AUTORITÉ DE SÛRETÉ NUCLÉAIRE

GUIDES DE L'ASN

TRANSPORT

En collaboration avec les Autorités de sûreté européennes

Transport à usage civil de colis ou de substances radioactives sur la voie publique

Tome 2 : Dossier de sûreté des modèles de colis, guide européen « Package Design Safety Report »

GUIDE N° 7

Version de septembre 2012

Technical Guide

Package Design Safety Reports for the Transport of Radioactive Material

Disclaimer – in the event of any conflict between the requirements stated in this document and those stated in the IAEA TS-R-1 Regulations [1], the IAEA TS-R-1 Regulations shall take precedence.

Comments on this document

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by using the feedback form attached to this document.

FOREWORD

This Technical Guide has been developed by the *competent authorities* and their support organizations responsible for the transport of *radioactive material* of Belgium, France, Germany, Spain and the United Kingdom and the World Nuclear Transport Institute (WNTI) and Areva as industry representatives. It was distributed the first time as Issue 1 to the EU member states by the Standing Working Group on Safe Transport of Radioactive Material in August 2008. The current Issue 2 is a revision of Issue 1 which takes into account feedback from member states and the latest IAEA transport regulations TS-R-1 (2009 Edition).

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It is intended that this Technical Guide will be used within European member states and that all European *competent authorities* responsible for the transport of *radioactive material* will authorize the use of this Technical Guide and consider it as assistance for justifying that the *package design* meets the applicable requirements of the dangerous goods transport regulations.

AMENDMENT RECORD

Issue 1	
Creation of document	
Issue 2	
Whole document	Now based on 2009 Edition of TS-R-1, wording clarifications, format corrections, history and amendment record update, use of "should" throughout the text
1.1	Documents referenced but not included in the PDSR should not be listed in the general contents list. Remark: These documents should be included in a list of references in the subdocument where they are referenced.
1.4	All material specifications for *packaging* components should be included in the PDSR
2.1.3	Requirements adapted to TS-R-1
Annexe 2, 2.2.4	List of requirements adapted to TS-R-1
Annexe 4, 2.2.1	Clarification of the different temperature requirements for different aspects of the assessment
Annexe 4, 2.2.2	Clarification of wording: absorptivity and emissivity coefficient
Annexe 5, 1.5	Deleted: "Concerning the description of the *confinement system*, it should be confirmed whether there is any risk of heterogeneous flooding of internal volumes during *package* preparation in case of incident or accident." Reason for deletion: Incident or accident conditions during *package* preparation depend on the facility where the *package* is prepared. They are not known to the person assessing criticality safety for transport. The safety during loading including incidents or accidents has to be demonstrated in the safety assessment for the facility. Credible conditions of transport that might lead to heterogeneous flooding of *packages* are mentioned in 2.2.5
Annexe 5, 2.2.5	New text concerning *packages* where special features preventing water inleakage are considered for the criticality safety analysis for an individual *package* in isolation (TS-R-1 para. 677): "The criterion for watertightness to be defined by the *package designer* and accepted by the *competent authority* should be given and justified in the PDSR. This criterion should be set in a way excluding ingress of such an amount of water which could influence the criticality safety assessment. The testing conditions defined in TS-R-1 para. 677 should be taken into account as well as a single error." Deleted: "Relating to isolated *packages*, for which subcriticality is demonstrated assuming no penetration of water, limited quantities of water should still be considered, corresponding to the quantities that would penetrate the *package* during the immersion test under 0.9 m of water during 8 hours." Reason for change: If such special features are defined as watertight, there should be no need to consider water ingress in the criticality safety assessment of the isolated *package* under normal and accident conditions of transport.
Annexe 5, 2.2.5	Added: "Credible conditions of transport that might lead to preferential (hetero-geneous) flooding of packages increasing the neutron multiplication should be considered."
Annexe 5, 2.2.5	Consideration of damage under normal conditions of transport added.

CONTENTS

0 INTRODUCTION AND GENERALITIES

0.1 Introduction

For each *design* of a *package* for the transport of *radioactive material* it is necessary to demonstrate compliance with national and international regulations as applicable. For *package designs* which need *approval* by a *competent authority* the documentary evidence of compliance with the regulations is the basis for the application for *package design approval*, and it is commonly known as a Package Design Safety Report (PDSR). For *packages* not requiring *competent authority approval* the *consignor* shall be able to provide documentary evidence of the compliance of the *package design* with all applicable requirements. It is proposed that for these *package designs* the same discipline of approach is adopted as for *packages* requiring *competent authority approval*, with the scope and technical content set at the appropriate levels to demonstrate compliance with the regulatory requirements. In the following, every such documentary evidence of the compliance of a *package design* with all applicable requirements will be called PDSR, independently of the *package* type.

0.2 Objective and Scope

This document is intended to assist in the preparation of the PDSR to demonstrate compliance of a *design* of a *package* for the transport of *radioactive material* with the regulatory requirements. It covers *package designs* requiring *competent authority approval* (Type B(U), Type B(M), Type C, packages containing *fissile material* not excepted from the requirements of the regulations that apply to *fissile material* and *packages* designed to contain 0.1 kg or more of uranium hexafluoride). This document also covers *package designs* not requiring *competent authority approval* (*Excepted package*, *Industrial package (Type IP-1, Type IP-2, Type IP-3)*, *Type A package*).

This document is based on the IAEA TS-R-1 Regulations[1] upon which the regulations for the road, rail, sea, inland waterways and air modes of transport are based, namely ADR[2], RID[3], IMDG code[4], ADN[5] and ICAO[6] respectively.

This document does not replace the regulations or limit their application but proposes for each *package* type a structure and a minimum content for a PDSR to enable the applicant, in case of a *package design* subject to *competent authority approval*, or the *package designer* and/or user, in case of a *package design* not requiring *competent*

authority approval in demonstrating compliance with the provisions of TS-R-1 and the modal regulations applicable to the respective *package type*.

If there are any discrepancies between this document and the regulations, the requirements in the regulations apply.

This document does not relieve the *package design*er from any additional analysis need associated with the concerned specific *package design*.

0.3 Definitions

The definitions stated in the IAEA TS-R-1 Regulations[1] apply throughout this document. In addition the following definition shall apply:

Package designer

The person or organisation that is responsible for the *design* of the *package*; each *package design* should have only one *package designer*.

Controlled document

A document that is approved and maintained. It should be signed and dated and bear a reference including the revision state. The number of pages and annexes should be mentioned. Changes between revisions of the document should be clearly marked.

Design drawing

A controlled engineering drawing that states for the *packaging* components the geometrical or other parameters that have an effect upon the safety assessment of the *package design*.

All definitions (including those in TS-R-1) are identified in this document in *italics*.

0.4 Structure of this document

This document provides in the chapters 1 and 2 a generic structure and contents of a PDSR, namely Parts 1 and 2, which applies to all *package* types. This structure is also presented in Figure 1. The contents are described in a comprehensive way to cover all important aspects. Some of these aspects may not be applicable to specific *package* type and details can be found in the annexes.

Chapter 0 contains requirements to be taken into account for the documents cited in chapters 1 and 2.

A matrix of paragraph numbers of the IAEA TS-R-1[1] and ADR[2] Regulations (as one example of the regulations for the different transport modes) applicable to each *package* type is shown in Table 1.

The annexes provide further guidance for the scope of the contents of a PDSR specifically for each *package* type.

This guide uses 'should' statements throughout, for optional as well as for such provisions stated as mandatory in TS-R-1.

0.5 Unit system

The S.I. unit system should be used throughout the *Package Design* Safety Report.

0.6 Document control

The *Package Design* Safety Report should be a *controlled document* and should include a record of its compilation and review and its *approval* by the *package designer*.

Each individual document in Part 1 of the PDSR should be a *controlled document* and be approved for issue by the author/owner of the document and the *package designer*.

Each individual document in Part 2 of the PDSR should be a *controlled document* and be approved for issue by a technical specialist responsible for the technical discipline being assessed.

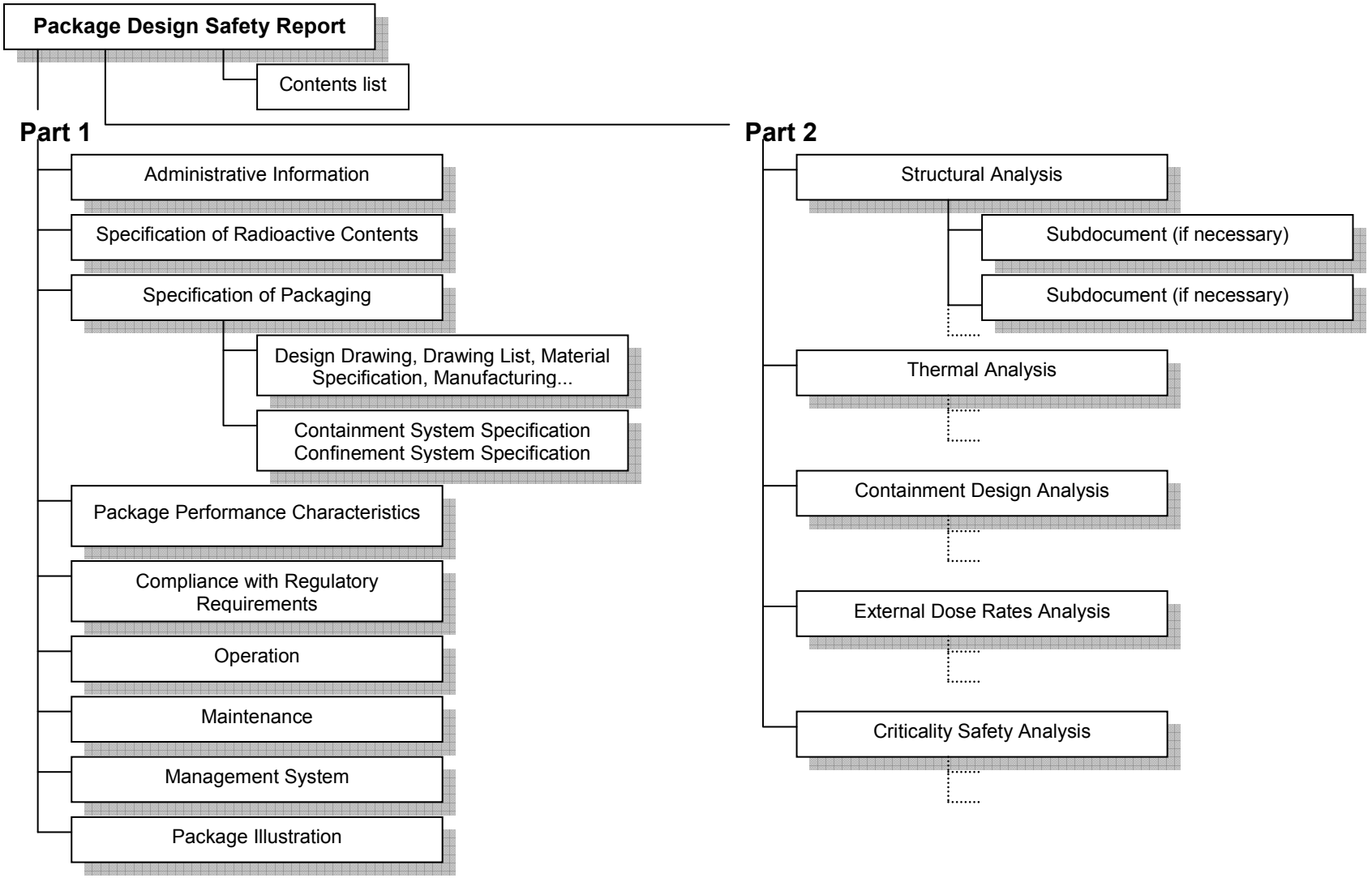

FIGURE 1: Structure of Package Design Safety Report

1 *PACKAGE DESIGN* SAFETY REPORT: PART 1

Part 1 of the PDSR should include the following information:

1.1 Contents list of the PDSR

The contents of the PDSR, Part 1 and Part 2, should be listed including the issue status of each individual document included in the PDSR.

1.2 Administrative information

(a) Colloquial name of *package*, if applicable

(b) Identification of *package designer* (name, address, contact details)

(c) Type of *package*

(d) *Packaging* / *package design* identification and restrictions in *packaging* serial number(s) (if applicable)

(e) Modes of transport for which the *package* is *design*ed and any operational restrictions)

(f) Reference to applicable regulations, including the edition of the IAEA Regulations for the Safe Transport of Radioactive Material to which the *package design* is referring.

1.3 Specification of contents

Detailed descriptions of the permitted contents of the *package design* should be defined by stating, but not limited to, the following information, as applicable (see annexes):

(a) Nuclides / nuclide composition; daughter radionuclides, if applicable

(b) Limitations in activity, mass and concentrations, heterogeneities if applicable

(c) Physical and chemical state, geometric shape, arrangement, irradiation parameters, moisture content, material specifications

(d) *Special form radioactive material* or *low dispersible radioactive material*, if applicable

(e) Nature and characteristics of the radiation emitted

(f) Limitations in heat generation rate of contents

(g) Mass of *fissile material* and nuclides

(h) Other dangerous properties

(i) Other limitations to the contents

Safety relevant limits for non-*radioactive material*s (e.g. moderators, materials subject to radiolysis) should be stated, for example by material composition, density, form, location within *package*, restrictions of relative quantities of materials.

The A_1/A_2 values of a radionuclide to be carried that is not listed in IAEA TS-R-1 Regulations[1] should be determined in accordance with IAEA paras 403 – 407 and included in the PDSR and may be subject to *multilateral approval* (see [1], para. 403).

1.4 Specification of *packaging*

The *packaging design* should be defined including the following information, as applicable (see annexes):

(a) A list of all *packaging* components and complete *design drawings*

(b) A parts list of all Standard items such as bolts, seals, etc

(c) A list of the material specifications of all *packaging* components and Standard items and methods of their manufacture including requirements for material procurement, welding, other special processes, non-destructive evaluation and testing. All material specifications for *packaging* components should be included in the PDSR.

A description of:

(d) The *packaging* body, lid (closure mechanism) and inserts

(e) The *packaging* components of the *containment system*

(f) The *packaging* components required for shielding

(g) The *package* components of the *confinement system*

(h) The *packaging* components for thermal protection

(i) The *packaging* components for heat dissipation

(j) The protection against corrosion

(k) The protection against *contamination*

(l) The shock limiting components

(m) The transport concept including any devices required for the transport, safe handling, stowage, trans-shipment and securing in or on the *conveyance* which has an effect on the safety of the *package*.

1.5 *Package* performance characteristics

This section shall describe the main *design* principles and performance characteristics of the *package design* to meet the different safety requirements of the regulations (e.g. containment, heat removal, dose rates, and criticality safety). Furthermore it should describe how analysis assumptions and data used for the safety analysis – especially regarding release of *radioactive material*, dose rates and criticality safety (if applicable) - are derived from the *design* and the behaviour of the *package* under routine, normal and accident conditions of transport, also taking into account the intended number of transport cycles for one *packaging*.

This should help to ensure that the *design* and the various parts of the safety demonstration match and that any subsequent decisions taken concerning changes to the *package design* due to manufacturing, repair, improved operation, etc include appropriate consideration of the possible influence on the *package* performance criteria and regulatory compliance.

1.6 Compliance with regulatory requirements

The *Package Design* Safety Report (PDSR) should include a complete list of all paragraphs of the international regulations[1 - 6] and any other national regulations applicable to the respective *package design.* Demonstration of compliance with these paragraphs should be by reference to where in the PDSR compliance is demonstrated or other justification. Table 1 provides a cross reference between the paragraphs of the IAEA and ADR regulations for each *package* type.

1.7 Operation

The minimum requirements for the following activities should be fully defined for the *packaging*/*package*, as applicable (see annexes):

(a) Testing requirements and controls before first use

(b) Testing requirements and controls before each transport

(c) Handling and tie down requirements

(d) Requirements for loading and unloading of the *package* contents.

(e) Requirements for assembling of the *packaging* components

(f) Any proposed supplementary equipment and operational controls to be applied during transport which are necessary to ensure the *package* meets the regulatory requirements for transport, e.g. for heat dissipation: thermal barriers, duration limits, temperature limits (including *exclusive use* and special stowage conditions).

1.8 Maintenance

The minimum requirements for the following activities should be fully defined for the *packaging/package*, as applicable (see annexes):

(a) Maintenance and inspection requirements before each *shipment*

(b) Maintenance and inspection requirements at periodic intervals throughout the lifetime use of the *packaging/package*.

1.9 Management systems

Specification of the management system [10] including the *quality assurance* programme as requested in the IAEA TS-R-1 Regulations [1] to ensure compliance with the relevant provisions regarding (including change control):

(a) *Design*, PDSR, documentation, records

(b) Manufacture and testing,

Also the requirements relating to the following

(c) Operation (loading, transport, unloading, storage in transit)

(d) Maintenance and repair

(e) Compliance of any activity to the PDSR.

1.10 *Package* illustration

A reproducible illustration, not larger than 16 cm by 22 cm, showing the make-up of the *package*, including shock limiters, devices for thermal insulation and *packaging* inserts, if applicable; the illustration should indicate at least the overall outside dimensions, the masses of the main components of the *packaging* and the gross masses for empty and loaded condition.

2 *PACKAGE DESIGN* SAFETY REPORT: PART 2

Part 2 of the PDSR should provide the detailed technical analyses to support the demonstration of compliance with the regulations in Part 1 of the PDSR, as referred to in section 1.6.

Section 2.1 of this guide provides the common provisions which should be applied to all technical analyses to be included into Part 2 of the PDSR.

Section 2.2 of the guide gives a list of the technical analyses that may be necessary in the PDSR together with their main contents. Further guidance on the content of the technical analyses required for each *package* type is provided in the annexes.

2.1 Common provisions for all technical analyses in Part 2 of the PDSR

The information in Section 2.1 should be included in each of the technical analyses in section 2.2.

2.1.1 Reference to *package design*

In each of the technical analyses of section 2.2 the package design which is evaluated should be precisely referenced by mentioning a *design drawing* or *packaging* drawing list (including revision state) and the document specifying the *radioactive contents* (with revision state), as appropriate.

2.1.2 Acceptance criteria and *design* assumptions

The acceptance criteria for the technical analysis and the *package design* assumptions in terms of geometry or performance characteristics should be defined and justified when necessary.

2.1.3 Description and justification of analysis methods

The safety demonstration of a *package design* can be accomplished by a combination of the following as appropriate (see annexes):

(a) The results of physical testing of prototypes or models of appropriate scale.

(b) By reference to previous satisfactory demonstrations of a sufficiently similar nature. Test results of *designs* similar to the *design* under consideration are

permissible if the similarity can be demonstrated sufficiently by justification and validation.

(c) By calculation or reasoned argument, when the calculation procedures are generally agreed to be suitable and conservative. Assumptions made may require justification by physical testing.

The methods/standards used in each analysis listed in sections 2.2.1 – 2.2.5 should include a description of the analysis technique used, its limitations and accuracy, together with the justification for how it has been used for the analysis of the *package design*.

If computer codes are used for the safety analysis then additional information will be required in order to justify that the code is verified/validated in its field of use. Justification for the applicability of these codes should include a statement of possible sources of errors and/or uncertainties relative to the effects of the operating platform (computer) used and of modelling assumptions and simplifications as well as any other parameter influencing the calculated results.

2.1.4 Analysis of *package design*

The performance characteristics of the *package design* should be assessed, as appropriate (see annexes), with an appropriate and identified sensitivity analysis and levels of accuracy stated.

It is conceivable that more than one accident and consequential damage scenario will need to be considered to ensure that the various safety functions, to be fulfilled by different components of the *package design*, comply with the regulatory requirements.

Other risks which may have a consequential effect on the safety functions should be analysed. This may concern corrosion, combustion, pyrophoricity or other chemical reactions, radiolysis, phase changes, etc

2.1.5 Comparison between acceptance criteria and results of analysis

The results of the analyses detailed in section 2.1.4 should be compared with the acceptance criteria and *package design* assumptions (section 2.1.2) and regulatory compliance should be justified accordingly.

2.2 Technical analyses

2.2.1 Structural analysis

Assessment of the mechanical behaviour (including fatigue analysis, brittle fracture, creep… if applicable) under routine, normal and accident conditions of transport, as applicable for the type of *package*, for

(a) The *package* components of the *containment system*

(b) The *package* components that provide radiation shielding

(c) The *package* components of the *confinement system*

(d) The *package* components for which their performance will have a consequential effect upon (a), (b) and (c)

(e) The *packaging* attachments used for lifting the *packaging*/*package* (routine and normal conditions only)

(f) The *packaging* attachments used for restraining the *package*/*packaging* to its *conveyance* during transport (routine and normal conditions only).

2.2.2 Thermal analysis

Assessment of thermal behaviour for routine, normal and accident conditions of transport including an evaluation of thermal stresses, surface temperatures and the thermal behaviour of, as applicable for the type of *package*:

(a) The components of the *containment system*

(b) The components of shielding

(c) The components of the *confinement system*

(d) The *package* components for which their performance will have a consequential effect upon (a), (b) and (c).

2.2.3 Containment design analysis

Assessment regarding the requirements for preventing the loss or dispersal or for limiting the release of *radioactive material* under routine, normal and accident conditions of transport, as applicable.

2.2.4 External dose rates analysis

The assessment of the dose rates and dose rate increase ratio for routine, normal and accident conditions as applicable. The analysis should assume a maximum radioactive content or a content that would create the maximum dose rates at the surface of the *package* and at distances defined in the regulations.

2.2.5 Criticality safety analysis

For *package*s *design*ed to transport *fissile material* not excepted from the requirements for *package*s containing *fissile material*, assessment of criticality safety for routine, normal and accident conditions of transport, for the isolated *package* and for the arrays of *package*s.

3 REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Regulations for the safe Transport of *Radioactive material*, 2009 Edition, Safety Requirements No. TS-R-1, IAEA, Vienna

[2] ECONOMIC COMMISSION FOR EUROPE, European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR), United Nations, New York and Geneva, 2011 Edition.

[3] INTERGOVERNMENTAL ORGANISATION FOR INTERNATIONAL CARRIAGE BY RAIL (OTIF), Convention concerning International Carriage by Rail (COTIF) Appendix B. Uniform Rules concerning the Contract for International Carriage of Goods by Rail (CIM) Annex 1 Regulations concerning the International Carriage of Dangerous Goods by Rail (RID). 2011 Edition.

[4] INTERNATIONAL MARITIME ORGANIZATION, International Maritime Dangerous Goods (IMDG) Code, International Maritime Organization, London 2010 Edition.

[5] ECONOMIC COMMISSION FOR EUROPE, European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN), United Nations, New York and Geneva, 2011 Edition.

[6] INTERNATIONAL CIVIL AVIATION ORGANIZATION, Technical Instructions for the Safe Transport of dangerous Goods by Air, International Civil Aviation Organization, Montréal, 2011-2012 Edition.

[7] UNITED NATIONS, Recommendations on the Transport of Dangerous Goods, sixteenth Revised Edition (ST/SG/AC.10/1/Rev.16), UN, New York and Geneva (2009).

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Advisory Material for the IAEA Regulations for the Safe Transport of *Radioactive material*, Safety Guide No.TS-G-1.1 (Rev. 1), IAEA, Vienna (2008).

[9] INTERNATIONAL ATOMIC ENERGY AGENCY, Compliance Assurance for the Safe Transport of *Radioactive material*, IAEA Safety Standards Series No.TS-G-1.5, IAEA, Vienna (2009).

References

[10] INTERNATIONAL ATOMIC ENERGY AGENCY, The Management Systems for the Safe Transport of *Radioactive material*, IAEA Safety Standards Series No. TS-G-1.4, IAEA, Vienna (2008).

[11] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANISATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, WORLD HEALTH ORGANIZATION, International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No. 115, IAEA Vienna (1996).

Table 1: Matrix of IAEA, ADR regulatory requirements and *package* type

	§ TS-R-1 (2009)	§ 2011ADR *	*package* type							additional provisions		remarks
			excepted	IP-1	IP-2	IP-3	A	B(U), B(M)	C	fissile	UF6	
DEFINITIONS	222	2.2.7.1.3								x		*fissile material*
	225	2.2.7.1.3						x				LDM
	226	2.2.7.1.3		x	x	x						LSA
	239	2.2.7.1.3	x				x	x	x			special form material
	241	2.2.7.1.3		x	x	x						SCO
QA	306	1.7.3	x	x	x	x	x	x	x			quality assurance
ACTIVITY LIMITS AND CLASSIFICATION	421-426	2.2.7.2.4 - 2.2.7.2.4.1.6	x									§§423(e) and 424(c): transport by post
	408-411	2.2.7.2.3.1.2 (M) 2.2.7.2.4.2 and 3.3.1 SP 336		x	x	x						LSA classification and activity limits, §410: transport by air
	412-414	2.2.7.2.3.2 and 2.2.7.2.4.3		x	x	x						SCO classification and activity limits
	428-429	2.2.7.2.4.4					x					activity limit for type A *package*
	430-432	2.2.7.2.4.6.1 (M) - 2.2.7.2.4.6.3 (M)						x				classification as type B(U) and B(M) *package*and activity limits
	433	3.3.1 SP 337 (M)						x				activity limits for type B(U) and B(M) *package* by air
	430, 434	2.2.7.2.4.6.1 (M), 2.2.7.2.4.6.4 (M)							x			classification as type C *package* and activity limits

* In this column the symbol "-" denotes "completely missing compared to TS-R-1", "M" denotes "modified in comparison to TS-R-1"

Table 1: Matrix of IAEA, ADR regulatory requirements and *package* type

	§ TS-R-1 (2009)	§ 2011ADR *	*package* type							additional provisions		remarks
			excepted	IP-1	IP-2	IP-3	A	B(U), B(M)	C	fissile	UF6	
	417, 418	2.2.7.2.3.5 (M), 4.1.9.3								x		classification as *fissile material* and restrictions
	419, 420	2.2.7.2.4.5, 2.2.7.2.4.5.1									x	classification as uranium hexafluoride and restrictions
REQUIREMENTS AND CONTROLS FOR TRANSPORT	503	4.1.9.1.3 (M)		x	x	x	x	x	x			transport of other goods
	506	1.7.5 (M), 2.1.3.5.3,(M)	x	x	x	x	x	x	x			subsidiary risk
	507	4.1.9.1.2	x	x	x	x	x	x	x			non fixed contamination on *package* - §609
	514-515	1.7.1.5 (M), 2.2.7.2.4.1.2 (M)	x									excepted *package* requirements
	516	4.1.9.2.1		x	x	x						radiation level of unshielded LSA or SCO
	519	4.1.9.2.4		x	x	x						
	520	7.5.11 CV33 (2)		x	x	x						activity limit on conveyance
	524	4.1.9.1.9		x	x	x	x	x	x	x		TI and CSI limits
	525,526	4.1.9.1.10 and 11		x	x	x	x	x	x			radiation level at contact of a *package*
	569	7.5.11 CV33 (3.5)		x	x	x	x	x	x			exclusive use
	571	-		x	x	x	x	x	x			transport by sea
	574	-						x				transport by air for type B(M) *package*

Table 1: Matrix of IAEA, ADR regulatory requirements and *package* type

	§ TS-R-1 (2009)	§ 2011ADR *	*package* type							additional provisions		remarks
			excepted	IP-1	IP-2	IP-3	A	B(U), B(M)	C	fissile	UF6	
REQUIREMENTS FOR *RADIOACTIVE MATERIALS* AND FOR *PACKAGINGS* AND *PACKAGES*	601	2.2.7.2.3.1.3			x	x						for LSA-III
	602-604	2.2.7.2.3.3.1 and 2	x				x	x				for special form
	605	2.2.7.2.3.4.1						x				for LDM
	606-616	6.4.2.1 - 11	x	x	x	x	x	x	x			general provisions
	617-619	-	x	x	x	x	x	x	x			transport by air and for type C *package*
	622	6.4.5.2			x							
	623	6.4.5.3				x						
	624	6.4.5.4.1			x							alternative requirements
	625-628	6.4.5.4.2 - 5			x	x						alternative requirements
	629-632	6.4.6.1 - 4									x	
	634	6.4.7.2		x	x	x	x	x	x	x		
	635-645	6.4.7.3 - 13				x	x	x	x			
	646	6.4.7.14				x	x	b) only	b) only			
	647	6.4.7.15				x	x	x	x			liquids
	648	6.4.7.16					x					liquids
	649	6.4.7.17					x					gases

Table 1: Matrix of IAEA, ADR regulatory requirements and *package* type

	§ TS-R-1 (2009)	§ 2011ADR *	*package* type							additional provisions		remarks
			excepted	IP-1	IP-2	IP-3	A	B(U), B(M)	C	fissile	UF6	
	651-655	6.4.8.2 - 6						x	x			
	656-658	6.4.8.7 - 6.4.8.9						x				
	659-664	6.4.8.10 - 15						x	x			
	665,666	6.4.9.1 and 2						x				
	668-670	6.4.10.2 – 6.4.10.4							x			
	671	6.4.11.1								x		
	672	6.4.11.2	x	x	x	x	x	x	x			fissile excepted material
	673-683	6.4.11.3 - 13								x		
TEST PROCEDURES	701	6.4.12.1	x	x	x	x	x	x	x	x	x	demonstration of compliance
	702	6.4.12.2			x	x	x	x	x	x	x	assessment after tests
	703	2.2.7.2.3.1.4			x	x		x				leaching test for LSA-III and LDRM
	704-711	2.2.7.2.3.3.4 - 2.2.7.2.3.3.8	x				x	x	x			tests for special form radioactive material
	712	2.2.7.2.3.4.2						x				tests for LDRM
	713-715	6.4.12.3			x	x	x	x	x	x	x	preparation of a package for testing
	716	6.4.13			x	x	x	x	x	x	x	integrity of containment, shielding and assessing criticality safety

Table 1: Matrix of IAEA, ADR regulatory requirements and *package* type

§ TS-R-1 (2009)	§ 2011ADR *	*package* type							additional provisions		remarks
		excepted	IP-1	IP-2	IP-3	A	B(U), B(M)	C	fissile	UF6	
717	6.4.14			x	x	x	x	x	x	x	target for drop tests
718	6.4.21.5									x	structural test
719-720	6.4.15.1 - 6.4.15.2			x	x	x	x	x	x	x	general provisions for normal conditions tests
721	6.4.15.3				x	x	x	x	x		water spray test
722	6.4.15.4			x	x	x	x	x	x	x	free drop test
723	6.4.15.5			x	x	x	x	x	x		stacking test
724	6.4.15.6				x	x	x	x	x		penetration test
725	6.4.16					x					additional tests for Type A (liquids and gases)
726	6.4.17.1						x	x	x		general provisions for accident conditions tests
727 (a)	6.4.17.2 (a)						x	x	x		9 m drop test
727 (b)	6.4.17.2 (b)						x		x		drop test onto a bar
727 (c)	6.4.17.2 (c)						x	x	x		dynamic crush test
728	6.4.17.3						x		x	x	thermal test
729	6.4.17.4						x		x		water immersion test
730	6.4.18						x	x			enhanced water immersion test
731-733	6.4.19.1 - 6.4.19.3								x		water leakage test

Table 1: Matrix of IAEA, ADR regulatory requirements and *package* type

	§ TS-R-1 (2009)	§ 2011ADR *	*package* type							additional provisions		remarks
			excepted	IP-1	IP-2	IP-3	A	B(U), B(M)	C	fissile	UF6	
	734	6.4.20.1							x			general provisions for Type C packages tests
	735	6.4.20.2							x			puncture/tearing test
	736	6.4.20.3							x			enhanced thermal test:
	737	6.4.20.4							x			impact test

Annexe 1

Excepted packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6.

Part 1	
1.1	To be complied with
1.2	To be complied with (c) The kind(s) of *excepted package* as assigned by UN numbers should be specified: • Empty Packaging (UN 2908), or • Articles Manufactured From Natural Uranium or Depleted Uranium or Natural Thorium (UN 2909), or • Limited Quantity of Material (UN 2910), or • Instruments or Articles (UN 2911). (e) Compliance with additional requirements for air transport (see Table 1) should be considered, if applicable.
1.3	To be complied with, except (f) (b) Compliance with the activity limits for *excepted packages* according to Table 5 of TS-R-1 and paras 423 and 424 (for transport by post) and with para. 425 (for empty packagings), if applicable, should be considered. (d) A valid special form certificate should be available if *special form radioactive material* is used. (g) *Fissile material* is allowed only if excepted according to para. 417 of TS-R-1. (h) Subsidiary risks of the contents should be taken into account which may result in classification and *design* requirements according to the predominant subsidiary risk (see [7], Chapter 3.3 SP 290).
1.4	To be complied with , except (g) - (i)

Annexe 1

Excepted packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6.

	(e) may be supported by special form material if applicable (see also comment under 1.3 (d) above)
1.5	The main *design* principles and performance characteristics for the *package design* to meet the containment and shielding integrity requirements for *excepted packages* under routine conditions of transport according to paras 606 - 616, paras 617 - 619 for packages to be transported by air, paras 514, 515 and if applicable paras 423 (a) and (c), 424 (a) and 426 of TS-R-1 (see also Table 1) should be described.
1.6	The appropriate paragraphs as indicated in Table 1 for *excepted package* should be addressed.
1.7	Appropriate instructions for use of the *package* should be developed covering all items under 1.7. Compliance to requirements in paras 561 and 606 - 608 should be justified taking into account the foreseen routine conditions of transport. Routine conditions of transport should be identified: minimum and maximum ambient temperature during transport, minimum ambient pressure, specifications on bolt torquing requirements, number of transport cycles (to be used in fatigue analysis) for each mode of transport should be included if applicable.
1.8	Appropriate instructions for maintenance of the *package* should be developed covering all items under 1.8.
1.9	The management system shall be appropriate to the complexity of the *design* of the *package* to ensure that the *package* is designed and tested if necessary to demonstrate it meets the regulatory requirements. This shall include a reliable document control system. The management system should also ensure that the requirements and standards for: manufacture; inspection before first use and subsequent inspections during use (for repeated use of *packaging*); maintenance; operating (loading, unloading, operating, transporting) are clearly defined in the PDSR. More detailed guidance is available

Annexe 1

Excepted packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6.

	from [10].
1.10	To be complied with

Part 2	
2.1	To be complied with to the extent applicable to demonstrate compliance with the *design* requirements for *excepted package*.
2.2.1	To be complied with for routine conditions of transport only and not for (c) (a) may be supported by special form material if applicable Structural analysis should be performed to such an extent that it provides evidence that all applicable *design* requirements according to paras 606 - 616, 617 - 619 (for air transport), 620 and 634 (for fissile excepted material), if applicable are met. It should take into account ambient temperatures and pressures that are likely to be encountered in routine conditions of transport as well as the specific temperature and pressure requirements for air transport. In particular attention should be paid to ensure that any nuts, bolts and other retention devices keep their safety functions during routine conditions of transport even after repeated use. For more guidance see also TS-G-1.1, paras 606.1 - 619.3
2.2.2	To be complied with for routine conditions of transport only and not for (c) Thermal analysis should be performed to such an extent that it provides evidence that all applicable *design* requirements with thermal aspects according to paras 606-619 are met, in particular paras 612, 613, 615 and 616 - 618 if applicable. For more guidance see also TS-G-1.1, paras 606.1 - 619.3
2.2.3	To be complied with for routine conditions of transport only. It should be performed to such an extent that containment integrity for all relevant aspects according to paras 606-616 and 617-619, if applicable, is

Annexe 1

Excepted packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6.

	demonstrated. Other dangerous properties of contents – see paras 110 and 506.
2.2.4	To be complied with for routine conditions of transport only (see paras 507, 508 and 515). Shielding analysis should be performed to such an extent that it provides evidence that all applicable *radiation level* requirements are met according to paras 515 and 423 (a), if applicable. If calculation methods are used the calculations of source terms should take into account the interactions, secondary emissions, multiplication factors when relevant. The appropriate ICRP recommendations should be taken into account. If measurements are used the measuring source should be representative for the *radioactive contents* of the package design.
2.2.5	Not applicable: non excepted *fissile material* is not allowed in *excepted packages*.

Annexe 2

Industrial packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6

Part 1	
1.1	To be fully complied with
1.2	To be complied with (c) the type of industrial package should be specified: - *Industrial package Type 1* (Type IP-1); - *Industrial package Type 2* (Type IP-2) or - *Industrial package Type 3* (Type IP-3) (e) compliance with additional requirements for air transport (see Table 1) should be considered
1.3	To be complied with. (b) Limitations in *specific activity* (Bq/g) and surface *contamination* (Bq/cm^2) may be required. Regarding classification of material in TS-R-1 the contents should be classified as *LSA-I*, *LSA-II* or *LSA-III* (para. 409) or *SCO-I* or *SCO-II* (para. 412). According to this classification of contents the type of *Industrial Package* should be justified (para. 519 and Table 6 of TS-R-1) Compliance with the dose rate limit at 3 m from the unshielded contents established in para. 516 should be assessed. *Conveyance* activity limits according to Table 7 of TS-R-1 should also be taken into account to limit the activity of a single *package*, if applicable. (c) Limits of contents in *industrial package* depend of physical state. In case of *LSA–III*, as applicable for *Type IP-2* or *Type IP-3* according to the Table 6 of TS-R-1, compliance with para. 601 should be justified.

Annexe 2

Industrial packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6

	(f) if applicable (g) If the package contains fissile excepted materials, compliance to provisions in para. 417 of TS-R-1 should be justified; if the package contains non-excepted fissile materials, refer to Annexe 5.
1.4	To be complied with, except (i) (g) if applicable, see Annexe 5 (h) if applicable in connection with Annexe 5 or 6
1.5	The main *design* principles and performance characteristics for the *package design* should be described to meet the containment and shielding integrity requirements for: - *Type IP-1* under routine conditions of transport according to paras 606 - 619 and 634 of TS-R-1. - *Type IP-2* under routine and normal conditions of transport according to paras 606 - 619, 622 and 634 of TS-R-1 or alternative requirements in paras 624 - 628 for *packages*, *tank* containers, *tanks* (other than *tank* containers), *freight containers* and metal *intermediate bulk containers*. - *Type IP-3* under routine and normal conditions of transport according to paras 606 - 619, 634 - 647 or alternative requirements in paras 625 - 628 for *tank* containers, *tanks* (other than *tank* containers), *freight containers* and metal *intermediate bulk containers*. - *Type IP-1*, *Type IP-2* and *Type IP-3* according to paras 524 - 526 of TS-R-1 (see also Table 1)
1.6	The appropriate paragraphs as indicated in Table 1 for *Type IP-1*, *Type IP-2* and *Type IP-3 package* should be addressed

Annexe 2

Industrial packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6

1.7	Appropriate instructions for use of the *package* should be developed covering all items under 1.7. Details of the *package* handling operations may be included in more exhaustive written procedures to which reference may be made in this part of the PDSR. (a) In compliance with para. 501(a) of TS-R-1, if the design pressure of the *containment system* exceeds 35 kPa, a procedure for testing the integrity of the *containment system* under that pressure should be included. (b) Testing and control procedures should be included to ensure that: • All the requirements specified in the relevant provisions of TS-R-1 applicable to *Industrial Packages* have been satisfied, according to para. 502 (a) of TS-R-1. • Lifting attachments which do not meet the requirements of para. 607 of TS-R-1 have been removed or otherwise rendered incapable of being used for lifting the *package*, according to para. 502 (b) of TS-R-1. (c) Specifications on bolt torquing requirements, number of transport cycles (to be used in fatigue analysis) for each mode of transport should be included if applicable. In addition to the radioactive properties, any other dangerous properties of the contents of the *package* should be taken into account. (see para. 506)
1.8	Appropriate instructions for maintenance of the *package* should be developed covering all items under 1.8.
1.9	The management system shall be appropriate to the complexity of the *design* of the *package* to ensure that the *package* is designed and tested if necessary to demonstrate it meets the regulatory requirements. This shall include a reliable document control system.

Annexe 2

Industrial packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6

	The management system should also ensure that the requirements and standards for manufacture; inspection before first use and subsequent inspections during use (for repeated use of *packaging*); maintenance; operating (loading, unloading, operating, transporting) are clearly defined in the PDSR. More detailed guidance is available from [10].
1.10	To be complied with
Part 2	
2.1	To be complied with to the extent applicable to demonstrate compliance with the regulatory requirements for *Type IP-1*, *IP-2* and *IP-3 package*s
2.2.1	Structural analysis should be performed to such an extent that it provides evidence that: (I) *Type IP-1 package* complies with requirements defined for routine conditions of transport according to paras 606-619; in particular, this analysis should consider: • Attachments used for restraining the *package* (para. 606) • Attachments used for lifting the *package* (paras 607 and 608) • Features added to the *package* during transport (para. 611) • Behaviour of *package* and their components with respect to the effects of any acceleration, vibration or vibration resonance (para. 612) • Behaviour of *package* with respect to ambient temperatures and pressures that are likely to be encountered in routine conditions (para. 615) (II) *Type IP-2 package* complies with requirements defined for routine conditions and normal conditions of transport according to paras 606 - 619 and 622 of TS-R-1 or alternative requirements in paras 624 - 628; in

Annexe 2

Industrial packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6

	particular this analysis should consider the same points showed for *Type IP-1 package* above and in addition the assessment of compliance with the acceptance criteria defined in para. 622 for the mechanical tests specified in paras 722 and 723 of TS-R-1. (III) *Type IP-3 package* complies with requirements defined for routine conditions and normal conditions of transport according to paras 606 - 619, 634 - 647 or alternative requirements in paras 625 - 628; in particular this analysis should consider the same points showed for *Type IP-1 package* above and in addition: • The assessment of compliance with the acceptance criteria defined in para. 646 for the mechanical tests specified in paras 721 - 724. • An analysis of the tie-down attachments on the *package*, if applicable (para. 636) If the testing assessment is conducted by real tests the test report should address that: • drop tests are carried out according to a *quality assurance* program • specimen, prototype or sample is representative of the *package* • Drop tests are performed so as to cause the worst damage. The demonstration that the drop test orientation causes the worst damage to the tested function (containment or shielding) should be established according to a *quality assurance* program. • The target for drop tests complies with applicable prescriptions. This test report should also contain pictures showing and explaining the performing conditions of the tests and their results. For more guidance see also the corresponding paragraphs of TS-G-1.1

Annexe 2

Industrial packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6

2.2.2	Thermal analysis should be performed in such a way that it provides evidence that all applicable *design* requirements with thermal aspects are met, in particular for: *Type IP-1* and *Type IP-2 packages*: • Behaviour with respect to the ambient temperatures to be encountered in routine conditions (para. 615 of TS-R-1). • Analysis of temperatures on accessible surfaces of the *package*, in cases of air transport (para. 617). • Behaviour with respect to ambient temperatures ranging from –40°C to +55°C, in case of air transport (para. 618). *Type IP-3 package*: the same points shown for *Type IP-1* and *Type IP-2 packages* above and, in addition, an assessment of the behaviour with respect to temperatures ranging from –40°C to +70°C range (paras 637 and 647). (a) Attention should be paid to ensure that sealing joints retain their safety functions for the temperature ranges indicated above. For more guidance see also the corresponding paragraphs of TS-G-1.1
2.2.3	Containment analysis should be performed in such a way that it provides evidence that all applicable requirements applicable to the *containment system* are met, in particular for: - *Type IP-1*: • Protection of valves through which the contents could otherwise escape, if applicable (para. 614 of TS-R-1). • Behaviour of *package* with respect to reduction of ambient pressures in air transport (para. 619). - *Type IP-2 packages*: the same points shown for *Type IP-1* and, in addition:

Annexe 2

Industrial packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6

	prevention of loss or dispersal of the *radioactive contents* (paras 622(a), 624(c)(i), 627(c)(i), 628(b)(i) as applicable) - *Type IP-3 package*, the same points shown for *Type IP-1* and *Type IP-2 packages* above and, in addition: • Fastening device of the *containment system* (paras 639 and 641). • An analysis that internal pressure in *package*, if applicable, will not impair the fastening device of the *containment system* (para. 639). • Behaviour of the *containment system* with respect to the radiolysis caused by the contents, if applicable (par.642). • Behaviour of *containment system* with respect to a reduction of ambient pressure to 60 kPa (para. 643). • Leakage retention systems in valves, other than pressure relief, if applicable (para. 644). • *Design* of shielding enclosing components of the *containment system* (645). The assessment of the *containment system* under all operating conditions should be accomplished considering the most limiting *package* contents from the chemical and physical point of view and taking into account the maximum internal pressures. Where appropriate, an analysis and justification of the tightening torques to be used to maintain containment under routine and normal conditions should be performed, as applicable. A description of the leak tests required to demonstrate that the *package* fulfils the containment requirements, such as tests performed during and following the manufacturing of the *packaging*, periodic testing and tests prior to each transport operation should be included. For more guidance see also the corresponding paragraphs of TS-G-1.1

Annexe 2

Industrial packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6

2.2.4	The analysis of aspects relating to the shielding system of the *packaging* should assure that the dose rate limits established by the regulations will be met, in particular for: - *Type IP-1 packages*, the dose rate limits for routine conditions of transport (paras 524-526 of TS-R-1). - *Type IP-2 packages*, in addition to the limits for routine conditions, when the packages were subjected to the specified tests it would prevent more than a 20% increase in the maximum *radiation level* at any external surface of the *package* according to paras 622(b), 624(c)(ii), 625(c), 626(c), 627(c)(ii) and 628(b)(ii) as applicable. - *Type IP-3 packages*, in addition to the limits for routine conditions, when the packages were subjected to the specified tests it would prevent more than a 20% increase in the maximum *radiation level* at the external surface of the *package*, according to paras 625(c), 626(c), 627(c)(ii), 628(b)(ii) and 646(b) as applicable. For *Type IP-2* and *Type IP-3 packages* attention should be given to define precisely the retention system inside the *package* if applicable (example: transport of contaminated tools) in order to prevent any displacement of the contents that would lead to more than 20% increase in the maximum *radiation level*. If calculation methods are used, the calculations of source terms should take into account the interactions, secondary emissions, multiplication factors when relevant. If measurements are used the measuring source should be representative for the *radioactive contents* of the *package design*. For more guidance see also the corresponding paragraphs of TS-G-1.1
2.2.5	If applicable, see also Annexe 5

Annexe 3

Type A packages

Specific additional guidance to provide the information as requested in
Part 1 and 2 of the PDSR. In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6.

Part 1	
1.1	To be complied with
1.2	To be complied with (e) compliance with additional requirements for air transport (see Table 1) should be considered
1.3	To be complied with. (b) Compliance with the activity limits for *Type A packages* according to paras 428 - 429 of TS-R-1 should be considered. (c) there are additional *design* requirements for liquids and gases contents (d) a valid special form certificate should be available if *special form radioactive material* is used (f) if applicable (g) If the *package* contains fissile excepted material, compliance to provisions in para. 417 of TS-R-1 should be justified; if the *package* contains non-excepted *fissile material*, refer to Annexe 5.
1.4	To be complied with, except (i) (e) may be supported by special form material if applicable (see also comment under 1.3 (d) above) (g) if applicable, see annexe 5 (h) if applicable in connection with annexe 5 or 6
1.5	The main *design* principles and performance characteristics for the *package design* should be described to meet the containment and shielding integrity requirements for *Type A package*s under routine and normal conditions of transport according to paras 606 - 619, 634 - 646 and 524 - 526 of TS-R-1. See also paras 647 - 649 for

Annexe 3

Type A packages

Specific additional guidance to provide the information as requested in
Part 1 and 2 of the PDSR. In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6.

	liquids and gases contents. (see also Table 1)
1.6	The appropriate paragraphs as indicated in Table 1 for *Type A package* should be addressed.
1.7	Appropriate instructions for use of the *package* should be developed covering all items under 1.7. In particular also specifications on bolt torquing requirements, number of transport cycles (to be used in fatigue analysis) for each mode of transport should be included if applicable. In addition to the radioactive properties, any other dangerous properties of the contents of the *package* should be taken into account (see para. 506). (e) including compliance with para. 635.
1.8	Appropriate instructions for maintenance of the *package* should be developed covering all items under 1.8.
1.9	The management system shall be appropriate to the complexity of the *design* of the *package* to ensure that the *package* is designed and tested if necessary to demonstrate it meets the regulatory requirements. This shall include a robust document control system. The management system should also ensure that the requirements and standards for manufacture; inspection before first use and subsequent inspections during use (for repeated use of *packaging*); maintenance; operating (loading, unloading, operating, transporting) are clearly defined in the PDSR. More detailed guidance is available from [10].
1.10	To be complied with
Part 2	
2.1	To be complied with to the extent applicable to demonstrate compliance with the regulatory requirements for *Type A package*s.

Annexe 3

Type A packages

Specific additional guidance to provide the information as requested in
Part 1 and 2 of the PDSR. In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6.

2.1.2	All characteristics (mechanical, thermal…) of each component of the *package* and acceptance criteria for technical analyses should be defined. Examples Compliance with para. 637 should include criteria for some of the items as : - expansion/contraction of components relative to the structural or sealing functions; - decomposition or changes of state of component materials at extreme conditions; - tensile/ductile properties and *package* strength; - shielding *design*.
2.1.4	For structural analysis, compliance with the para. 646(a) should include a criterion to ensure that under normal transport conditions the *radioactive contents* of the *package* cannot escape in quantities that may create a radiological or *contamination* hazard. (See also TS-G-1.1 paras 646.1 - 646.6) The conformity of the drop tests with the requirements should be demonstrated and an exhaustive description of the drop tests should be documented. The following should also be addressed : - Drop tests are accomplished according to a *quality assurance* program. - Specimen, prototype or sample is representative of the *package.* - Drop tests are performed so as to cause the worst damage. The demonstration that the drop test orientation causes the worst damage to the tested function (containment, shielding or criticality safety) should be established according to a *quality assurance* program - The target for drop tests complies with applicable prescriptions. It should be flat and unyielding (a steel plate of sufficient thickness floated on to a concrete block), massive enough to resist to any displacement.

Annexe 3

Type A packages

Specific additional guidance to provide the information as requested in
Part 1 and 2 of the PDSR. In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6.

	- A drop test report is established according to a *quality assurance* program, addressing the verification of the *package* before testing, the description of the test site, the measurement equipments used and their calibration, the results of performed measures ensuring that pre-established criterions are met. This report should also contain pictures showing and explaining the performing conditions of the tests and their results. Subsidiary risks should be addressed in the demonstrations of compliance.
2.2.1	To be complied with for routine and normal conditions of transport and not for (c) (a) may be supported by special form material if applicable (para. 640). Structural analysis should be performed to such an extent that it provides evidence that all applicable *design* requirements according to paras 606 - 619, paras 634 - 646 and if applicable paras 647 - 649 are met. Attention should be paid to ensure that any nuts, bolts and other retention devices remain their safety functions during routine conditions of transport even after repeated use. It should take into account temperatures and pressures according to paras 637 and 643. For more guidance see also TS-G-1.1, paras 606.1 - 619.3 and paras 634.1 - 649.3 Tests procedures take into account requirements of paras 701 - 702, 713 - 715, 716 and 719 - 724 (see also 725 for additional tests for *Type A packages* designed for liquids and gases).

Annexe 3

Type A packages

Specific additional guidance to provide the information as requested in
Part 1 and 2 of the PDSR. In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6.

2.2.2	To be complied with for routine and normal conditions of transport and not for (c) Thermal analysis should be performed to such an extent that it provides evidence that all applicable *design* requirements with thermal aspects according to paras 606 - 619 and paras 634-649 are met, in particular paras 612, 613, 615, 637, 646 and 616-617, 640, 642 if applicable. For more guidance see also TS-G-1.1, paras 606.1 - 619.3 and 634.1 - 649.3.
2.2.3	To be complied with for routine and normal conditions of transport. It should be performed to such an extent that containment integrity for all relevant aspects according to paras 606 - 619 and 634 - 649 can be demonstrated (in particular paras 639 - 643). Attention should be paid to define precisely the contents. Assumptions and demonstrations are different according to the contents. Attention should be paid to demonstrate the ability to withstand reduced ambient pressure due to altitude encountered during transportation (para. 643 and para. 619 if applicable). Where *special form radioactive material* constitutes part of the *containment system*, consideration should be given to the appropriate performance of the special form material under the routine and normal conditions of transport.
2.2.4	To be complied with for routine and normal conditions of transport. See para. 645 and TS-G-1.1, paras 645.1 - 645.2. If calculation methods are used the calculations of source terms should take into account the interactions, secondary emissions, multiplication factors when relevant. The appropriate ICRP recommendations should be taken into account. If measurements are used the measuring source should be representative for the *radioactive contents* of the *package design*.

Annexe 3

Type A packages

Specific additional guidance to provide the information as requested in
Part 1 and 2 of the PDSR. In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6.

	Routine conditions of transport Shielding analysis should be performed to such an extent that it provides evidence that all applicable *radiation level* requirements are met according to paras 525 - 526. **Normal conditions of transport** If the *package* were subjected to the tests specified in paras 719 - 724, it would prevent more than a 20% increase in the maximum *radiation level* at the external surface of the *package* according to para. 646. Attention should be given to define precisely the tie-down system inside the *package* if applicable (example: transport of contaminated tools) in order to prevent any displacement of the contents that would lead to more than 20% increase in the maximum *radiation level*.
2.2.5	If applicable, see also Annexe 5

Annexe 4

Type B(U), Type B(M) and Type C packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6.

Part 1	
1.1	To be complied with
1.2	To be complied with
1.3	To be complied with – including 1.3(g) when contents are fissile or fissile excepted. (d) A valid special form certificate should be available if *special form radioactive material* is used; a valid *low dispersible radioactive material* certificate should be available if *low dispersible radioactive material* is used (g) If the *package* contains fissile excepted materials, compliance to provisions in para. 417 of TS-R-1 should be justified; if the *package* contains non- excepted *fissile materials*, refer to Annexe 5. The description of the contents and of their physical, chemical and radioactive forms should be sufficiently precise to allow the demonstration of compliance with the requirements for containment, radiation protection, the criticality-safety and protection against heat. The description should include all dimensions (drawings), material grades and mechanical properties which are used in demonstrating the required safety performances. The description should include • the total numbers of A_2 or A_1 in the contents • if applicable, the maximum burn-up and minimum cooling time; • the composition and the weight of hydrogenated materials that may interact with the contents (for neutron multiplication or radiolysis) The properties of materials should be given for temperatures ranging from -40°C to the maximum temperature in normal conditions of transport.

Annexe 4

Type B(U), Type B(M) and Type C packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6.

1.4	To be complied with (e) may be supported by special form material if applicable (see also comment under 1.3 (d) above) (g) if applicable, see annexe 5
1.5	To be complied with
1.6	The appropriate paragraphs as indicated in Table 1 for *Type B(U)*, *Type B(M)* or *Type C package* should be addressed.
1.7	To be complied with Detailed description of the methods used for operational controls and tests, in particular those required in paras 501 (a), 502, 507, 521, 525 and 526. For drying operations, method used should prevent formation of ice. For leaktightness testing, when the *competent authority* accepts methods using slackened criteria, qualified methods for detection of defects (that might create in operating conditions a leakage with a rate higher than permissible) should be implemented (see 2.2.3). The absence of defects should be ensured by a specific inspection procedure with appropriate qualification. The control of tightening torques of the bolts and of the correct position of the lid and the adjustment of the internal atmosphere and pressure should be specified.
1.8	To be complied with • Detailed description of the maintenance activities, in particular: • Periodic controls of the components of the *containment system* (screws, bolts, welds, O-rings…) • Periodic controls of the tie-down and handling attachments…

Annexe 4

Type B(U), Type B(M) and Type C packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6.

	• The definition of the periodicity of replacement of the *packaging* components should take into account any reduction in efficiency due to wear, corrosion, ageing and change in seal compression with time etc. The justification of the periodicity of controls, when needed, may take place in this section.

1.9	To be complied with (see para. 306). The management system shall be appropriate to the complexity of the *design* of the *package* to ensure that the *package* is designed and tested if necessary to demonstrate it meets the regulatory requirements. This shall include a robust document control system. The management system should also ensure that the requirements and standards for: manufacture; inspection before first use and subsequent inspections during use (for repeated use of *packaging*); maintenance; operating (loading, unloading, operating, transporting) are clearly defined in the PDSR. This includes: • The PDSR should describe the principles and requirements of Quality Management Systems which have been and will be applied to all the activities involved in the transport of *radioactive* and/or *fissile materials* in the package being assessed (*design* including design modification, qualification, safety studies, manufacture, commissioning, preparation for transport, loading, transport, transit, unloading, maintenance). • The PDSR should define and classify all significant components for safety with, for each the associated functions of safety, the parameters to be guaranteed for the maintenance of these functions and the level of controls to be performed during manufacturing. • The PDSR should justify qualification of the computer codes used for verification.

Annexe 4

Type B(U), Type B(M) and Type C packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6.

	More detailed guidance is available from [10]
1.10	To be complied with
Part 2	
2.1	To be complied with
2.1.3	(a) When a campaign of tests is implemented for a specific design to be approved by *competent authorities*, the campaign should be notified to the *competent authorities* in advance of the testing programme and the *competent authority* should be allowed to witness testing.
2.1.4	For the assessment of effects concerning radiolysis and/or thermolysis on the performance characteristics of the *package design* the following should be considered: • In all cases where water or hydrocarbonated materials is/are present (cellulose, polymers, aqueous or organic solutions, absorbed humidity), proof of the absence of the risk of accumulation of combustible gases exceeding the limiting concentration for inflammability shall be included. • Use of calculation codes in order to justify the absence of radiolysis hazards in a *package* is acceptable if these codes are qualified, through experimental measurements, incorporating the chemical composition of the environment considered and such physical parameters as temperature, pressure, filling gas, etc. Otherwise, a gradual and cautious approach should be selected, considering an experimental check at reduced activity level of the contents and performed, for instance, during first transports in order to reset the codes used. • When the radiolysis phenomenon limits the maximum duration of transport, this duration shall necessarily integrate duration for incident and emergency response operations.

Annexe 4

Type B(U), Type B(M) and Type C packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6.

	• In the event of loading of leaking fuel rods, contained water shall be taken into account, except justification In addition, if applicable, the risks of chemical or physical reactions for materials which react with water or oxygen, for example, sodium, UF6, plutonium and metallic uranium, etc, or which can suffer a change of phase (freezing, melting, boiling, etc) should be considered.
2.2.1	To be complied with **(i) General remarks** 1. Demonstration of the compliance with the performance standards (TS-R-1) shall be accomplished by methods listed in TS-R-1 para. 701. *2.* The mechanical properties of the materials considered in the safety demonstration should be representative for the range of mechanical properties of the *package* components considering e.g. the applicable temperature ranges between -40°C and +70°C (see para. 637) and the temperature range of the respective *package* components in normal conditions of transport (see para. 651). *3.* For instance the following points should be considered*:* • The impacts on the *package* behaviour due to variations in the shock absorbing properties of the shock absorber material (wood, polymers, plaster, concrete etc.) with temperature range from -40°C to the maximum temperature in normal conditions of transport, or moisture should be analysed. • The safety against brittle fracture at -40°C of components of the *containment system* made of potentially brittle materials (e.g. ferritic steels, cast iron) should be analysed. • Strength of lid bolts should be justified for all drop orientations. • Preferably avoid any excursion in the plastic domain for *containment system* components such as bolts, gasket seats etc. (which would require additional

Annexe 4

Type B(U), Type B(M) and Type C packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6.

	complex proofs concerning the mechanics of the rupture or the maintenance of sufficient gasket seating …). • Possible damage of metallic seals after drops due to vibrations or sliding of the lid should be evaluated. • Verification that internal components are not liable to damage the *containment system*. • The condition of the *containment system* should be determined to enable the requirements of 2.2.3 to be demonstrated within the temperature range concerned (-40°C, maximum temperature in accident conditions of transport). • Retention, after the mechanical tests for accident conditions of transport, of sufficient thermal protection to guarantee the containment or other components safety function. • Verification of the mechanical behaviour of the content and the basket • The effect of the thermal test on the mechanical behaviour of the package components are to be considered (e.g. thermal stresses and strains, thermo-mechanical interactions between package components). • Proof of the ability to withstand the maximum pressure in normal conditions of transport and accident conditions of transport (taking into account fire and radiolysis, physical changes, chemical reactions etc.). • Considering the appropriate water immersion test depending on the content activity of the *package*. • Concerning *packages* transported with a cavity containing water, the PDSR should include the demonstration that the water presence does not impair the validity of the *containment system* tightness inspection by sealing the leakage paths. • Analysis of the influence of any devices described in 1.4 (m) on the performances of the *package* in accident conditions of transport if necessary.

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Type B(U), Type B(M) and Type C packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6.

(ii) Experimental drop testing

1. Determination of the most severe drop test positions and sequences under consideration of the protection objectives (containment, criticality safety, shielding).
2. 9 m drop tests (horizontal, slap down, vertical, oblique.) and 1 m puncture tests which maximise loading of the *package* (such as stress, strain, acceleration and deformation) with consideration of the different *package* components (cask body, lid system, impact limiter, etc.). The drop test positions are to be selected in such a way that critical load conditions of the individual *package* components are met. For instance the following aspects should be considered*:*
   - Drop tests which maximise the stresses and acceleration (flat, slap down …): The greater the impact area is, the harder is the impact (constant stiffness per unit area assumed).
   - Drop test which maximise the deformation (on corner, on edges …): in contrast, the smaller the impact area is, the greater is the crushing.
   - Drop tests which maximise the damages to orifices, notably by a puncture bar. The containment components in the orifices are often thin and more liable to be damaged by the bar than the body of the *packaging*.
   - Drop tests which maximise the risk of perforation by a puncture bar, possibly oblique: if the package impacted surface is oblique with respect to the puncture bar, the initial impact takes place on an edge of the puncture bar and the risk of perforation are much higher.
3. For reduced scale models similar or conservative geometry and material properties are to be used as with the original *design*.
4. It is to be guaranteed that the results of the drop test with reduced scale models are covering and/or transferable to the original *design*.

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Type B(U), Type B(M) and Type C packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6.

	5. Representativeness of drop tests performed with reduced scale models: • Drop heights: when the demonstrations of the mechanical resistance of a *package* are based on tests with reduced scale models, it may be necessary to increase the drop heights to simulate the total potential energy that would have been received by the *package* at full scale. This is especially to be considered for drop tests where the characteristic deformation of the structure is not negligible in comparison to the drop height. 6. Appropriate geometry scaling of all components of the *containment system* (lids, nuts and bolts, grooves for the seals etc.). • Metallic gaskets: same *design*, same material and homothetic transformation with regard to elastic restitution. • O-rings: the similarity should be based on the useful elastic restitution taking into account the compression set. The change of material properties according to temperature conditions should be considered. • The scaling of tightening torques for bolts of the reduced scale model should take into account the dispersion of friction conditions, precision of torques and technical limitations in an exact geometrical and physical scaling of the *containment system* components. • Similar welding seams. • In case of reduced scale model drop testing with significant deformations of impact limiters, the original *package* performance should be carefully justified. **(iii) Calculation** 1. See point 1. and 2. under (ii). 2. Calculations are to be used only with verified and validated computation models. It should be proven that input parameters (material laws, characteristic values, boundary conditions etc.) describe sufficiently and precise the real

Annexe 4

Type B(U), Type B(M) and Type C packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6.

	technical/physical problems. 3. If uncertainties exist regarding important input parameters (e.g. material laws) conservative *design* calculations including the possible range of material properties should be performed in order to assess limiting values within the target magnitudes of technical problems (e.g. stresses, deformations, temperatures). 4. All data used (material laws, boundary conditions, load assumptions etc.) and calculation results are to be documented in detail and comprehensibly.
2.2.2	To be complied with • Consideration of the effects of insolation on a period of 12 hours according to para. 655 of TS-R-1. Averaging on 24 hours should not be accepted. • Consideration of the presence of protective systems liable to oppose heat dissipation in normal conditions of transport: tarpaulins, canopies, additional screens, outer *packaging* (containers, boxes, etc), if applicable. • Justification of simplifying assumptions used for calculation in normal and accident conditions of transport (for example: absence of trunnions). • *Packaging* in accident conditions of transport should be analyzed in the position more penalizing (horizontal or vertical). • The solar insolation before and after the fire test should be taken into account as defined in TS-R-1 para. 728. • The absorptivity coefficient of the external surface of the *package* should not be lower than 0.8, without additional justification (see para. 728(a)), during and after the fire test to account for deposits upon *package* surface. The absorptivity coefficient should also not be lower than the possible maximum value of the emissivity coefficient in routine conditions of transport. • The evaluation of the minimum/maximum temperatures of the various components of the *packaging* should take account of all the possible positions

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Type B(U), Type B(M) and Type C packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6.

	for the *radioactive contents*. • The profile of heat power according to burn up distribution in irradiated fuels should be taken into account in the thermal analyses. • When thermal analysis is based on test results, it should be justified that the temperature measurements were performed at thermal equilibrium. • When the thermal test is made in a furnace and that it is noted that some *package* components burn, the concentration of oxygen present in the furnace should be controlled and in conformity with that obtained in a hydrocarbon fuel-air fire. In addition, control of heat input should be considered thoroughly. • The influence of combustible materials which generate additional heat input and affect the fire duration should be taken into account for safety analyses. • The safety margins on temperature results derived using numerical modelling should be commensurate with the uncertainty associated to the numerical model. • Analysis of the influence of the devices specified in 1.4 (m) in fire conditions on the performances of the *package*, if applicable. • Demonstration that the spare volume in the gasket grooves allows for gasket thermal expansion in normal and accident transport conditions, unless appropriate justification is provided.
2.2.3	To be complied with The technical assessment should demonstrate compliance with the release criteria in normal and accident conditions of transport. Consideration of all the possible releases, in the form of gases, liquids, solids or aerosols, through leaks or by permeation should be included. • Accident conditions of transport: Mechanical resistance of the irradiated fuel assemblies with respect to the internal pressure should be assessed. The risk of rupture due to creep of the rods under the effect of the internal pressure

Annexe 4

Type B(U), Type B(M) and Type C packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6.

	should be evaluated, taking into account the mechanical properties of the fuel rod for the temperature conditions in normal conditions of transport and for the burn up of the irradiated fuel assemblies, in combination with the free drop test. • Analysis of the condition of the irradiated fuel assemblies in accident conditions of transport (risk of cracking or rupture of the fuel rod at their ends) should be included if necessary for safety demonstration. • Justification of fission gas release percentage out of fuel material. • The presence of debris and of aerosols in the container cavity for irradiated fuels in the case of complete rupture due to the shearing of the rods should be considered. • The formation of aerosols for contents consisting of materials in powder form should be considered in accident conditions of transport. • The long term behaviour of gasket material should be considered. • A reduction of ambient pressure to 60 kPa should be considered for evaluation of activity release.
2.2.4	To be complied with. • Compliance with dose rate limits under routine, normal and accident conditions of transport should be demonstrated for the maximum *radioactive content* or a content that would create the maximum dose rates at the surface of the *package* and at distances defined in the regulations (paras 524-526, 646(b), 657(b)(i) or 669(b) as appropriate). • Dose rate analysis should be performed in such a way that in particular *package* surface areas with maximum dose rates are identified and analysed like e.g. trunnion areas, areas containing gaps which give rise to "radiation passes" and other areas with the potential of increased dose rates due to *design* determined, reduced shielding parts (weak points for shielding). • Based on dose rates analysis the maximum *radioactive contents* of the

Annexe 4

Type B(U), Type B(M) and Type C packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6.

	package design should be justified by various methods and parameters like e.g. nuclide specific radioactivity values, nuclide specific source terms for gamma and neutron emitters and others as appropriate. • If measurements are applied to demonstrate compliance with the dose rates limits then representative radiation sources should be selected as well as appropriate calibrated dose rate measuring techniques used for gamma and neutron radiation, as applicable. • All calculational methods used for dose rate analysis should be qualified and validated for the specific conditions of the *package design* they are applied to. Dose rate calculations should take account of the current ICRP recommendations. • The expected areas for peak dose rates to be checked before *shipment* should be specified. • Proof that the sources are maintained secure in their storage positions in the irradiators (under drop test sequence conditions) should be provided, if applicable. • Local fusion of the materials providing radiation protection under fire conditions should be considered, if applicable, taking into account the effects of the bar or demonstration that this fusion is limited to a volume which is compatible with the regulatory dose rate criteria in accident conditions of transport. • Justification of the consolidation height of lead (lead slump) after the 9 m drop test taking into account the temperature of the lead due to the normal conditions of transport should be provided, if applicable. • Evaluation of the risks associated with the segregation phenomena (for example precipitation of salts in solution...). • Justification of the absence of loss of protection which would result in an increase of more than 20 % of the maximum dose rate in normal conditions of

Annexe 4

Type B(U), Type B(M) and Type C packages

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR.
In addition further guidance is also available from TS-G-1.1
For *packages* containing *fissile* (not excepted) *material* see in addition Annexe 5.
For *packages* containing more than 0.1 kg uranium hexafluoride see in addition Annexe 6.

	transport.
2.2.5	If applicable, see also Annexe 5

Annexe 5

Additional requirements for *packages* containing *fissile material*

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR. They apply in addition to those items belonging to the *package* type defined by the radioactive properties of the contents, see Annexes 2 to 4 and 6. Further guidance is also available from TS-G-1.1.

Part 1	
1.2	To be complied with. 1.2(e) – If transported by air, then the air transport testing requirements of TS-R-1 para. 680(a) and (b) for a single *package* should be accounted for.
1.3	1.3(c) and (i) – Criticality safety can be very sensitive to the presence and geometrical arrangement of *fissile material* (e.g. possibility and size of lattice arrangements), moderators (water, graphite, beryllium, and other light elements) and reflectors. This should be taken into account in the description of the contents (permitted and not permitted). 1.3(g) -to be complied with. Also describe quantities of nuclides able to sustain chain reaction whereas not defined as fissile: if certain actinides could be present in sufficient quantity or concentration to increase the neutron multiplication factor, their concentrations and/or quantities should be defined. All variants of contents should be defined.
1.4	1.4(g) to be complied with
1.5	To be complied with All assumptions about the state of the *package* used in the criticality safety assessment for normal and accident conditions of transport should be listed and well justified. The condition of the parts of the *confinement system* under normal and accident conditions should be derived from the *design* and the behaviour of the *package* under these test conditions, otherwise conservative assumptions should be taken and their conservatism should be shown. Often test conditions leading to the maximum damage in terms of activity release or dose rate increase do not result in the maximum neutron multiplication. Therefore,

Annexe 5

Additional requirements for *packages* containing *fissile material*

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR. They apply in addition to those items belonging to the *package* type defined by the radioactive properties of the contents, see Annexes 2 to 4 and 6. Further guidance is also available from TS-G-1.1.

	for the criticality safety assessment additional tests may have to be considered. For any parameter not justified the value leading to maximum neutron multiplication should be identified and used in the criticality safety assessment. For cases where complete or partial water filling of cavities is important for criticality safety the filling states considered and those excluded from the assessment should be described and well justified.
1.6	To be complied with The appropriate paragraphs as indicated in Table 1 for packages containing fissile material should be addressed.
1.7	To be complied with, especially (b). Check the presence of absorber rods or selection of inner equipment with the correct neutron absorber content, if applicable.
Part 2	
2.1	To be complied with. Helpful advice on criticality safety assessments is given in Appendix VI to IAEA TS-G-1.1 (Rev. 1). Information on the use of burn up credit in criticality safety assessments of spent nuclear fuel can be found in publications from the NEA WPNCS Expert group on burn up credit criticality safety (see http://www.nea.fr/html/science/wpncs/buc/index.html) and from IAEA meetings on this topic.
2.2.1	2.2.1. 2.2.1(c) and 2.2.1(d) to be complied with. This includes the mechanical stability of the fissile material and any structure that is used to maintain its geometry, if necessary for the criticality safety assessment. Other important criticality safety relevant items to be considered are e.g. water leaking into or out of the *package* (totally, partially), the rearrangement of the *fissile*

Annexe 5

Additional requirements for *packages* containing *fissile material*

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR. They apply in addition to those items belonging to the *package* type defined by the radioactive properties of the contents, see Annexes 2 to 4 and 6. Further guidance is also available from TS-G-1.1.

	material and the degradation of neutron traps. If transported by air, then the air transport requirements of TS-R-1 para. 680(a) and (b) for a single *package* should be accounted for, whereas for arrays of *packages* under accident conditions of transport the testing requirements of para. 682(b) apply. Requirements according to para. 634 should be met. See also the remarks to 1.5.
2.2.2	2.2.2(c) and 2.2.2(d) to be complied with. See also the remarks to 2.2.1.
2.2.5	To be complied with. See also the remarks to 1.3, 1.5, 2.1 and 2.2.1. The following typical items, if applicable, should be taken into account in criticality analysis (however, this list is not exhaustive): A) Contents i) Justifications should account for all possible configurations with any possible geometrical and physical characteristics (dimensional tolerances, positions of the components, density of powders in normal or accident conditions). ii) If materials whose hydrogen concentration is higher than that of water can be present in the *package*, the demonstration of criticality safety should take account of these materials. iii) If *natural or depleted uranium* could be present in the *package* it should be taken into account in the criticality safety justification with appropriate assumptions relative to quantities and localisation. B) Configurations to be analysed

Annexe 5

Additional requirements for *packages* containing *fissile material*

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR. They apply in addition to those items belonging to the *package* type defined by the radioactive properties of the contents, see Annexes 2 to 4 and 6. Further guidance is also available from TS-G-1.1.

	i) Consider proof of the sub-criticality for isolated *packages* under routine, normal and accident conditions of transport and arrays of *packages* in normal conditions of transport and accident conditions of transport. ii) For *packages* where special features preventing water inleakage are considered for the criticality safety analysis for an individual *package* in isolation (TS-R-1 para. 677): • The criterion for watertightness to be defined by the *package* designer and accepted by the *competent authority* should be given and justified in the PDSR. This criterion should be set in a way excluding ingress of such an amount of water which could influence the criticality safety assessment. The testing conditions defined in TS-R-1 para. 677 should be taken into account as well as a single error. • The applicant should also guarantee the criticality safety of the undamaged isolated *package* with water penetration to cover occurrences liable during *package* preparation including in case of human error. iii) Relating to air transport, the damaged isolated *package* should be assessed for damages resulting from *Type C* tests reflected by 20 cm of water, with no water penetration. In case of absence of any demonstration of the content and *packaging* mechanical behaviour, typical envelope configurations should be considered such as: • *fissile material* (without consideration of water ingress from outside the *package*) in spherical shape reflected by 20 cm of water, • the spherical *fissile material* (without consideration of water from outside the *package*) surrounded by the package reflecting materials

Annexe 5

Additional requirements for *packages* containing *fissile material*

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR. They apply in addition to those items belonging to the *package* type defined by the radioactive properties of the contents, see Annexes 2 to 4 and 6. Further guidance is also available from TS-G-1.1.

	(steel, lead…) and reflected by 20 cm of water, • the *fissile material* mixed with the *package* moderator materials, reflected by 20 cm of water. iv) In modelling, all the elements of structures out of steel or other materials (aluminium, titanium...) that could increase the neutron multiplication should be taken into account. v) The applicant should check the qualification of criticality calculation tools and should specify the critical experiments representative of the planned transport configuration. Special attention should be paid to environments (low-moderation environments, fuel assemblies…) for which the qualification base is not really extended and for which it is desirable to use calculation models which are conservative enough (calculation assumptions) and provide margins in order to compensate for the lack of qualification, when applicable. vi) When appropriate, the justifications should take into account all the possible ranges of the masses and moderations. Credible conditions of transport that might lead to preferential (heterogeneous) flooding of *packages* increasing the neutron multiplication should be considered. vii) It is advisable to study, for certain configurations for which the interactions can be dominating, impact of the variations of density of the fissile medium. viii) Consider the heterogeneous shapes of the *fissile materials* as transported. ix) For spent fuel initially containing plutonium, consider a conservative irradiation level that takes into account the possible evolution of reactivity during irradiation. C) Damages to consider i) Absence or extent of damages to *fissile material* in normal and accident

Annexe 5

Additional requirements for *packages* containing *fissile material*

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR. They apply in addition to those items belonging to the *package* type defined by the radioactive properties of the contents, see Annexes 2 to 4 and 6. Further guidance is also available from TS-G-1.1.

	conditions of transport should be derived from structural and thermal analysis as appropriate (see 2.2.1 and 2.2.2) ii) Absence or extent of damages to *package* inner structures in normal and accident conditions of transport should be derived from structural and thermal analysis as appropriate (see 2.2.1 and 2.2.2) iii) Any damage to moderating materials in accident conditions should be taken into account.

Annexe 6

Additional requirements for *packages* containing more than 0.1 kg uranium hexafluoride

Specific additional guidance to provide the information as requested in Part 1 and 2 of the PDSR. They apply in addition to those items belonging to the package type defined by the radioactive and fissile properties of the contents, see Annexes 2 to 5. Further guidance is also available from TS-G-1.1.

Part 1	
1.1	See annexe of relevant *package design*
1.2	See annexe of relevant *package design*
1.3	To be fully complied with - except (f). To reflect the limits derived from all analyses in Part 2, some of these parameters may be conflicting for example temperatures and permitted *radioactive contents* and decay chains.
1.4	See annexe of relevant *package design* - except (g)
1.5	See annexe of relevant *package design*
1.6	See annexe of relevant *package design*
1.7	compliance to para. 420
1.8	compliance to ISO 7195 Standard and to para. 629
1.9	See annexe of relevant *package design*
1.10	To be complied with
Part 2	
2.1	See annexe of relevant *package design*
2.2.1	compliance to para. 630 a) and b)
2.2.2	compliance to para. 630 c)
2.2.3	See annexe of relevant *package design*
2.2.4	See annexe of relevant *package design*
2.2.5	See annexe of relevant *package design*

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