

INFORMATION PAPER

New Fissile Exception Provisions in the IAEA Transport Regulations (SSR-6)



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Background

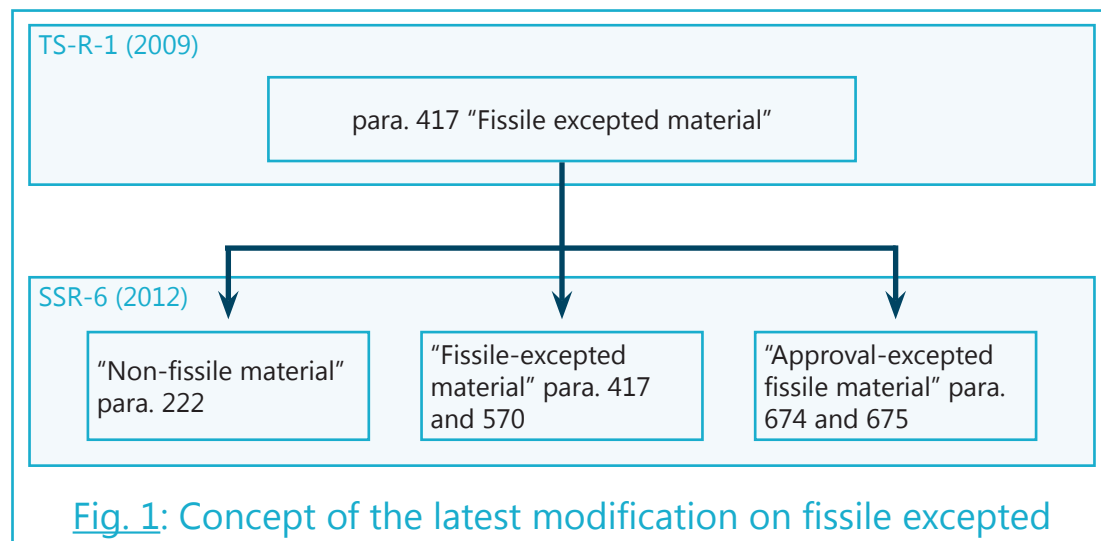
Criticality is one of the most serious potential risks of nuclear fissile material; as such special considerations should be taken into account for the transport of such material. A “fissile package” which contains a certain amount of fissile material is specially categorised and requires additional tests together with the approval from related Competent Authorities (CAs) to ensure the critical safety under the IAEA Transport Regulations. However, due to the potential risk and additional burdens for the transport of fissile material, some transporters and airlines refuse to transport fissile packages even if the packages contain very limited fissile material with no risk of criticality. Therefore, it is very important for carriers or consignors as to whether the packages are categorised as a fissile package or not. In particular, the provisions for fissile exception are important because a package containing fissile material which can satisfy all the requirements of one of the provisions for fissile-excepted does not then need to be treated as a fissile package, which means it can be transported more smoothly. However, some industry members thought that some requirements for fissile-excepted in the previous IAEA Regulations for the Safe Transport of Radioactive Materials, also known as IAEA Transport Regulations (TS-R-1(2009) ^[1]) were too strict from the practical point of view. However, the contrary view was held by some CAs who were concerned about the possibility of the accumulation of fissile-excepted packages containing fissile material on a conveyance and thought the regulations were too permissive in some cases. The previous fissile exception provisions in the TS-R-1 (2009) had been challenged from both sides.

Introduction

The provisions of fissile exception have been in the IAEA Transport Regulations since the first edition in 1961. As these provisions are important for the industry and CAs, some major changes had been conducted from the first edition and another major change has been made in the latest edition of the IAEA Transport Regulations (now known as SSR-6 (2012)) ^[2]. Although the latest changes had been discussed for over ten years, only minor changes ^[3] had been incorporated to the regulations before the SSR-6, mainly because a wide range of issues had been raised during the discussions and it was very difficult to reach consensus among all stakeholders. The main issues were; (a) concerns about accumulation of fissile excepted packages on a conveyance from CAs, (b) the validity of the fissile mass limits from criticality experts, and (c) expansion of fissile exception for low concentration of fissile material which has no risk of criticality from industries. Intensive discussions on all of these have been held with the criticality experts, CAs and industries for many years ^[4,5,6,7] and finally, the consensus was obtained with safety, practicality and flexibility. Ultimately there are winners and losers for the new provisions.

New provisions of fissile exception

The concept of the new provisions is shown in Fig.1. The fissile exception in the previous regulations (TS-R-1) is categorised into three concepts, “Non-fissile”, “Fissile-excepted” and “Approval-excepted fissile material” in the new regulations (SSR-6). The comparison of the related provisions between the previous regulations and SSR-6 is shown in Table 1 in detail.



(1) Non-fissile

Although the basic definitions of fissile nuclides have not changed, the minimum value (0.25g) for fissile nuclides in a package is introduced to the new para.222 (c). Also the combination of the provisions para.222 (d) and a supplemental remark is added in the case of an unpackaged shipment.

According to the new provisions, it is clarified that the trace or impurities of fissile nuclides can be ignored as fissile material. Also, some fissile-excepted packages in the previous regulations may be categorised as non-fissile packages based on this new provision.

The threshold value 0.25g is determined based on the fact that the accumulation of a vast number (several thousands) of packages containing "non-fissile material" is necessary to reach the theoretical possibility of criticality (para. 222.5 and 222.6 in the new Advisory Material for the IAEA Regulations for the Transport of Radioactive Material (TS-G-1.1)^[8]). Further, the technical basis and remarks are added to para. 222.7 to 222.11 in the TS-G-1.1 and it may be useful to check these when para.222 is applied.

(2) Fissile-excepted Material

Fissile-excepted material is defined in para. 417 and 570 simultaneously in the SSR-6 and one kind of exception is allowed per consignment. The fissile-excepted material definition in para.417 (b) and (c) in the previous regulations survives in the SSR-6 as para.417 (a) and (b) respectively. However, the "15g limit" for a package based on para.417 (a) in the previous regulations was withdrawn in the SSR-6 because it may be difficult to control the accumulation of the packages of this type on a conveyance. This provision limited fissile mass only in a package and a consignment, but some Competent Authorities (CAs) were concerned about the possibility of accumulation of some consignments of this type on a conveyance. This concept moves to para. 674 in which the accumulation of packages containing fissile material is controlled by Criticality Safety Index (CSI).

Instead of this being withdrawn, new provisions are introduced in para. 417 (c) – (f) in the SSR-6. The excepted mass limits of para. 417(c)-(e) are about a factor of 10 less than those allowed by the previous regulations. This

significant reduction was determined based on the concerns of accumulation of these packages on a conveyance.

The limit per package of para. 417(c) is determined based on the historical transport of UF_6 samples with the maximum enrichment of 5%. The consignment limit is about 1/20th of the mass value that provides an adequate margin of subcriticality (Table 13 in the SSR-6). Thirteen packages loaded with the maximum 3.5g would be allowed in a consignment according to the fissile mass limit for a consignment in para. 570(c). Also para. 417(d) is a similar concept to para. 417(c). This provision is introduced for the transport of small samples with irradiated or unirradiated fissile material or environmental samples with unknown masses of fissile material. The 2g limit isn't linked to its enrichment as well as the limit of para. 417(c). Although this provision can apply to samples with less than 2g of plutonium, Pu-239 with the mass greater than 0.5g would definitely need to be shipped as a Type B package and there are little benefits for them to be categorised as fissile-excepted. Seven packages loaded with the maximum 2g would be allowed in a consignment according to the fissile mass limit for a consignment in para. 570(d). The consignment limit in para. 570(d) is set not for a safety reason, but for a practical reason (physical protection). Para. 417 (e) is introduced for the larger mass limit of fissile-excepted than para. 417(c) and (d) in case of exclusive use which has no concern about the amount of packages on a conveyance. Furthermore, this provision is the only provision that allows unpackaged fissile material.

Para. 417(f) is a completely new and powerful concept to allow CAs to except specific fissile

material to give the regulations flexibility and rationale ^[9] and additional requirements are shown in para. 606. This provision is introduced mainly from the needs of nuclear fuel cycle, especially the back-end area. Large volumes of various kinds of very low risk fissile material are produced in this area, but it was very difficult to reach consensus on general specifications or requirements that can properly determine the boundary between fissile and fissile-excepted. Some examples are shown in para. 606 in the new TS-G-1.1. This provision may be very useful for industry and the information should be shared among industry members.

Para. 417.5 to 417.8, 570.1, 570.2 and 606.1 to 606.10 in the new TS-G-1.1 give technical explanations and guidance to the new concept of fissile-excepted material and it may be useful to check these when para. 417 is applied.

(3) Approval-excepted fissile material

Approval-excepted fissile material defined in para. 674 (a) – (c) and 675 is a new concept to control the accumulation on a conveyance by CSI. A package with this kind of material is categorised as a fissile package, but it is not necessary to get approval for a fissile package. Common requirements for packages are as follows;

- UN number and proper shipping name for fissile material;
- Labeled as FISSILE;
- Compliance of packages to requirements for packages containing fissile material and approval "F" are not required;

- Total CSI per conveyance: 50 (This limit can be increased to 100 under certain conditions);
- Loading together with all other packages containing fissile material or fissile-excepted material is allowed provided the CSI limits per conveyance is complied with.

Para. 674 (a) – (c) can be applied for all fissile nuclides and para. 675 is dedicated for a certain kind of plutonium. When one of para. 674 (a) – (c) is applied for a package containing fissile material with beryllium, deuterium, graphite or beryllium-copper alloy, the limits of para. 674 (d) should be complied with because these materials can be more effective for criticality than water which is considered for the evaluation of Z values in Table 13. The Z values were fully reevaluated by the several IAEA Member States during the last revision cycle. Although two kinds of moderators (water and polyethylene) were considered in the TS-R-1 (2009), a more conservative value in every enrichment is selected in the table for simplicity. The new values are more generous than previous ones in Table 4 in TS-R-1 (2009) for low enrichment.

The following provisions are used to permit the transport of fissile material without the CA approval for a specific package design. Also, the detailed background and some examples are described in 674.1 to 674.10 in the new TS-G-1.1.

- (a) no specific requirements for packages

Para. 674(a) does not require anything for the package except 10cm for the minimum dimension of packages. CSI should be calculated with the following equation and the maximum value of the CSI is 10.

$$CSI = 50 \times 5 \times \left(\frac{U-235(g)}{Z} + \frac{other_fissile_nuclide(g)}{280} \right)$$

That means that the allowed mass is up to 18g to 88g of U-235 and up to 11.2g for other fissile nuclides for any packages.

- (b) minimum package size requirement

Para. 674(b) requires that the package shall retain fissile material contents and preserve the smallest dimension of 30cm after the Normal Conditions of Transport (NCT) tests. CSI should be calculated the following equation and the maximum value of the CSI is 10.

$$CSI = 50 \times 2 \times \left(\frac{U-235(g)}{Z} + \frac{other_fissile_nuclide(g)}{280} \right)$$

That means that the allowed mass is up to 45g to 220g of U-235 and up to 28g for other fissile nuclides for packages with certain structural strength.

- (c) maximum mass limit per package

Para. 674(c) requires that the package shall retain fissile material contents and preserve the smallest dimension of 10cm after the NCT tests. CSI should be calculated with the following equation and the maximum mass of fissile nuclides is 15 g per package.

$$CSI = 50 \times 2 \times \left(\frac{U-235(g)}{450} + \frac{other_fissile_nuclide(g)}{280} \right)$$

The 15g single package limit is deliberately chosen to be the same limit as para. 417(a) (i) in the TS-R-1 (2009) in order to facilitate transition from previous regulations. The above equation uses the most conservative value for 100% enriched uranium in Table 13 for simplicity.

(d) Specific requirements for plutonium

Para. 675 basically survives from the previous regulations (para. 417(d)). This provision does not require anything for the package because the Type B(U) or Type B(M) package is required from the nature of the plutonium mass. CSI should be calculated with the following equation and the maximum mass of plutonium is 1,000g per package.

$$\text{CSI} = 50 \times 2 \times \frac{\text{mass_of_Plutonium(g)}}{1000}$$

Not more than 20% of the plutonium by mass is fissile nuclides and the mass of uranium shall be no more than 1% of plutonium if uranium is present with the plutonium.

(4) Transitional arrangements

As the provisions relevant to fissile exceptions have been changed significantly, para. 822 is provided for transitional arrangements in the SSR-6. This provision allows that the packages prepared for transport before 31 December 2014 may continue in transport. However, care should be given that such transitional arrangements may not be endorsed into domestic regulations in some IAEA Member States.

Conclusion

The provisions on the fissile exception have changed widely and fundamentally after long discussions between experts, CAs and industry including the WNTI. The new provisions are safer, more rational and flexible than previous ones. It is necessary to understand the new provisions and applicants should be careful to comply with them, including the transitional arrangements. Furthermore, industry is encouraged and it is recommended to share our experience among all the stakeholders,

especially on the CA's approval based on para. 417(f). Also such feedback is crucial for improving safe and rational regulations in the next review cycle.

Acknowledgments

This Information Paper is based on the presentations of Mr. Sam Darby (then Sellafield Limited, now UK Office of Nuclear Regulation) and Mr. Bruno Desnoyers (AREVA), together with discussions in the WNTI Back-End Transport Industry Working Group. The WNTI appreciates their contributions.

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Table 1: Comparison between previous and New fissile exception provisions

TS-R-1 (2009)	SS-R-6 (2012)	Remarks
<p>Fissile nuclides and fissile material</p> <p>222. <i>Fissile nuclides</i> shall mean uranium-233, uranium-235, plutonium-239 and plutonium-241. <i>Fissile material</i> shall mean a material containing any of the <i>fissile nuclides</i>. Excluded from the definition of <i>fissile material</i> are:</p> <p>(a) <i>Natural uranium or depleted uranium</i> which is unirradiated; and (b) <i>Natural uranium or depleted uranium</i> which has been irradiated in thermal reactors only.</p>	<p>Fissile nuclides and fissile material</p> <p>222. <i>Fissile nuclides</i> shall mean uranium-233, uranium-235, plutonium-239 and plutonium-241. <i>Fissile material</i> shall mean a material containing any of the <i>fissile nuclides</i>. Excluded from the definition of <i>fissile material</i> are the following:</p> <p>(a) <i>Natural uranium or depleted uranium</i> that is unirradiated; (b) <i>Natural uranium or depleted uranium</i> that has been irradiated in thermal reactors only. (c) <u>Material with <i>fissile nuclides</i> less than a total of 0.25g.</u> (d) <u>Any combination of (a), (b) and/or (c).</u> <u>These exclusions are only valid if there is no other material with <i>fissile nuclides</i> in the <i>package</i> or in the <i>consignment</i> if shipped unpackaged.</u></p>	<p>"Non-fissile"</p> <p>The minimum threshold value 0.25 g per package is newly introduced in the SSR-6 from a practical point of view and supplemental explanations are also added for clarification.</p> <p>The expansion of fissile nuclides was discussed but it did not get consensus in the revision cycle; some remarks are added in 222.3 in the TS-G-1.1.</p>
<p>Fissile material</p> <p>417. <i>Packages</i> containing <i>fissile material</i> shall be classified under the relevant entry in Table 1 for <i>fissile material</i> unless the conditions in para. 672 and one of the following conditions are met:</p> <p>(a) - (See next column) (b) Uranium enriched in uranium-235 to a maximum of 1% by mass, and with a total plutonium and uranium-233 content not exceeding 1% of the mass of uranium-235, provided that the <i>fissile nuclides</i> are distributed essentially homogeneously throughout the material. In addition, if uranium-235 is present in metallic, oxide or carbide forms, it shall not form a lattice arrangement. (c) Liquid solutions of uranyl nitrate enriched in uranium-235 to a maximum of 2% by mass, with a total plutonium and uranium-233 content not exceeding 0.002% of the mass of uranium, and with a minimum nitrogen to uranium atomic ratio (N/U) of 2.</p>	<p>Fissile material</p> <p>417. <i>Fissile material</i> and <i>packages</i> containing <i>fissile material</i> shall be classified under the relevant entry as FISSILE in accordance with Table 1 unless excepted by one of the provisions of subparas (a)-(f) of this paragraph and transported subject to the requirements of para 570. All provisions apply only to material in <i>packages</i> that meets the requirements of para. 636 unless unpackaged material is specifically allowed in the provision.</p> <p>(a) <i>Uranium</i> enriched in uranium-235 to a maximum of 1% by mass, and with a total plutonium and uranium-233 content not exceeding 1% of the mass of uranium-235, provided that the <i>fissile nuclides</i> are distributed essentially homogeneously throughout the material. In addition, if uranium-235 is present in metallic, oxide or carbide forms, it shall not form a lattice arrangement; (b) Liquid solutions of uranyl nitrate enriched in uranium-235 to a maximum of 2% by mass, with a total plutonium and uranium-233 content not exceeding 0.002% of the mass of <i>uranium</i>, and with a minimum nitrogen to <i>uranium</i> atomic ratio (N/U) of 2; (c) <u>Uranium with a maximum uranium enrichment of 5% by mass uranium-235 provided:</u> (i) <u>There is no more than 3.5 g of uranium-235 per <i>package</i>.</u> (ii) <u>The total plutonium and uranium-233 content does not exceed 1% of the mass of uranium-235 per <i>package</i>.</u> (iii) <u>Transport of the <i>package</i> is subject to the <i>consignment</i> limit provided in para 570 (c).</u></p>	<p>"Fissile-excepted"</p> <p>Criteria for fissile exception are based on material properties and package quantities.</p> <p>No criticality label "FISSILE" is required for packages shipped under 417.</p> <p>Para. 417 (a) and (b) in the SSR-6 are same as para. 672 (b) and (c) in the TS-R-1(2009).</p> <p>Para. 417 (c) - (f) are newly introduced based on industry requests in the SSR-6.</p> <p>Para. 417 (c) is mainly introduced for UF₆ samples.</p>

<p>802.Competent authority approval shall be required for the following:</p> <p>(a) Designs for:</p> <p>i) Special form radioactive material (see paras 803, 804 and 818);</p> <p>ii) Low dispersible radioactive material (see paras 803 and 804);</p>	<p>(d) <u>Fissile nuclides with a total mass not greater than 2.0 g per package provided the package is transported subject to the consignment limit provided in para. 570(d).</u></p> <p>(e) <u>Fissile nuclides with a total mass not greater than 45 g either packaged or unpackaged subject to limits provided in para 570 (e).</u></p> <p>(f) <u>A fissile material that meets the requirements of paras 570 (b), 606 and 802.</u></p> <p><u>570. Fissile material meeting one of the provisions (a)–(f) of para. 417 shall meet the following requirements:</u></p> <p>(a) <u>Only one of the provisions (a)–(f) of para. 417 is allowed per consignment.</u></p> <p>(b) <u>Only one approved fissile material in packages classified in accordance with para. 417(f) is allowed per consignment unless multiple materials are authorized in the certificate of approval.</u></p> <p>(c) <u>Fissile material in packages classified in accordance with para. 417(c) shall be transported in a consignment with no more than 45 g of fissile nuclides.</u></p> <p>(d) <u>Fissile material in packages classified in accordance with para. 417(d) shall be transported in a consignment with no more than 15 g of fissile nuclides.</u></p> <p>(e) <u>Unpackaged or packaged fissile material classified in accordance with para. 417(e) shall be transported under exclusive use on a conveyance with no more than 45 g of fissile nuclides.</u></p> <p>REQUIREMENTS FOR MATERIAL EXCEPTED FROM FISSILE CLASSIFICATION</p> <p><u>606. A fissile material excepted from classification as “FISSILE” under para. 417(f) shall be subcritical without the need for accumulation control under the following conditions:</u></p> <p>(a) <u>The conditions of para. 673(a);</u></p> <p>(b) <u>The conditions consistent with the assessment provisions stated in paras 684(b) and 685(b) for packages;</u></p> <p>(c) <u>The conditions specified in para. 683(a), if transported by air.</u></p> <p>802. Competent authority approval shall be required for the following:</p> <p>(a) Designs for:</p> <p>i) <i>Special form radioactive material</i> (see paras 803, 804 and 823);</p> <p>ii) <i>Low dispersible radioactive material</i> (see paras 803 and 804);</p> <p>iii) <u>Fissile material excepted under para. 417(f) (see paras 805 and 806);</u></p> <p>iv) <i>Packages containing 0.1 kg or more of uranium hexafluoride</i> (see para. 807);</p>	<p>Para. 417 (d) is mainly introduced for samples of high enriched uranium or plutonium.</p> <p>Para. 417 (e) can only apply for unpackaged samples.</p> <p>417(f) is a powerful new concept to allow Competent Authorities (CAs) to except specific fissile material to give the regulations flexibility and rationale. The principles explained in the TS-G-1. Multilateral approval would be required for 417(f). These principles allow fissile material to be excepted provided that there would be no significant criticality risk (e.g. $K_{inf} < 1$) under normal and accident conditions of transport. The CAs may require a small criticality assessment. The details including the U.S. requirements are explained in the TS-G-1.1.</p> <p>Para. 570 is newly introduced for fissile exceptions in para. 417 for transport requirements (consignment limits).</p> <p>Para. 606 is newly introduced for new para. 417 (f) which requires the Competent Authority's approval.</p> <p>Para. 802(a) iii) is added for new para. 417(f).</p>
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<p>iii) Packages containing 0.1 kg or more of uranium hexafluoride (see para. 805);</p> <p>iv) All packages containing fissile material unless excepted by para. 417 (see paras 812–814, 816 and 817);</p> <p>v) Type B(U) packages and Type B(M) packages (see paras 806–811, 816 and 817);</p> <p>vi) Type C packages (see paras 806–808).</p>	<p>v) Packages containing <i>fissile material</i>, unless excepted by para. 417, 674 or 675 (see paras 814–816 and 820);</p> <p>vi) Type B(U) packages and Type B(M) packages (see paras 808–813 and 820);</p> <p>vii) Type C packages (see paras 808–810).</p>	
<p>Fissile material</p> <p>417. Packages containing <i>fissile material</i> shall be classified under the relevant entry in Table 1 for <i>fissile material</i> unless the conditions in para. 672 and one of the following conditions are met:</p> <p>(a) A mass limit per <i>consignment</i> provided that the smallest external dimension of each <i>package</i> is not less than 10 cm, such that,</p> $\frac{\frac{\text{mass_of_U-235(g)}}{X} + \frac{\text{mass_of_other_fissile_nuclides(g)}}{Y}}{<1}$ <p>where X and Y are the mass limits defined in Table 4, provided that either:</p> <p>(i) Each individual <i>package</i> contains not more than 15 g of <i>fissile nuclides</i>; for unpackaged material, this quantity limitation shall apply to the <i>consignment</i> being carried in or on the <i>conveyance</i>; or</p> <p>(ii) The <i>fissile material</i> is a homogeneous hydrogenous solution or mixture where the ratio of <i>fissile nuclides</i> to hydrogen is less than 5% by mass; or</p> <p>(iii) There are not more than 5 g of <i>fissile nuclides</i> in any 10 L volume of material.</p>	<p>674. Packages containing <i>fissile material</i> that meet subpara (d) and one of the provisions of subparagraphs (a)–(c) of this paragraph are excepted from the requirements of paras 676– 686.</p> <p>(a) Packages containing <i>fissile material</i> in any form provided that:</p> <p>(i) The smallest external dimension of the <i>package</i> is not less than 10 cm.</p> <p>(ii) The <i>CSI</i> of the <i>package</i> is calculated using the following formula:</p> $CSI = 50 \times 5 \times \{[\text{mass of U-235 in package (g)}] / Z + [\text{mass of other fissile nuclides}^1 \text{ in package (g)}] / 280\}$ <p>where the values of Z are taken from Table 13.</p> <p>(iii) The <i>CSI</i> of any <i>package</i> does not exceed 10.</p> <p>(b) Packages containing <i>fissile material</i> in any form provided that:</p> <p>(i) The smallest external dimension of the <i>package</i> is not less than 30 cm;</p> <p>(ii) The <i>package</i>, after being subjected to the tests specified in paras 719–724:</p> <ul style="list-style-type: none"> - Retains its <i>fissile material</i> contents; - Preserves the minimum overall outside dimensions of the <i>package</i> to at least 30 cm; - Prevents the entry of a 10 cm cube. <p>(iii) The <i>CSI</i> of the <i>package</i> is calculated using the following formula:</p> $CSI = 50 \times 2 \times \{[\text{mass of U-235 in package (g)}] / Z + [\text{mass of other fissile nuclides}^1 \text{ in package (g)}] / 280\}$ <p>where the values of Z are taken from Table 13.</p> <p>(iv) The <i>CSI</i> of any <i>package</i> does not exceed 10.</p> <p>(c) Packages containing <i>fissile material</i> in any form provided that:</p> <p>(i) The smallest external dimension of the <i>package</i> is not less than 10 cm;</p>	<p>“Approval-excepted fissile”</p> <p>The label “FISSILE” is required for packages shipped using new para. 674 and 675, but the approval from the CAs is not required.</p> <p>Para. 674 (a) is for packages which cannot be shown to pass the tests for NCT.</p> <p>Para. 674 (b) is for larger packages (> 30 cm size) that can pass the tests for NCT.</p> <p>The 15 g single package limit of para. 674(c) is deliberately chosen to be the same limit as para. 417(a)(i) in the TS-R-1 (2009) in order to facilitate transition from previous provisions.</p>

Beryllium shall not be present in quantities exceeding 1% of the applicable *consignment* mass limits provided in Table 4 except where the concentration of beryllium in the material does not exceed 1 g beryllium in any 1000 g. Deuterium shall also not be present in quantities exceeding 1% of the applicable *consignment* mass limits provided in Table 4 except where deuterium occurs up to natural concentration in hydrogen.

(b) (See above)

(c) (See above)

TABLE 4. CONSIGNMENT MASS LIMITS FOR EXCEPTIONS FROM THE REQUIREMENTS FOR PACKAGES CONTAINING FISSILE MATERIAL

<i>Fissile nuclide</i>	<i>Fissile nuclide mass (g) mixed with substances having an average hydrogen density less than or equal to water</i>	<i>Fissile nuclide mass (g) mixed with substances having an average hydrogen density greater than water</i>
Uranium-235 (X)	400	290
Other <i>fissile nuclide</i> (Y)	250	180

- (ii) The *package*, after being subjected to the tests specified in paras 719–724:
- 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:

$$CSI = 50 \times 2 \times \{[\text{mass of U-235 in } package \text{ (g)}] / 450 + [\text{mass of other } fissile \text{ nuclides}^1 \text{ in } package \text{ (g)}] / 280\}$$
- (iv) The maximum 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 their total concentration does not exceed 1 g in any 1000 g of material. Beryllium incorporated in copper alloys up to 4% in weight of the alloy does not need to be considered.

TABLE 13. VALUES OF Z FOR CALCULATION OF CSI IN ACCORDANCE WITH PARA. 674

Enrichment ^a	Z
Uranium enriched up to 1.5 %	2200
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 <i>package</i> contains <i>uranium</i> with varying enrichments of U-235, then the value corresponding to the highest enrichment shall be used for Z.	

The criteria in 417(a) (ii) and (iii) in the TS-R-1 (2009) are no longer allowed because of safety concerns:

- An accident (e.g. fire) could concentrate the fissile material.
 - There is no consignment control
- Multiple consignments - especially under accident conditions - could result in more than a safe mass under optimum moderation.

Para. 674(d) are limits of specific moderators that can be more effective for criticality than water. The restrictions on beryllium and deuterium are similar to the TS-R-1 (2009) and new limits of carbon and Be-Cu alloy are introduced.

Table 13 is newly recalculated by some member states to reach consensus. The new limits are more generous for low enriched uranium (LEU) than the ones in TS-R-1 (2009).

<p>(d) Plutonium containing not more than 20% of <i>fissile nuclides by mass up to a maximum of 1 kg of plutonium per consignment. Shipments under this exception shall be under exclusive use.</i></p>	<p><u>675. Packages containing not more than 1000 g of plutonium are excepted from the application of paras 676–686 provided that:</u> (a) <u>Not more than 20% of the plutonium by mass is <i>fissile nuclides</i>.</u> (b) <u>The <i>CSI</i> of the <i>package</i> is calculated using the following formula:</u> $CSI = 50 \times 2 \times [\text{mass of plutonium (g)}/1000]$ (c) <u>If <i>uranium</i> is present with the plutonium, the mass of <i>uranium</i> shall be no more than 1% of the mass of the plutonium.</u></p>	<p>Para. 675 is basically the same as para. 417 (d) in the TS-R-1 (2009), but Pu should be transported as fissile packages.</p>
	<p>APPROVAL OF MATERIAL EXCEPTED FROM FISSILE CLASSIFICATION</p> <p><u>805. The design for a fissile material excepted from “FISSILE” classification in accordance with Table 1, under para. 417(f) shall require multilateral approval. An application for approval shall include:</u> (a) <u>A detailed description of the material; particular reference shall be made to both physical and chemical states.</u> (b) <u>A statement of the tests that have been carried out and their results, or evidence based on calculative methods, to show that the material is capable of meeting the requirements specified in para. 606.</u> (c) <u>A specification of the applicable management system as required in para. 306.</u> (d) <u>A statement of specific actions to be taken prior to shipment.</u></p>	<p>Transition provisions are introduced in the SSR-6 because the changes on fissile exceptions are significant.</p>



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