

Chapter 6.4

Provisions for the construction, testing and approval of packages for radioactive material and for the approval of such material

Note: This chapter includes provisions which apply to the construction, testing and approval of certain packages and material only when transported by air. Whilst these provisions do not apply to packages/material transported by sea, the provisions are reproduced for information/identification purposes, since such packages/material, designed, tested and approved for air transport, may also be transported by sea.

6.4.1 [Reserved]

6.4.2 General provisions

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

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

6.4.2.3 Attachments and any other features on the outer surface of the package which could be used to lift it shall be designed either to support its mass in accordance with the provisions of 6.4.2.2 or shall be removable or otherwise rendered incapable of being used during transport.

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

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

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

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

■ **6.4.2.8** The design of the package shall take into account ageing mechanisms.

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

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

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

△ **6.4.2.12** A package shall be so designed that it provides sufficient shielding to ensure that, under routine conditions of transport and with the maximum radioactive contents that the package is designed to contain, the dose rate at any point on the external surface of the package would not exceed the values specified in 2.7.2.4.1.2, 4.1.9.1.11 and 4.1.9.1.12, as applicable, with account taken of 7.1.4.5.3.3 and 7.1.4.5.5.

- △ 6.4.2.13 For radioactive material having other dangerous properties, the package design shall take into account those properties; see 4.1.9.1.5, 2.0.3.1 and 2.0.3.2.
- △ 6.4.2.14 Manufacturers and subsequent distributors of packagings shall provide information regarding procedures to be followed and a description of the types and dimensions of closures (including required gaskets) and any other components needed to ensure that packages as presented for transport are capable of passing the applicable performance tests of this chapter.

6.4.3 Additional provisions for packages transported by air

- 6.4.3.1 For packages to be transported by air, the temperature of the accessible surfaces shall not exceed 50°C at an ambient temperature of 38°C with no account taken for insolation.
- 6.4.3.2 Packages to be transported by air shall be so designed that, if they were exposed to ambient temperatures ranging from –40°C to +55°C, the integrity of containment would not be impaired.
- 6.4.3.3 Packages containing radioactive material, to be transported by air, shall be capable of withstanding, without loss or dispersal of radioactive contents from the containment system, an internal pressure which produces a pressure differential of not less than maximum normal operating pressure plus 95 kPa.

6.4.4 Provisions for excepted packages

- △ An excepted package shall be designed to meet the requirements specified in 6.4.2.1 to 6.4.2.12 and, in addition, the requirements of 6.4.7.2 if it contains fissile material allowed by one of the provisions of sub-paragraphs .1 to .6 of 2.7.2.3.5, and the requirements of 6.4.3 if transported by air.

6.4.5 Provisions for industrial packages

- 6.4.5.1 A Type IP-1 package shall be designed to meet the provisions specified in 6.4.2 and 6.4.7.2, and, in addition, shall meet the provisions of 6.4.3 if carried by air.
- 6.4.5.2 A package, to be qualified as a Type IP-2 package, shall be designed to meet the provisions for Type IP-1 as specified in 6.4.5.1 and, in addition, if it were subjected to the tests specified in 6.4.15.4 and 6.4.15.5, it would prevent:
 - .1 loss or dispersal of the radioactive contents, and
 - .2 more than a 20% increase in the maximum dose rate at any external surface of the package.
- 6.4.5.3 A package, to be qualified as a Type IP-3 package, shall be designed to meet the provisions for Type IP-1 as specified in 6.4.5.1 and, in addition, the provisions specified in 6.4.7.2–6.4.7.15.

6.4.5.4 Alternative provisions for Type IP-2 and Type IP-3 packages

- 6.4.5.4.1 Packages may be used as Type IP-2 package provided that:
 - .1 they satisfy the provisions for Type IP-1 specified in 6.4.5.1;
 - .2 they are designed to satisfy the provisions for packing group I or II in chapter 6.1 of this Code; and
 - .3 when subjected to the tests for UN packing group I or II in chapter 6.1, they would prevent:
 - (i) loss or dispersal of the radioactive contents; and
 - (ii) more than a 20% increase in the maximum dose rate at any external surface of the package.
- 6.4.5.4.2 Portable tanks may also be used as Type IP-2 or Type IP-3 packages provided that:
 - .1 they satisfy the provisions for Type IP-1 specified in 6.4.5.1;
 - .2 they are designed to satisfy the provisions of chapter 6.7 of this Code, and are capable of withstanding a test pressure of 265 kPa; and
 - .3 they are designed so that any shielding which is provided shall be capable of withstanding the static and dynamic stresses resulting from handling and routine conditions of transport and of preventing more than a 20% increase in the maximum dose rate at any external surface of the portable tanks.
- △ 6.4.5.4.3 Tanks, other than portable tanks, may also be used as Type IP-2 or Type IP-3 packages for transporting LSA-I and LSA-II as prescribed in the table under 4.1.9.2.5, provided that:
 - .1 they satisfy the provisions of 6.4.5.1;
 - .2 they are designed to satisfy the provisions prescribed in regional or national regulations for the transport of dangerous goods and are capable of withstanding a test pressure of 265 kPa; and

- .3 they are designed so that any additional shielding which is provided shall be capable of withstanding the static and dynamic stresses resulting from handling and routine conditions of transport and of preventing more than a 20% increase in the maximum dose rate at any external surface of the tanks.

6.4.5.4.4 Freight containers with the characteristics of a permanent enclosure may also be used as Type IP-2 or Type IP-3 packages provided that:

- .1 the radioactive contents are restricted to solid materials;
- .2 they satisfy the provisions for Type IP-1 specified in 6.4.5.1; and
- .3 they are designed to conform to the standards prescribed in ISO 1496-1:1990(E), *Series 1 Freight Containers – Specifications and Testing – Part 1: General Cargo Containers*, and subsequent amendments 1:1993, 2:1998, 3:2005, 4:2006 and 5:2006, excluding dimensions and ratings. They shall be designed such that, if subjected to the tests prescribed in that document and the accelerations occurring during routine conditions of transport, they would prevent:
 - .1 loss or dispersal of the radioactive contents; and
 - .2 more than a 20% increase in the maximum dose rate at any external surface of the package.

6.4.5.4.5 Metal intermediate bulk containers may also be used as Type IP-2 or Type IP-3 packages provided that:

- .1 they satisfy the provisions for Type IP-1 specified in 6.4.5.1; and
- .2 they are designed to satisfy the provisions of chapter 6.5 of this Code for packing group I or II, and if they were subjected to the tests prescribed in that chapter, but with the drop test conducted in the most damaging orientation, they would prevent:
 - .1 loss or dispersal of the radioactive contents; and
 - .2 more than a 20% increase in the maximum dose rate at any external surface of the package.

6.4.6 Provisions for packages containing uranium hexafluoride

6.4.6.1 Packages designed to contain uranium hexafluoride shall meet the requirements which pertain to the radioactive and fissile properties of the material prescribed elsewhere in this Code. Except as allowed in 6.4.6.4, uranium hexafluoride in quantities of 0.1 kg or more shall also be packaged and transported in accordance with ISO 7195:2005, *Nuclear energy – Packaging of uranium hexafluoride (UF₆) for transport*, and the provisions of 6.4.6.2 to 6.4.6.3.

△ 6.4.6.2 Each package designed to contain 0.1 kg or more of uranium hexafluoride shall be designed so that the package would meet the following provisions:

- .1 withstand, without leakage and without unacceptable stress, as specified in ISO 7195:2005, the structural test as specified in 6.4.21 except as allowed in 6.4.6.4;
- .2 withstand, without loss or dispersal of the uranium hexafluoride, the free drop test specified in 6.4.15.4; and
- .3 withstand, without rupture of the containment system, the thermal test specified in 6.4.17.3 except as allowed in 6.4.6.4.

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

6.4.6.4 Subject to multilateral approval, packages designed to contain 0.1 kg or more of uranium hexafluoride may be transported if the packages are designed:

- (a) to international or national standards other than ISO 7195:2005, provided an equivalent level of safety is maintained;
- (b) to withstand, without leakage and without unacceptable stress, a test pressure of less than 2.76 MPa as specified in 6.4.21; and/or
- (c) to contain 9000 kg or more of uranium hexafluoride and the packages do not meet the requirement of 6.4.6.2.3.

In all other respects, the provisions of 6.4.6.1 to 6.4.6.3 shall be satisfied.

6.4.7 Provisions for Type A packages

6.4.7.1 Type A packages shall be designed to meet the general provisions of 6.4.2, shall meet the provisions of 6.4.3 if carried by air, and shall meet the provisions of 6.4.7.2–6.4.7.17.

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

- 6.4.7.3 The outside of the package shall incorporate a feature, such as a seal, which is not readily breakable and which, while intact, will be evidence that it has not been opened.
- 6.4.7.4 Any tie-down attachments on the package shall be so designed that, under normal and accident conditions of transport, the forces in those attachments shall not impair the ability of the package to meet the provisions of this Code.
- 6.4.7.5 The design of the package shall take into account temperatures ranging from -40°C to $+70^{\circ}\text{C}$ for the components of the packaging. Attention shall be given to freezing temperatures for liquids and to the potential degradation of packaging materials within the given temperature range.
- 6.4.7.6 The design and manufacturing techniques shall be in accordance with national or international standards, or other provisions, acceptable to the competent authority.
- 6.4.7.7 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.
- 6.4.7.8 Special form radioactive material may be considered as a component of the containment system.
- △ 6.4.7.9 If the containment system forms a separate unit of the package, the containment system shall be capable of being securely closed by a positive fastening device which is independent of any other part of the packaging.
- 6.4.7.10 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.
- 6.4.7.11 The containment system shall retain its radioactive contents under a reduction of ambient pressure to 60 kPa.
- 6.4.7.12 All valves, other than pressure relief valves, shall be provided with an enclosure to retain any leakage from the valve.
- 6.4.7.13 A radiation shield which encloses a component of the package specified as a part of the containment system shall be so designed as to prevent the unintentional release of that component from the shield. Where the radiation shield and such component within it form a separate unit, the radiation shield shall be capable of being securely closed by a positive fastening device which is independent of any other packaging structure.
- 6.4.7.14 A package shall be so designed that, if it were subjected to the tests specified in 6.4.15, it would prevent:
- loss or dispersal of the radioactive contents; and
 - more than a 20% increase in the maximum dose rate at any external surface of the package.
- 6.4.7.15 The design of a package intended for liquid radioactive material shall make provision for ullage to accommodate variations in the temperature of the contents, dynamic effects and filling dynamics.
- Type A packages to contain liquids*
- 6.4.7.16 A Type A package designed to contain liquid radioactive material shall, in addition:
- be adequate to meet the conditions specified in 6.4.7.14(a) above if the package is subjected to the tests specified in 6.4.16; and
 - either
 - be provided with sufficient absorbent material to absorb twice the volume of the liquid contents. Such absorbent material must be suitably positioned so as to contact the liquid in the event of leakage; or
 - be provided with a containment system composed of primary inner and secondary outer containment components designed to enclose the liquid contents completely and ensure their retention within the secondary outer containment components even if the primary inner components leak.
- Type A packages to contain gas*
- △ 6.4.7.17 A Type A package designed for gases shall prevent loss or dispersal of the radioactive contents if the package were subjected to the tests specified in 6.4.16, except for a Type A package designed for tritium gas or for noble gases.
- 6.4.8 Provisions for Type B(U) packages**
- 6.4.8.1 Type B(U) packages shall be designed to meet the requirements specified in 6.4.2, the requirements specified in 6.4.3 if carried by air, and of 6.4.7.2 to 6.4.7.15, except as specified in 6.4.7.14(a), and, in addition, the requirements specified in 6.4.8.2 to 6.4.8.15.

- 6.4.8.2 A package shall be so designed that, under the ambient conditions specified in 6.4.8.5 and 6.4.8.6, heat generated within the package by the radioactive contents shall not, under normal conditions of transport, as demonstrated by the tests in 6.4.15, adversely affect the package in such a way that it would fail to meet the applicable provisions 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 cause one or more of the following:
- (a) alter the arrangement, the geometrical form or the physical state of the radioactive contents or, if the radioactive material is enclosed in a can or receptacle (for example, clad fuel elements), cause the can, receptacle or radioactive material to deform or melt;
 - △ (b) lessening of the efficiency of the packaging through differential thermal expansion or cracking or melting of the radiation shielding material;
 - (c) in combination with moisture, accelerate corrosion.
- 6.4.8.3 A package shall be so designed that, under the ambient condition specified in 6.4.8.5 and in the absence of insolation, the temperature of the accessible surfaces of a package shall not exceed 50°C, unless the package is transported under exclusive use.
- 6.4.8.4 Except as required in 6.4.3.1 for a package transported by air, the maximum temperature of any surface readily accessible during transport of a package under exclusive use shall not exceed 85°C in the absence of insolation under the ambient conditions specified in 6.4.8.5. Account may be taken of barriers or screens intended to give protection to persons without the need for the barriers or screens being subject to any test.
- 6.4.8.5 The ambient temperature shall be assumed to be 38°C.
- 6.4.8.6 The solar insolation conditions shall be assumed to be as specified in the table hereunder.

Insolation data

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

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

- 6.4.8.7 A package which includes thermal protection for the purpose of satisfying the provisions of the thermal test specified in 6.4.17.3 shall be so designed that such protection will remain effective if the package is subjected to the tests specified in 6.4.15 and 6.4.17.2(a) and (b) or 6.4.17.2(b) and (c), as appropriate. Any such protection on the exterior of the package shall not be rendered ineffective by ripping, cutting, skidding, abrasion or rough handling.
- 6.4.8.8 A package shall be so designed that, if it were subjected to:
- .1 the tests specified in 6.4.15, it would restrict the loss of radioactive contents to not more than $10^{-6}A_2$ per hour; and
 - .2 the tests specified in 6.4.17.1, 6.4.17.2(b), 6.4.17.3 and 6.4.17.4 and either the test in:
 - (i) 6.4.17.2(c), when the package has a mass not greater than 500 kg, an overall density not greater than 1,000 kg/m³ based on the external dimensions, and radioactive contents greater than $1,000A_2$ not as special form radioactive material, or
 - (ii) 6.4.17.2(a), for all other packages,
 it would meet the following provisions:
 - △ – retain sufficient shielding to ensure that the dose rate at 1 m from the surface of the package would not exceed 10 mSv/h with the maximum radioactive contents which the package is designed to contain; and
 - restrict the accumulated loss of radioactive contents in a period of one week to not more than $10A_2$ for krypton-85 and not more than A_2 for all other radionuclides.
- △ Where mixtures of different radionuclides are present, the provisions of 2.7.2.2.4–2.7.2.2.6 shall apply except that for krypton-85 an effective $A_2(i)$ value equal to $10A_2$ may be used. For case .1 above, the assessment shall take into account the external non-fixed contamination limits of 4.1.9.1.2.

- 6.4.8.9 A package for radioactive contents with activity greater than $10^5 A_2$ shall be so designed that, if it were subjected to the enhanced water immersion test specified in 6.4.18, there would be no rupture of the containment system.
- 6.4.8.10 Compliance with the permitted activity release limits shall depend neither upon filters nor upon a mechanical cooling system.
- 6.4.8.11 A package shall not include a pressure relief system from the containment system which would allow the release of radioactive material to the environment under the conditions of the tests specified in 6.4.15 and 6.4.17.
- 6.4.8.12 A package shall be so designed that, if it were at the maximum normal operating pressure and it were subjected to the tests specified in 6.4.15 and 6.4.17, the level of strains in the containment system would not attain values which would adversely affect the package in such a way that it would fail to meet the applicable provisions.
- 6.4.8.13 A package shall not have a maximum normal operating pressure in excess of a gauge pressure of 700 kPa.
- 6.4.8.14 A package containing low dispersible radioactive material shall be so designed that any features added to the low dispersible radioactive material that are not part of it, or any internal components of the packaging, shall not adversely affect the performance of the low dispersible radioactive material.
- 6.4.8.15 A package shall be designed for an ambient temperature range from -40°C to $+38^\circ\text{C}$.

6.4.9 Provisions for Type B(M) packages

- △ 6.4.9.1 Type B(M) packages shall meet the provisions for Type B(U) packages specified in 6.4.8.1, except that, for packages to be transported solely within a specified country or solely between specified countries, conditions other than those given in 6.4.7.5, 6.4.8.4 to 6.4.8.6 and 6.4.8.9 to 6.4.8.15 above may be assumed, with the approval of the competent authorities of these countries. The provisions for Type B(U) packages specified in 6.4.8.4 and 6.4.8.9 to 6.4.8.15 shall be met as far as practicable.
- 6.4.9.2 Intermittent venting of Type B(M) packages may be permitted during transport, provided that the operational controls for venting are acceptable to the relevant competent authorities.

6.4.10 Provisions for Type C packages

- 6.4.10.1 Type C packages shall be designed to meet the provisions specified in 6.4.2 and 6.4.3, and of 6.4.7.2 to 6.4.7.15, except as specified in 6.4.7.14, and of the provisions specified in 6.4.8.2 to 6.4.8.6, 6.4.8.10 to 6.4.8.15, and, in addition, of 6.4.10.2–6.4.10.4.
- 6.4.10.2 A package shall be capable of meeting the assessment criteria prescribed for tests in 6.4.8.8.2 and 6.4.8.12 after burial in an environment defined by a thermal conductivity of $0.33 \text{ W/(m}\cdot\text{K)}$ and a temperature of 38°C in the steady state. Initial conditions for the assessment shall assume that any thermal insulation of the package remains intact, the package is at the maximum normal operating pressure and the ambient temperature is 38°C .
- 6.4.10.3 A package shall be so designed that, if it were at the maximum normal operating pressure and subjected to:
- the tests specified in 6.4.15, it would restrict the loss of radioactive contents to not more than $10^{-6} A_2$ per hour; and
 - the test sequences in 6.4.20.1,
 - it would retain sufficient shielding to ensure that the dose rate at 1 m from the surface of the package would not exceed 10 mSv/h with the maximum radioactive contents which the package is designed to contain; and
 - it would restrict the accumulated loss of radioactive contents in a period of 1 week to not more than $10 A_2$ for krypton-85 and not more than A_2 for all other radionuclides.

Where mixtures of different radionuclides are present, the provisions of 2.7.2.2.4 to 2.7.2.2.6 shall apply except that for krypton-85 an effective $A_2(i)$ value equal to $10 A_2$ may be used. For case (a) above, the assessment shall take into account the external contamination limits of 4.1.9.1.2.

- 6.4.10.4 A package shall be so designed that there will be no rupture of the containment system following performance of the enhanced water immersion test specified in 6.4.18.

6.4.11 Provisions for packages containing fissile material

- 6.4.11.1 Fissile material shall be transported so as to:
- maintain subcriticality during routine, normal and accident conditions of transport; in particular, the following contingencies shall be considered:
 - water leaking into or out of packages;

- (ii) the loss of efficiency of built-in neutron absorbers or moderators;
 - (iii) rearrangement of the contents either within the package or as a result of loss from the package;
 - (iv) reduction of spaces within or between packages;
 - (v) packages becoming immersed in water or buried in snow; and
 - (vi) temperature changes; and
- (b) meet the provisions:
- (i) of 6.4.7.2 except for unpackaged material when specifically allowed by 2.7.2.3.5.5;
 - (ii) prescribed elsewhere in this Code which pertain to the radioactive properties of the material;
 - (iii) of 6.4.7.3 unless the material is excepted by 2.7.2.3.5;
 - (iv) of 6.4.11.4 to 6.4.11.14, unless the material is excepted by 2.7.2.3.5, 6.4.11.2 or 6.4.11.3.

6.4.11.2 Packages containing fissile material that meet the provisions of subparagraph (d) and one of the provisions of (a) to (c) below are excepted from the requirements of 6.4.11.4 to 6.4.11.14.

- (a) Packages containing fissile material in any form provided that:
- (i) the smallest external dimension of the package is not less than 10 cm;
 - (ii) the criticality safety index (CSI) of the package is calculated using the following formula:

$$CSI = 50 \times 5 \times \left(\frac{\text{Mass of U-235 in package (g)}}{Z} + \frac{\text{Mass of other fissile nuclides* in package (g)}}{280} \right)$$

* Plutonium may be of any isotopic composition provided that the amount of Pu-241 is less than that of Pu-240 in the package.

where the values of Z are taken from table 6.4.11.2;

- (iii) the CSI of any package does not exceed 10.
- (b) Packages containing fissile material in any form provided that:
- (i) the smallest external dimension of the package is not less than 30 cm;
 - (ii) the package, after being subjected to the tests specified in 6.4.15.1 to 6.4.15.6:
 - retains its fissile material contents;
 - preserves the minimum overall outside dimensions of the package to at least 30 cm;
 - prevents the entry of a 10 cm cube;
 - (iii) the CSI of the package is calculated using the following formula:

$$CSI = 50 \times 2 \times \left(\frac{\text{Mass of U-235 in package (g)}}{Z} + \frac{\text{Mass of other fissile nuclides* in package (g)}}{280} \right)$$

* Plutonium may be of any isotopic composition provided that the amount of Pu-241 is less than that of Pu-240 in the package.

where the values of Z are taken from table 6.4.11.2.

- (iv) the CSI of any package does not exceed 10;
- (c) Packages containing fissile material in any form provided that:
- (i) the smallest external dimension of the package is not less than 10 cm;
 - (ii) the package, after being subjected to the tests specified in 6.4.15.1 to 6.4.15.6:
 - retains its fissile material contents;
 - preserves the minimum overall outside dimensions of the package to at least 10 cm;
 - prevents the entry of a 10 cm cube.
 - (iii) the CSI of the package is calculated using the following formula:

$$CSI = 50 \times 2 \times \left(\frac{\text{Mass of U-235 in package (g)}}{450} + \frac{\text{Mass of other fissile nuclides* in package (g)}}{280} \right)$$

* Plutonium may be of any isotopic composition provided that the amount of Pu-241 is less than that of Pu-240 in the package.

- △ (iv) The total mass of fissile nuclides in any package does not exceed 15 g;
- △ (d) The total mass of beryllium, hydrogenous material enriched in deuterium, graphite and other allotropic forms of carbon in an individual package shall not be greater than the mass of fissile nuclides in the package except where the total concentration of these materials does not exceed 1 g in any 1,000 g of material. Beryllium incorporated in copper alloys up to 4% in weight of the alloy does not need to be considered.

Table 6.4.11.2 – Values of Z for calculation of criticality safety index in accordance with 6.4.11.2

Enrichment ^a	Z
Uranium enriched up to 1.5%	2,200
Uranium enriched up to 5%	850
Uranium enriched up to 10%	660
Uranium enriched up to 20%	580
Uranium enriched up to 100%	450

^a If a package contains uranium with varying enrichments of U-235, then the value corresponding to the highest enrichment shall be used for Z.

6.4.11.3 Packages containing not more than 1,000 g of plutonium are excepted from the application of 6.4.11.4 to 6.4.11.14 provided that:

- (a) not more than 20% of the plutonium by mass is fissile nuclides;
- (b) the criticality safety index of the package is calculated using the following formula:

$$CSI = 50 \times 2 \times \frac{\text{mass of plutonium (g)}}{1,000}$$

- (c) if uranium is present with the plutonium, the mass of uranium shall be no more than 1% of the mass of the plutonium.

6.4.11.4 Where the chemical or physical form, isotopic composition, mass or concentration, moderation ratio or density, or geometric configuration is not known, the assessments of 6.4.11.8 to 6.4.11.13 shall be performed assuming that each parameter that is not known has the value which gives the maximum neutron multiplication consistent with the known conditions and parameters in these assessments.

6.4.11.5 For irradiated nuclear fuel, the assessments of 6.4.11.8 to 6.4.11.13 shall be based on an isotopic composition demonstrated to provide either:

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

6.4.11.6 The package, after being subjected to the tests specified in 6.4.15, shall:

- (a) preserve the minimum overall outside dimensions of the package to at least 10 cm; and
- (b) prevent the entry of a 10 cm cube.

6.4.11.7 The package shall be designed for an ambient temperature range of –40°C to +38°C unless the competent authority specifies otherwise in the certificate of approval for the package design.

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

- (a) multiple high-standard water barriers, not less than two of which would remain watertight if the package were subject to the tests prescribed in 6.4.11.13(b), a high degree of quality control in the manufacture, maintenance and repair of packagings and tests to demonstrate the closure of each package before each shipment; or
- (b) for packages containing uranium hexafluoride only, with maximum enrichment of 5 mass percent uranium-235:

- △ (i) packages where, following the tests prescribed in 6.4.11.13(b), there is no physical contact between the valve or the plug and any other component of the packaging other than at its original point of attachment and where, in addition, following the test prescribed in 6.4.17.3, the valves and the plug remain leaktight; and
- (ii) a high degree of quality control in the manufacture, maintenance and repair of packagings coupled with tests to demonstrate closure of each package before each shipment.

6.4.11.9 It shall be assumed that the confinement system is closely reflected by at least 20 cm of water or such greater reflection as may additionally be provided by the surrounding material of the packaging. However, when it can be demonstrated that the confinement system remains within the packaging following the tests prescribed in 6.4.11.13(b), close reflection of the package by at least 20 cm of water may be assumed in 6.4.11.10(c).



- 6.4.11.10 The package shall be subcritical under the conditions of 6.4.11.8 and 6.4.11.9 and with the package conditions that result in the maximum neutron multiplication consistent with:
- routine conditions of transport (incident-free);
 - the tests specified in 6.4.11.12(b);
 - the tests specified in 6.4.11.13(b).
- 6.4.11.11 For packages to be transported by air:
- the package shall be subcritical under conditions consistent with the Type C package tests specified in 6.4.20.1 assuming reflection by at least 20 cm of water but no water in-leakage; and
 - △ (b) in the assessment of 6.4.11.10, use of special features as specified in 6.4.11.8 is allowed provided that leakage of water into or out of the void spaces is prevented when the package is submitted to the Type C package tests specified in 6.4.20.1 followed by the water leakage test specified in 6.4.19.3.
- 6.4.11.12 A number “*N*” shall be derived, such that five times “*N*” packages shall be subcritical for the arrangement and package conditions that provide the maximum neutron multiplication consistent with the following:
- there shall not be anything between the packages, and the package arrangement shall be reflected on all sides by at least 20 cm of water; and
 - the state of the packages shall be their assessed or demonstrated condition if they had been subjected to the tests specified in 6.4.15.
- 6.4.11.13 A number “*N*” shall be derived, such that two times “*N*” packages shall be subcritical for the arrangement and package conditions that provide the maximum neutron multiplication consistent with the following:
- hydrogenous moderation between packages, and the package arrangement reflected on all sides by at least 20 cm of water; and
 - the tests specified in 6.4.15 followed by whichever of the following is the more limiting:
 - the tests specified in 6.4.17.2(b) and either 6.4.17.2(c), for packages having a mass not greater than 500 kg and an overall density not greater than 1000 kg/m³ based on the external dimensions, or 6.4.17.2(a), for all other packages; followed by the test specified in 6.4.17.3 and completed by the tests specified in 6.4.19.1–6.4.19.3; or
 - the test specified in 6.4.17.4; and
 - where any part of the fissile material escapes from the containment system following the tests specified in 6.4.11.13(b), it shall be assumed that fissile material escapes from each package in the array and all of the fissile material shall be arranged in the configuration and moderation that results in the maximum neutron multiplication with close reflection by at least 20 cm of water.
- 6.4.11.14 The criticality safety index (CSI) for packages containing fissile material shall be obtained by dividing the number 50 by the smaller of the two values of *N* derived in 6.4.11.12 and 6.4.11.13 (i.e. $CSI = 50/N$). The value of the criticality safety index may be zero, provided that an unlimited number of packages is subcritical (i.e. *N* is effectively equal to infinity in both cases).

6.4.12 Test procedures and demonstration of compliance

- 6.4.12.1 Demonstration of compliance with the performance standards required in 2.7.2.3.3.1, 2.7.2.3.3.2, 2.7.2.3.4.1, 2.7.2.3.4.2, **2.7.2.3.4.3** and 6.4.2–6.4.11 shall be accomplished by any of the methods listed below or by a combination thereof.
- △ (a) Performance of tests with specimens representing special form radioactive material, or low dispersible radioactive material or with prototypes or samples of the packaging, where the contents of the specimen or the packaging for the tests shall simulate as closely as practicable the expected range of radioactive contents and the specimen or packaging to be tested shall be prepared as presented for transport.
 - (b) Reference to previous satisfactory demonstrations of a sufficiently similar nature.
 - (c) Performance of tests with models of appropriate scale incorporating those features which are significant with respect to the item under investigation when engineering experience has shown results of such tests to be suitable for design purposes. When a scale model is used, the need for adjusting certain test parameters, such as penetrator diameter or compressive load, shall be taken into account.
 - (d) Calculation, or reasoned argument, when the calculation procedures and parameters are generally agreed to be reliable or conservative.
- 6.4.12.2 After the specimen, prototype or sample has been subjected to the tests, appropriate methods of assessment shall be used to assure that the provisions of this chapter have been fulfilled in compliance with the performance and acceptance standards prescribed in this chapter (see , 2.7.2.3.3.1, 2.7.2.3.3.2, 2.7.2.3.4.1, 2.7.2.3.4.2, **2.7.2.3.4.3** and 6.4.2–6.4.11).

- 6.4.12.3 All specimens shall be inspected before testing in order to identify and record faults or damage, including the following:
- (a) divergence from the design;
 - (b) defects in manufacture;
 - (c) corrosion or other deterioration; and
 - (d) distortion of features.

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

6.4.13 Testing the integrity of the containment system and shielding and evaluating criticality safety

- △ After each test or group of tests or sequence of the applicable tests, as appropriate, specified in 6.4.15 to 6.4.21:
- (a) faults and damage shall be identified and recorded;
 - (b) it shall be determined whether the integrity of the containment system and shielding has been retained to the extent required in this chapter for the package under test; and
 - (c) for packages containing fissile material, it shall be determined whether the assumptions and conditions used in the assessments required by 6.4.11.1 to 6.4.11.14 for one or more packages are valid.

6.4.14 Target for drop tests

The target for the drop tests specified in 2.7.2.3.3.5.1, 6.4.15.4, 6.4.16(a), 6.4.17.2 and 6.4.20.2 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.

6.4.15 Test for demonstrating ability to withstand normal conditions of transport

- 6.4.15.1 The tests are: the water spray test, the free drop test, the stacking test and the penetration test. Specimens of the package shall be subjected to the free drop test, the stacking test and the penetration test, preceded in each case by the water spray test. One specimen may be used for all the tests, provided that the provisions of 6.4.15.2 are fulfilled.
- 6.4.15.2 The time interval between the conclusion of the water spray test and the succeeding test shall be such that the water has soaked in to the maximum extent, without appreciable drying of the exterior of the specimen. In the absence of any evidence to the contrary, this interval shall be taken to be two hours if the water spray is applied from four directions simultaneously. No time interval shall elapse, however, if the water spray is applied from each of the four directions consecutively.
- 6.4.15.3 Water spray test: The specimen shall be subjected to a water spray test that simulates exposure to rainfall of approximately 5 cm per hour for at least one hour.
- 6.4.15.4 Free drop test: The specimen shall drop onto the target so as to suffer maximum damage in respect of the safety features to be tested.
- △ (a) The height of the drop measured from the lowest point of the specimen to the upper surface of the target, shall be not less than the distance specified in the table hereunder for the applicable mass. The target shall be as defined in 6.4.14.
- (b) For rectangular fibreboard or wood packages not exceeding a mass of 50 kg, a separate specimen shall be subjected to a free drop onto each corner from a height of 0.3 m.
 - (c) For cylindrical fibreboard packages not exceeding a mass of 100 kg, a separate specimen shall be subjected to a free drop onto each of the quarters of each rim from a height of 0.3 m.

Free drop distance for testing packages to normal conditions of transport

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

- 6.4.15.5** Stacking test: Unless the shape of the packaging effectively prevents stacking, the specimen shall be subjected, for a period of 24 hours, to a compressive load equal to the greater of the following:
- (a) the equivalent of 5 times the maximum weight of the package; and
 - (b) the equivalent of 13 kPa multiplied by the vertically projected area of the package.

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

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

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

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

- (a) Free drop test: The specimen shall drop onto the target so as to suffer the maximum damage in respect of containment. The height of the drop measured from the lowest part of the specimen to the upper surface of the target shall be 9 m. The target shall be as defined in 6.4.14.
- (b) Penetration test: The specimen shall be subjected to the test specified in 6.4.15.6 except that the height of drop shall be increased to 1.7 m from the 1 m specified in 6.4.15.6(b).

6.4.17 Tests for demonstrating ability to withstand accident conditions of transport

- 6.4.17.1** The specimen shall be subjected to the cumulative effects of the tests specified in 6.4.17.2 and 6.4.17.3, in that order. Following these tests, either this specimen or a separate specimen shall be subjected to the effect(s) of the water immersion test(s) as specified in 6.4.17.4 and, if applicable, 6.4.18.

- 6.4.17.2** Mechanical test: The mechanical test consists of three different drop tests. Each specimen shall be subjected to the applicable drops as specified in 6.4.8.8 or 6.4.11.13. The order in which the specimen is subjected to the drops shall be such that, on completion of the mechanical test, the specimen shall have suffered such damage as will lead to the maximum damage in the thermal test which follows.

- (a) For drop I, the specimen shall drop onto the target so as to suffer the maximum damage, and the height of the drop measured from the lowest point of the specimen to the upper surface of the target shall be 9 m. The target shall be as defined in 6.4.14.
- △ (b) For drop II, the specimen shall drop onto a bar rigidly mounted perpendicularly on the target so as to suffer the maximum damage. The height of the drop measured from the intended point of impact of the specimen to the upper surface of the bar shall be 1 m. The bar shall be of solid mild steel of circular cross-section, (15.0 ± 0.5) cm in diameter and 20 cm long unless a longer bar would cause greater damage, in which case a bar of sufficient length to cause maximum damage shall be used. The upper end of the bar shall be flat and horizontal with its edge rounded off to a radius of not more than 6 mm. The target on which the bar is mounted shall be as described in 6.4.14.
- (c) For drop III, the specimen shall be subjected to a dynamic crush test by positioning the specimen on the target so as to suffer maximum damage by the drop of a 500 kg mass from 9 m onto the specimen. The mass shall consist of a solid mild steel plate 1 m by 1 m and shall fall in a horizontal attitude. The lower face of the steel plate shall have its edges and corners rounded off to a radius of not more than 6 mm. The height of the drop shall be measured from the underside of the plate to the highest point of the specimen. The target on which the specimen rests shall be as defined in 6.4.14.

- 6.4.17.3** Thermal test: The specimen shall be in thermal equilibrium under conditions of an ambient temperature of 38°C, subject to the solar insolation conditions specified in the table under 6.4.8.6 and subject to the design maximum rate of internal heat generation within the package from the radioactive contents. Alternatively, any of these parameters are allowed to have different values prior to and during the test, providing due account is taken of them in the subsequent assessment of package response.

The thermal test shall then consist of:

- (a) exposure of a specimen for a period of 30 minutes to a thermal environment which provides a heat flux at least equivalent to that of a hydrocarbon fuel/air fire in sufficiently quiescent ambient conditions to give a minimum average flame emissivity coefficient of 0.9 and an average temperature of at least 800°C, fully

engulfing the specimen, with a surface absorptivity coefficient of 0.8 or that value which the package may be demonstrated to possess if exposed to the fire specified, followed by:

- △ (b) exposure of the specimen to an ambient temperature of 38°C, subject to the solar insolation conditions specified in the table under 6.4.8.6 and subject to the design maximum rate of internal heat generation within the package by the radioactive contents, for a sufficient period to ensure that temperatures in the specimen are decreasing in all parts of the specimen and/or are approaching initial steady-state conditions. Alternatively, any of these parameters are allowed to have different values following cessation of heating, providing due account is taken of them in the subsequent assessment of package response.

During and following the test, the specimen shall not be artificially cooled and any combustion of materials of the specimen shall be permitted to proceed naturally.

- 6.4.17.4 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 in the attitude which will lead to maximum damage. For demonstration purposes, an external gauge pressure of at least 150 kPa shall be considered to meet these conditions.

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

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

6.4.19 Water leakage test for packages containing fissile material

- 6.4.19.1 Packages for which water in-leakage or out-leakage to the extent which results in greatest reactivity has been assumed for purposes of assessment under 6.4.11.8 to 6.4.11.13 shall be excepted from the test.
- 6.4.19.2 Before the specimen is subjected to the water leakage test specified below, it shall be subjected to the tests in 6.4.17.2(b), and either 6.4.17.2(a) or (c) as required by 6.4.11.13, and the test specified in 6.4.17.3.
- 6.4.19.3 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.

6.4.20 Tests for Type C packages

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

- (a) the tests specified in 6.4.17.2(a), 6.4.17.2(c), 6.4.20.2 and 6.4.20.3; and
- (b) the test specified in 6.4.20.4.

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

- 6.4.20.2 Puncture/tearing test: The specimen shall be subjected to the damaging effects of a vertical, solid probe made of mild steel. The orientation of the package specimen and the impact point on the package surface shall be such as to cause maximum damage at the conclusion of the test sequence specified in 6.4.20.1(a).

- (a) The specimen, representing a package having a mass less than 250 kg, shall be placed on a target and subjected to a probe having a mass of 250 kg falling from a height of 3 m above the intended impact point. For this test, the probe shall be a 20 cm diameter cylindrical bar with the striking end forming a frustum of a right circular cone with the following dimensions: 30 cm height and 2.5 cm in diameter at the top with its edge rounded off to a radius of not more than 6 mm. The target on which the specimen is placed shall be as specified in 6.4.14.

- (b) For packages having a mass of 250 kg or more, the base of the probe shall be placed on a target and the specimen dropped onto the probe. The height of the drop, measured from the point of impact with the specimen to the upper surface of the probe, shall be 3 m. For this test, the probe shall have the same properties and dimensions as specified in (a) above, except that the length and mass of the probe shall be such as to incur maximum damage to the specimen. The target on which the base of the probe is placed shall be as specified in 6.4.14.

- 6.4.20.3 Enhanced thermal test: The conditions for this test shall be as specified in 6.4.17.3, except that the exposure to the thermal environment shall be for a period of 60 min.

- 6.4.20.4 Impact test: The specimen shall be subject to an impact on a target at a velocity of not less than 90 m/s, at such an orientation as to suffer maximum damage. The target shall be as defined in 6.4.14, except that the target surface may be at any orientation provided that the surface is normal to the specimen path.

6.4.21 Tests for packagings designed to contain uranium hexafluoride

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

6.4.22 Approvals of package designs and materials

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

- (a) Each design that meets the provisions of 6.4.6.4 shall require multilateral approval;
- (b) Each design that meets the provisions of 6.4.6.1 to 6.4.6.3 shall require unilateral approval by the competent authority of the country of origin of the design, unless multilateral approval is otherwise required by this Code.

6.4.22.2 Each Type B(U) and Type C package design will require unilateral approval, except that:

- (a) a package design for fissile material which is also subject to 6.4.22.4, 6.4.23.7 and 5.1.5.2.1 will require multilateral approval; and
- (b) a Type B(U) package design for low dispersible radioactive material will require multilateral approval.

6.4.22.3 Each Type B(M) package design, including those for fissile material which are also subject to 6.4.22.4, 6.4.23.7 and 5.1.5.2.1 and those for low dispersible radioactive material, will require multilateral approval.

6.4.22.4 Each package design for fissile material which is not excepted by any of the paragraphs 2.7.2.3.5.1 to 2.7.2.3.5.6, 6.4.11.2 and 6.4.11.3 shall require multilateral approval.

6.4.22.5 The design for special form radioactive material will require unilateral approval. The design for low dispersible radioactive material will require multilateral approval (see also 6.4.23.8).

6.4.22.6 The design for a fissile material excepted from "FISSILE" classification in accordance with 2.7.2.3.5.6 shall require multilateral approval.

6.4.22.7 Alternative activity limits for an exempt consignment of instruments or articles in accordance with 2.7.2.2.2.2 shall require multilateral approval.

6.4.23 Applications for approval and approvals for radioactive material transport

6.4.23.1 [Reserved]

6.4.23.2 An application for approval of shipment shall include:

- (a) the period of time, related to the shipment, for which the approval is sought;
- (b) the actual radioactive contents, the expected modes of transport, the type of conveyance, and the probable or proposed route; and
- (c) the details of how the precautions and administrative or operational controls referred to in the certificate of approval for the package design, if applicable, issued under 5.1.5.2.1.1.3, 5.1.5.2.1.1.6 or 5.1.5.2.1.1.7, are to be put into effect.

■ 6.4.23.2.1 An application for approval of SCO-III shipments shall include:

- (a) a statement of the respects in which, and of the reasons why, the consignment is considered SCO-III;
- (b) justification for choosing SCO-III by demonstrating that:
 - (i) no suitable packaging currently exists;
 - (ii) designing and/or constructing a packaging or segmenting the object is not practically, technically or economically feasible;
 - (iii) no other viable alternative exists;
- (c) a detailed description of the proposed radioactive contents with reference to their physical and chemical states and the nature of the radiation emitted;
- (d) a detailed statement of the design of the SCO-III, including complete engineering drawings and schedules of materials and methods of manufacture;
- (e) all information necessary to satisfy the competent authority that the requirements of 4.1.9.2.4.5 and the requirements of 7.1.4.5.1, if applicable, are satisfied;
- (f) a transport plan;
- (g) a specification of the applicable management system as required in 1.5.3.1.

- 6.4.23.3 An application for approval of shipments under special arrangement shall include all the information necessary to satisfy the competent authority that the overall level of safety in transport is at least equivalent to that which would be provided if all the applicable provisions of this Code had been met. The application shall also include:
- (a) a statement of the respects in which, and of the reasons why, the shipment cannot be made in full accordance with the applicable provisions; and
 - (b) a statement of any special precautions or special administrative or operational controls which are to be employed during transport to compensate for the failure to meet the applicable provisions.
- 6.4.23.4 An application for approval of Type B(U) or Type C package design shall include:
- (a) a detailed description of the proposed radioactive contents with reference to their physical and chemical states and the nature of the radiation emitted;
 - (b) a detailed statement of the design, including complete engineering drawings and schedules of materials and methods of manufacture;
 - (c) a statement of the tests which have been done and their results, or evidence based on calculative methods or other evidence that the design is adequate to meet the applicable provisions;
 - (d) the proposed operating and maintenance instructions for the use of the packaging;
 - (e) if the package is designed to have a maximum normal operating pressure in excess of 100 kPa gauge, a specification of the materials of manufacture of the containment system, the samples to be taken, and the tests to be made;
 - (f) if the package is to be used for shipment after storage, a justification of considerations to ageing mechanisms in the safety analysis and within the proposed operating and maintenance instructions;
 - △ (g) where the proposed radioactive contents are irradiated nuclear fuel, a statement and a justification of any assumption in the safety analysis relating to the characteristics of the fuel and a description of any pre-shipment measurement required by 6.4.11.5(b);
 - △ (h) any special stowage provisions necessary to ensure the safe dissipation of heat from the package, considering the various modes of transport to be used and type of conveyance or freight container;
 - △ (i) a reproducible illustration, not larger than 21 cm by 30 cm, showing the make-up of the package;
 - △ (j) a specification of the applicable management system as required in 1.5.3.1; and
 - (k) for packages which are to be used for shipment after storage, a gap analysis programme describing a systematic procedure for a periodic evaluation of changes of regulations, changes in technical knowledge and changes of the state of the package design during storage.
- 6.4.23.5 An application for approval of a Type B(M) package design shall include, in addition to the information required in 6.4.23.4 for Type B(U) packages:
- (a) a list of the provisions specified in 6.4.7.5, 6.4.8.4 to 6.4.8.6 and 6.4.8.9 to 6.4.8.15 with which the package does not conform;
 - (b) any proposed supplementary operational controls to be applied during transport not regularly provided for in this Code, but which are necessary to ensure the safety of the package or to compensate for the deficiencies listed in (a) above;
 - (c) a statement relative to any restrictions on the mode of transport and to any special loading, carriage, unloading or handling procedures; and
 - (d) a statement of the range of ambient conditions (temperature, solar radiation) which are expected to be encountered during transport and which have been taken into account in the design.
- 6.4.23.6 The application for approval of designs for packages containing 0.1 kg or more of uranium hexafluoride shall include all information necessary to satisfy the competent authority that the design meets the provisions of 6.4.6.1, and a specification of the applicable management system as required in 1.5.3.1.
- 6.4.23.7 An application for a fissile package approval shall include all information necessary to satisfy the competent authority that the design meets the provisions of 6.4.11.1, and a specification of the applicable management system as required in 1.5.3.1.
- 6.4.23.8 An application for approval of design for special form radioactive material and design for low dispersible radioactive material shall include:
- (a) a detailed description of the radioactive material or, if a capsule, the contents; particular reference shall be made to both physical and chemical states;
 - (b) a detailed statement of the design of any capsule to be used;
 - △ (c) a statement of the tests which have been done and their results, or evidence based on calculations to show that the radioactive material is capable of meeting the performance standards, or other evidence

that the special form radioactive material or low dispersible radioactive material meets the applicable provisions of this Code;

- (d) a specification of the applicable management system as required in 1.5.3.1; and
- (e) any proposed pre-shipment actions for use in the consignment of special form radioactive material or low dispersible radioactive material.

6.4.23.9 An application for approval of design for fissile material excepted from “FISSILE” classification in accordance with table 2.7.2.1.1, under 2.7.2.3.5.6 shall include:

- (a) a detailed description of the material; particular reference shall be made to both physical and chemical states;
- (b) a statement of the tests that have been carried out and their results, or evidence based on calculation methods to show that the material is capable of meeting the requirements specified in 2.7.2.3.6;
- (c) a specification of the applicable management system as required in 1.5.3.1;
- (d) a statement of specific actions to be taken prior to shipment.

6.4.23.10 An application for approval of alternative activity limits for an exempt consignment of instruments or articles shall include:

- (a) an identification and detailed description of the instrument or article, its intended uses and the radionuclide(s) incorporated;
- (b) the maximum activity of the radionuclide(s) in the instrument or article;
- (c) maximum external dose rates arising from the instrument or article;
- (d) the chemical and physical forms of the radionuclide(s) contained in the instrument or article;
- (e) details of the construction and design of the instrument or article, particularly as related to the containment and shielding of the radionuclide in routine, normal and accident conditions of transport;
- (f) the applicable management system, including the quality testing and verification procedures to be applied to radioactive sources, components and finished products to ensure that the maximum specified activity of radioactive material or the maximum dose rates specified for the instrument or article are not exceeded, and that the instruments or articles are constructed according to the design specifications;
- (g) the maximum number of instruments or articles expected to be shipped per consignment and annually;
- △ (h) dose assessments in accordance with the principles and methodologies set out in the *Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GSR Part 3, IAEA, Vienna (2014)*, including individual doses to transport workers and members of the public and, if appropriate, collective doses arising from routine, normal and accident conditions of transport, based on representative transport scenarios the consignments are subject to.

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

VRI/number/type code

- (a) Except as provided in 6.4.23.12(b), “VRI” represents the distinguishing sign used on vehicles in international road traffic* 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 or alternative activity limit for exempt consignment. The identification mark of the approval of shipment shall be clearly related to the identification mark of the approval of design.
- (c) The following type codes shall be used, in the order listed, to indicate the types of certificate of approval issued:

AF	Type A package design for fissile material
B(U)	Type B(U) package design (“B(U)F” if for fissile material)
B(M)	Type B(M) package design (“B(M)F” if for fissile material)
C	Type C package design (“CF” if for fissile material)
IF	industrial package design for fissile material
S	special form radioactive material
LD	low dispersible radioactive material
FE	fissile material complying with the requirements of 2.7.2.3.6
T	shipment

* Distinguishing sign of the State of registration used on motor vehicles and trailers in international road traffic, e.g. in accordance with the Geneva Convention on Road Traffic of 1949 or the Vienna Convention on Road Traffic of 1968.

- X special arrangement
- AL alternative activity limits for an exempt consignment of instruments or articles.

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

- H(U) unilateral approval
- H(M) multilateral approval.

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6.4.23.12 These identification marks shall be applied as follows:

- △ (a) each certificate and each package shall bear the appropriate identification marks, comprising the symbols prescribed in 6.4.23.11(a), (b) and (c) above, except that, for packages, only the applicable design type codes shall appear following the second stroke; that is, the “T” or “X” shall not appear in the identification mark on the package. Where the approval of design and the approval of shipment are combined, the applicable type codes do not need to be repeated. For example:
- A/132/B(M)F**: a Type B(M) package design approved for fissile material, requiring multilateral approval, for which the competent authority of Austria has assigned the design number 132 (to be marked on both the package and on the certificate of approval for the package design);
 - A/132/B(M)/FT**: the approval of shipment issued for a package bearing the identification mark elaborated above (to be marked on the certificate only);
 - A/137/X**: an approval of special arrangement issued by the competent authority of Austria, to which the number 137 has been assigned (to be marked on the certificate only);
 - A/139/IF**: an industrial package design for fissile material approved by the competent authority of Austria, to which package design number 139 has been assigned (to be marked on both the package and on the certificate of approval for the package design); and
 - A/145/H(U)**: a package design for fissile-excepted uranium hexafluoride approved by the competent authority of Austria, to which package design number 145 has been assigned (to be marked on both the package and on the certificate of approval for the package design);
- (b) where multilateral approval is effected by validation in accordance with 6.4.23.20, only the identification mark issued by the country of origin of the design or shipment shall be used. Where multilateral approval is effected by issue of certificates by successive countries, each certificate shall bear the appropriate identification mark and the package whose design was so approved shall bear all appropriate identification marks. For example:
- A/132/B(M)F**
 - CH/28/B(M)F**
- would be the identification mark of a package which was originally approved by Austria and was subsequently approved, by separate certificate, by Switzerland. Additional identification marks would be tabulated in a similar manner on the package;
- (c) the revision of a certificate shall be indicated by a parenthetical expression following the identification mark on the certificate. For example, **A/132/B(M)F (Rev.2)** would indicate revision 2 of the Austrian certificate of approval for the package design; or **A/132/B(M)/F (Rev.0)** would indicate the original issuance of the Austrian certificate of approval for the package design. For original issuances, the parenthetical entry is optional and other words such as ‘original issuance’ may also be used in place of ‘Rev.0’. Certificate revision numbers may only be issued by the country issuing the original certificate of approval;
- (d) additional symbols (as may be necessitated by national provisions) may be added in parentheses to the end of the identification mark. For example, **A/132/B(M)F (SP503)**; and
- (e) it is not necessary to alter the identification mark on the packaging each time that a revision to the design certificate is made. Such re-marking shall be required only in those cases where the revision to the package design certificate involves a change in the letter type codes for the package design following the second stroke.

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

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

- (g) Design specifications for the special form radioactive material or low dispersible radioactive material, which may include references to drawings.
- (h) A specification of the radioactive contents which includes the activities involved and which may include the physical and chemical form.
- (i) A specification of the applicable management system as required in 1.5.3.1.
- (j) Reference to information provided by the applicant relating to specific actions to be taken prior to shipment.
- (k) If deemed appropriate by the competent authority, reference to the identity of the applicant.
- (l) Signature and identification of the certifying official.

6.4.23.14 Each certificate of approval issued by a competent authority for material excepted from classification as “FISSILE” shall include the following information:

- (a) Type of certificate.
- (b) The competent authority identification mark.
- (c) The issue date and an expiry date.
- (d) List of applicable national and international regulations, including the edition of the IAEA *Regulations for the Safe Transport of Radioactive Material* under which the exception is approved.
- (e) A description of the excepted material.
- (f) Limiting specifications for the excepted material.
- (g) A specification of the applicable management system as required in 1.5.3.1.
- (h) Reference to information provided by the applicant relating to specific actions to be taken prior to shipment.
- (i) If deemed appropriate by the competent authority, reference to the identity of the applicant.
- (j) Signature and identification of the certifying official.
- (k) Reference to documentation that demonstrates compliance with 2.7.2.3.6.

6.4.23.15 Each certificate of approval issued by a competent authority for a special arrangement shall include the following information:

- (a) Type of certificate.
- (b) The competent authority identification mark.
- (c) The issue date and an expiry date.
- (d) Mode(s) of transport.
- (e) Any restrictions on the modes of transport, type of conveyance, freight container, and any necessary routing instructions.
- (f) List of applicable national and international regulations, including the edition of the IAEA *Regulations for the Safe Transport of Radioactive Material* under which the special arrangement is approved.
- (g) The following statement: “This certificate does not relieve the consignor from compliance with any requirement of the government of any country through or into which the package will be transported.”
- (h) References to certificates for alternative radioactive contents, other competent authority validation, or additional technical data or information, as deemed appropriate by the competent authority.
- (i) Description of the packaging by a reference to the drawings or a specification of the design. If deemed appropriate by the competent authority, a reproducible illustration, not larger than 21 cm by 30 cm, showing the make-up of the package shall also be provided, accompanied by a brief description of the packaging, including materials of manufacture, gross mass, general outside dimensions and appearance.
- (j) A specification of the authorized radioactive contents, including any restrictions on the radioactive contents which might not be obvious from the nature of the packaging. This shall include the physical and chemical forms, the activities involved (including those of the various isotopes, if appropriate), mass in grams (for fissile material or for each fissile nuclide when appropriate), and whether special form radioactive material, low dispersible radioactive material or fissile material excepted under 2.7.2.3.5.6, if applicable.
- (k) Additionally, for packages containing fissile material:
 - (i) a detailed description of the authorized radioactive contents;
 - (ii) the value of the criticality safety index;
 - △ (iii) reference to the documentation that demonstrates the criticality safety of the package;
 - (iv) any special features, on the basis of which the absence of water from certain void spaces has been assumed in the criticality assessment;

- (v) any allowance (based on 6.4.11.5(b)) for a change in neutron multiplication assumed in the criticality assessment as a result of actual irradiation experience; and
- (vi) the ambient temperature range for which the special arrangement has been approved.
- (l) A detailed listing of any supplementary operational controls required for preparation, loading, carriage, unloading and handling of the consignment, including any special stowage provisions for the safe dissipation of heat.
- (m) If deemed appropriate by the competent authority, reasons for the special arrangement.
- (n) Description of the compensatory measures to be applied as a result of the shipment being under special arrangement.
- (o) Reference to information provided by the applicant relating to the use of the packaging or specific actions to be taken prior to the shipment.
- (p) A statement regarding the ambient conditions assumed for purposes of design if these are not in accordance with those specified in 6.4.8.5, 6.4.8.6 and 6.4.8.15, as applicable.
- (q) Any emergency arrangements deemed necessary by the competent authority.
- (r) A specification of the applicable management system as required in 1.5.3.1.
- (s) If deemed appropriate by the competent authority, reference to the identity of the applicant and to the identity of the carrier.
- (t) Signature and identification of the certifying official.

6.4.23.16 Each certificate of approval for a shipment issued by a competent authority shall include the following information:

- (a) Type of certificate.
- (b) The competent authority identification mark(s).
- (c) The issue date and an expiry date.
- (d) List of applicable national and international regulations, including the edition of the IAEA *Regulations for the Safe Transport of Radioactive Material* under which the shipment is approved.
- (e) Any restrictions on the modes of transport, type of conveyance, freight container, and any necessary routing instructions.
- (f) The following statement: “This certificate does not relieve the consignor from compliance with any requirement of the government of any country through or into which the package will be transported.”
- (g) A detailed listing of any supplementary operational controls required for preparation, loading, carriage, unloading and handling of the consignment, including any special stowage provisions for the safe dissipation of heat or maintenance of criticality safety.
- (h) Reference to information provided by the applicant relating to specific actions to be taken prior to shipment.
- (i) Reference to the applicable certificate(s) of approval of design.
- (j) A specification of the actual radioactive contents, including any restrictions on the radioactive contents which might not be obvious from the nature of the packaging. This shall include the physical and chemical forms, the total activities involved (including those of the various isotopes, if appropriate), mass in grams (for fissile material or for each fissile nuclide when appropriate), and whether special form radioactive material, low dispersible radioactive material or fissile material excepted under 2.7.2.3.5.6, if applicable.
- (k) Any emergency arrangements deemed necessary by the competent authority.
- (l) A specification of the applicable management system as required in 1.5.3.1.
- (m) If deemed appropriate by the competent authority, reference to the identity of the applicant.
- (n) Signature and identification of the certifying official.

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

- (a) Type of certificate.
- (b) The competent authority identification mark.
- (c) The issue date and an expiry date.
- (d) Any restriction on the modes of transport, if appropriate.
- (e) List of applicable national and international regulations, including the edition of the IAEA *Regulations for the Safe Transport of Radioactive Material* under which the design is approved.
- (f) The following statement: “This certificate does not relieve the consignor from compliance with any requirement of the government of any country through or into which the package will be transported.”
- (g) References to certificates for alternative radioactive contents, other competent authority validation, or additional technical data or information, as deemed appropriate by the competent authority.

- (h) A statement authorizing shipment where approval of shipment is required under 5.1.5.1.2, if deemed appropriate.
- (i) Identification of the packaging.
- (j) Description of the packaging by a reference to the drawings or specification of the design. If deemed appropriate by the competent authority, a reproducible illustration, not larger than 21 cm by 30 cm, showing the make-up of the package shall also be provided, accompanied by a brief description of the packaging, including materials of manufacture, gross mass, general outside dimensions and appearance.
- (k) Specification of the design by reference to the drawings.
- (l) A specification of the authorized radioactive content, including any restrictions on the radioactive contents which might not be obvious from the nature of the packaging. This shall include the physical and chemical forms, the activities involved (including those of the various isotopes, if appropriate), mass in grams (for fissile material the total mass of fissile nuclides or the mass for each fissile nuclide, when appropriate) and whether special form radioactive material, low dispersible radioactive material or fissile material excepted under 2.7.2.3.5.6, if applicable.
- (m) A description of the containment system;
- (n) For package designs containing fissile material which require multilateral approval of the package design in accordance with 6.4.22.4:
 - (i) a detailed description of the authorized radioactive contents;
 - (ii) a description of the confinement system;
 - (iii) the value of the criticality safety index;
 - △ (iv) reference to the documentation that demonstrates the criticality safety of the package;
 - (v) any special features, on the basis of which the absence of water from certain void spaces has been assumed in the criticality assessment;
 - (vi) any allowance (based on 6.4.11.5(b)) for a change in neutron multiplication assumed in the criticality assessment as a result of actual irradiation experience; and
 - (vii) the ambient temperature range for which the package design has been approved.
- (o) For Type B(M) packages, a statement specifying those prescriptions of 6.4.7.5, 6.4.8.4, 6.4.8.5, 6.4.8.6 and 6.4.8.9–6.4.8.15 with which the package does not conform and any amplifying information which may be useful to other competent authorities.
- (p) For package designs subject to 6.4.24.2, a statement specifying those requirements of the current regulations with which the package does not conform.
- △ (q) For packages containing more than 0.1 kg of uranium hexafluoride, a statement specifying those prescriptions of 6.4.6.4 that apply, if any, and any amplifying information which may be useful to other competent authorities.
- △ (r) A detailed listing of any supplementary operational controls required for preparation, loading, carriage, unloading and handling of the consignment, including any special stowage provisions for the safe dissipation of heat.
- △ (s) Reference to information provided by the applicant relating to the use of the packaging or specific actions to be taken prior to shipment.
- △ (t) A statement regarding the ambient conditions assumed for purposes of design if these are not in accordance with those specified in 6.4.8.5, 6.4.8.6 and 6.4.8.15, as applicable.
- △ (u) A specification of the applicable management system as required in 1.5.3.1.
- △ (v) Any emergency arrangements deemed necessary by the competent authority.
- △ (w) If deemed appropriate by the competent authority, reference to the identity of the applicant.
- △ (x) Signature and identification of the certifying official.

6.4.23.18 Each certificate issued by a competent authority for alternative activity limits for an exempt consignment of instruments or articles according to 5.1.5.2.1.4 shall include the following information:

- (a) Type of certificate.
- (b) The competent authority identification mark.
- (c) The issue date and an expiry date.
- (d) List of applicable national and international regulations, including the edition of the IAEA *Regulations for the Safe Transport of Radioactive Material* under which the exemption is approved.
- (e) The identification of the instrument or article.
- (f) A description of the instrument or article.
- (g) Design specifications for the instrument or article.
- (h) A specification of the radionuclide(s), the approved alternative activity limit(s) for the exempt consignment(s) of the instrument(s) or article(s).

- (i) Reference to documentation that demonstrates compliance with 2.7.2.2.2.
- (j) If deemed appropriate by the competent authority, reference to the identity of the applicant.
- (k) Signature and identification of the certifying official.

6.4.23.19 The competent authority shall be informed of the serial number of each packaging manufactured to a design approved under 6.4.22.2, 6.4.22.3, 6.4.22.4 and 6.4.24.2.

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

6.4.24 Transitional measures for class 7

△ Packages not requiring competent authority approval of design under the 1985, 1985 (As Amended 1990), 1996 Edition, 1996 Edition (Revised), 1996 (As Amended 2003), 2005, 2009 Editions of IAEA Safety Series No. 6 and 2012 Edition of IAEA Safety Standards Series No. SSR-6

△ 6.4.24.1 Packages not requiring competent authority approval of design (excepted packages, Type IP-1, Type IP-2, Type IP-3 and Type A packages) shall meet the provisions of this Code in full, except that:

△ (a) Packages that meet the requirements of the 1985 or 1985 (As Amended 1990) Editions of IAEA Regulations:

- (i) may continue in transport provided that they were prepared for transport prior to 31 December 2003 and are subject to the requirements of 6.4.24.5, if applicable; or
- (ii) may continue to be used, provided that all the following conditions are met:
 - they were not designed to contain uranium hexafluoride;
 - the applicable requirements of 1.5.3.1 of this Code are applied;
 - the activity limits and classification in chapter 2.7 of this Code are applied;
 - the requirements and controls for transport in parts 1, 3, 4, 5 and 7 of this Code are applied; and
 - the packaging was not manufactured or modified after 31 December 2003;

△ (b) Packages that meet the requirements of the 1996, 1996 (revised), 1996 (as amended 2003), 2005 or 2009 Editions of IAEA Safety Series No. 6, or 2012 Edition of IAEA Safety Standards Series No. SSR-6:

- (i) may continue in transport provided that they were prepared for transport prior to 31 December 2025 and are subject to the requirements of 6.4.24.5, if applicable; or
- (ii) may continue to be used, provided that all the following conditions are met:
 - The applicable requirements of 1.5.3.1 of this Code are applied;
 - The activity limits and classification in chapter 2.7 of this Code are applied;
 - The requirements and controls for transport in parts 1, 3, 4, 5 and 7 of this Code are applied; and
 - The packaging was not manufactured or modified after 31 December 2025.

△ Package designs approved under the 1985, 1985 (As Amended 1990), 1996 Edition, 1996 Edition (Revised), 1996 (As Amended 2003), 2005, 2009 Editions of IAEA Safety Series No. 6 and 2012 Edition of IAEA Safety Standards Series No. SSR-6

△ 6.4.24.2 Packages requiring competent authority approval of the design shall meet this Edition of **this Code** in full except that:

△ (a) Packagings that were manufactured to a package design approved by the competent authority under the provisions of 1985 or 1985 (As Amended 1990) Editions of IAEA Regulations may continue to be used provided that all of the following conditions are met:

- (i) the package design is subject to multilateral approval;
- (ii) the applicable requirements of 1.5.3.1 of this Code are applied;
- (iii) the activity limits and classification in chapter 2.7 of this Code are applied;
- (iv) the requirements and controls for transport in parts 1, 3, 4, 5 and 7 of this Code are applied;
- (v) for a package containing fissile material and transported by air, the requirement of 6.4.11.11 is met;

(b) Packagings that were manufactured to a package design approved by the competent authority under the provisions of the 1996, 1996 (revised), 1996 (as amended 2003), 2005 or 2009 Editions of IAEA Safety Series No. 6, or 2012 Edition of IAEA Safety Standards Series No. SSR-6 may continue to be used provided that all of the following conditions are met:

- (i) the package design is subject to multilateral approval after 31 December 2025;
- (ii) the applicable requirements of 1.5.3.1 of this Code are applied;

- (iii) the activity limits and material restrictions of chapter 2.7 of this Code are applied;
- (iv) the requirements and controls for transport in parts 1, 3, 4, 5 and 7 of this Code are applied.

6.4.24.3 No new manufacture of packagings to a package design meeting the provisions of the 1985, or 1985 (as amended 1990) editions of IAEA Safety Series No. 6 shall be permitted to commence.

- 6.4.24.4 No new manufacture of packagings of a package design meeting the provisions of the 1996, 1996 (revised), 1996 (as amended 2003), 2005 or 2009 Editions of IAEA Safety Series No. 6, or 2012 Edition of IAEA Safety Standards Series No. SSR-6 shall be permitted to commence after 31 December 2028.

Packages excepted from the requirements for fissile materials under the Regulations annexed to the 16th revised edition or the 17th revised edition of the United Nations Recommendations on the Transport of Dangerous Goods (2009 edition of IAEA Safety Standard Series No. TS-R-1)

- △ 6.4.24.5 Packages containing fissile material that is excepted from classification as “FISSILE” according to 2.7.2.3.5.1(i) or (iii) of the IMDG Code amendments 35-10 or 36-12 (paragraphs 417(a)(i) or (iii) of the 2009 edition of IAEA *Regulations for the Safe Transport of Radioactive Material*) prepared for transport before 31 December 2014 may continue in transport and may continue to be classified as non-fissile or fissile-excepted except that the consignment limits in table 2.7.2.3.5 of these editions shall apply to the conveyance. The consignment shall be transported under exclusive use.

△ **Special form radioactive material approved under the 1985, 1985 (As Amended 1990), 1996 Edition, 1996 Edition (Revised), 1996 (As Amended 2003), 2005, 2009 Editions of IAEA Safety Series No. 6 and 2012 Edition of IAEA Safety Standards Series No. SSR-6**

- △ 6.4.24.6 Special form radioactive material manufactured to a design that had received unilateral approval by the competent authority under the 1985, 1985 (as amended 1990), 1996, 1996 (revised), 1996 (as amended 2003), 2005 or 2009 Editions of IAEA Safety Series No. 6 or 2012 Edition of IAEA Safety Standards Series No. SSR-6 may continue to be used when in compliance with the mandatory management system in accordance with the applicable requirements of 1.5.3.1.

There shall be no new manufacture of special form radioactive material to a design that had received unilateral approval by the competent authority under the 1985 or 1985 (as amended 1990) Editions of IAEA Safety Series No. 6. No new manufacture of special form radioactive material to a design that had received unilateral approval by the competent authority under the 1996, 1996 (revised), 1996 (as amended 2003), 2005 or 2009 Editions of IAEA Safety Series No. 6, or 2012 Edition of IAEA Safety Standards Series No. SSR-6 shall be permitted to commence after 31 December 2025.