2</td>
</tr>
</tbody>
</table>

1. Limited by maximum internal diameter of inner receptacle

2. Limited by maximum internal volume of inner receptacle

(a) Uranium which includes no \( ^{233}\text{U} \) and no more than 93\% wt. \( ^{235}\text{U} \).
### TABLE XIX

**NON-HYDROGENOUS PLUTONIUM COMPOUNDS OR MIXTURES IN WHICH THE PLUTONIUM-239 CONCENTRATION DOES NOT EXCEED 10 g/cm³**

*Permissible mass of plutonium per package as a function of the packaging wood density*

**1. Limited by maximum internal diameter of inner receptacle**

<table>
<thead>
<tr>
<th>Inner receptacle diameter not exceeding (cm)</th>
<th>Wood density not exceeding 1.25 g/cm³ and not less than (g/cm³)</th>
<th>kg plutonium per package</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.6</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>0.8</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>1.05</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>1.15</td>
<td>1.25</td>
</tr>
</tbody>
</table>

No limit

**2. Limited by maximum internal volume of inner receptacle**

<table>
<thead>
<tr>
<th>Inner receptacle volume not exceeding (l)</th>
<th>Wood density not exceeding 1.25 g/cm³ and not less than (g/cm³)</th>
<th>kg plutonium per package</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.6</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
<td>0.75</td>
</tr>
</tbody>
</table>

No limit

(?) Mixtures containing beryllium and deuterium are excluded and the mass of carbon must not exceed 1/10 of the allowed mass of plutonium.
### UNMODERATED PLUTONIUM METAL

Permissible mass of plutonium per package as a function of the packaging wood density

<table>
<thead>
<tr>
<th>Inner receptacle diameter not exceeding (cm)</th>
<th>Wood density not exceeding 1.25 g/cm³ and not less than (g/cm³)</th>
<th>kg plutonium per package</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.6</td>
<td>0.65</td>
</tr>
<tr>
<td>10</td>
<td>3.20</td>
<td>3.60</td>
</tr>
<tr>
<td>No limit</td>
<td>0.405</td>
<td>0.405</td>
</tr>
<tr>
<td>No limit</td>
<td>3.20</td>
<td>3.60</td>
</tr>
</tbody>
</table>

2. Limited by maximum internal volume of inner receptacle

<table>
<thead>
<tr>
<th>Inner receptacle volume not exceeding (l)</th>
<th>Wood density not exceeding 1.25 g/cm³ and not less than (g/cm³)</th>
<th>kg plutonium per package</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.6</td>
<td>0.65</td>
</tr>
<tr>
<td>3</td>
<td>3.20</td>
<td>3.60</td>
</tr>
<tr>
<td>4</td>
<td>3.20</td>
<td>3.60</td>
</tr>
<tr>
<td>5</td>
<td>2.44</td>
<td>2.44</td>
</tr>
<tr>
<td>7</td>
<td>1.20</td>
<td>1.20</td>
</tr>
<tr>
<td>No limit</td>
<td>0.405</td>
<td>0.405</td>
</tr>
<tr>
<td>No limit</td>
<td>3.20</td>
<td>3.60</td>
</tr>
</tbody>
</table>

(a) These enhanced masses apply where the fissile material is in the form of massive metal pieces weighing not less than 2 kg each and free from re-entrant surfaces.
### TABLE XXI

**Plutonium Compounds or Mixtures in Which the Plutonium Concentration Does Not Exceed** \( \frac{26.56}{H/\text{Pu}+1.35} \) g/cm³

Permissible mass of plutonium per package as a function of the packaging wood density

1. **Limited by maximum internal diameter of inner receptacle**

<table>
<thead>
<tr>
<th>Inner receptacle diameter not exceeding (cm)</th>
<th>Wood density not exceeding 1.25 g/cm³ and not less than (g/cm³)</th>
<th>kg plutonium per package</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.6 0.65 0.7 0.75 0.8 0.85 0.9 0.95 1.0 1.05 1.1 1.15 1.2 1.25</td>
<td>No limit</td>
</tr>
<tr>
<td>4</td>
<td>3.2 3.60 3.90 4.2 4.4 4.4 4.4 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5</td>
<td>No limit</td>
</tr>
<tr>
<td>6</td>
<td>2.80 3.60 3.90 4.2 4.4 4.4 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5</td>
<td>No limit</td>
</tr>
<tr>
<td>8</td>
<td>2.50 3.40 3.80 4.2 4.4 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5</td>
<td>No limit</td>
</tr>
<tr>
<td>10</td>
<td>2.20 3.10 3.70 4.2 4.4 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5</td>
<td>No limit</td>
</tr>
<tr>
<td>No limit</td>
<td>1.90 2.70 3.40 4.1 4.4 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>1.60 2.30 3.0 3.80 4.4 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>1.30 1.80 2.40 3.20 3.80 4.3 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>0.97 1.29 1.80 2.40 3.00 3.60 3.80 4.0 4.2 4.4 4.4 4.4 4.4 4.4 4.4</td>
<td>4.4</td>
</tr>
</tbody>
</table>

2. **Limited by maximum internal volume of inner receptacle**

<table>
<thead>
<tr>
<th>Inner receptacle volume not exceeding (l)</th>
<th>Wood density not exceeding 1.25 g/cm³ and not less than (g/cm³)</th>
<th>kg plutonium per package</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.6 0.65 0.7 0.75 0.8 0.85 0.9 0.95 1.0 1.05 1.1 1.15 1.2 1.25</td>
<td>No limit</td>
</tr>
<tr>
<td>2</td>
<td>0.152 0.309 0.52 0.80 1.16 1.59 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>3</td>
<td>0.097 0.133 0.247 0.380 0.700 0.76 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>4</td>
<td>0.022 0.078 0.133 0.247 0.700 0.76 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>5</td>
<td>0.022 0.053 0.085 0.118 0.700 0.700 0.700 0.700 0.700 0.700 0.700 0.700 0.700 0.700</td>
<td>4.5</td>
</tr>
<tr>
<td>7</td>
<td>0.022 0.053 0.084 0.114 0.700 0.700 0.700 0.700 0.700 0.700 0.700 0.700 0.700 0.700 0.700</td>
<td>4.5</td>
</tr>
<tr>
<td>No limit</td>
<td>0.022 0.053 0.084 0.114 0.143 0.171 0.199 0.226 0.250 0.274 0.294 0.311 0.327 0.339</td>
<td>0.339</td>
</tr>
</tbody>
</table>
### Aqueous Solutions of Uranium-233 Nitrate or Uranium-233 Fluoride

**Permissible mass of uranium per package as a function of the packaging wood density**

<table>
<thead>
<tr>
<th>Inner receptacle diameter not exceeding (cm)</th>
<th>Wood density not exceeding 1.25 g/cm² and not less than (g/cm²)</th>
<th>kg uranium per package</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.6               0.65            0.7            0.75            0.8            0.85            0.9            0.95            1.0            1.05           1.1            1.15           1.2            1.25</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>No limit          No limit          No limit          No limit          No limit          No limit          No limit          No limit          No limit          No limit          No limit          No limit          No limit          No limit</td>
<td></td>
</tr>
<tr>
<td>9.5</td>
<td>0.035             0.067            No limit          No limit          No limit          No limit          No limit          No limit          No limit          No limit          No limit          No limit          No limit          No limit</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>0.035             0.067            0.100            0.134            0.169            0.200            0.231            0.261            0.289            0.316            0.340            0.361            0.371            0.391</td>
<td></td>
</tr>
<tr>
<td>No limit</td>
<td>0.035             0.067            0.100            0.134            0.169            0.200            0.231            0.261            0.289            0.316            0.340            0.361            0.371            0.391</td>
<td></td>
</tr>
</tbody>
</table>

2. Limited by maximum internal volume of inner receptacle

<table>
<thead>
<tr>
<th>Inner receptacle volume not exceeding (l)</th>
<th>Wood density not exceeding 1.25 g/cm² and not less than (g/cm²)</th>
<th>kg uranium per package</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.6               0.65            0.7            0.75            0.8            0.85            0.9            0.95            1.0            1.05           1.1            1.15           1.2            1.25</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.152             0.309            0.475            0.71            0.99            1.33            1.71            2.11            2.54            2.99            3.44            3.94            4.41            4.8</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.085             0.133            0.180            0.228            0.285            0.332            0.389            0.446            0.50            0.56            0.60            0.67            0.73            0.78</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.085             0.133            0.180            0.228            0.285            0.332            0.389            0.446            0.50            0.56            0.60            0.67            0.73            0.78</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.035             0.076            0.116            0.152            0.190            0.223            0.256            0.292            0.323            0.356            0.389            0.422            0.451            0.484</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0.035             0.076            0.116            0.152            0.190            0.223            0.256            0.292            0.323            0.356            0.389            0.422            0.451            0.484</td>
<td></td>
</tr>
<tr>
<td>No limit</td>
<td>0.035             0.067            0.100            0.134            0.169            0.200            0.231            0.261            0.289            0.316            0.340            0.361            0.377            0.391</td>
<td></td>
</tr>
</tbody>
</table>
(c) The configuration of the contents and the geometry of the containment system would not be altered so as to increase the reactivity significantly.

616. Fissile Class II packages shall satisfy the nuclear safety criteria described in paras 617-619.

The individual package considered in isolation

617. The following conditions shall be assumed:

(a) the package is damaged (for this purpose "damaged" shall mean the evaluated or demonstrated condition of the package if it had been subjected either to the tests specified in Section VII, paras 709-714 and 718-720 followed by that in paras 722-724 or to the tests specified in Section VII, paras 709-714 and 721, whichever combination is the more limiting); and

(b) water can leak into all void spaces of the packages, including those within the containment system, except that, where the package design incorporates special features to prevent the leakage of water into certain void spaces even as a result of human error, absence of water from those void spaces may be assumed (such special features may include either:

   (i) multiple high-standard water barriers, each of which would remain leaktight if the package were subjected to the combinations of tests specified in para.617(a); or
   (ii) a high degree of quality control in the production and maintenance of packagings, coupled with special tests to demonstrate closure of each package before shipment).

618. The package shall be sub-critical by an adequate margin (see p.57, footnote 6) under the conditions specified in para.617, the physical and chemical characteristics being taken into account, including any change in those characteristics which could occur under the conditions of para.617, and with the conditions of moderation and reflection as specified below:

(a) with the material within the containment system:

   (i) the most reactive configuration and moderation foreseeable under the conditions of para.617.
   (ii) close full water reflection of the containment system or such greater reflection of the containment system as may be provided by the surrounding material of the packaging; and, in addition,
(b) if any part of the material escapes from the containment system under the conditions of para. 617:

(i) the most reactive configuration and moderation considered credible;
(ii) close full water reflection of the material.

Consignments of one or more packages

An "allowable number" shall be derived for each Fissile Class II package design, such that:

(a) five times the allowable number of undamaged packages shall be sub-critical if stacked together in any arrangement without anything between the packages, close reflection on all sides of the stack by the equivalent of water being assumed; for this purpose "undamaged" shall mean the condition in which the packages are designed to be presented for transport; and

(b) twice the allowable number of such packages when damaged shall be sub-critical if stacked together in any arrangement and closely reflected on all sides of the stack by the equivalent of water (for this purpose "damaged" shall mean the evaluated or demonstrated condition of each package if it had been subjected either to the tests specified in Section VII, paras 709-714 and 718-720 followed by that in paras 722-724, or to the tests specified in Section VII, paras 709-714 and 721, whichever combination is the more limiting); hydrogenous moderation between packages and water leakage into the package consistent with test results shall be assumed to the extent which results in the greatest reactivity.

Examples of package designs requiring multilateral approval

Member States are invited to submit examples.

Examples of package designs requiring unilateral approval

Member States are invited to submit examples.
Examples of package designs requiring no further competent authority approval

Example I

Packages for Fissile Class II require no further competent authority approval of package design provided that the following conditions are met:

(a) Packaging: the criticality safety of these consignments does not depend upon the integrity of the packaging. Any packaging which complies with the other relevant requirements of these Regulations with respect to the non-fissile radioactive characteristics may, therefore, be used; and

(b) Contents - uranium metal, compounds and/or mixtures: the contents of any consignment consisting of the "allowable number" of packages must not exceed the permissible mass of $^{235}$U given in Table XXIII per consignment as a function of enrichment for materials satisfying the following conditions:

(i) Uranium-233 must not be present.
(ii) Beryllium and hydrogenous material enriched in deuterium must not be present.
(iii) The total mass of graphite present must not exceed 150 times the total mass of uranium-235.
(iv) Mixtures of fissile material with substances having a higher hydrogen density than water, e.g. some hydrocarbon oils, must not be present. This does not preclude the use of polyethylene for packing or wrapping; or

(c) Contents - uranium metal, compounds and/or mixtures not forming a lattice: the contents of any consignment consisting of the allowable number of packages must not exceed the permissible mass of $^{235}$U given in Table XXIV per consignment as a function of enrichment for materials satisfying the following conditions:

(i) Uranium-233 must not be present.
(ii) Beryllium and hydrogenous material enriched in deuterium must not be present.
(iii) The total mass of graphite present must not exceed 150 times the total mass of uranium-235.
(iv) Mixtures of fissile material with substances having a higher hydrogen density than water, e.g. some hydrocarbon oils, must not be present. This does not preclude the use of polyethylene for packing or wrapping.
(v) The fissile materials must be distributed homogeneously throughout the material. In addition, the material shall not form a lattice arrangement within the package; or
### TABLE XXIII. PERMISSIBLE MASS OF URANIUM-235 PER CONSIGNMENT

<table>
<thead>
<tr>
<th>Uranium enrichment in weight per cent of uranium-235 not exceeding</th>
<th>Permissible mass per consignment in grams of uranium-235</th>
</tr>
</thead>
<tbody>
<tr>
<td>93</td>
<td>160</td>
</tr>
<tr>
<td>75</td>
<td>168</td>
</tr>
<tr>
<td>60</td>
<td>176</td>
</tr>
<tr>
<td>40</td>
<td>184</td>
</tr>
<tr>
<td>30</td>
<td>192</td>
</tr>
<tr>
<td>20</td>
<td>208</td>
</tr>
<tr>
<td>15</td>
<td>224</td>
</tr>
<tr>
<td>11</td>
<td>240</td>
</tr>
<tr>
<td>10</td>
<td>256</td>
</tr>
<tr>
<td>9.5</td>
<td>262</td>
</tr>
<tr>
<td>9</td>
<td>270</td>
</tr>
<tr>
<td>8.5</td>
<td>276</td>
</tr>
<tr>
<td>8</td>
<td>284</td>
</tr>
<tr>
<td>7.5</td>
<td>294</td>
</tr>
<tr>
<td>7</td>
<td>300</td>
</tr>
<tr>
<td>6.5</td>
<td>312</td>
</tr>
<tr>
<td>6</td>
<td>324</td>
</tr>
<tr>
<td>5.5</td>
<td>340</td>
</tr>
<tr>
<td>5</td>
<td>360</td>
</tr>
<tr>
<td>4.5</td>
<td>380</td>
</tr>
<tr>
<td>4</td>
<td>400</td>
</tr>
<tr>
<td>3.5</td>
<td>440</td>
</tr>
<tr>
<td>3</td>
<td>500</td>
</tr>
<tr>
<td>2.5</td>
<td>600</td>
</tr>
<tr>
<td>2</td>
<td>820</td>
</tr>
<tr>
<td>1.5</td>
<td>1360</td>
</tr>
<tr>
<td>1.35</td>
<td>1600</td>
</tr>
<tr>
<td>1</td>
<td>3400</td>
</tr>
<tr>
<td>0.92</td>
<td>6000</td>
</tr>
</tbody>
</table>

(d) Contents - uranium and/or plutonium metal, compounds and/or mixtures: the material must satisfy the following conditions:

(i) Beryllium and hydrogenous material enriched in deuterium must not be present.
(ii) The total mass of graphite present must not exceed 150 times the total mass of uranium and plutonium.
(iii) Mixtures of fissile material with substances having a higher hydrogen density than water, e.g. some hydrocarbon oils, etc., must not be present. This does not preclude the use of polyethylene for packing or wrapping.
TABLE XXIV. PERMISSIBLE MASS OF URANIUM-235 PER CONSIGNMENT

<table>
<thead>
<tr>
<th>Uranium enrichment in weight per cent of uranium-235 not exceeding</th>
<th>Permissible mass per consignment in grams of uranium-235</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>420</td>
</tr>
<tr>
<td>3.5</td>
<td>460</td>
</tr>
<tr>
<td>3</td>
<td>560</td>
</tr>
<tr>
<td>2.5</td>
<td>740</td>
</tr>
<tr>
<td>2</td>
<td>1200</td>
</tr>
<tr>
<td>1.5</td>
<td>2800</td>
</tr>
<tr>
<td>1.35</td>
<td>4000</td>
</tr>
</tbody>
</table>

The total mass of fissile material per consignment must be such that:

\[
\frac{^{235}U\text{(grams)}}{160} + \frac{Pu\text{(grams)}}{90} + \frac{^{233}U\text{(grams)}}{100} \geq 1; \text{ and}
\]

(e) Allowable number: the allowable number for a particular package to this specification will depend on the actual contents and is equal to the fissile mass limit per consignment divided by the actual fissile mass present in the package. In the case of the mixed nuclides in (d) above, the allowable number is 160 \((^{235}U + 1.6^{233}U + 1.778 Pu)\), where \(^{235}U\), \(^{233}U\) and \(Pu\) are the numbers of grams of \(^{235}U\), \(^{233}U\) and \(Pu\) present in the package. Where the package forms part of a mixed consignment, the requirements of p.2, footnote 1, must be met; and

(f) Shipment is subject to multilateral approval.

PROVISIONS SPECIFIC TO FISSILE CLASS III PACKAGES

621. Fissile Class III packages shall meet the general requirements of para.602 and shall be approved in accordance with Section VIII, paras 810-814 and 815-818.

Examples of package designs requiring multilateral approval

Member States are invited to submit examples.
Examples of package designs requiring unilateral approval

Example I

Packages to the following specification require only unilateral approval of the package design provided that both the following conditions are fulfilled:

(a) The number of packages in any one consignment shall be so limited that:

(i) twice this number of undamaged packages shall be sub-critical if stacked together in any arrangement without anything between the packages, assuming close reflection on all sides of the stack by the equivalent of water; for this purpose 'undamaged' shall mean the condition in which the packages are designed to be presented for transport; and

(ii) this number of packages when 'damaged' shall be sub-critical if stacked together in any arrangement and closely reflected on all sides of the stack by the equivalent of water (for this purpose 'damaged' shall mean the evaluated or demonstrated condition of each package if it had been subjected either to the tests specified in Section VII, paras 709-714 and 718-720 followed by that in paras 722-724 or the tests specified in Section VII, paras 709-714 and 721, whichever combination is the more limiting — hydrogenous moderation (see p.58, footnote 7) between the packages and water leakage into the packages consistent with test results shall be assumed to the extent which results in the greatest reactivity.

(b) Shipment of these packages is made only under arrangements approved by the competent authorities in conformity with Section VIII, paras 815-818, so as to prevent loading, transport or storage of these packages with other labelled packages of radioactive material.

Examples of package designs requiring no further competent authority approval

Example I

Packages for Fissile Class III require no further competent authority approval of package design provided that both of the following conditions are met:
(a) The package is currently approved as a Fissile Class II package and the number in any one consignment does not exceed twice the allowable number associated with the Fissile Class II approval.

(b) Shipment of these packages is made only under arrangements approved by the competent authorities in conformity with Section VIII, paras 815-818, so as to prevent loading, transport or storage of these packages with other Fissile Class II or Class III packages. Examples of such arrangements are:

(i) no other labelled packages of radioactive materials may be carried with the consignment in the same road or rail vehicle or the same hold of a ship or the same aircraft; and
(ii) transport must be direct to the consignee without any intermediate transit storage; or
(iii) controls must be imposed, by the provision of an escort, to prevent the packages of the consignment from being stacked with or alongside any other packages of radioactive material after an accident, or at any other time; in the case of road or rail transport, the escort must travel in a separate vehicle.

Example II

624. Packages for Fissile Class III require no further competent authority approval of package design provided that the following conditions are met:

(a) Packaging: the criticality safety of these consignments does not depend upon the integrity of the packaging. Any packaging which complies with the other relevant requirements of these Regulations may therefore be used, provided it does not incorporate lead exceeding 5 cm in thickness, tungsten or uranium shielding; and

(b) Contents – uranium metal, compounds and/or mixtures: the contents of any consignment must not exceed the permissible mass of $^{235}$U given in Table XXV per consignment as a function of enrichment for materials satisfying the following conditions:

(i) Uranium-233 must not be present.
(ii) Beryllium and hydrogenous material enriched in deuterium must not be present.
(iii) The total mass of graphite present must not exceed 150 times the total mass of uranium-235.
(iv) Mixtures of fissile material with substances having
### TABLE XXV. PERMISSIBLE MASS OF URANIUM-235 PER CONSIGNMENT

<table>
<thead>
<tr>
<th>Uranium enrichment in weight per cent of uranium-235 not exceeding</th>
<th>Permissible mass per consignment in grams of uranium-235</th>
</tr>
</thead>
<tbody>
<tr>
<td>93</td>
<td>400</td>
</tr>
<tr>
<td>75</td>
<td>420</td>
</tr>
<tr>
<td>60</td>
<td>440</td>
</tr>
<tr>
<td>40</td>
<td>460</td>
</tr>
<tr>
<td>30</td>
<td>480</td>
</tr>
<tr>
<td>20</td>
<td>520</td>
</tr>
<tr>
<td>15</td>
<td>560</td>
</tr>
<tr>
<td>11</td>
<td>600</td>
</tr>
<tr>
<td>10</td>
<td>640</td>
</tr>
<tr>
<td>9.5</td>
<td>655</td>
</tr>
<tr>
<td>9</td>
<td>675</td>
</tr>
<tr>
<td>8.5</td>
<td>690</td>
</tr>
<tr>
<td>8</td>
<td>710</td>
</tr>
<tr>
<td>7.5</td>
<td>730</td>
</tr>
<tr>
<td>7</td>
<td>750</td>
</tr>
<tr>
<td>6.5</td>
<td>780</td>
</tr>
<tr>
<td>6</td>
<td>810</td>
</tr>
<tr>
<td>5.5</td>
<td>850</td>
</tr>
<tr>
<td>5</td>
<td>900</td>
</tr>
<tr>
<td>4.5</td>
<td>950</td>
</tr>
<tr>
<td>4</td>
<td>1000</td>
</tr>
<tr>
<td>3.5</td>
<td>1100</td>
</tr>
<tr>
<td>3</td>
<td>1250</td>
</tr>
<tr>
<td>2.5</td>
<td>1500</td>
</tr>
<tr>
<td>2</td>
<td>2050</td>
</tr>
<tr>
<td>1.5</td>
<td>3400</td>
</tr>
<tr>
<td>1.35</td>
<td>4000</td>
</tr>
<tr>
<td>1</td>
<td>8500</td>
</tr>
<tr>
<td>0.92</td>
<td>15000</td>
</tr>
</tbody>
</table>

A higher hydrogen density than water, e.g. some hydrocarbon oils, must not be present. This does not preclude the use of polyethylene for packing or wrapping; or

(c) Contents - uranium metal, compounds and/or mixtures not forming a lattice: Table XXVI gives the permissible mass of uranium-235 per consignment as a function of enrichment, for materials satisfying the following conditions:

(i) Uranium-233 must not be present.
(ii) Beryllium and hydrogenous material enriched in deuterium must not be present.
### TABLE XXVI. PERMISSIBLE MASS OF URANIUM-235 PER CONSIGNMENT

<table>
<thead>
<tr>
<th>Uranium enrichment in weight per cent of uranium-235 not exceeding</th>
<th>Permissible mass per consignment in kilograms of uranium-235</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1.05</td>
</tr>
<tr>
<td>3.5</td>
<td>1.15</td>
</tr>
<tr>
<td>3</td>
<td>1.4</td>
</tr>
<tr>
<td>2.5</td>
<td>1.8</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>1.5</td>
<td>7</td>
</tr>
<tr>
<td>1.35</td>
<td>10</td>
</tr>
</tbody>
</table>

(iii) The total mass of graphite present must not exceed 150 times the total mass of uranium-235.

(iv) Mixtures of fissile material with substances having a higher hydrogen density than water, e.g. some hydrocarbon oils, must not be present. This does not preclude the use of polyethylene for packing or wrapping.

(v) The fissile materials must be distributed homogeneously throughout the material. In addition, the material shall not form a lattice arrangement within the package; or

(d) Contents - uranium and/or plutonium metal, compounds and/or mixtures: the material must satisfy the following conditions:

(i) Beryllium and hydrogenous material enriched in deuterium must not be present.

(ii) The total mass of graphite present must not exceed 150 times the total mass of uranium and plutonium.

(iii) Mixtures of fissile material with substances having a higher hydrogen density than water, e.g. some hydrocarbon oils, must not be present. This does not preclude the use of polyethylene for packing or wrapping.

The total mass of fissile material per consignment must be such that:

\[
\frac{235\text{U(grams)}}{400} + \frac{\text{Pu(grams)}}{225} + \frac{233\text{U(grams)}}{250} \neq 1; \text{ and}
\]

(e) Conditions of transport: the following administrative controls must be applied throughout the transport of the consignment:

(i) the quantity of material in a consignment must not exceed that defined in (b), (c) or (d) above;

(ii) transport must be direct to the consignee, without any intermediate transit storage; and

(f) Shipment is subject to multilateral approval.
SECTION VII - TEST AND INSPECTION PROCEDURES

DEMONSTRATION OF COMPLIANCE WITH THE TESTS

701. Demonstration of compliance with the test requirements of Section VII may be accomplished by any of the methods listed below or by a combination thereof.

(a) Performance of tests with prototypes or samples of the packaging as normally presented for transport, in which case the contents of the packaging for the test shall simulate as closely as practicable the expected normal radioactive contents.

(b) Reference to previous satisfactory demonstrations of 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 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 the penetrator diameter or the compressive load, shall be taken into account.

(d) Calculation, or reasoned argument, when the calculative procedures and parameters are generally agreed to be reliable or conservative.

702. With respect to the initial conditions for the tests of this Section, except those in paras 721-725, the demonstration of compliance shall be based on the assumption that the package is in equilibrium at an ambient temperature of 38°C. The effects of solar radiation may be neglected. The effects of equilibrium conditions such as temperature and pressure, in so far as they affect the demonstration of compliance, may be assessed separately, but shall be taken into account in evaluating results of both the mechanical and the thermal tests.

TESTS FOR PACKAGING

Number of specimens to be tested

703. The number of specimens actually subjected to the tests should be related to the number of packagings of that type which are to be produced, the frequency of use and the cost. The results of the tests may necessitate an increase in the number of specimens to meet the requirements of the test procedures in respect of maximum damage.
Preparation of a specimen for testing

704. All specimens shall be examined before testing to identify and record faults or damage including the following:

(a) divergence from the specifications or the drawings;
(b) defects in construction;
(c) corrosion or other deterioration; and
(d) distortion of features.

705. The containment system of the packaging shall be clearly specified.

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

Testing the integrity of containment and shielding

707. After any of the tests specified in paras 709-721, it shall be further demonstrated that the integrity of the containment, or of the containment and shielding, has been retained to the extent required in Section II for the packaging under test.

Target for the drop tests specified in paras 712, 716, 719 and 732

708. The target 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 the damage to the specimen.

Tests for demonstrating ability to withstand normal conditions of transport

709. The tests are: the water spray test, the free drop test, the compression test and the penetration test. Prototypes of the package must be subjected to the free drop test, the compression test and the penetration test, preceded in each case by the water spray test. One prototype may be used for all the tests, provided that the requirements of para. 710 are complied with.

710. 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 about two hours if the water spray is applied from four directions simultaneously. No time interval should elapse, however, if the water spray is applied from each of the four directions consecutively.

711. **Water spray test:** Any water spray test shall be considered as satisfactory provided that:

(a) the amount of water per unit of ground area is approximately equivalent to a rainfall rate of 5 cm per hour;

(b) the water impinges upon the specimen at an angle of approximately 45° from the horizontal;

(c) the water is approximately uniformly distributed, as in a rainfall, over the entire surface of the specimen in the direction of the spray;

(d) the duration of the spray is at least one hour;

(e) the orientation of the packaging is such that the effects are expected to be the most severe for the features under investigation, and the specimen is supported so that it does not sit in a pool of water.

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

(a) The height of fall measured from the lowest point of the package to the upper surface of the target shall be not less than 1.2 m; except that for packages weighing more than 5000 kg, the height of fall shall not be less than the distance specified in Table XXVII for the applicable package weight.

### TABLE XXVII. FREE-FALL DISTANCE FOR PACKAGES WEIGHING MORE THAN 5000 kg

<table>
<thead>
<tr>
<th>Package weight (kg)</th>
<th>Free fall distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 000 to &lt; 10 000</td>
<td>0.9</td>
</tr>
<tr>
<td>10 000 to &lt; 15 000</td>
<td>0.6</td>
</tr>
<tr>
<td>More than 15 000</td>
<td>0.3</td>
</tr>
</tbody>
</table>
(b) For Fissile Class II packages, the free drop specified above shall be preceded by a free drop from a height of 0.3 m on each corner or, in the case of a cylindrical package, onto each of the quarters of each rim.

(c) For fibreboard or wood rectangular packages not exceeding 50 kg in weight, a separate specimen shall be subjected to a free drop onto each corner from a height of 0.3 m.

(d) For fibreboard cylindrical packages not exceeding 100 kg in weight, 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.

713. **Compression test:** 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 weight of the actual package;

(b) the equivalent of 1300 kg/m² 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 normally stand.

714. **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 of 3.2-cm diameter with a hemispherical end and weighing 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 fall of the bar measured from its lower end to the upper surface of the specimen shall be 1 m.

Additional tests for Type A packaging designed for liquids and gases

715. 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.

716. **Free drop test:** the specimen shall fall onto the target so as to suffer the maximum damage in respect of containment. The height
of the fall measured from the lowest part of the specimen to the upper surface of the target shall be 9 m.

717. **Penetration test:** the specimen shall be subjected to the test specified in para.714 except that the height of fall shall be increased to 1.7 m from the 1 m specified in para.714(b).

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

718. The specimen shall be subjected to the cumulative effects of the mechanical tests specified in para.719 and the thermal test specified in para.720, in that order. A separate specimen shall be subjected to the effect of the water immersion test in para.721.

719. **Mechanical test:** the test shall consist of two drops onto a target. The order in which the specimen is subjected to the two drops shall be such that, on completion of the mechanical test, the specimen will have suffered such damage as will lead to the maximum damage in the thermal test which follows.

(a) For drop I, the specimen shall fall onto the target so as to suffer the maximum damage, and the height of fall 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.708.

(b) For drop II, the specimen shall fall onto the target so as to suffer the maximum damage, and the height of fall measured from the intended point of impact of the specimen to the upper surface of the target shall be 1 m. The target shall be the upper end of a solid mild steel bar of circular section, 15 cm ± 0.5 cm in diameter. The target surface shall be flat and horizontal with its edges rounded off to a radius of not more than 6 mm. The bar shall be rigidly mounted perpendicularly on the foundation target described in para.708 and shall be 20 cm long unless a longer bar would cause greater damage; in that case, a bar of sufficient length to cause maximum damage shall be used.

720. **Thermal test:** any thermal test shall be considered as satisfactory provided that the heat flux incident on the specimen is not less than that which would result from exposure for 30 minutes of the whole specimen to a radiation environment of 800°C with an emissivity coefficient of at least 0.9. For purposes of calculation, the surface absorptivity shall be either that value which the package may be expected to possess if exposed to a fire or 0.8, whichever
is greater. In addition, when significant, convective heat input shall be included on the basis of still ambient air at 800°C during the thirty-minute period. After cessation of the external heat input to the specimen:

(a) the specimen shall not be cooled artificially until another three hours have elapsed or until it has been demonstrated that all internal temperatures have begun to fall, whichever is the earlier; and

(b) any combustion of materials of the specimen shall be allowed to proceed for three hours after the cessation of external heating to the specimen unless it terminates earlier naturally.

721. **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 eight hours. For test purposes, an external pressure of water of 1.5 kg/cm² (gauge) will be considered to meet these conditions.

Water in-leakage test for fissile material packages

722. Packages other than Fissile Class I or Fissile Class II packages and any packages for which water in-leakage to the extent which results in greatest reactivity has been assumed for purposes of assessment under Section VI, paras 610 and 619(b), shall be exempted from the test.

723. Before the specimen is subjected to the water in-leakage test specified below, it shall be subjected to the tests in paras 719 and 720.

724. The specimen shall be immersed under a head of water of at least 0.9 m for a period of not less than eight hours and in the attitude for which maximum leakage is expected. For this test an ambient temperature of 38°C is not required.

Tests for integrity of containment and shielding

725. Any test or inspection method can be employed to determine whether the requirements of Section VII have been met after the specimen has been subjected to the tests in paras 709-721, provided that the method can be demonstrated to meet the relevant requirements of Section II.
TESTS FOR SPECIAL FORM RADIOACTIVE MATERIAL

General

726. The tests are: the impact test, the percussion test, the bending test and the heat test.

727. Specimens (solid radioactive material or capsules) to be tested shall be prepared as normally presented for transport. The radioactive material shall be duplicated as closely as practicable.

728. A different specimen may be used for each of the tests.

729. The specimen shall not break or shatter when subjected to the impact, percussion or bending tests.

730. The specimen shall not melt or disperse when subjected to the heat test.

731. After each test, a leaching assessment shall be performed on the specimen by a method no less sensitive than the methods given in paras 736 and 737.

Test methods

732. Impact test: the specimen shall fall onto the target from a height of 9 m. The target shall be as defined in para. 708.

733. 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 steel billet so as to produce an impact equivalent to that resulting from a free fall of 1.4 kg through 1 m. The flat face of the billet shall be 25 mm in diameter with the edges rounded off to a radius of 3 mm ± 0.3 mm. The lead, of hardness number 3.5 to 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 billet shall strike the specimen so as to cause maximum damage.

734. Bending test: the test is applicable 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 billet.
The billet shall strike the specimen so as to produce an impact equivalent to that resulting from a free vertical fall of 1.4 kg through 1 m. The flat face of the billet shall be 25 mm in diameter with the edges rounded off to a radius of 3 mm ± 0.3 mm.

735. **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 min and shall then be allowed to cool.

**Leaching assessment methods**

736. For indispersible solid material:

(a) The specimen shall be immersed for 7 days in water at ambient temperature. The water shall have a pH of 6 - 8 and a maximum conductivity of 10 μmho/cm at 20°C.

(b) The water with specimen shall then be heated to a temperature of 50° ± 5°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 stored for at least 7 days in still air of humidity not less than 90% at 30°C.

(e) The specimen shall then be immersed in water of the same specification as in (a) above and the water with specimen heated to 50° ± 5°C and maintained at this temperature for 4 hours.

(f) The activity of the water shall then be determined.

The activities determined in (c) and (f) above shall not exceed 0.05 μCi.

737. For encapsulated material:

(a) The specimen shall be immersed in water at ambient temperature. The water shall have a pH of 6 - 8 with a maximum conductivity of 10 μmho/cm. The water and specimen shall be heated to a temperature of 50° ± 5°C and maintained at this temperature for 4 hours.

(b) The activity of the water shall then be determined.

(c) The specimen shall then be stored for at least 7 days in still air at a temperature not less than 30°C.

(d) Repeat (a).

(e) The activity of the water shall then be determined.

The activities determined in (b) and (e) above shall not exceed 0.05 μCi.
SECTION VII

INSPECTION REQUIREMENTS TO BE FULFILLED BEFORE FIRST SHIPMENT AND BEFORE EACH SHIPMENT OF CERTAIN TYPES OF PACKAGE

Before first shipment

738. Before first shipment of any package, the following requirements shall be complied with:

(a) For each Type B(U) and Type B(M) package, it shall be ensured that the effectiveness of its shielding and containment, and, where necessary, the heat transfer characteristics, are within the limits applicable to or specified for the approved design.

(b) If the design pressure of the containment system exceeds 0.35 kg/cm² (gauge), it shall be ensured that the containment system of each package conforms with the approved design requirements relating to the capability of that system to maintain its integrity under pressure.

(c) Where, in order to comply with the nuclear safety criteria, neutron poisons are specifically included as components of the packaging primarily for this purpose, tests shall be performed to confirm the presence and distribution of that poisoning.

Before each shipment

739. Before each shipment of any package, the following requirements shall be complied with:

(a) Type B(U) and Type B(M) packages shall be held until equilibrium conditions have been closely enough approached to demonstrate compliance with the shipment requirements for temperature and pressure unless an exemption from these requirements has received unilateral approval.

(b) It shall be ensured that all the requirements specified in the approval certificates have been satisfied.

(c) It shall be ensured by examination and/or appropriate tests that all closures, valves 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 Section II, paras 230 and 243, were made.

(d) It shall be ensured that the provisions of Section II, para.205, with regard to lifting attachments have been complied with.
SECTION VIII - ADMINISTRATIVE REQUIREMENTS

GENERAL

801. Approval by competent authorities is not required for package designs for materials covered in Section III and for Type A package designs for non-fissile radioactive material.

APPROVAL OF SPECIAL FORM RADIOACTIVE MATERIAL

802. If the activity of the radioactive material involved exceeds $10^3 \text{ A}_1$, the design for special form radioactive material shall require unilateral approval. An application for approval shall include:

(a) a detailed description of the 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, including complete engineering drawings and schedules of materials and methods of construction 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 material is capable of meeting the tests, or other evidence that the special form radioactive material meets the requirements of these Regulations.

803. The competent authority shall establish a certificate stating that the approved design meets the definition of special form radioactive material in Section I, para.135, and shall attribute to that design an identification mark. The certificate shall specify the details of the radioactive material.

APPROVAL OF PACKAGE DESIGNS

Approval of Type B(U) package designs (including those for Fissile Class I, Class II and Class III packages which are also subject to paras 810-814

804. Each Type B(U) package design shall require unilateral approval.

805. An application for approval shall include:

(a) a detailed description of the proposed contents with particular 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 construction to be used;
(c) a statement of the tests which have been done and their results, or evidence based on calculative methods or other evidence that the packaging design is adequate to meet the requirements of Section II, paras 228-241;
(d) the proposed operating and maintenance instructions for the use of the package;
(e) if the package is designed to have a maximum normal operating pressure in excess of 1.0 kg/cm² (gauge), the application for approval shall, in particular, state, in respect of the materials of construction of the containment system, the specifications, the samples to be taken and the tests to be made;
(f) where the proposed contents are irradiated fuel, the applicant shall state and justify any assumption in the safety analysis relating to the characteristics of the fuel;
(g) any special stowage provisions necessary to ensure the safe dissipation of heat from the package; consideration shall be given to the various modes of transport to be used and the type of vehicle or freight container (see para.832(a));
(h) a reproducible illustration not larger than 21 cm × 30 cm, showing the make-up of the package.

806. The competent authority shall establish a certificate stating that the approved design meets the requirements of these Regulations for Type B(U) packages (see paras 822-824).

Approval of Type B(M) package designs (including those for Fissile Class I, Class II and Class III packages which are also subject to paras 810-814)

807. Each Type B(M) package design shall require multilateral approval.

808. An application for approval of a Type B(M) package design shall include, in addition to the information required in para.805 for Type B(U) packages:

(a) a list of those specific additional requirements for Type B(U) packages specified in Section II, paras 234-241, with which the package does not conform;
(b) any proposed supplementary operational controls\(^9\) to compensate for the deficiencies listed in (a) above; and
(c) a statement relative to any restrictions on the mode of transport and to any special loading, carriage, unloading, or handling procedures;
(d) the maximum and minimum ambient conditions (temperature, solar radiation) expected to be encountered during transport and which have been taken into account in the design.

\(^8\) This publication is no longer valid
Please see http://www-ns.iaea.org/standards/

809. The competent authority shall establish a certificate stating that the approved package design meets the requirements of these Regulations for Type B(M) packages (see para. 821).

Approval of Fissile Class I, Class II and Class III package designs

810. Package designs complying with the examples in Section VI, paras 620, 623 and 624 shall require no further competent authority approvals.

811. Package designs complying with the examples in Section VI, paras 612-614 and 622 shall require unilateral approval.

812. All other package designs 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 Section VI of these Regulations.

814. The competent authority shall establish a certificate (see paras 822-824) stating that the approved package design meets the requirements of Section VI.

APPROVAL OF SHIPMENTS

815. Multilateral shipment approvals shall be required for the following packages:

(a) Vented Type B(M) packages;
(b) Type B(M) packages containing radioactive materials with an activity greater than \(3 \times 10^3 \text{ A}_1\) or \(3 \times 10^3 \text{ A}_2\), as appropriate, or \(3 \times 10^4 \text{ Ci}\), whichever is the least;
\(^9\) That is, operational controls during transport not routinely provided for in the Regulations but which are considered necessary to ensure the safety of the package during transport, such as human intervention for temperature or pressure measurements or for periodical venting. These controls should also take into account the possibility of unexpected delay.
(c) Fissile Class III packages.

However, a competent authority can authorize transport into or through its country (see p.6, footnote 2), without shipment approval, by a specific provision in its design approval.

816. 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 contents, the expected modes of transport, the type of vehicle and the probable or proposed route; and
(c) how the special precautions and special administrative and operational controls referred to in the package design certificates issued under Section VIII, paras 807-814, are to be put into effect.

817. Upon approval of the shipment, the competent authority shall issue a certificate (see paras 822-824).

818. The package and shipment certificates may be combined into a single certificate.

APPROVAL OF TRANSPORT BY SPECIAL ARRANGEMENT

819. A consignment of radioactive materials which does not satisfy all the applicable requirements of these Regulations shall be transported only by special arrangement, which always requires multilateral approval. The special arrangement shall be adequate to ensure that the overall level of safety in transport is at least equivalent to that which would be provided if all the applicable requirements of the Regulations had been met.

820. An application for approval shall include the information required under paras 804-818 and also:

(a) a statement of the respects in which, and of the reasons why, the consignment cannot be made in full accordance with the applicable requirements of these Regulations; and
(b) a statement of any special precautions or special administrative or operational controls which must be taken during transport to compensate for the failure to meet the applicable requirements of these Regulations.

821. Upon approval of the special arrangement, the competent authority shall issue a certificate (see paras 822-824).
COMPETENT AUTHORITY CERTIFICATES OF APPROVAL

Competent authority identification marks

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

VRI/Number/Type Code

(a) 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 package design approval identification mark.

(c) The following type codes shall be used in the order listed to indicate the types of approval certificates issued:

- A Type A package design
- B(U) Type B(U) package design
- B(M) Type B(M) package design
- F Fissile Class package design
- S Special form material approval
- T Shipment
- X Special arrangement.

These type codes shall be applied as follows:

(a) Each certificate and each package shall bear the appropriate identification mark. For example:

A/132/B(M)F: A Type B(M) Fissile Class package approved by Austria with certificate number 132 (to be marked on both the package itself and on the package design approval certificate).

A/132/B(M)FT: The shipment approval issued for that package (to be marked on the shipment approval certificate only).

Where package design approval and shipment approval are combined on the same certificate, the identification mark on the certificate would be of the form: A/132/B(M)F - A/132/B(M)FT. However, only A/132/B(M)F would be marked on the package.
Where multilateral approval is effected by validation, only the identification marks issued by the country of origin of the design or shipment would be used. Where multilateral approval is effected by issue of certificates by successive countries, each certificate would bear the appropriate mark and the package whose design was so approved would bear all appropriate identification marks. For example,

\[ \begin{cases} \text{A/132/B(M)F} \\ \text{CH/28/B(M)F} \end{cases} \]

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.

The revision of certificates shall be indicated by a dash and a number following the certificate number. For example, A/132-2/B(U)F would indicate revision 2 of the Austrian-approved package. Such revision numbers may only be issued by the country issuing the original certificate number. Revision by other than the issuing country shall require a new certificate and identification mark.

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(U)F (SP503).

Information required in certificates

Each approval certificate issued by a competent authority shall include the relevant information from the following:

(a) The competent authority identification mark.
(b) A very brief description of the packaging, including materials of construction, gross weight, general outside dimensions, and appearance. This shall include a reproducible illustration not larger than 21 cm by 30 cm, showing the make-up of the package.
(c) A brief specification of the permitted contents, including any restrictions on contents which might not be obvious from the nature of the packaging. This should include the physical and chemical forms, the activities in curies (including those of the various isotopes, if appropriate), amounts in grams (for fissile materials), and whether in special form.
(d) Additionally, for Fissile Class packages:

(i) Fissile Class I: a detailed description of the permissible contents and any special features, on the basis of which the absence of water from certain void spaces has been assumed in the criticality assessment (see Section VI, para.607(b), (i) and (ii).

(ii) Fissile Class II: a detailed description of the permissible contents, the corresponding allowable numbers (or transport index) and any special features, on the basis of which the absence of water from certain void spaces has been assumed in the criticality assessment (see Section VI, para.617(b)(i) and (ii).

(iii) Fissile Class III: a detailed description of the individual consignments including the permissible contents and the corresponding allowable numbers (or transport indices) together with any special precautions to be taken during transport.

(e) A statement regarding the ambient conditions assumed for purposes of design (see Section II, para.232).

(f) For Type B(M) packages, a statement specifying those prescriptions of Section II, paras 234-241, with which the package does not conform and any amplifying information which may be useful to other competent authorities.

(g) A reference to the following information provided by the applicant:

(i) instructions on the use and maintenance of the packaging;

(ii) the actions to be taken by the consignor prior to the shipment.

(h) A detailed listing of any supplementary operational controls required (see p.80, footnote 9) for package preparation, loading, transport, stowage, unloading, and handling, including any special stowage provisions for the safe dissipation of heat from the package, or a statement that no such controls are required.

(i) A statement authorizing shipment where shipment approval is required under paras 815-818.

(k) Any restrictions on the modes of transport, types of vehicle, freight containers, and any necessary routing instructions.

(l) Emergency arrangements specific to the approved design.

(m) 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".
(n) An issue date, and, if appropriate, an expiry date.
(o) Signature and identification of the certifying official.
(p) References to appropriate governmental regulations, including the current edition of the IAEA Regulations for the Safe Transport of Radioactive Materials.
(q) Appendices containing certificates for alternative package contents, other competent authority validations, or additional technical data or information.

Validation of certificates

825. 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.

CONSIGNOR'S RESPONSIBILITIES

826. Compliance with the requirements of Section V, paras 510-519, for labelling and marking shall be the responsibility of the consignor.

Consignor's certification

827. The consignor shall include in the transport documents a declaration in the following terms or in terms having an equivalent meaning:

"This is to certify that the contents of this consignment are properly described by name; are properly packaged, marked, and labelled; and are in proper condition for transport; according to the applicable regulations."

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

829. The consignor's certification shall be signed and dated by the consignor. Facsimile signatures are authorized where applicable laws and regulations recognize the legal validity of facsimile signatures.

830. The consignor's certification shall be made on the same document which contains the particulars of consignment listed in para.831.
SECTION VIII

Particulars of consignment

831. The consignor shall include in the transport documents for each consignment of radioactive materials at least the following information:

(a) The words "radioactive material";
   (i) for a consignment of low specific activity material transported under Section III, paras 314-316, the words "LOW SPECIFIC ACTIVITY";
   (ii) for a consignment of low-level solid radioactive material transported under Section III, para.317, the words "LOW-LEVEL SOLID".

(b) The identification mark for each competent authority certificate (special form, package design, and shipment) applicable to the consignment.

(c) The name of the radioactive material or nuclide.

(d) A description of the physical and chemical form of the material, or whether it is in special form.

(e) The activity of the radioactive material in appropriate curie units.

(f) The category of the package, i.e. I-WHITE, II-YELLOW, III-YELLOW.

(g) The transport index (Categories II- and III-YELLOW only).

(h) For a consignment of fissile materials:
   (i) if exempted under Section VI, para.601, the words "FISSILE EXEMPT"; or
   (ii) if not so exempted, the Fissile Class of the package(s).

Information for carriers

832. The consignor shall provide in the transport documents a statement regarding actions, if any, that must 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 operational requirements for loading, transport, storage, unloading, handling, and stowage for safe dissipation of heat, or a statement that no supplementary operational requirements are necessary (see para.824(h));
(b) restrictions on the mode of transport and any necessary routing instructions (see para. 824(k));
(c) emergency arrangements specific to the approved design (see para. 824(l)).

833. The applicable competent authority certificates need not necessarily accompany the consignment to which they relate. The consignor shall, however, be prepared to provide them to the carriers before loading, unloading and any transshipment.

Notification to competent authorities

834. Before the first shipment of a Type B(U) package containing radioactive materials with an activity greater than $3 \times 10^3 A_1$ or $3 \times 10^3 A_2$, as appropriate, or $3 \times 10^4\text{Ci}$, whichever is the least, 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 each country through or into which (see p. 6, footnote 2) 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.

835. For each shipment listed in (a) to (d) below inclusive, the consignor shall notify the competent authorities of each country through or into which (see p. 6, footnote 2) 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 15 days in advance.

(a) Type B(U) packages containing radioactive materials with an activity greater than $3 \times 10^3 A_1$ or $3 \times 10^3 A_2$, as appropriate, or $3 \times 10^4\text{Ci}$, whichever is the least.
(b) Type B(M) packages.
(c) Fissile Class III packages under para. 812.
(d) Transport by special arrangement.

836. The consignment notification shall include:

(a) sufficient information to enable the identification of the package, including all applicable certificate numbers and identification marks; and
(b) information on the date of shipment, the expected date of arrival and proposed routing.
837. 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. 816).

Possession of certificates

838. Except in the case of designs published as examples in Section VI, the consignor shall have in his possession a copy of each certificate required under Section VIII and a copy of the instructions with regard to the proper closing of the package and other preparation for shipment before making any shipment under the terms of the certificates.

QUALITY CONTROL IN FABRICATION AND MAINTENANCE OF PACKAGING

839. The manufacturer, consignor, or user of an approved package design shall be prepared to demonstrate to any cognizant competent authority that:

(a) the constructional methods and materials used for the construction of the packaging are in accordance with the approved design requirements; the competent authority may carry out inspection of the packaging during construction;

(b) all packagings built to an approved design shall be maintained in good condition so that they continue to comply with all relevant regulatory criteria, even after repeated use.
APPENDIX

SCHEDULES LISTING IN AN ABBREVIATED FORM THE REQUIREMENTS TO BE MET FOR THE TRANSPORT OF SPECIFIED TYPES OF CONSIGNMENT

These schedules are provided as an aid to users who do not wish to refer to the detailed provisions of the Regulations. They are also intended to serve as a basic guide to national authorities and international organizations that may wish to adapt the Regulations in schedule form to suit their own specific transport requirements.

SCHEDULE 1 - EMPTY PACKAGES
(see Section III, para.313)

1. MATERIALS

A package which has contained radioactive material.

2. PACKAGING

(a) Packages must be securely closed and in good condition.
(b) Permitted internal contamination levels:

- beta/gamma/some low toxicity alpha emitters $10^{-2}$ $\mu$Ci/cm$^2$;
- natural/depleted uranium/natural thorium $10^{-1}$ $\mu$Ci/cm$^2$;
- other alpha emitters $10^{-3}$ $\mu$Ci/cm$^2$.

(c) Maximum permitted surface radiation levels 0.5 mrem/h.

3. MIXED PACKING

No restrictions.

4. CONTAMINATION ON PACKAGES (see Section V, para.502)

Non-fixed external contamination limits:

- beta/gamma/some low toxicity alpha emitters $10^{-4}$ $\mu$Ci/cm$^2$;
- natural/depleted uranium/natural thorium $10^{-3}$ $\mu$Ci/cm$^2$;
- other alpha emitters $10^{-5}$ $\mu$Ci/cm$^2$. 
5. MARKING AND LABELLING OF PACKAGES AND FREIGHT CONTAINERS

(a) Packages

Post

Any national regulations must be complied with. For international shipments: (1) External - consignor's name and address and request to return if not delivered, and the words "RADIOACTIVE MATERIAL" must be crossed out on the postal white label; (2) Domestic - consignor's name and address and nature of consignment.

Other modes

No marking or labelling required.

(b) Freight containers

No marking or labelling required.

(c) Any labels specified in Section V, para.519, must not be visible.

6. TRANSPORT DOCUMENTS

Packages to be described as "EXEMPT EMPTY PACKAGES".

7. DESPATCH, TRANSIT AND STORAGE

(a) Post

Consignors must be authorized by the competent national authority and packages must be despatched by the quickest route. Any national regulations must be complied with.

(b) Other modes

No restrictions.
8. TRANSPORT IN BULK OR IN TANK WAGONS

Not applicable.

9. PLACARDING OF VEHICLES

Not required.

10. MIXED LOADING

No restrictions.

11. DECONTAMINATION OF CONVEYANCES (see Section V, para.552)

12. OTHER PRESCRIPTIONS, ACCIDENTS, CUSTOMS, EXPOSURE LIMITS, ETC.

No special requirements, but see Section I, paras 146-149 and Section V, para.554.
SCHEDULE 2 - ARTICLES MANUFACTURED FROM NATURAL OR DEPLETED URANIUM OR NATURAL THORIUM

1. MATERIALS

Manufactured articles in which the sole radioactive material is natural or depleted uranium or natural thorium. Such articles may be packagings for the transport of radioactive materials.

2. PACKAGING

(a) The outer surface must be enclosed in a substantial inactive sheath.

(b) Maximum permitted surface radiation level: 0.5 mrem/h.

3. MIXED PACKING

No restrictions.

4. CONTAMINATION ON PACKAGES (see Section V, para.502)

Non-fixed external contamination limits:

- beta/gamma/some low toxicity alpha emitters: $10^{-4} \mu\text{Ci/cm}^2$;
- natural/depleted uranium/natural thorium: $10^{-3} \mu\text{Ci/cm}^2$;
- other alpha emitters: $10^{-5} \mu\text{Ci/cm}^2$.

5. MARKING AND LABELLING OF PACKAGES AND FREIGHT CONTAINERS

(a) Packages

Post

Any national regulations must be complied with. For international shipments: (1) External - white label marked "RADIOACTIVE MATERIAL", and consignor's name, address and request to return if not delivered; (2) Domestic - consignor's name and address and the contents.
Other modes

Outermost surface of the containment system must be marked "RADIOACTIVE" as a warning on opening the package.

(b) Freight containers

No marking or labelling required.

6. TRANSPORT DOCUMENTS

Articles to be described as "EXEMPT RADIOACTIVE ARTICLES".

7. DESPATCH, TRANSIT AND STORAGE

(a) Post

Consignors must be authorized by the competent national authority and packages must be despatched by the quickest route.
Any national regulations must be complied with.

(b) Other modes

No restrictions.

8. TRANSPORT IN BULK OR IN TANK WAGONS

Not applicable.

9. PLACARDING OF VEHICLES

Not required.

10. MIXED LOADING

No restrictions.
11. DECONTAMINATION OF CONVEYANCES (see Section V, para.552)

12. OTHER PRESCRIPTIONS, ACCIDENTS, CUSTOMS, EXPOSURE LIMITS, ETC.

No special requirements, but see Section I, paras 146-149 and Section V, para.559.
SCHEDULE 3 – SMALL QUANTITIES OF RADIOACTIVE MATERIALS

1. MATERIALS

As specified in item 2(b) but not more than 15 g $^{235}$U.

2. PACKAGING

(a) Packages containing $^{235}$U, in a form other than specified in Schedule 2, shall have no external dimension less than 10 cm.
(b) Activity limits:

<table>
<thead>
<tr>
<th>Nature of Materials</th>
<th>Package Limits (Post)</th>
<th>Package Limits (Other Modes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solids and gases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tritium</td>
<td>2 Ci</td>
<td>20 Ci</td>
</tr>
<tr>
<td>Special form</td>
<td>$10^{-4}$ A$_1$</td>
<td>$10^{-3}$ A$_1$</td>
</tr>
<tr>
<td>Other forms</td>
<td>$10^{-4}$ A$_2$</td>
<td>$10^{-3}$ A$_2$</td>
</tr>
<tr>
<td>Liquids</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tritiated water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 0.1 Ci/l</td>
<td>100 Ci</td>
<td>1000 Ci</td>
</tr>
<tr>
<td>Between 0.1 Ci/l and 1.0 Ci/l</td>
<td>10 Ci</td>
<td>100 Ci</td>
</tr>
<tr>
<td>&gt; 1.0 Ci/l</td>
<td>$10^{-1}$ Ci</td>
<td>1 Ci</td>
</tr>
<tr>
<td>Other liquids</td>
<td>$10^{-5}$ A$_2$</td>
<td>$10^{-4}$ A$_2$</td>
</tr>
</tbody>
</table>

For mixtures of other radionuclides, see Section IV, paras 406-411.

(c) Under normal conditions of transport there must be no leakage of radioactive material.
(d) Maximum permitted surface radiation level: 0.5 mrem/h.
3. MIXED PACKING

No restrictions.

4. CONTAMINATION ON PACKAGES (see Section V, para.502)

Non-fixed external contamination limit:

- beta/gamma/some low toxicity alpha emitters: $10^{-4} \mu\text{Ci/cm}^2$
- natural uranium/depleted uranium/natural thorium: $10^{-3} \mu\text{Ci/cm}^2$
- other alpha emitters: $10^{-5} \mu\text{Ci/cm}^2$

5. MARKING AND LABELLING OF PACKAGES AND FREIGHT CONTAINERS

(a) Packages

Post

Any national regulations must be complied with. For international shipments: (1) External - white label marked "RADIOACTIVE MATERIAL"; and consignor's name and address and request to return if not delivered; (2) Domestic - consignor's name and address and the contents.

Other modes

Outermost surface of the containment system must be marked "RADIOACTIVE" as a warning on opening the package.

(b) Freight containers

No marking or labelling required.

6. TRANSPORT DOCUMENTS

Materials to be described as "EXEMPT RADIOACTIVE MATERIALS".
7. DESPATCH, TRANSIT AND STORAGE

(a) Post

Consignors must be authorized by the competent national authority and packages must be despatched by the quickest route.
Any national regulations must be complied with.

(b) Other modes

No restrictions.

8. TRANSPORT IN BULK OR IN TANK WAGONS

Permitted only under the provisions of Schedule 6.

9. PLACARDING OF VEHICLES

Not required.

10. MIXED LOADING

No restrictions.

11. DECONTAMINATION OF CONVEYANCES (see Section V, para.552)

12. OTHER PRESCRIPTIONS, ACCIDENTS, CUSTOMS, EXPOSURE LIMITS, ETC.

No special requirements, but see Section I, paras 146-149 and Section V, para.554.
1. MATERIALS

Instruments and manufactured articles such as clocks, electronic tubes or apparatus having radioactive material as a component part, but not more than 15 g $^{235}\text{U}$.

2. PACKAGING

(a) Securely packed.
(b) Packages containing $^{235}\text{U}$, in a form other than specified in Schedule 2, shall have no external dimension less than 10 cm.
(c) Activity limits:

<table>
<thead>
<tr>
<th>Nature of Materials</th>
<th>Item Limits</th>
<th>Package Limits (Post)</th>
<th>Package Limits (Other Modes)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Solid</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special form</td>
<td>$10^{-2} A_1$</td>
<td>$10^{-1} A_1$</td>
<td>$A_1$</td>
</tr>
<tr>
<td>Other forms</td>
<td>$10^{-3} A_2$</td>
<td>$10^{-1} A_2$</td>
<td>$A_2$</td>
</tr>
<tr>
<td><strong>Liquids</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid</td>
<td>$10^{-3} A_2$</td>
<td>$10^{-2} A_2$</td>
<td>$10^{-1} A_2$</td>
</tr>
<tr>
<td><strong>Gases</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tritium</td>
<td>20 Ci</td>
<td>20 Ci</td>
<td>200 Ci</td>
</tr>
<tr>
<td>Special form</td>
<td>$10^{-2} A_1$</td>
<td>$10^{-3} A_1$</td>
<td>$10^{-2} A_1$</td>
</tr>
<tr>
<td>Other forms</td>
<td>$10^{-3} A_2$</td>
<td>$10^{-3} A_2$</td>
<td>$10^{-2} A_2$</td>
</tr>
</tbody>
</table>

For mixtures of radionuclides, see Section IV, paras 406-411.

(d) Maximum permitted package surface radiation level, 0.5 mrem/h. Maximum permitted radiation level at 10 cm from external surface of unpacked instrument or article, 10 mrem/h.
3. MIXED PACKING

No restrictions.

4. CONTAMINATION ON PACKAGES (see Section V, para.502)

Non-fixed external contamination limits:

- beta/gamma/some low toxicity alpha emitters: $10^{-4}$ $\mu$Ci/cm$^2$
- natural/depleted uranium/natural thorium: $10^{-3}$ $\mu$Ci/cm$^2$
- other alpha emitters: $10^{-5}$ $\mu$Ci/cm$^2$

5. MARKING AND LABELLING OF PACKAGES AND FREIGHT CONTAINERS

(a) Packages

Post

Any national regulations must be complied with.
For international shipments: (1) External - white label marked "RADIOACTIVE MATERIAL", and consignor's name and address and request to return if not delivered; (2) Domestic - consignor's name and address and the contents.

Other modes

No external label but each item (except radioluminescent timepieces or devices) to be marked "RADIOACTIVE".

(b) Freight containers

No marking or labelling required.

6. TRANSPORT DOCUMENTS

Contents shall be described as "EXEMPT RADIOACTIVE INSTRUMENTS/ARTICLIES".
7. DESPATCH, TRANSIT AND STORAGE

(a) Post

Consignors must be authorized by the competent national authority and packages must be despatched by the quickest route. Any national regulations must be complied with.

(b) Other modes

No restrictions.

8. TRANSPORT IN BULK OR IN TANK WAGONS

Not required.

9. PLACARDING OF VEHICLES

Not required.

10. MIXED LOADING

No restrictions.

11. DECONTAMINATION OF CONVEYANCES (see Section V, para.552).

12. OTHER PRESCRIPTIONS, ACCIDENTS, CUSTOMS, EXPOSURE LIMITS, ETC.

No special requirements, but see Section I, paras 146-149 and Section V, para.554.
SCHEDULE 5 – LOW SPECIFIC ACTIVITY MATERIALS (I)

1. MATERIALS (see Section I, para.121, for full details)

(a) Uranium/thorium ores or concentrates.
(b) Unirradiated natural or depleted uranium or unirradiated natural thorium.
(c) Tritiated water, 10 Ci/litre or less.
(d) Uniformly distributed materials, $10^{-4}$ $\text{A}_2/\text{g}$ or less.
(e) Contaminated objects, with non-fixed contamination not greater than 10 times the figures in table of item 4 below, and contamination no greater than $10^{-4}$ $\text{A}_2/\text{g}$.

2. PACKAGING

(a) Strong industrial packages conforming with the design requirements in Section II, paras 201-209, inclusive, so as to retain contents during normal conditions of transport and have minimum dimension of 10 cm.
   Unlimited quantity per package.
   Maximum permitted surface radiation level, 200 mrem/h.
(b) Strong industrial packages, full load, conforming with the design requirements in Section II, paras 201-209.
   Unlimited quantity per package.
   Maximum permitted surface radiation level, 1000 mrem/h under specified conditions, see Section V, paras 534 and 537.

3. MIXED PACKING

Only articles or documents for use with the contents are allowed, see Section V, para.501.

4. CONTAMINATION ON PACKAGES (see Section V, para.502)

Non-fixed external contamination limits:

- beta/gamma/some low toxicity alpha: $10^{-4} \mu\text{Ci/cm}^2$;
- natural/depleted uranium/natural thorium: $10^{-3} \mu\text{Ci/cm}^2$;
- other alpha emitters: $10^{-5} \mu\text{Ci/cm}^2$.
5. MARKING AND LABELLING OF PACKAGES AND FREIGHT CONTAINERS

(a) Packages

Other than full load: completed WHITE or YELLOW labels applied to two opposite sides, see Section V, paras 501-513. Full load: marked or stencilled "RADIOACTIVE LSA" and overstamped "FULL LOAD".

(b) Freight containers

Other than full load: completed WHITE or YELLOW labels affixed to all four sides, see Section V, paras 510-513. Full load: marked or stencilled "RADIOACTIVE LSA" and overstamped "FULL LOAD".

6. TRANSPORT DOCUMENTS

(a) Consignor's certificate and details on consignment note, see Section VIII, paras 827-831.
(b) Information for carriers, see Section VIII, paras 832-833.

7. DESPATCH, TRANSIT AND STORAGE

(a) Storage and segregation (persons and film), see Section V, paras 520-525.
(b) Transport index. Other than full load, must be controlled, see Section V, paras 522, 531 and 532. However, if package maintained in compact stack and labelled as 5(a) above, no restriction
Full load: no restriction.
(c) Full load: Total activity content not to exceed that given below.
APPENDIX

<table>
<thead>
<tr>
<th>Nature of Material</th>
<th>'Vehicle, Aircraft, Hold, Compartment or Deck Area of Seagoing Vessel'</th>
<th>Hold or Compartment of an Inland Waterway Craft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solids</td>
<td>No limit</td>
<td>$100 \times A_2$</td>
</tr>
<tr>
<td>Tritiated water</td>
<td>$50,000 \text{ Ci}$</td>
<td>$5,000 \text{ Ci}$</td>
</tr>
<tr>
<td>Other liquids and gases</td>
<td>$100 \times A_2$</td>
<td>$100 \times A_2$</td>
</tr>
<tr>
<td></td>
<td>(see also Section V, paras 538-540)</td>
<td>(see also Section V, paras 538-540)</td>
</tr>
</tbody>
</table>

(d) Vehicle and large freight container radiation level: under full load conditions, the external radiation levels are limited (see Section V, paras 532(a), 534(b) and (c), 537(b), (c) and (d).
(e) Post: not allowed unless meeting Schedules 1 to 4.
(f) Liquid pyrophoric radioactive materials: not allowed in aircraft.

8. TRANSPORT IN BULK OR IN TANK WAGONS

Not allowed in aircraft and only allowed under full load conditions by other modes of transport. Quantity limitation as in table of item 7(c) above.

9. PLACARDING OF VEHICLES

The placard shown in Section V, Fig.5, is to be used on each of the two external lateral walls.

10. MIXED LOADING (see Section V, paras 527, 528, 530)

11. DECONTAMINATION OF CONVEYANCES (see Section V, paras 552 and 553)

12. OTHER PRESCRIPTIONS, ACCIDENTS, CUSTOMS, EXPOSURE LIMITS, ETC.

No special requirements, but see Section I, paras 146-149 and Section V, para.554.
APPENDIX

SCHEDULE 6 – LOW SPECIFIC ACTIVITY MATERIALS (II)

1. MATERIALS (see Section I, para.121, for details)

(a) Uniformly distributed materials (other than in Schedule 5, item 1(d)): \(10^{-4} \text{ A}_2/g\) or less.

(b) Contaminated objects: contamination non-dispersible and less than \(1 \mu\text{Ci/cm}^2\) (beta/gamma/low toxicity alphas) or \(0.1 \mu\text{Ci/cm}^2\) (other alphas).

2. PACKAGING

Strong industrial packages, full load, conforming to design requirements in Section II, paras 201-209, so as to retain contents during normal conditions of transport, and have minimum dimension of 10 cm.

Unlimited quantity per package.

Maximum permitted surface radiation level: 1000 mrem/h under specified conditions, see Section V, paras 534 and 537.

3. MIXED PACKING

Only articles or documents for use with contents are allowed, see Section V, para.501.

4. CONTAMINATION ON PACKAGES (see Section V, para.502)

Non-fixed contamination limit:

- beta/gamma/some low toxicity alpha emitters: \(10^{-4} \mu\text{Ci/cm}^2\);
- natural/depleted uranium/natural thorium: \(10^{-3} \mu\text{Ci/cm}^2\);
- other alphas: \(10^{-5} \mu\text{Ci/cm}^2\).

5. MARKING AND LABELLING OF PACKAGES AND FREIGHT CONTAINERS

(a) Packages

Completed WHITE or YELLOW labels, overstamped "FULL LOAD", affixed to two opposite sides, contents indicated as "LSA", see Section V, paras 510-513.
(b). Freight containers

Completed WHITE or YELLOW labels, overstamped "FULL LOAD", affixed to all four sides, contents indicated as "LSA", see Section V, paras 510-513.

6. TRANSPORT DOCUMENTS

(a) Consignor's certificate and details of consignment note, see Section VIII, paras 827-831.
(b) Information for carriers, see Section VIII, paras 832-833.

7. DESPATCH, TRANSIT AND STORAGE

(a) Storage and segregation (persons and films), see Section V, paras 520-525.
(b) As full load, no control over transport index.
(c) Activity limits:

<table>
<thead>
<tr>
<th>Nature of Material</th>
<th>Vehicle, Aircraft, Hold, Compartment or Deck Area of Seagoing Vessel</th>
<th>Hold or Compartment of an Inland Waterway Craft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solids</td>
<td>No limit</td>
<td>100 x $A_2$</td>
</tr>
<tr>
<td>Tritiated water</td>
<td>50,000 Ci</td>
<td>5,000 Ci</td>
</tr>
<tr>
<td>Other liquids and gases</td>
<td>100 x $A_2$</td>
<td>100 x $A_2$</td>
</tr>
<tr>
<td></td>
<td>(see also Section V, paras 538-541)</td>
<td>(see also Section V, paras 538-541)</td>
</tr>
</tbody>
</table>

(d) Vehicle and freight container radiation levels: permitted external levels are limited (see Section V, paras 532(a), 534(b) and (c), 537(b), (c) and (d).
(e) Post: not allowed unless complying with Schedules 1 to 4.
(f) Liquid pyrophoric radioactive materials: not allowed in aircraft.
8. TRANSPORT IN BULK OR IN TANK WAGONS

Not allowed.

9. PLACARDING OF VEHICLES

The placard shown in Section V, Fig.5, is to be used on each of the two external lateral walls.

10. MIXED LOADING (see Section V, paras 527, 528, 530)

11. DECONTAMINATION OF CONVEYANCES (see Section V, paras 552 and 553)

12. OTHER PRESCRIPTIONS, ACCIDENTS, CUSTOMS, EXPOSURE LIMITS, ETC.

No special requirements, but see Section I, paras 146-149 and Section V, para.554.
SCHEDULE 7 - LOW-LEVEL SOLID RADIOACTIVE MATERIALS

1. MATERIALS (see Section I, para.120, for full details)

(a) Solids - consolidated waste, activated materials, etc. - uniformly distributed and compacted.

(b) Contaminated objects: contamination non-dispersible and less than 20 $\mu$Ci/cm$^2$ (beta/gamma/low toxicity alpha emitters); 2 $\mu$Ci/cm$^2$ (other alpha emitters).

(c) Empty packages: higher levels of external radiation and internal contamination are permitted than for exempt empty packages (Schedule 1).

2. PACKAGING

Strong industrial packaging conforming to UN Performance Tests, carried full load and conforming to design requirements, see Section II, paras 201-209, and having minimum dimensions of 10 cm. Unlimited quantity per package allowed. Maximum permitted surface radiation level: 1000 mrem/h under special conditions, see Section V, paras 534 and 537.

3. MIXED PACKING

Only articles or documents for use with contents are allowed, see Section V, para.501.

4. CONTAMINATION ON PACKAGES (see Section V, para.502)

Non-fixed contamination limit:

- $\text{beta/gamma/some low toxicity alpha emitters} \quad 10^{-4} \mu\text{Ci/cm}^2$
- $\text{natural/depleted uranium/natural thorium} \quad 10^{-3} \mu\text{Ci/cm}^2$
- $\text{other alphas} \quad 10^{-6} \mu\text{Ci/cm}^2$.
5. MARKING AND LABELLING OF PACKAGES AND FREIGHT CONTAINERS

(a) Packages

Completed WHITE or YELLOW labels, overstamped "FULL LOAD", affixed to two opposite sides, contents indicated as "LLS", see Section V, paras 510-513.

(b) Freight containers

Completed WHITE or YELLOW labels, overstamped "FULL LOAD", affixed to all four sides, contents indicated as "LLS", see Section V, paras 510-513.

6. TRANSPORT DOCUMENTS

(a) Consignor's certificate and details of consignment note, see Section VIII, paras 827-831.

(b) Information for carriers, see Section VIII, paras 832-833.

7. DESPATCH, TRANSIT AND STORAGE

(a) Stowage and segregation (persons and film), see Section V, paras 520-525.

(b) As full load, no control over transport index.

(c) Total radioactive content not to exceed the following:

<table>
<thead>
<tr>
<th>Nature of Material</th>
<th>Vehicle, Aircraft, Hold, Compartment or Deck Area of Seagoing Vessel</th>
<th>Hold or Compartment of an Inland Waterway Craft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solids</td>
<td>No limit</td>
<td>$100 \times A_2$</td>
</tr>
<tr>
<td>Tritiated water</td>
<td>50000 Ci</td>
<td>5000 Ci</td>
</tr>
<tr>
<td>Other liquids and gases</td>
<td>$100 \times A_2$</td>
<td>$100 \times A_2$</td>
</tr>
<tr>
<td></td>
<td>(see also Section V, paras 538-541)</td>
<td>(see also Section V, paras 538-541)</td>
</tr>
</tbody>
</table>
(d) Vehicle radiation levels: external radiation levels of road and rail vehicle limited (see Section V, paras 532(a), 534(b) and (c), 537(b), (c) and (d)). Applicable also to freight containers.

(e) Post: not allowed unless complying with Schedules 1 to 4.

(f) Liquid pyrophoric radioactive materials: not allowed in aircraft.

8. TRANSPORT IN BULK OR IN TANK WAGONS

Not allowed.

9. PLACARDING OF VEHICLES

The placard shown in Section V, Fig.5, is to be used on each of the two external lateral walls.

10. MIXED LOADING (see Section V, paras 527, 528, 530).

11. DECONTAMINATION OF CONVEYANCES (see Section V, para.552).

12. OTHER PRESCRIPTIONS, ACCIDENTS, CUSTOMS, EXPOSURE LIMITS, ETC.

No special requirements, but see Section I, paras 146-149 and Section V, para.554.
SCHEDULE 8 - MATERIALS IN TYPE A PACKAGES

1. MATERIALS

Radioactive materials up to an activity per package of $A_2$, or $A_1$ if in special form.

2. PACKAGING

Package design requirements, see Section II, paras 201-208 and 210-227. Minimum package dimension, 10 cm. Maximum permitted surface radiation level, 200 mrem/h unless full load under specified conditions, see Section V, paras 534(a) and 537(a), whereby 1000 mrem/h is allowed.

3. MIXED PACKING

Only articles or documents for use with the contents are allowed, see Section V, para.501.

4. CONTAMINATION ON PACKAGES (see Section V, para.502)

Non-fixed external contamination limits:

- beta/gamma/some low toxicity alpha emitters $10^{-4}$ $\mu$Ci/cm$^2$;
- natural/depleted uranium/natural thorium $10^{-3}$ $\mu$Ci/cm$^2$;
- other alpha emitters $10^{-5}$ $\mu$Ci/cm$^2$.

5. MARKING AND LABELLING OF PACKAGES AND FREIGHT CONTAINERS

(a) Packages (see Section V, paras 514-515)

Completed WHITE or YELLOW labels affixed to two opposite sides overstamped "FULL LOAD" if appropriate. To be plainly and durably marked externally with: (i) "TYPE A"; (ii) the weight, if over 50 kg.
(b) Freight containers (see Section V, paras 510-513)

Completed WHITE or YELLOW labels affixed to all four sides, overstamped "FULL LOAD" if appropriate.

6. TRANSPORT DOCUMENTS

(a) Consignor's certificate and details of consignment note, see Section VIII, paras 827-831.
(b) Information for carrier, see Section VIII, paras 832-833.
(c) If advantage is taken of the relaxation for material in special form in 2 above, unilateral competent authority approval certification for special form design is required, see Section VIII, paras 802-803, and the consignor must be in possession of a copy of this before the first shipment of any package.

7. DESPATCH, TRANSIT AND STORAGE

(a) Storage and segregation (persons and film), see Section V, paras 520-525.
(b) Transport index limitations: generally, in storage or on conveyances the total transport index is limited to 50 with segregation of 6 m between groups of 50.
   Full load: this restriction does not apply provided the allowable number of Fissile Class II or III packages is not exceeded, see Section V, para.531(b).
   Passenger aircraft: the total sum of transport indexes in freight containers must not exceed 50.
(c) Vehicle radiation level: under full load conditions, the external radiation levels of road and rail vehicles are limited, see Section V, paras 534(b) and (c), 537(b), (c) and (d).
   This also applies to freight containers.
(d) Air transport only: packages with surface radiation levels in excess of 200 mrem/h are only allowed by special arrangement.
(e) Post: not allowed.

8. TRANSPORT IN BULK OR IN TANK WAGONS

Not allowed.
9. PLACARDING OF VEHICLES

The placard shown in Section V, Fig.5, is to be affixed to each of two external lateral walls.

10. MIXED LOADING (see Section V, paras 527, 528, 530)

11. DECONTAMINATION OF CONVEYANCES (see Section V, para.552)

12. OTHER PRESCRIPTIONS, ACCIDENTS, CUSTOMS, EXPOSURE LIMITS, ETC.

No special requirements, but see Section I, paras 146-149 and Section V, para.554.
SCHEDULE 9 - MATERIALS IN TYPE B(U) PACKAGES

1. MATERIALS

Radioactive materials: no limit to total activity except as prescribed in the approval certificates.

2. PACKAGING

Packages must meet design requirements, see Section II, paras 201-208 and 210-241. Minimum package dimension, 10 cm. Package design requires unilateral competent authority approval. Maximum permitted surface radiation level, 200 mrem/h unless full load under specified conditions, see Section V, paras 534(a) and 537(a), whereby 1000 mrem/h is allowed.

3. MIXED PACKING

Only articles or documents for use with the contents are allowed, see Section V, para.501.

4. CONTAMINATION ON PACKAGES (see Section V, para.502)

Non-fixed internal contamination limits:

- beta/gamma/some low toxicity alpha emitters \(10^{-4} \mu\text{Ci/cm}^2\);
- natural/depleted uranium/natural thorium \(10^{-3} \mu\text{Ci/cm}^2\);
- other alpha emitters \(10^{-5} \mu\text{Ci/cm}^2\).

5. MARKING AND LABELLING OF PACKAGES AND FREIGHT CONTAINERS

(a) Packages

Completed WHITE or YELLOW labels affixed to two opposite sides, overstamped "FULL LOAD" if appropriate. To be plainly and durably marked externally with: (i) competent authority identification mark; (ii) "TYPE B(U)"; (iii) the weight if over 50 kg.
APPENDIX

The outside of the outermost fire and water resistant receptacle is to be embossed or stamped with the trefoil symbol, see Section V, para.517.

(b) Freight containers

Completed WHITE or YELLOW labels affixed to all four sides, overstamped "FULL LOAD" if appropriate, see Section V, paras 510-513.

6. TRANSPORT DOCUMENTS

(a) Consignor’s certificate and details of consignment note, see Section VIII, paras 827-831.

(b) Information for carriers, see Section VIII, paras 832-833.

(c) Unilateral component authority package design approval certificate required, see Section VIII, paras 804-806.

(d) Before first shipment of a particular type B(U) package design:

consignor is to have in his possession copies of all appropriate approval certificates;
if, however, the activity is greater than $3 \times 10^3$ A$_2$; $3 \times 10^3$ A$_1$ if in special form, or $3 \times 10^4$ Ci, consignor is to ensure that competent authority certificates are supplied to all competent authorities affected by the movement, see Section VIII, para.834.

(e) Prior to each shipment, where the activity is greater than $3 \times 10^3$ A$_2$, $3 \times 10^3$ A$_1$ in special form, or $3 \times 10^4$ Ci, consignor is to notify all affected competent authorities, preferably 15 days in advance, see Section VIII, para.835.

(f) If advantage is taken of the relaxations for material in special form in item 6(d) or (e) above, competent authority approval certification for the special form design is required, see Section VIII, paras 802-803.

7. DESPATCH, TRANSIT AND STORAGE

(a) Storage and segregation (persons and film), see Section V, paras 520-525.
(b) Any instructions in competent authority approved certificate to be observed. Stowage among other cargo may be restricted if the average surface heat flux from a package exceeds 15 W/m², see Section V, para.527.

(c) Consignor shall have complied with pre-shipment requirements of Section VII, paras 738-739.

(d) Full load conditions apply if surface temperature exceeds 50°C. NB: Package must be Type B(M) if above 82°C, see Section II, para.232 for ambient conditions to be used and item 7(g) below for air transport.

(e) Transport index limitations: generally, in storage or on conveyances the total transport index is limited to 50 with segregation of 6 m between groups of 50. Full load: this restriction does not apply provided the allowable number of Fissile Class II or III packages is not exceeded, see Section V, para.531(b). Passenger aircraft: the total sum of transport indexes for freight containers must not exceed 50.

(f) Vehicle and freight container radiation level: under FULL LOAD conditions, the permitted external radiation levels are limited, see Section V, paras 534(b) and (c), 537(b), (c) and (d).

(g) Air transport only

Temperature of package not to exceed 50°C.
Liquid pyrophoric materials are not permitted.
Packages with surface radiation level in excess of 200 mrem/h only allowed by special arrangement under Schedule 12.

8. TRANSPORT IN BULK OR IN TANK WAGONS

Not allowed.

9. PLACARDING OF VEHICLES

The placard shown in Section V, Fig.5, is to be affixed to each of two external lateral walls.

10. MIXED LOADING (see Section V, paras 527, 528, 530)
11. DECONTAMINATION OF CONVEYANCES (see Section V, para 552)

12. OTHER PRESCRIPTIONS, ACCIDENTS, CUSTOMS, EXPOSURE LIMITS, ETC.

(a) Maintenance of packages, see Section VIII, para.839.
(b) Quality control of packages, see Section VIII, para.839. See also Section I, paras 146-149 and Section V, para 554.
SCHEDULE 10 - MATERIALS IN TYPE B(M) PACKAGES

1. MATERIALS

Radioactive materials: no limit to total activity except as prescribed in the approval certificates.

2. PACKAGING

For design requirements see Section II, paras 201-208, 210-233, and 241-243. Minimum package dimension 10 cm. Package design requires multilateral competent authority approval. Maximum permitted surface radiation level: 200 mrem/h unless full load under specified conditions, see Section V, paras 534(a) and 537(a), whereby 1000 mrem/h is allowed.

3. MIXED PACKING

Only articles or documents for use with the contents are allowed, see Section V, para.501.

4. CONTAMINATION ON PACKAGES (see Section V, para.502)

Non-fixed external contamination limits:

- beta/gamma/some low toxicity alpha emitters $10^{-4} \mu\text{Ci/cm}^2$
- natural/depleted uranium/natural thorium $10^{-3} \mu\text{Ci/cm}^2$
- other alpha emitters $10^{-5} \mu\text{Ci/cm}^2$

5. MARKING AND LABELLING OF PACKAGES AND FREIGHT CONTAINERS

(a) Packages

Completed WHITE or YELLOW labels to be affixed to two opposite sides, overstamped "FULL LOAD" if appropriate. To be plainly and durably marked externally with: (i) competent authority identification mark; (ii) "TYPE B(M)"; (iii) the weight if over 50 kg.
APPENDIX

The outside of the outermost fire and water resistant receptacle to be embossed or stamped with the trefoil symbol, see Section V, para.517.

(b) Freight containers

Completed WHITE or YELLOW labels to be affixed to all four sides, overstamped "FULL LOAD" if appropriate, see Section V, paras 510-513.

6. TRANSPORT DOCUMENTS

(a) Consignor's certificate and details of consignment note, see Section VIII, paras 827-831.
(b) Information for carriers, see Section VIII, paras 832-833.
(c) Multilateral competent authority package design approval certificate required, see Section VIII, paras 807-809.
(d) If package is a vented Type B(M) or if the total contents exceed $3 \times 10^3 A_2$, $3 \times 10^3 A_1$ in special form, or $3 \times 10^4$ Ci, multilateral shipment approval is required, see Section VIII, paras 815-816.
(e) Notification of each shipment to all the competent authorities affected is required, preferably at least 15 days in advance, see Section VIII, para.835.
(f) If advantage is taken of the relaxation for material in special form in item 6(d) above, unilateral competent authority approval certification for the special form design is required, see Section VIII, paras 802 and 803.
(g) Before the first shipment of any package, the consignor must be in possession of copies of all appropriate approval certificates.

7. DESPATCH, TRANSIT AND STORAGE

(a) Storage and segregation (persons and film), see Section V, paras 520-525.
(b) Any instructions in the competent authority approval certificate are to be observed. Stowage among other cargo may be restricted if the average surface heat flux from the package exceeds 15 W/m$^2$, see Section V, para.527.
(c) Consignor shall have complied with the preshipment requirements of Section VII, paras 738 and 739.
(d) Transport index limitations: generally, in storage or on conveyances the total transport index is limited to 50 with segregation of 6 m between groups of 50. Full load: this restriction does not apply provided the allowable number of Fissile Class II or III packages is not exceeded, see Section V, para.531(b).

(e) Vehicle and freight container radiation level: under full load conditions, the permitted external radiation levels of road and rail vehicles are limited, see Section V, paras 534(b) and (c), 537(b), (c) and (d).

(f) Air transport only: (i) packages are allowed only in cargo aircraft; (ii) surface temperature of package not to exceed 50°C; (iii) vented Type B(M) packages not allowed; (iv) no packages allowed which require ancillary cooling system or operational controls; (v) liquid pyrophoric materials not permitted; (vi) packages with surface radiation level in excess of 200 mrem/h are only allowed by special arrangement.

(g) Post: not allowed.

8. TRANSPORT IN BULK OR IN TANK WAGONS

Not allowed.

9. PLACARDING OF VEHICLES

The placard shown in Section V, Fig.5, is to be affixed to each of the two external lateral walls.

10. MIXED LOADING (see Section V, paras 527, 528, 530)

11. DECONTAMINATION OF CONVEYANCES (see Section V, para 552)

12. OTHER PRESCRIPTIONS, ACCIDENTS, CUSTOMS, EXPOSURE LIMITS, ETC.

(a) Maintenance of packages, see Section VIII, para.839.
(b) Quality control of packages, see Section VIII, para.839. See also Section I, paras 146-149 and Section V, para.554.
1. MATERIAL

Uranium-233, uranium-235, plutonium-238, plutonium-239, plutonium-241, or any material containing any of the foregoing, except unirradiated natural and depleted uranium. Fissile materials must also comply with the requirements of one of the other Schedules, as appropriate to their radioactivity.

2. PACKAGING

(a) The following materials, specified fully in Section VI, para.601, are exempt from the special packaging requirements of this Schedule:

(i) fissile material in quantity not exceeding 15 g;
(ii) natural or depleted uranium irradiated in a thermal reactor;
(iii) dilute hydrogenous solutions in limited concentrations and quantities;
(iv) enriched uranium with not more than 1% of uranium-235 should not form a lattice arrangement if metal or oxide;
(v) material distributed at not more than 5 g per 10 litre volume;
(vi) plutonium, where less than 1 kg per package and where not more than 20% consists of plutonium-239 or -241;
(vii) enriched uranyl nitrate solution containing uranium with not more than 2 wt% uranium-235.

(b) For general design prescriptions for nuclear safety and provisions for Fissile Classes I, II and III, see Section VI, paras 602-624.

3. MIXED PACKING

Only articles or documents intended for use with the contents are allowed, see Section V, para.501.
4. CONTAMINATION ON PACKAGES

See appropriate Schedule.

5. MARKING AND LABELLING OF PACKAGES AND FREIGHT CONTAINERS

(a) Fissile Class I packages

Completed WHITE or YELLOW labels affixed to two opposite sides as required by appropriate Schedule.

(b) Fissile Class II packages

Completed YELLOW labels affixed to two opposite sides, see Section V, paras 506, 508 and 519.

(c) Fissile Class III packages

Completed Category III - YELLOW labels affixed to two opposite sides may need to be overstamped "FULL LOAD" for criticality reasons, see Section VI, paras 621-624.

(d) Freight containers

Completed WHITE or YELLOW labels affixed to two opposite sides, overstamped "FULL LOAD" if appropriate, see Section V, paras 505, 507 and 509.

6. TRANSPORT DOCUMENTS

(a) Consignor's certificate and details of consignment note, see Section VIII, paras 827-831.

(b) Information for carriers, see Section VIII, paras 832-833.

(c) Competent authority package design approval certificate is required, see Section VIII, paras 810-814.

(d) Fissile Class III packages requiring multilateral design approval also require multilateral competent authority shipment approval, see Section VIII, para.815.

(e) Before the first shipment of any package, the consignor must be in possession of copies of all appropriate approval certificates.
7. DESPATCH, TRANSIT AND STORAGE

(a) Storage and segregation (persons and films), see Section V, paras 520-525.
(b) Any instructions regarding Fissile Class III packages in the competent authority approval certificate must be observed.
(c) Consignor shall have complied with the pre-shipment requirements of Section VII, paras 738-739.
(d) Transport index limitation: generally, in storage or on conveyances the total transport index is limited to 50 with segregation of 6 m between groups of 50.
   Full load: the allowable number of Fissile Class II or III packages must not be exceeded. For seagoing vessels the total number of full loads containing Fissile Class II or III package shall not exceed 4 except with competent authority’s permission, see Section V, para.541.
   Passenger aircraft: the total sum of transport indexes for freight containers must not exceed 50.
(e) Post: not allowed.

8. TRANSPORT IN BULK OR IN TANK WAGONS

(a) No restrictions for fissile material up to 15 g total or for solutions within certain concentrations and quantity limits, see item 2(a) above and Section VI, para.601.
(b) Not allowed for Fissile Class I or II packages.
(c) Permitted under Fissile Class III only if so specified in the competent authority certificate.

9. PLACARDING OF VEHICLES

The placard shown in Section V, Fig.5, is to be affixed to each of the two external lateral walls.

10. MIXED LOADING (see Section V, paras 527, 528, 530)

11. DECONTAMINATION OF CONVEYANCES (see Section V, para.552)

12. OTHER PRESCRIPTIONS, ACCIDENTS, CUSTOMS, EXPOSURE LIMITS, ETC.

No special requirements, but see Section I, paras 146-149, and Section V, para.554.
SCHEDULE 12 - MATERIALS TRANSPORTED UNDER SPECIAL ARRANGEMENT

1. MATERIALS

Radioactive materials including those which are explosive.

2. PACKAGING

Any deficiencies in the packaging design or failure to comply with shipment requirements must be compensated for by special arrangements which ensure an overall level of safety no less than if the applicable packaging requirements had been met in full.

3. MIXED PACKING

Unless permitted under the terms of the approval certificate only articles or documents intended for use with the contents are allowed, see Section V, para.501.

4. CONTAMINATION ON PACKAGES (see Section V, para.502)

Non-fixed external contamination limits:

- beta/gamma/some low toxicity alpha emitters  $10^{-4}$ $\mu$Ci/cm$^2$;
- natural/depleted uranium/natural thorium  $10^{-3}$ $\mu$Ci/cm$^2$;
- other alpha emitters  $10^{-5}$ $\mu$Ci/cm$^2$.

5. MARKING AND LABELLING OF PACKAGES AND FREIGHT CONTAINERS (see Section V, paras 509-513)

In addition to any labelling or marking specified in the approval certificate the following is required:

(a) Packages

Completed Category III - YELLOW labels affixed to two opposite sides, overstamped "FULL LOAD" if appropriate.
APPENDIX

(b) Freight containers

Completed Category III - YELLOW labels affixed to all four sides, overstamped "FULL LOAD" if appropriate.

6. TRANSPORT DOCUMENTS

(a) Consignor's certificate and details of consignment note, see Section VIII, paras 827-831.
(b) Information for carriers, see Section VIII, paras 832-833.
(c) Multilateral competent authority approval certificate is required, see Section VIII, paras 819-821.
(d) Prior to each shipment the consignor must notify the competent authority of each country through or into which the consignment is to be transported at least 15 days in advance, see Section VIII, para.835.

7. DESPATCH, TRANSIT AND STORAGE

(a) Unless otherwise specified in the approval certificate for storage and segregation (persons and films), see Section V, paras 520-525.
(b) The consignor is responsible for complying with conditions specified in the approval certificate.
(c) For pre-shipment requirements, see Sections VII, paras 738-739.
(d) The total transport index per conveyance shall be in accordance with Section V, para.531, unless otherwise specified in the approval certificate. The same applies to external radiation levels.
(e) When transported by air, the maximum accessible surface temperature must not exceed 50°C and no ancillary cooling is permitted, except as specified in the approval certificate.

8. TRANSPORT IN BULK OR IN TANK WAGONS

Not allowed unless specified in the approval certificate.

9. PLACARDING OF VEHICLES

The placard shown in Section V, Fig.5, to be affixed to each of the two external lateral walls.
10. MIXED LOADING

In accordance with Section V, paras 527, 528 and 530, unless specified in the approval certificate.

11. DECONTAMINATION OF CONVEYANCES

Unless otherwise specified, see Section V, para.552.

12. OTHER PRESCRIPTIONS, ACCIDENTS, CUSTOMS, EXPOSURE LIMITS, ETC.

No special requirements, but see Section I, paras 146-149 and Section V, para.554, and conditions specified in the approval certificate.
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