Overview of Proposed Modifications for Exemptions to the Requirements for Transport of Fissile Material

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Introduction

- Currently, transport of fissile material using TS-R-1 is performed consistent with one of two sets of provisions:

  - Fissile material in packaging (with identification mark "F") subject to CA design approval and CSI control of accumulation (2009 paras 671-683)

  - Fissile material excepted from all requirements of para 671-673 if specified characteristics and limits are met (2009 para 417). Traditional "fissile-excepted"

- **Concerns expressed:**
  - Safety: Insufficient control for accumulation of excepted fissile material
  - Accuracy: Material which is excepted should still be classified as UN FISSILE
  - Transport of very low-risk material in "F" packages (regulatory burden)
- **Proposed solution** represents a graded approach for fissile material transport
  - Revise criteria and material limits for full exception from operation and packaging requirements
  - Add new criteria that provides control for mass accumulation but does not have package requirements of packages with "F" identification mark

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Current exceptions (TS-R-1 para 417)

- Fissile material enriched with <1 wt% U-235 and homogeneous
- Uranyl nitrate solutions enriched with < 2wt% U-235
- **Up to 1 kg of Pu with no more than 20% fissile nuclides**
- **Consignment with up to 400 g of U-235 (250 g of fissile nuclides) subject to**
  - **No more than 15 g fissile nuclides per package**
  - **Homogeneous hydrogenous solution where the ratio of fissile nuclides to hydrogen is < 5 wt%**
  - **No more than 5 g fissile nuclides per 10L volume**

Issue: Large number of packages exist that have been loaded and stored consistent with these criteria

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IAEA TS-R-1 2009 fissile exceptions

Proposed new para 417
Package and CSI exception

- No requirements to be treated as fissile material (not classified as UN FISSILE)
  - Specified material (e.g., < 1wt% enriched homogeneous
  - Very small masses per package subject to consignment control
  - Unpackaged material mass limit (45g under exclusive use)
  - **Specified material subject to CA approval**

Proposed new para 674
CSI control with limited package requirements

- Material classified as UN FISSILE
- Packages must meet specified criteria but no CA approval
- Accumulation control by CSI* assures subcriticality
- Mass of fissile nuclides per package is limited (maximum CSI = 10) to support "dilution" of material

*CSI = 50/N

DS437, Draft 2.4

Summary of principles

- Assure identified safety concerns addressed
- Assure consistency in terms of safety margin for each of the “sets” of provisions
- Seek industry input to understand needs
  - Limited masses for low-enriched material
  - Small gram samples of material with high or unknown enrichment
  - Shipment of waste with low-concentrations of fissile nuclides
- Minimize impact of transition
  - Sought to include provisions that would enable safe transport of packages previously loaded using existing exception criteria

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Graded approach summary

- Set 1 – Package designs approved to transport fissile material: No change, require CA assessment
- Set 2 – proposed new para 674
  - Classified and controlled as UN FISSILE
  - Masses limited via CSI control to assure subcritical margins consistent with assessments performed for approved package designs: 2N under accident conditions of transport and 5N “normal conditions of transport”
  - Exception from Set 1 is on packaging requirements
- Set 3 – proposed new para 417
  - Not classified or controlled as UN FISSILE
  - Exception from Set 1 is on packaging and operational requirements

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Safety basis of proposed changes:

Package excepted from CA approval, control by CSI

- Material must maintain subcriticality during transport
  - Account for (not necessarily test for) routine, normal, and accident conditions of transport in the same way as packages approved by CAs. In other words, assume package does not pass tests for ACT nor tests for NCT unless specified.
  - 5 “groups of packages” under normal conditions of transport (NCT).
  - 2 “groups of packages” under accident conditions of transport (ACT)
  - Determined consensus values of safe subcritical mass for U (1.5 wt% 235U to 100% 235U) and other fissile nuclides
    - Model: Optimum configuration and moderation, regulatory reflection, and accounting for typical packaging materials that could increase k-eff.
    - Values used to judge safety of proposed paras and derive conveyance limits in Table 13 of proposed TS-R-1.

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Safe subcritical masses

Fissile nuclide	Uranium enrichment in mass percent of U-235 not exceeding	Allowed conveyance mass	Consensus safely subcritical masses
U-235 (Z)[i]	1.5	2200	3200
	5	850	1000
	10	660	810
	20	580	700
	100	450	540
Other fissile nuclides (Y)[ii]	Not Applicable	280	350

Notes:

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

ii) Plutonium may be of any isotopic composition provided that Pu-241 < Pu-240.

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Technical basis of proposed changes

Package excepted from CA approval, control by CSI

CSI = 50 / N

Where N selected such that 5N packages must be subcritical under NCT and 2N packages must be subcritical under ACT

Packages meet NCT, then N = (allowed conveyance mass) / 2; thus

CSI = 50 x 2 [(mass of U-235 / Z) + (mass of other fissile) / Y)]

Demonstration of subcriticality under NCT done using array models with fully loaded packages and masses for CSI = 10 based on consensus subcritical values – demonstrated need for 30 cm minimum external dimension.

Packages not meeting NCT, then N = (allowed conveyance mass / 5) ; thus

CSI = 50 x 5 [(mass of U-235 / Z) + mass of other fissile / Y)]

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Technical basis of proposed changes

Package excepted from CA approval, control by CSI

- Limit masses of fissile nuclides in packages (new para 674)
  Three options provided, all subject to CSI control and maximum package CSI = 10
- 674a: Fissile material mass per package limited such that 5 “groups of packages” < safe subcritical mass assuming packages do not meet NCT
  - Maximum mass per package (CSI = 10) = 18 g for pure 235U
- 674b: Fissile material mass limited such that
  - 5 “groups of packages” < safe subcritical mass under NCT
  - 2 “groups of packages” < safe subcritcal mass (packages assumed not to meet ACT)
  - Package limited to max CSI = 10 (e.g., 45 g pure 235U) and 30 cm minimum external dimension
- 674c: Same as 674b EXCEPT as follows:
  - Contents limit of 15 g (CSI = 3.3) allows array of packages with 10 cm external dimension to be shown as subcritical under NCT
  - Enables larger mass in a “group of packages” as compared to 674a

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Technical basis of proposed changes

Package excepted from both CA approval AND control by CSI

- Fissile material not required to be classified as UN FISSILE and not subject to CSI control (new 417 a-b, no change)
  - 417a: U enriched to < 1 wt% 235U
  - 417b Uranyl Nitrate with U enriched to < 2 wt% 235U

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Technical basis of proposed changes

Package excepted from both CA approval AND control by CSI

- (new 417 continued)
  - New para 417c: Up to 3.5 g ^{235}U per package if U enriched < 5 wt% with consignment limit of 45 g (from 570c)
    - Package limits based on expressed needs of industry for shipping UF6 and environment samples
    - 10 consignments required to accumulate safe subcritical mass limit
  - New para 417d: Up to 2 g of fissile nuclides per package, with consignment limit of 15 g (from 570d)
    - >18 consignments required to accumulate safe subcritical mass

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Technical basis of proposed changes (Set 3)

Set 3 = Package excepted from both CA approval AND control by CSI

- (new 417 continued)
  - New para 417e and 570e: 45 g of fissile nuclides, unpackaged or packaged, shipped under exclusive use (10 conveyances to achieve safe subcritical mass)
  - New para 417f: Multilateral approval of material per requirements of 606:
    - Infinite or "beyond credible" array of packages subcritical under normal and accident conditions of transport:
      - no need for accumulation control
      - with the conditions of para. 671(a) considered (i.e., water inleakage, temperature variation, geometry changes, etc.)
    - Enables each Member State to approve exceptions for low-risk material based upon CA review

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Other changes

- Fissile material definition changes such that natural and depleted uranium is NOT excluded if other fissile material in package
- Fissile material definition excludes material with < 0.25 g of fissile nuclides per package

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Summary

New graded approach with proposed TS-R-1 addresses existing safety concerns while providing additional flexibility for industry and Member States to address transport of low-risk fissile material.