FORMAT AND CONTENT OF THE PACKAGE DESIGN SAFETY REPORT (PDSR) FOR THE TRANSPORT OF RADIOACTIVE MATERIAL

SPECIFIC SAFETY GUIDE

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 20xx
Table of Contents

SECTION I .......................................................................................................................... 5
INTRODUCTION ................................................................................................................. 5
  BACKGROUND .................................................................................................................. 5
  OBJECTIVE ..................................................................................................................... 6
  SCOPE 6
  STRUCTURE .................................................................................................................... 6

SECTION II .......................................................................................................................... 9
DEFINITIONS AND ABBREVIATIONS ............................................................................... 9
DEFINITIONS ..................................................................................................................... 9
  Package designer ........................................................................................................... 9
  Controlled document .................................................................................................... 9
  Design drawing ............................................................................................................. 9
ABBREVIATIONS .............................................................................................................. 9

APPENDIX I PART 1: INFORMATION IN THE PACKAGE DESIGN SAFETY REPORT .............. 10
  CONTENTS LIST OF THE PDSR .................................................................................. 10
  ADMINISTRATIVE INFORMATION .............................................................................. 10
  SPECIFICATION OF CONTENTS .................................................................................. 10
  SPECIFICATION OF PACKAGING .............................................................................. 11
  AGEING CONSIDERATION ............................................................................................ 12
  PACKAGE PERFORMANCE CHARACTERISTICS ...................................................... 12
  COMPLIANCE WITH REGULATORY REQUIREMENTS .............................................. 12
  OPERATION .................................................................................................................. 12
  MAINTENANCE ............................................................................................................. 13
  GAP ANALYSIS PROGRAMME .................................................................................... 13
  MANAGEMENT SYSTEM .............................................................................................. 13
  PACKAGE ILLUSTRATION ......................................................................................... 14

APPENDIX II PART 2: GUIDANCE ON THE DETAILED TECHNICAL ANALYSES ................ 15
SECTION I
INTRODUCTION

BACKGROUND

1.1. Each design of packages for transport of radioactive material is required to demonstrate compliance with national and international regulations as applicable. The documentary evidence of compliance with the regulations, for package designs that require approval by a competent authority, is the basis for the application for such package design approval, and it is commonly known as the Package Design Safety Report (PDSR). For packages not requiring competent authority approval, the documentary evidence of compliance of the package design with all applicable requirements is also necessary, in accordance with paragraph 801 of IAEA Safety Standards Series No. SSR-6 (Rev. 1), Regulations for the Safe Transport of Radioactive Material (2018 Edition) [1], hereinafter referred to as Transport Regulations¹. The scope and technical content of the PDSR should be set at the appropriate level, in accordance with the graded approach applied in the IAEA Safety Standards, to demonstrate compliance with the regulatory requirements. Hereafter, every such documentary evidence of compliance of a package design with all applicable requirements will be called PDSR, independently of the type of the package.

1.2. In addition, for packages that do not require competent authority approval, some form of ‘certificate of compliance’ could apply and the PDSR would be the documentary evidence of compliance with the regulations (see para. 801.3 in IAEA Safety Standards Series No. SSG-26 (Rev. 1), Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material (2018 Edition) [2]).

1.3. This safety guide is prepared on the basis of the Transport Regulations [1] upon which the United Nations Recommendations on the Transport of Dangerous Goods – Model Regulations [3] and – after transposal – international, regional and national regulations are based, for all modes of transport.

1.4. A generic structure and contents of a PDSR, namely Part 1 and Part 2, which apply to all package types, are presented in Figure 1. The contents of the PDSR are described in Appendices I and II in a comprehensive way to cover all important aspects. Some of these aspects may not be applicable to a specific package type; details can be found in the specific Appendices III to VIII.

1.5. The S.I. unit system should be used throughout the PDSR.

1.6. The PDSR should be a controlled document approved for issue in accordance with the package designer’s management system. It includes a record of its production, review and approval by the package designer. Each individual document in Part 1 and in Part 2 of the PDSR should be a controlled document. Each individual document in Part 2 of the PDSR should be produced and verified by technical specialists in the discipline being assessed.

¹ Throughout this publication, reference to ‘Transport Regulations’ always refers to the latest edition unless otherwise stated.
OBJECTIVE

1.7. This safety guide 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.

1.8. This safety guide does not replace the regulations or limit their application. Rather it proposes for each type of package a structure and a typical 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, to demonstrate compliance with the requirements of the Transport Regulations applicable to the respective package type.

1.9. This safety guide does not relieve the package designer from any additional analysis need associated with the concerned specific package design. If there are any discrepancies between this document and the Transport Regulations, the requirements in the Transport Regulations apply.

SCOPE

1.10. This safety guide covers package designs requiring competent authority approval:
   - Type B(U);
   - Type B(M);
   - Type C;
   - Packages containing fissile material that is not excepted from the requirements of the Transport Regulations that apply to fissile material;
   - Packages designed to contain 0.1 kg or more of uranium hexafluoride.

1.11. This safety guide 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.

1.12. This safety guide covers only package designs. It does not cover designs of special form radioactive material, designs of low dispersible radioactive material, unpackaged low specific activity material (LSA-I material) and unpackaged surface contaminated objects (SCO-I and SCO-III).

STRUCTURE

1.13. This safety guide is structured so that Section II includes definitions and abbreviations. Appendix I describes the information that needs to be provided in the PDSR; Appendix II provides guidance on the detailed technical analyses; Appendices III to VI describe the
information that needs to be provided in the PDSR for Excepted Packages, Industrial Packages, Type A Packages, and Type B(U), Type B(M) and Type C Packages; Appendix VII describes the additional information to be provided in the PDSR for packages containing fissile material; and Appendix VIII describes the additional information to be provided for packages containing 0.1 kg or more of uranium hexafluoride, respectively. Annex I provides a matrix of applicable paragraphs of the Transport Regulations to be included in the compliance demonstration for each package type and additional provisions for packages containing fissile nuclides and packages containing 0.1 kg or more of uranium hexafluoride; and Annex II provides a list of reference publications used by competent authorities for technical assessment.
FIG. 1: Structure and contents of a Package Design Safety Report
SECTION II
DEFINITIONS AND ABBREVIATIONS

DEFINITIONS

2.1 The definitions stated in the Transport Regulations apply throughout this safety guide. In addition, the following definitions are specific to this publication and are not provided in the Transport Regulations.

Package designer

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

Controlled document

2.3 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

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

ABBREVIATIONS

2.5 All abbreviations and acronyms used in this safety guide, while not specified in this section, come from the Transport Regulations.
APPENDIX I
PART 1: INFORMATION IN THE PACKAGE DESIGN SAFETY REPORT

CONTENTS LIST OF THE PDSR

I.1. 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.

ADMINISTRATIVE INFORMATION

I.2. The following administrative information should be included:
(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. Restrictions in packaging serial number(s), if applicable;
(e) Modes of transport for which the package is designed, including any operational restriction that can apply;
(f) Reference to applicable regulations, including the edition of the IAEA Transport Regulations to which the package design is referring.

SPECIFICATION OF CONTENTS

I.3. Detailed descriptions of the permitted contents of the package design should be defined by stating, but not limited to, the following information, as applicable:
(a) General nature of contents (e.g., articles, instruments, metallurgical specimens, internal contamination of the package);
(b) Nuclides / nuclide composition; daughter radionuclides;
(c) Limitations in activity, mass and concentrations, heterogeneities. Compliance with the activity limits for excepted packages in accordance with Table 4 of the Transport Regulations, and paras 423 and 424 (for transport by post) and para. 427 (for empty packagings), if applicable, should be considered;
(d) Physical and chemical state;
(e) Special form radioactive material or low dispersible radioactive material. A valid certificate should be available if any of these materials are used;
(f) Nature and characteristics of the radiation emitted;
(g) Heat generation of the contents;
(h) Mass of fissile material and nuclides, enrichment;
(i) Other dangerous properties. Subsidiary hazard of the contents should be taken into account which may result in classification and design requirements in accordance with the predominant subsidiary hazard (see [3], Chapter 3.3 SP 290);

(j) Other limitations to the contents.

I.4. Safety relevant limits for non-radioactive materials (e.g. materials subject to radiolysis) should be stated, for example by material composition, density, form, location within package, restrictions of relative quantities of materials.

I.5. The $A_1/A_2$ values of a radionuclide to be carried that is not listed in the Transport Regulations should be determined in accordance with paras 403 – 407 of [1] and included in the PDSR, and may be subject to multilateral approval in accordance with para. 403of [1].

SPECIFICATION OF PACKAGING

I.6. The packaging design should be defined including the following information, as applicable (see Appendices III to VIII for specific details):

   (a) Schematic drawings;
   
   (b) The overall dimensions and the maximum (fully loaded) mass and minimum (empty) mass;
   
   (c) A list of all packaging components important to safety and their design drawings;
   
   (d) For each component listed in (b) should be detailed:
       
       (i) Material specifications;
       
       (ii) Dimensions;
       
       (iii) Methods of their manufacture including requirements for material procurement, welding, other special processes, non-destructive evaluation and testing;
   
   (e) The maximum normal operating pressure (MNOP);

A description of:

(f) The packaging body, lid (closure mechanism and tamper-indicating features), inserts, and components for lifting and tie-down;

(g) The packaging components of the containment system (including the definition of the containment boundary);

(h) The packaging components required for shielding;

(i) The package components of the confinement system (such as neutron poisons, moderators, flux traps and spacer);

(j) The packaging components for thermal protection;

(k) The packaging components for heat dissipation;

(l) The protection against corrosion;

(m) The protection against contamination;
(n) The shock limiting components.

AGEING CONSIDERATION

I.7. This section of the PDSR should include:

(a) Those intended conditions of use of the package which may influence ageing;

(b) A list of potential ageing mechanisms which are relevant for the package design, taking into account its intended conditions of use;

(c) Operational measures (including maintenance and inspection before shipment) to monitor and limit the ageing effects;

(d) Analysis on the influence of the ageing of packaging and contents on the design assumptions for demonstration of compliance with the regulations including the technical analyses in Part 2 of the PDSR, considering the specified intended conditions of use, ageing mechanisms and operational measures. See paras 613A.1 to 613A.4 of SSG-26 (Rev. 1) [2].

PACKAGE PERFORMANCE CHARACTERISTICS

I.8. This section should describe the main design principles and performance characteristics of the package design to meet the requirements of the Transport Regulations (e.g. containment, dose rates, heat removal, and criticality safety).

I.9. Furthermore, this section should summarize the analyses performed in Part 2 and 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 the package. This should demonstrate that the design and the various parts of the safety demonstration are compatible with one another.

COMPLIANCE WITH REGULATORY REQUIREMENTS

I.10. The PDSR should include a complete list of all paragraphs of the regulations [1], [3] and other international or national regulations applicable to the package design. Reference to the paragraphs of the PDSR where compliance with the regulations is demonstrated could be included in this part. It could be done in a format of table or narrative justification. Annex I of this safety guide provides references to applicable paragraphs of the Transport Regulations for different package types.

OPERATION

I.11. The minimum requirements for the following activities should be fully defined for the packaging/package, as applicable (see appendices):

(a) Assembling of the packaging components;

(b) Loading and unloading of the package contents (including torque requirements for lids);

(c) Testing and controls before first use to transport radioactive material (acceptance tests to ensure compliance of the fabrication to the design);
(d) Testing and controls before each shipment (including contamination control as relevant);

(e) Handling and tie down specifications;

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

Description of the package operations may include more exhaustive written procedures than reference made in this part of the PDSR.

MAINTENANCE

I.12. The minimum requirements for the following activities should be fully defined for the packaging/package, as applicable (see appendices):

   (a) Maintenance and inspection before each shipment;

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

Description of the package maintenance may include more exhaustive written procedures than the reference made in this part of the PDSR.

GAP ANALYSIS PROGRAMME

I.13. For packages to be used for shipment after storage, the PDSR should consider the need for a gap analysis programme describing a systematic procedure for a periodic evaluation of changes of regulations and changes of the state of the package design during storage (see also SSG-26 (Rev. 1) [2]).

MANAGEMENT SYSTEM

I.14. This section should describe the specification of the management system, including the quality assurance programme as requested in SSR-6 [1] para. 306 of the Transport Regulations, to ensure compliance with the relevant requirements regarding (including change control):

   (a) Design, PDSR, documentation, records;

   (b) Manufacture and testing;

   (c) Operation (loading, transport, storage in transit, receipt, and unloading);

   (d) Maintenance, repair and inspection.

The actions to be performed to check the compliance of the operational documents with the PDSR and the management of deviations detected in the framework of any transport activity should be described.
PACKAGE ILLUSTRATION

I.15. A reproducible illustration should be provided showing the make-up of the package, including shock limiters, devices for thermal protection and packaging inserts, if applicable. The illustration should indicate at least the overall outside dimensions and the gross masses for empty and loaded condition.
APPENDIX II
PART 2: GUIDANCE ON THE DETAILED TECHNICAL ANALYSES

II.1. 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 paragraph I.10. In respect of the graded approach applied in the Transport Regulations, each analysis should be set at the appropriate level considering the package type.

II.2. Paragraphs II.4 to II.13 of this safety guide provide the general considerations that should be applied to all technical analyses to be included into Part 2 of the PDSR.

II.3. Paragraphs II.14 to II.18 of this safety guide present a list of the technical analyses that may be necessary in the PDSR together with their main contents. Guidance on the content of the technical analyses required for each package type is provided in the appendices.

GENERAL CONSIDERATIONS FOR ALL TECHNICAL ANALYSES

II.4. The information in paragraphs II.5 to II.13 should be included in each of the technical analyses in paragraphs II.14 to II.18.

Reference to package design

II.5. In each of the technical analyses of paragraphs II.14 to II.18, 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.

Acceptance criteria and design assumptions

II.6. The acceptance criteria for the technical analyses and the package design assumptions in terms of geometry or performance characteristics should be defined and justified. The acceptance criteria are the quantitative limits specified by the designer, derived from the regulatory criteria and other applicable standards to meet the regulatory requirements. The design assumptions include the design specification provided in paras I.3 to I.6 and other assumptions derived from the design specification and used in the technical analyses. Examples:

- For dose rate analysis, one acceptance criteria could be the regulatory dose rate limits around the package;
- For thermal analysis, one acceptance criteria could be the melting temperature of lead, as the presence of lead could be a design assumption for the dose rate analysis.

Description and justification of analysis methods

II.7. The safety demonstration of a package design is required to be accomplished by any of the following methods listed below or by a combination thereof as established in paragraph 701 of (see appendices for specific guidance):

(a) Performance of tests with specimens representing special form radioactive material, or low dispersible radioactive material, or with prototypes or samples of the packaging, where the contents of the specimen or the packaging for the tests shall simulate as closely as practicable the expected range of radioactive contents and the specimen or packaging to be tested shall be prepared as presented for transport;
(b) Reference to previous satisfactory demonstrations of a sufficiently similar nature;

(c) Performance of tests with models of appropriate scale, incorporating those features that are significant with respect to the item under investigation when engineering experience has shown the results of such tests to be suitable for design purposes. When a scale model is used, the need for adjusting certain test parameters, such as penetrator diameter or compressive load, shall be taken into account;

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

The actual method or combination used should be indicated in this point of the PDSR.

II.8. The methods/standards used in each analysis listed in paragraphs II.14 to II.18 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.

II.9. If computer codes are used to perform the safety analysis, 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.

**Analysis of package design**

II.10. The performance characteristics of the package design should be assessed, as appropriate (see Appendices III to VIII for specific cases). When necessary, the results of sensitivity analyses and levels of accuracy should be stated.

II.11. More than one sequence of tests might need to be considered to ensure that the safety functions, to be fulfilled by different components of the package design, comply with the regulatory requirements.

II.12. Other hazards 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.

**Comparison between acceptance criteria and results of analyses**

II.13. The results of the analyses detailed in paragraphs II.14 to II.19 should be compared with the acceptance criteria and package design assumptions (paragraph II.6) and regulatory compliance should be justified accordingly.

**TECHNICAL ANALYSES**

**Structural analysis**

II.14. Assessment of the mechanical behaviour (e.g., 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 whose performance will have a consequential effect upon (a),
    (b) and (c);
(e) The packaging attachments used for lifting the package (routine conditions only);
(f) The packaging attachments used for restraining the package to its conveyance during
    transport (routine conditions only).

**Thermal analysis**

II.15. 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 whose performance could have a consequential effect upon
    (a), (b) and (c).

**Containment design analysis**

II.16. 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.

**Dose rate analysis**

II.17. 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 Transport Regulations. The assessment should consider the appropriate
recommendations of the International Commission on Radiation Protection (ICRP).

**Criticality safety analysis**

II.18. For packages designed to transport fissile material, assessment of criticality safety for
routine, normal and accident conditions of transport, for the isolated package and for arrays of
packages, is required to be performed.

**Other analyses**

II.19. Applicable to Type B(U), Type B(M) and Type C packages.
APPENDIX III EXCEPTED PACKAGES

This appendix provides specific guidance about the information recommended in Part 1 and 2 of the PDSR for excepted packages.

In addition, further guidance is also available in SSG-26 (Rev. 1) [2].

Excepted packages require a PDSR. As per the graded approach and the lower risks presented by excepted packages, the PDSR may be less extensive than for other types of packages.

For packages containing fissile nuclides, one of the exceptions of paragraph 417 of the Transport Regulations is required to apply.

For packages containing less than 0.1 kg of uranium hexafluoride, see Chapter 3.3, SP 290, in Ref. [3].

The numbers in the first column of the table below refer to paragraph numbers in Appendices I and II of this safety guide.

<p>| Part 1 |</p>
<table>
<thead>
<tr>
<th>CONTENTS OF THE PDSR</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ADMINISTRATIVE INFORMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.2</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SPECIFICATION OF CONTENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.3</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
### APPENDIX III - EXCEPTED PACKAGES

The Transport Regulations, and paras 423 and 424 (for transport by post) and para. 427 (for empty packagings), if applicable, should be considered:

- **d)** Physical and chemical state;

- **e)** Special form radioactive material or low dispersible radioactive material. A valid certificate should be available if any of these materials are used;

- **f)** Nature and characteristics of the radiation emitted;

- **g)** In case when fissile nuclides excepted under para. 417 of the Transport Regulations are contained, mass of fissile material and nuclides, enrichment;

- **h)** Other dangerous properties. Subsidiary hazard of the contents should be taken into account which may result in classification and design requirements in accordance with the predominant subsidiary hazard (see [3], Chapter 3.3 SP 290);

- **i)** Other limitations to the contents.

| I.4 | Safety relevant limits for non-radioactive materials (e.g. materials subject to radiolysis) should be stated, for example by material composition, density, form, location within package, restrictions of relative quantities of materials. |
| I.5 | The $A_1/A_2$ values of a radionuclide to be carried that is not listed in the Transport Regulations should be determined in accordance with paras 403 – 407 of [1] and included in the PDSR, and may be subject to multilateral approval in accordance with para. 403. |

### SPECIFICATION OF PACKAGING

The packaging design should be defined to the extent necessary to demonstrate compliance with the Transport Regulations, including the following information, as applicable:

- **a)** Schematic drawings;

- **b)** The overall dimensions and the maximum (fully loaded) mass and minimum (empty) mass;

- **c)** A list of all packaging components important to safety;

- **d)** For each component listed in (b) should be detailed:

  - (i) Material specifications;
  
  - (ii) Dimensions;
  
  - (iii) Methods of their manufacture including requirements for material procurement, welding, other special processes, non-destructive evaluation and testing;

- **e)** The maximum normal operating pressure (MNOP).
### AGEING CONSIDERATION

| I.7 | Not needed for excepted packages. |

### PACKAGE PERFORMANCE CHARACTERISTICS

| I.8 | Not needed for excepted packages. |
| I.9 | Not needed for excepted packages. |

### COMPLIANCE WITH REGULATORY REQUIREMENTS

| I.10 | The PDSR should include a complete list of all paragraphs of the international regulations [1], [3] and other international or 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. Annex I provides references to applicable paragraphs of the Transport Regulations for excepted packages. |

### OPERATION

| I.11 | The minimum requirements for the following activities should be fully defined for the packaging/package, as applicable:  
(a) Assembling of the packaging components (including compliance with para. 637 in [1] for Type IP-3);  
(b) Loading and unloading of the package contents (including torque requirements for lids);  
(c) Requirements and controls before first use to transport radioactive material (acceptance tests to ensure compliance of the fabrication to the design);  
(d) Requirements and controls before each shipment. The methods used for operational controls and tests, in particular those required in paras 502, 503 (a), 508, 523, 526, 527 and 528 in [1], should be detailed;  
(e) Handling and tie down specifications. 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;  
(f) Any proposed supplementary equipment and operational controls to be applied during transport, which are necessary to ensure that the design meets the regulatory requirements for transport, e.g. for heat dissipation: thermal barriers, duration limits, temperature limits (including exclusive use and special stowage conditions); |

In addition to the radioactive properties, any other dangerous properties of the contents of the package should be taken into account (see para. 507 in [1]).
Description of the package operations may include more exhaustive written descriptions than references made in this part of the PDSR.

### MAINTENANCE

The minimum requirements for the following activities should be fully defined for the packaging/package, as applicable:

- (a) Maintenance and inspection requirements before each shipment;
- (b) Maintenance and inspection requirements at periodic intervals throughout the lifetime use of the packaging/package.

Inspection of the package prior to shipment may be enough for excepted packages. For single use packages, periodic maintenance does not need to be considered. Details of the package maintenance may be included in more exhaustive written procedures to which reference may be made in this part of the PDSR.

### GAP ANALYSIS PROGRAMME

Not needed for excepted packages.

### MANAGEMENT SYSTEM

The PDSR should include the specification of the management system as requested in para. 306 in [1] to ensure compliance with the relevant provisions.

The management system should be appropriate to the complexity of the design of the package to ensure that the package is designed to demonstrate it meets the regulatory requirements. This should include a reliable document control system. More detailed guidance is available in TS-G-1.4 [4].

### PACKAGE ILLUSTRATION

A reproducible illustration should be provided showing the make-up of the package. The illustration should indicate at least the overall outside dimensions and the mass for loaded condition. This is not needed for excepted packages, provided that the relevant information is specified in paras I.6 (a) and I.6 (b).

### Part 2

### GENERAL INFORMATION
| II.1 II.2 II.3 | Demonstration of compliance can be provided by the designer either directly in the table recommended in para. I.10 for all or parts of the applicable paragraphs or, if necessary, in Part 2 of the PDSR. |

**GENERAL CONSIDERATIONS**

| II.4 | For each of the technical analyses in paras II.14, II.16 and II.17 of this table, the following considerations apply. |

**REFERENCE TO PACKAGE DESIGN**

| II.5 | The package design which is evaluated should be precisely referenced by mentioning the drawing (see para. I.6), including revision state, and the specification of contents (see paras I.3 to I.5), including revision state. |

**ACCEPTANCE CRITERIA AND DESIGN ASSUMPTIONS**

| II.6 | The acceptance criteria for the technical analyses and the package design assumptions in terms of geometry or performance characteristics should be defined and justified when necessary.  
The acceptance criteria are the quantitative limits specified by the designer derived from the regulatory criteria and other applicable standards to meet the regulatory requirements.  
The design assumptions include the design specification provided in paras I.3 to I.6 and other assumptions derived from the design specification and used in the technical analyses.  
*Example:*  
- *For dose rate analysis, one acceptance criterion could be the regulatory dose rate limits around the package;* |

**DESCRIPTION AND JUSTIFICATION OF ANALYSIS METHODS**

| II.7 II.8 II.9 | Not needed for excepted packages. |

**ANALYSIS OF PACKAGE DESIGN**

| II.10 II.11 II.12 | Not needed for excepted packages. |

**COMPARISON BETWEEN ACCEPTANCE CRITERIA AND RESULTS OF ANALYSES**
<table>
<thead>
<tr>
<th>II.13</th>
<th>The results of the technical analyses should be compared with the acceptance criteria and package design assumptions and regulatory compliance should be justified accordingly.</th>
</tr>
</thead>
</table>

**TECHNICAL ANALYSES**

**STRUCTURAL ANALYSIS**

| II.14 | The general considerations in paras II.1 to II.13 have to be taken into account when performing the structural analysis.  
The mechanical behaviour (including fatigue analysis, brittle fracture, creep, if applicable) under routine conditions of transport should be assessed, for:  
(a) The package components of the containment system (if transported by air) (paras 619 to 621 in [1]);  
Additionally, the mechanical resistance (including fatigue, brittle fracture, creep, if applicable) should be assessed, for:  
(b) The packaging attachments used for lifting the package (routine conditions only) (paras 608 and 609 in [1]);  
(c) The packaging attachments used for restraining the package to its conveyance during transport (routine conditions only).  
If the package is to be transported by air, structural analysis of the containment system 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 paras 607.1 - 621.3 in [2]. |
| --- | --- |

**THERMAL ANALYSIS**

<table>
<thead>
<tr>
<th>II.15</th>
<th>Not needed for excepted packages.</th>
</tr>
</thead>
</table>

**CONTAINMENT DESIGN ANALYSIS**

<table>
<thead>
<tr>
<th>II.16</th>
<th>The requirements for preventing the loss or dispersal of radioactive material, if transported by air (para. 621 of the Transport Regulations), should be assessed. Containment analysis is not needed provided that the structural analysis has shown the integrity of the containment boundary in these conditions (see para. II.14 in this table).</th>
</tr>
</thead>
</table>

**DOSE RATE ANALYSIS**

<table>
<thead>
<tr>
<th>II.17</th>
<th>The general considerations in paras. II.1 to II.13 have to be taken into account when performing the dose rate analysis.</th>
</tr>
</thead>
</table>
The dose rates for routine conditions of transport (see paras 516 and 423 (a) of the Transport Regulations, if applicable) should be assessed, to such an extent that it provides evidence that requirements are met.

The analysis should assume a maximum radioactive content or a content that would create the maximum dose rates at the surface of the package.

The assessment should take into account the appropriate ICRP recommendations.

The maximum dose rate should be determined, taking into account potential significant amplifying phenomena such as movement of the radioactive contents, or, in the case of packages containing liquids, change in the state of the contents, including segregation and/or precipitation of the radionuclides.

See paras 516.5 and 523.7 in [2].

If measurements are used, the source used for the measurements should be representative for the radioactive contents of the package design.

<table>
<thead>
<tr>
<th>CRITICALITY SAFETY ANALYSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>II.18</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OTHER ANALYSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>II.19</td>
</tr>
</tbody>
</table>
APPENDIX IV
INDUSTRIAL PACKAGES

This appendix provides specific guidance about the information recommended in Part 1 and 2 of the PDSR for industrial packages.

In addition, further guidance is also available in SSG-26 (Rev. 1) [2].

Type IP-1, type IP-2 and type IP-3 packages require a PDSR. As per the graded approach and the lower risks presented by Type IP-1 packages, the PDSR may be less developed than for other types of packages.

For packages containing fissile nuclides, see in addition APPENDIX VII.

For packages containing 0.1 kg or more of uranium hexafluoride, see in addition APPENDIX VIII.

The numbers in the first column of the table below refer to paragraph numbers in Appendices I and II of this safety guide.

<table>
<thead>
<tr>
<th>Part 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTENTS OF THE PDSR</td>
</tr>
<tr>
<td>I.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ADMINISTRATIVE INFORMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.2</td>
</tr>
<tr>
<td>(a)</td>
</tr>
<tr>
<td>(b)</td>
</tr>
<tr>
<td>(c)</td>
</tr>
<tr>
<td>(d)</td>
</tr>
<tr>
<td>(e)</td>
</tr>
<tr>
<td>(f)</td>
</tr>
</tbody>
</table>

| SPECIFICATION OF CONTENTS |
I.3 Detailed descriptions of the permitted contents of the package design should be defined by stating, but not limited to, the following information, as applicable:

(a) General nature of contents (e.g., fresh fuel, contaminated tools, waste);

(b) Nuclides / nuclide composition; daughter radionuclides;

(c) Limitations in activity, mass and concentrations, heterogeneities. The contents should be classified appropriately in one of the categories of LSA (para. 409) or SCO (para. 413). Limitations in specific activity (Bq/g) and surface contamination (Bq/cm²) may be required. Conveyance activity limits in accordance with Table 6 of the Transport Regulations should also be taken into account to limit the activity of a single package, if applicable;

(d) Physical and chemical state, geometric shape, arrangement, material specifications. Limits of contents in industrial packages depend on the physical state;

(e) Special form radioactive material or low dispersible radioactive material. A valid certificate should be available if any of these materials are used;

(f) Nature and characteristics of the radiation emitted;

(g) Not required for Industrial Packages;

(h) Mass of fissile material and nuclides, enrichment (see also APPENDIX VII, if necessary);

(i) Other dangerous properties. Subsidiary hazard of the contents should be taken into account which may result in additional design requirements in accordance with the subsidiary hazard (see [3], Chapter 3.3 SP 172);

(j) Other limitations to the contents (moisture contents, presence of acid, etc.).

I.4 Safety relevant limits for non-radioactive materials (e.g. materials subject to radiolysis) should be stated, for example by material composition, density, form, location within package, restrictions of relative quantities of materials.

I.5 The A₁/A₂ values of a radionuclide to be carried that is not listed in the Transport Regulations should be determined in accordance with paras 403 – 407 of [1] and included in the PDSR, and may be subject to multilateral approval in accordance with para. 403.

SPECIFICATION OF PACKAGING
The packaging design should be defined to the extent necessary to demonstrate compliance with the Transport Regulations, including the following information, as applicable:

(a) Schematic drawings;
(b) The overall dimensions and the maximum (fully loaded) mass and minimum (empty) mass;
(c) A list of all packaging components important to safety and their design drawings;
(d) For each component listed in (b) should be detailed:
   (i) Material specifications;
   (ii) Dimensions;
   (iii) Methods of their manufacture including requirements for material procurement, welding, other special processes, non-destructive evaluation and testing.
(e) The maximum normal operating pressure (MNOP) (particularly, in case of air transport).

For Type IP-3, a description of:

(f) The packaging body, lid (closure mechanism and tamper-indicating features) and inserts, and components for lifting and tie-down;
(g) The packaging components required for shielding;
(h) The protection against corrosion;
(i) The protection against contamination;
(j) The shock limiting components;
(k) Testing requirements and controls before first use to transport radioactive material (acceptance tests to ensure compliance of the fabrication to the design).

**AGEING CONSIDERATION**

Depending on the package design, the information expected in this section can be provided by the designer directly in the table recommended in para. I.10 of this table. In this case, this section should be left blank.

This section of the PDSR should include:

(a) Those intended conditions of use of the package which may influence ageing;
(b) A list of potential ageing mechanisms which are relevant for the package design, taking into account its intended conditions of use;
(c) Operational measures (including maintenance and inspection before shipment) to monitor and limit the ageing effects;
(d) Analysis on the influence of the ageing of packaging and contents on the design assumptions for demonstration of compliance with the regulations including the technical analyses in Part 2 of the PDSR, considering the specified intended use conditions, ageing mechanisms and operational measures.

See paras 613A.1 to 613A.4 in [2].

<table>
<thead>
<tr>
<th>PACKAGE PERFORMANCE CHARACTERISTICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.8 I.9 Not needed for Type IP-1, Type IP-2 and Type IP-3 packages.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COMPLIANCE WITH REGULATORY REQUIREMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.10 The PDSR should include a complete list of all paragraphs of the international regulations [1], [2] and other international or 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. Annex I provides references to applicable paragraphs of the Transport Regulations for industrial packages.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OPERATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.11 The minimum requirements for the following activities should be fully defined for the packaging/package, as applicable:</td>
</tr>
<tr>
<td>(a) Requirements for assembling of the packaging components (except for Type IP-1 and including compliance with para. 637 in [1] for Type IP-3);</td>
</tr>
<tr>
<td>(b) Loading and unloading of the package contents;</td>
</tr>
<tr>
<td>(c) Requirements and controls before first use to transport radioactive material (acceptance tests to ensure compliance of the fabrication to the design);</td>
</tr>
<tr>
<td>(d) Requirements and controls before each shipment;</td>
</tr>
<tr>
<td>(e) Handling and tie down specifications. Specifications on bolt torqueing requirements, number of transport cycles (to be used in fatigue analysis) for each mode of transport should be included, if applicable;</td>
</tr>
<tr>
<td>(f) Any proposed supplementary equipment and operational controls to be applied during transport, which are necessary to ensure that the design meets the regulatory requirements for transport, e.g. for heat dissipation: thermal barriers, duration limits, temperature limits (including exclusive use and special stowage conditions).</td>
</tr>
</tbody>
</table>

In addition to the radioactive properties, any other dangerous properties of the contents of the package should be taken into account (see para. 507 in [1]).
Description of the package operations may include more exhaustive written descriptions than references made in this part of the PDSR.

**MAINTENANCE**

The minimum requirements for the following activities should be fully defined for the packaging/package, as applicable:

(a) Maintenance and inspection requirements before each shipment;
(b) Maintenance and inspection requirements at periodic intervals throughout the lifetime use of the packaging/package.

Ageing mechanisms during storage should be considered in the maintenance requirements, when applicable.

For single use packages, periodic maintenance does not need to be considered.

Details of the package maintenance may be included in more exhaustive written procedures to which reference may be made in this part of the PDSR.

**GAP ANALYSIS PROGRAMME**

For packages which are to be used for shipment after storage, the PDSR should consider the need for a gap analysis programme describing a systematic procedure for a periodic evaluation of changes of regulations and changes of the state of the package design during storage (see also paras 809.3 and 809.4 in [2]).

**MANAGEMENT SYSTEM**

The PDSR should include the specification of the management system as requested in para. 306 in [1] to ensure compliance with the relevant provisions.

The management system should be appropriate to the complexity of the design of the package to ensure that the package is designed to demonstrate it meets the regulatory requirements. This should include a reliable document control system.

More detailed guidance is available in TS-G-1.4 [4].

**PACKAGE ILLUSTRATION**

A reproducible illustration should be provided showing the make-up of the package.

The illustration should indicate at least the overall outside dimensions and the mass for loaded condition.

This is not needed for excepted packages, provided that the relevant information is specified in paras I.6 (a) and I.6 (b).

**Part 2**

**GENERAL INFORMATION**
II.1 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 para. I.7 of this table. The level of detail of the analysis should consider the complexity of the package design and the existing safety margins.

Depending on the way of demonstration, for some of the technical analyses of Part 2, demonstration of compliance can be provided by the designer directly in the table recommended in para. I.7 of this table. Conversely, the complexity of some analyses may require that the relevant section of the PDSR be divided in several documents or includes appendices.

For Type IP-1, usually the demonstration of compliance is provided by the designer directly in the table recommended in para. I.7 of this table.

**GENERAL CONSIDERATIONS**

II.4 For each of the technical analyses in paras II.14 to II.17 of this table, the following considerations apply.

**REFERENCE TO PACKAGE DESIGN**

II.5 The package design which is evaluated should be precisely referenced by mentioning the drawing (see para. I.6), including revision state, and the specification of contents (see paras I.3 to I.5), including revision state.

**ACCEPTANCE CRITERIA AND DESIGN ASSUMPTIONS**

II.6 The acceptance criteria for the technical analyses and the package design assumptions in terms of geometry or performance characteristics should be defined and justified when necessary.

The acceptance criteria are the quantitative limits specified by the designer derived from the regulatory criteria and other applicable standards to meet the regulatory requirements.

The design assumptions include the design specification provided in paras I.3 to I.6 of this table and other assumptions derived from the design specification and used in the technical analyses.

All mechanical, thermal and shielding characteristics of each component of the package and acceptance criteria used in technical analyses should be defined.

*Example: demonstration of compliance with para. 616 for Type IP-1 and Type IP-2 and para. 639 for Type IP-3 in [1] should include analysis of phenomena such as:*

  - *Expansion/contraction of components relative to the structural or sealing functions;*
  - *Decomposition or changes of state of component materials at extreme conditions.*
The design assumptions should take into account ageing mechanisms, as necessary (see also paras 613A.1 to 613A.4 in [2]).

**Example:**
- For dose rate analysis, one acceptance criterion could be the regulatory dose rate limits around the package.

### DESCRIPTION AND JUSTIFICATION OF ANALYSIS METHODS

<table>
<thead>
<tr>
<th>II.7</th>
<th>II.8</th>
<th>II.9</th>
</tr>
</thead>
</table>
| The safety demonstration of a package design can be accomplished by a combination of the following as appropriate (see para. 701 in [1]) (this is not required for Type IP-1, as there is no regulatory testing for Type IP-1):
- (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 specified in paras II.14 to II.19 of this table should include a description of the analysis technique used, its limitations and accuracy, together with the demonstration of the correct application of the technique 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.

### ANALYSIS OF PACKAGE DESIGN

<table>
<thead>
<tr>
<th>II.10</th>
<th>II.11</th>
<th>II.12</th>
</tr>
</thead>
<tbody>
<tr>
<td>The performance characteristics of the package design should be assessed. More than one sequence of tests might 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.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### COMPARISON BETWEEN ACCEPTANCE CRITERIA AND RESULTS OF ANALYSES

<table>
<thead>
<tr>
<th>II.13</th>
</tr>
</thead>
<tbody>
<tr>
<td>The results of the technical analyses should be compared with the acceptance criteria. The package design assumptions for subsequent analyses should be justified and regulatory compliance should be demonstrated accordingly.</td>
</tr>
</tbody>
</table>
The general considerations for all technical analyses have to be taken into account when performing the structural analysis.

The mechanical behaviour (including fatigue, brittle fracture and creep, if applicable) under routine and normal conditions of transport (limited to routine conditions of transport for Type IP-1) should be assessed, for:

(a) The components of the containment system (this is not required for Type IP-1, except if transported by air (paras 619 to 621 in [1]));
(b) The package components that provide radiation shielding (this is not required for Type IP-1);
(c) Any other package components for which their performance may have a consequential effect upon (a) and (b) above (not applicable for Type IP-1).

Additionally, the mechanical resistance (including fatigue, brittle fracture and creep, if applicable) should be assessed, for:

(d) The packaging attachments used for lifting the package (paras 608 and 609 in [1]);
(e) The packaging attachments used for restraining the package to the conveyance (analysis for routine conditions of transport).

If the package is to be transported by air (paras 619 to 621 in [1]), structural analysis of the containment system 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 addition, 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 paras 621.2, 621.3 and 613.1 in [2].

The following remarks should be considered.

(i) General remarks
1) 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 the temperatures likely to be encountered during routine conditions of transport (see para. 616 in [1]);
2) The impacts on the package behaviour due to variations in the shock absorbing properties of the shock absorber material (e.g. wood, polymers, plaster, concrete) with temperatures likely to be encountered during routine conditions of transport should be analysed;
3) The safety against brittle fracture at temperatures likely to be encountered during routine conditions of transport of components of the containment system made of potentially brittle materials (e.g., ferritic steels, cast iron) should be analysed if necessary;
4) Strength of lid bolts should be justified for all drop orientations;
5) It should be verified that internal components (content, basket, cage...) are not liable to damage the containment system;

6) The condition of the containment system should be determined to enable the requirements of II.16 of this table to be demonstrated within the temperature range likely to be encountered during routine conditions of transport;

7) The maximum pressure should consider phenomena such as radiolysis (internal pressure elevation, internal inflammation or explosion), physical changes and chemical reactions.

(ii) **Experimental mechanical testing**

1) The package orientations, in accordance with para. 722.6 in [2], 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.) and of the protection objectives (containment and shielding) should be determined;

2) For reduced scale models, similar or conservative geometry and material properties are to be used as with the original design;

3) 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;

4) Representativeness of drop tests performed with reduced scale models should be demonstrated.

The tests should be conducted and reported in accordance with a management system. The test report should address the verification of the package before testing, the description of the test site, the measurement equipment used and its calibration, the results of performed measurements. This report should also contain pictures showing and explaining the performing conditions of the tests and their results.

(iii) **Calculation**

1) See point (ii)(1) above;

2) Validated computer codes should be used. It should be justified that input parameters (material laws, characteristic values, boundary conditions etc.) describe sufficiently and precisely the real 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;

4) Data used (material laws, boundary conditions, load assumptions etc.) and calculation results are to be documented comprehensibly.

---

### THERMAL ANALYSIS

<table>
<thead>
<tr>
<th>II.15</th>
<th>The general considerations for all technical analyses have to be taken into account when performing the thermal analysis.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not needed for industrial packages: the range of temperatures to be considered for the components of the package for any demonstration of compliance is only the range of temperatures likely to be encountered in routine conditions of transport for Type IP-1 and Type IP-2, which is the range of temperatures specified in para. 639 in [1] for Type IP-3.</td>
</tr>
</tbody>
</table>
## CONTAINMENT DESIGN ANALYSIS

### II.16 Assessment regarding the requirements for preventing the loss or dispersal of radioactive material under routine conditions for all industrial packages and applicable normal conditions of transport for Type IP-2 and Type IP-3.

Containment analysis is not needed provided that the structural analysis has shown the integrity of the containment boundary, taking into account reduction of ambient pressure (para. 645 in [1]) and increase of pressure differential, if applicable (para. 621 in [1]).

## DOSE RATE ANALYSIS

### II.17 The general considerations for all technical analyses have to be taken into account when performing the dose rate analysis.

The dose rates under routine conditions of transport for all types of industrial packages and the dose rate increase ratio for normal conditions of transport for Type IP-2 and Type IP-3 should be assessed, to such an extent that it provides evidence that requirements are met.

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 [1].

The assessment should take into account the appropriate ICRP recommendations.

The maximum dose rate and the dose rate increase ratio under normal conditions of transport should be determined, taking into account potential amplifying phenomena such as movement of the radioactive contents (for instance, due to deficiencies of the retention system inside the package in case of transport of contaminated tools), or, in the case of packages containing liquids, change in the state of the contents, including segregation and/or precipitation of the radionuclides.

See 624.4 and 523.7 in [2].

The following remarks should be taken into account:

- **(a)** Dose rate analysis should be based on the maximum radioactive contents of the package design, which should be defined by various methods and parameters such as nuclide specific radioactivity values, nuclide specific source terms for gamma and neutron emitters and others as appropriate;
- **(b)** The dose rate limits can be shown to be met by calculations or measurements. If calculation methods are used, the calculations of source terms should take into account the interactions, secondary emissions and neutron multiplication factors when relevant. If measurements are used, the source used for the measurements should be representative for the radioactive contents of the package design;
- **(c)** 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.
<table>
<thead>
<tr>
<th>CRITICALITY SAFETY ANALYSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>II.18</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OTHER ANALYSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>II.19</td>
</tr>
</tbody>
</table>
APPENDIX V - TYPE A PACKAGES

APPENDIX V
TYPE A PACKAGES

This appendix provides specific guidance about the information recommended in Part 1 and 2 of the PDSR for Type A packages.

In addition, further guidance is also available in SSG-26 (Rev. 1) [2].

For packages containing fissile nuclides, see in addition APPENDIX VII.

For packages containing 0.1 kg or more of uranium hexafluoride, see in addition APPENDIX VIII.

The numbers in the first column of the table below refer to paragraph numbers in Appendices I and II of this safety guide.

<table>
<thead>
<tr>
<th>Part 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTENTS OF THE PDSR</td>
</tr>
<tr>
<td>I.1</td>
</tr>
<tr>
<td>ADMINISTRATIVE INFORMATION</td>
</tr>
<tr>
<td>I.2</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>SPECIFICATION OF CONTENTS</td>
</tr>
</tbody>
</table>
## I.3 Detailed descriptions of the permitted contents of the package design should be defined by stating, but not limited to, the following information, as applicable:

- **(a)** General nature of contents (e.g., irradiated fuel, metallurgical specimens, radiographic source);
- **(b)** Nuclides / nuclide composition; daughter radionuclides;
- **(c)** Limitations in activity, mass and concentrations, heterogeneities. Compliance with the activity limits for Type A packages in accordance with paras 429 – 430 in [1] should be considered;
- **(d)** Physical and chemical state (there are additional design requirements for liquids and gases contents), geometric shape, arrangement, irradiation parameters, material specifications;
- **(e)** Special form radioactive material or low dispersible radioactive material. A valid certificate should be available if any of these materials are used;
- **(f)** Nature and characteristics of the radiation emitted;
- **(g)** Mass of fissile material and nuclides, enrichment (see also APPENDIX V II, if necessary);
- **(h)** Other dangerous properties. Subsidiary hazard of the contents should be taken into account which may result in additional design requirements in accordance with the subsidiary hazard (see [3], Chapter 3.3 SP 172);
- **(i)** Other limitations to the contents (moisture contents, presence of acid, etc.).

## I.4 Safety relevant limits for non-radioactive materials (e.g. materials subject to radiolysis) should be stated, for example by material composition, density, form, location within package, restrictions of relative quantities of materials.

## I.5 The $A_1/A_2$ values of a radionuclide to be carried that is not listed in the Transport Regulations should be determined in accordance with paras 403 – 407 of [1] and included in the PDSR, and may be subject to multilateral approval in accordance with para. 403.

## SPECIFICATION OF PACKAGING

The packaging design should be defined to the extent necessary to demonstrate compliance with the Transport Regulations, including the following information, as applicable:

- **(a)** Design drawings;
- **(b)** The overall dimensions and the maximum (fully loaded) weight and minimum (empty) weight;
- **(c)** A list of packaging components important to safety and their materials, including their specifications;
- **(d)** The maximum normal operating pressure (MNOP) (particularly, in case of air transport).

A description of:

- **(e)** The packaging body, lid (closure mechanism and tamper-indicating features) and inserts, and components for lifting and tie-down;
### APPENDIX V - TYPE A PACKAGES

| (f) | The packaging components of the containment system (including the definition of the containment boundary) (and including the special features for liquid, see para. 650 in [1]). This may be supported by special form radioactive material, if applicable (see also comment under para. I.3 (e) of this table); |
| (g) | The packaging components required for shielding; |
| (h) | The protection against corrosion; |
| (i) | The protection against contamination; |
| (j) | The shock limiting components; |
| (k) | Testing requirements and controls before first use to transport radioactive material (acceptance tests to ensure compliance of the fabrication to the design). In compliance with para. 501 (a) in [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. |

### AGEING CONSIDERATION

Depending on the package design, the information expected in this section can be provided by the designer directly in the table recommended in para. I.7 of this table. In this case, this section should be left blank.

This section of the PDSR should include:

- **(a)** Those intended conditions of use of the package which may influence ageing;
- **(b)** A list of potential ageing mechanisms which are relevant for the package design, taking into account its intended conditions of use;
- **(c)** Operational measures (including maintenance and inspection before shipment) to monitor and limit the ageing effects;
- **(d)** Analysis on the influence of the ageing of packaging and contents on the design assumptions for demonstration of compliance with the regulations including the technical analyses in Part 2 of the PDSR, considering the specified intended use conditions, ageing mechanisms and operational measures.

See paras 613A.1 to 613A.4 in [2].

### PACKAGE PERFORMANCE CHARACTERISTICS

| I.8 | Not needed for Type A packages. |
| I.9 | |

### COMPLIANCE WITH REGULATORY REQUIREMENTS

| I.10 | The PDSR should include a complete list of all paragraphs of the international regulations [1], [2] and other international or 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. Annex I provides |
### OPERATION

The minimum requirements for the following activities should be fully defined for the packaging/package, as applicable:

(a) Testing requirements and controls before each shipment. The methods used for operational controls and tests, in particular those required in paras 502, 503 (a), 508, 523, 526, 527 and 528 in [1], should be detailed;

(b) Handling and tie down requirements. Specifications on bolt torqueing requirements, number of transport cycles (to be used in fatigue analysis) for each mode of transport should be included, if applicable;

(c) Requirements for loading and unloading of the package contents;

(d) Requirements for assembling of the packaging components (including compliance with para. 637 in [1]);

(e) Any proposed supplementary equipment and operational controls to be applied during transport.

In addition to the radioactive properties, any other dangerous properties of the contents of the package should be taken into account (see para. 507).

Details of the package operations may be included in more exhaustive written procedures to which reference may be made in this part of the PDSR.

### MAINTENANCE

The minimum requirements for the following activities should be fully defined for the packaging/package, as applicable:

(a) Maintenance and inspection requirements before each shipment;

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

Ageing mechanisms during storage should be considered in the maintenance requirements, when applicable.

For single use packages, periodic maintenance does not need to be considered.

Details of the package maintenance may be included in more exhaustive written procedures to which reference may be made in this part of the PDSR.

### GAP ANALYSIS PROGRAMME

For packages which are to be used for shipment after storage, the PDSR should consider the need for a gap analysis programme describing a systematic procedure for a periodic evaluation of changes of regulations and changes of the state of the package design during storage (see also [2]).
### I.14 The PDSR should include the specification of the management system as requested in para. 306 in [1] to ensure compliance with the relevant provisions.

The management system should be appropriate to the complexity of the design of the package to ensure that the package is designed to demonstrate it meets the regulatory requirements. This should include a reliable document control system.

More detailed guidance is available from TS-G-1.4 [4].

### PACKAGE ILLUSTRATION

I.15 A reproducible illustration should be provided showing the make-up of the package, including shock absorbers and packaging inserts, if applicable.

The illustration should indicate at least the overall outside dimensions and the masses for empty and loaded conditions.

### Part 2

### GENERAL INFORMATION

II.1 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 para. I.7 of this table. The level of detail of the analysis should consider the complexity of the package design and the existing safety margins.

Depending on the way of demonstration, for some of the technical analyses of Part 2, demonstration of compliance can be provided by the designer directly in the table recommended in para. I.7 of this table. Conversely, the complexity of some analyses may require that the relevant section of the PDSR be divided in several documents or includes appendices.

### GENERAL CONSIDERATIONS

II.4 For each of the technical analyses in paras II.14 to II.17 of this table, the following considerations apply.

### REFERENCE TO PACKAGE DESIGN

II.5 The package design which is evaluated should be precisely referenced by mentioning the drawing (see para. I.6 in this table) including revision state, and the specification of contents (see paras I.3 to I.5 in this table) including revision state.

### ACCEPTANCE CRITERIA AND DESIGN ASSUMPTIONS

II.6 The acceptance criteria for the technical analyses and the package design assumptions in terms of geometry or performance characteristics should be defined and justified when necessary.
The acceptance criteria are the quantitative limits specified by the designer derived from the regulatory criteria and other applicable standards to meet the regulatory requirements.

The design assumptions include the design specification provided in paras I.3 to I.6 of this table and other assumptions derived from the design specification and used in the technical analyses.

All mechanical, thermal and shielding characteristics of each component of the package and acceptance criteria used in technical analyses should be defined.

**Example:** demonstration of compliance with para. 639 in [1] should include analysis of phenomena such as:

- Expansion/contraction of components relative to the structural or sealing functions;
- Decomposition or changes of state of component materials at extreme conditions.

The design assumptions should take into account ageing mechanisms, as necessary (see also paras 613A.1 to 613A.4 in [2]).

**Example:**
- For dose rate analysis, one acceptance criterion could be the regulatory dose rate limits around the package.

### DESCRIPTION AND JUSTIFICATION OF ANALYSIS METHODS

<table>
<thead>
<tr>
<th>II.7</th>
<th>II.8</th>
<th>II.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>The safety demonstration of a package design can be accomplished by a combination of the following as appropriate (see para. 701 in [1]):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) The results of physical testing of prototypes or models of appropriate scale;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(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;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(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.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The methods/standards used in each analysis specified in paras II.14 to II.19 of this table should include a description of the analysis technique used, its limitations and accuracy, together with the demonstration of the correct application of the technique 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.
The performance characteristics of the package design should be assessed. More than one sequence of tests might 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.

The results of the technical analyses should be compared with the acceptance criteria. The package design assumptions for subsequent analyses should be justified and regulatory compliance should be demonstrated accordingly.

The general considerations for all technical analyses have to be taken into account when performing the structural analysis.

The mechanical behaviour (including fatigue, brittle fracture, creep, if applicable) under routine and normal conditions of transport should be assessed, for:

(a) The components of the containment system (this may be supported by special form radioactive material, if applicable (para. 642 in [1]));
(b) The package components that provide radiation shielding;
(c) Any other package components for which their performance may have a consequential effect upon (a) and (b) above.

Additionally, the mechanical resistance (including fatigue, brittle fracture, creep, if applicable) should be assessed, for:

(d) The packaging attachments used for lifting the package (paras 608 and 609 in [1]);
(e) The packaging attachments used for restraining the package to the conveyance (analysis for routine conditions of transport).

If the package is to be transported by air (paras 619 to 621 in [1]), structural analysis of the containment system 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 addition, 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 paras 621.2, 621.3 and 613.1 in [2].

The following remarks should be taken into account.

(i) **General remarks**
1) 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 the temperatures likely to be encountered during routine conditions of transport (see para. 616 in [1]);

2) The impacts on the package behaviour due to variations in the shock absorbing properties of the shock absorber material (e.g. wood, polymers, plaster, concrete) with temperatures likely to be encountered during routine conditions of transport should be analysed;

3) The safety against brittle fracture at temperatures likely to be encountered during routine conditions of transport of components of the containment system made of potentially brittle materials (e.g., ferritic steels, cast iron) should be analysed if necessary;

4) Strength of lid bolts should be justified for all drop orientations;

5) It should be verified that internal components (content, basket, cage…) are not liable to damage the containment system;

6) The condition of the containment system should be determined to enable the requirements of I.3 of this table to be demonstrated within the temperature range likely to be encountered during routine conditions of transport;

7) The maximum pressure should consider phenomena such as radiolysis (internal pressure elevation, internal inflammation or explosion), physical changes and chemical reactions.

(ii) Experimental mechanical testing

1) The package orientations, in accordance with para. 722.6 in [2], 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.) and of the protection objectives (containment and shielding) should be determined;

2) For reduced scale models, similar or conservative geometry and material properties are to be used as with the original design;

3) 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;

4) Representativeness of drop tests performed with reduced scale models should be demonstrated.

The tests should be conducted and reported in accordance with a management system. The test report should address the verification of the package before testing, the description of the test site, the measurement equipment used and its calibration, the results of performed measurements. This report should also contain pictures showing and explaining the performing conditions of the tests and their results.

(iii) Calculation

1) See point 1 under (ii) above;

2) Validated computer codes should be used. It should be justified that input parameters (material laws, characteristic values, boundary conditions etc.) describe sufficiently and precisely the real 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;
4) Data used (material laws, boundary conditions, load assumptions etc.) and calculation results are to be documented comprehensibly.

**THERMAL ANALYSIS**

II.15 The general considerations for all technical analyses have to be taken into account when performing the thermal analysis.

Not needed for Type A packages: the range of temperatures to be considered for the components of the package for any demonstration of compliance is the range of temperatures specified in para. 639 in [1].

**CONTAINMENT DESIGN ANALYSIS**

II.16 Assessment regarding the requirements for preventing the loss or dispersal of radioactive material under routine and normal conditions of transport (and additional drop tests for Type A packages containing liquids or gases; see paras 650 and 651 in [1]).

Attention should be paid to define precisely the contents, as assumptions and demonstrations are different in accordance with the contents. Where special form radioactive material constitutes part of the containment system, consideration should be given to the appropriate performance of the special form radioactive material under the routine and normal conditions of transport.

Containment analysis is not needed provided that the structural analysis has shown the integrity of the containment boundary, taking into account reduction of ambient pressure (para. 645 in [1]) and increase of pressure differential, if applicable (para. 621 in [1]).

**DOSE RATE ANALYSIS**

II.17 The general considerations for all technical analyses have to be taken into account when performing the dose rate analysis.

The dose rates under routine conditions of transport and the dose rate increase ratio for normal conditions of transport should be assessed, to such an extent that it provides evidence that requirements are met.

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 Transport Regulations.

The assessment should take into account the appropriate ICRP recommendations.

The maximum dose rate and the dose rate increase ratio under normal conditions of transport should be determined, taking into account potential amplifying phenomena such as movement of the radioactive contents (for instance, due to deficiencies of the retention system inside the package in case of transport of contaminated tools), or, in the case of packages containing liquids, change in the state of the contents, including segregation and/or precipitation of the radionuclides.
See paras 624.4 and 523.7 in [2].

The following remarks should be taken into account:

(a) Dose rate analysis should be based on the maximum radioactive contents of the package design, which should be defined by various methods and parameters such as nuclide specific activities, source terms for gamma and neutron emitters and others as appropriate;

(b) The dose rate limits can be shown to be met by calculations or measurements. If calculation methods are used, the calculations of source terms should take into account the interactions, secondary emissions and neutron multiplication factors when relevant. If measurements are used, the source used for the measurements should be representative for the radioactive contents of the package design;

(c) Dose rate analysis should be performed in such a way that in particular package surface areas with maximum dose rates are identified and analysed such as trunnion areas, areas containing gaps which give rise to “radiation passes” and other areas with the potential of increased dose rates due to the design of the package;

(d) All calculation methods used for dose rate analysis should be qualified and validated for the specific conditions of the package design they are applied to;

(e) The expected areas for peak dose rates to be checked before shipment should be specified;

(f) Proof that the sources are maintained secure in their storage positions (for instance, in the irradiators) (under drop test sequence conditions) should be provided in the structural analysis, if applicable.

CRITICALITY SAFETY ANALYSIS

II.18 See Appendix VII.

OTHER ANALYSES

II.19 Not needed for Type A packages.
APPENDIX VI - TYPE B(U), TYPE B(M) AND TYPE C PACKAGES

APPENDIX VI
TYPE B(U), TYPE B(M) AND TYPE C PACKAGES

This appendix provides specific guidance about the information recommended in Part 1 and 2 of the PDSR for Type B(U), Type B(M) and Type C packages.

In addition, further guidance is also available in SSG-26 (Rev. 1) [2].

For packages containing fissile nuclides, see in addition APPENDIX VII.

For packages containing 0.1 kg or more of uranium hexafluoride, see in addition APPENDIX VIII.

The numbers in the first column of the table below refer to paragraph numbers in Appendices I and II of this safety guide.

<table>
<thead>
<tr>
<th>Part 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTENTS OF THE PDSR</td>
</tr>
<tr>
<td>I.1</td>
</tr>
<tr>
<td>ADMINISTRATIVE INFORMATION</td>
</tr>
<tr>
<td>I.2</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>SPECIFICATION OF CONTENTS</td>
</tr>
<tr>
<td>I.3</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
in normal conditions of transport. The properties of materials of components that are expected to maintain their safety function under the thermal test, should be given for a range of temperature reachable during such a test.

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

(a) General nature of contents (e.g., irradiated fuel, metallurgical specimens, radiographic source);
(b) Nuclides / nuclide composition; daughter radionuclides;
(c) Limitations in activity, mass and concentrations, heterogeneities.

The description may include the total numbers of $A_1$ or $A_2$ in the contents.

There are additional design requirements depending on the activity (e.g., see para. 660 in [1]).

Compliance with the activity limits for Type B(U) and Type B(M) packages, if transported by air, in accordance with para. 433 in [1] should be considered.

(d) Physical and chemical state, geometric shape, arrangement, irradiation; parameters (if applicable, the maximum burnup and minimum cooling time), moisture content, material specifications;
(e) Special form radioactive material or low dispersible radioactive material. A valid certificate should be available if any of these materials are used;
(f) Nature and characteristics of the radiation emitted;
(g) Limitations in heat generation rate of contents;
(h) Mass of fissile material and nuclides, enrichment (see also APPENDIX VII, if necessary);
(i) Other dangerous properties. Subsidiary hazard of the contents should be taken into account which may result in additional design requirements in accordance with the subsidiary hazard (see [3], Chapter 3.3 SP 172);
(j) Other limitations to the contents (moisture contents, presence of acid, etc.).

### I.4

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

### I.5

The $A_1/A_2$ values of a radionuclide to be carried that is not listed in the Transport Regulations should be determined in accordance with paras 403 – 407 of [1] and included in the PDSR, and may be subject to multilateral approval in accordance with para. 403.
The packaging design should be defined to the extent necessary to demonstrate compliance with the Transport Regulations, including the following information, as applicable:

(a) Design drawings;
(b) The overall dimensions and the maximum (fully loaded) mass and minimum (empty) mass (additional configurations may be included, depending on the operation conditions);
(c) A list of packaging components important to safety and their materials, including their specifications and methods of manufacture, requirements for material procurement, welding, other special processes, non-destructive evaluation and testing. The properties of materials of components that are expected to maintain their safety function under the thermal test, should be given for a range of temperature reachable during such a test;
(d) The maximum normal operating pressure (MNOP);

A description of:
(e) The packaging body, lid (closure mechanism and tamper-indicating features) and inserts, and components for lifting and tie-down;
(f) The packaging components of the containment system (including the definition of the containment boundary). This may be supported by special form radioactive material, if applicable (see also comment under para. I.3 (e) of this table);
(g) The packaging components required for shielding;
(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) Testing requirements and controls before first use to transport radioactive material (acceptance tests to ensure compliance of the fabrication to the design). See also para. 501 in [1].

### AGEING CONSIDERATION

Depending on the package design, the information expected in this section can be provided by the designer directly in the table recommended in para. I.7 of this table. In this case, this section should be left blank.

This section of the PDSR should include:

(a) Those intended conditions of use of the package which may influence ageing;
(b) A list of potential ageing mechanisms which are relevant for the package design, taking into account its intended conditions of use;
(c) Operational measures (including maintenance and inspection before shipment) to monitor and limit the ageing effects;
(d) Analysis on the influence of the ageing of packaging and contents on the design assumptions for demonstration of compliance with the regulations.
including the technical analyses in Part 2 of the PDSR, considering the specified intended use conditions, ageing mechanisms and operational measures.

See paras 613A.1 to 613A.4 in [2] and TECDOC-XYZT Methodology for a Safety Case for a Dual Purpose Cask for Storage and Transport of Spent Fuel [5].

**PACKAGE PERFORMANCE CHARACTERISTICS**

This section should describe the main design principles and performance characteristics of the package design to meet the different safety requirements of the Transport Regulations (e.g. containment, heat removal and dose rates).

Furthermore, this section should summarize the analyses performed in Part 2 and describe how analysis assumptions and data used for the safety analysis – especially regarding release of radioactive material and dose rates – are derived from the design and the behaviour of the package under routine, normal and accident conditions of transport, also taking into account ageing mechanisms (see para. I.7 of this table).

This should help to ensure that the design and the various parts of the safety demonstration are compatible with one another.

**COMPLIANCE WITH REGULATORY REQUIREMENTS**

The PDSR should include a complete list of all paragraphs of the Transport Regulations and other international or 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. Annex I provides references to applicable paragraphs of the Transport Regulations for Type B(U), Type B(M) and Type C packages.

**OPERATION**

The minimum requirements for the following activities should be fully defined for the packaging/package, as applicable:

(a) Testing requirements and controls before each shipment:

   (i) The methods used for operational controls and tests, in particular those required in paras 502, 503, 508, 523, 526, 527 and 528 in [1], should be detailed;

   (ii) The measures aiming at preventing the presence of unauthorized objects (e.g. tools, small pieces of plastic, worn gaskets...) in the package should be defined;

   (iii) The control of all void spaces of the package (cavity and other spaces), in particular regarding water penetration, should be specified;

   (iv) For drying operations, method used should prevent formation of ice;

   (v) For leaktightness testing, qualified methods should be implemented (see I.3). For packages which are or which have been in contact with water, it should...
be demonstrated that the presence of water does not impair the validity of the leaktightness testing by sealing the leakage paths;

(vi) The absence of defects should be ensured by a specific inspection procedure with appropriate qualification;

(vii) 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.

(b) Handling and tie down requirements. 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;

(c) Requirements for loading and unloading of the package contents;

(d) Requirements for assembling of the packaging components (including compliance with para. 637 in [1]);

(e) Correction factor to be applied to the dose rate and transport index to take into account any amplifying phenomena (paras 624.4 and 523.7 in [2]);

(f) Any proposed supplementary equipment and operational controls to be applied during transport and, when relevant, during storage before transport, including those which may influence ageing mechanisms.

In addition to the radioactive properties, any other dangerous properties of the contents of the package should be taken into account (see para. 507 in [1]).

Details of the package operations may be included in more exhaustive written procedures to which reference may be made in this part of the PDSR.

MAINTENANCE

The minimum requirements for the following activities should be fully defined for the packaging/package, as applicable:

(a) Maintenance and inspection requirements before each shipment;

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

Periodic maintenance and inspection activities should be detailed. They may include, depending on the package design:

(c) Visual inspections and measurements (including tie-down and handling attachments);

(d) The control of all void spaces of the package (cavity and other spaces), in particular regarding water penetration, should be specified;

(e) Weld examinations;

(f) Structural and pressure tests (including tie-down and handling attachments);

(g) Leakage tests;

(h) Component and material tests (screws, bolts, welds, gaskets, seals, wood, foam, resin, etc.);

(i) Shielding tests;

(j) Thermal verification.
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 activities, when needed, may take place in this section. Details of the package maintenance may be included in more exhaustive written procedures to which reference may be made in this part of the PDSR.

GAP ANALYSIS PROGRAMME

For packages which are to be used for shipment after storage, the PDSR should include a gap analysis programme describing a systematic procedure for a periodic evaluation of changes of regulations, changes in technical knowledge and changes of the state of the package design during storage (see also 809.3 and 809.4 in [2] and Ref. [5]).

MANAGEMENT SYSTEM

The PDSR should include the specification of the management system as requested in para. 306 in [1] to ensure compliance with the relevant provisions. The management system should cover:
(a) Design, PDSR, documentation, records;
(b) Manufacture and testing;
(c) Operation (loading, transport, storage in transit, receipt, and unloading);
(d) Maintenance, repair and inspection.

The management system should be appropriate to the complexity of the design of the package to ensure that the package is designed to demonstrate it meets the regulatory requirements. This should include a reliable document control system. The actions to be performed to check the compliance of the operational documents with the PDSR and the management of deviations detected in the framework of any transport activity should be described in the management system.

For all components significant for safety, the PDSR should define the parameters to be guaranteed and the level of controls during manufacturing and maintenance. More detailed guidance is available in TS-G-1.4 [4].

PACKAGE ILLUSTRATION

A reproducible illustration should be provided showing the make-up of the package, including shock absorbers, devices for thermal protection and packaging inserts, if applicable. The illustration should indicate at least the overall outside dimensions and the masses for empty and loaded conditions.

Part 2
## GENERAL INFORMATION

| II.1 | 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 para. I.7 of this table. The level of detail of the analysis should consider the complexity of the package design and the existing safety margins. Depending on the way of demonstration, for some of the technical analyses of Part 2, demonstration of compliance can be provided by the designer directly in the table recommended in para. I.7 of this table. Conversely, the complexity of some analyses may require that the relevant section of the PDSR be divided in several documents or includes appendices. |
| II.2 | |
| II.3 | |

## GENERAL CONSIDERATIONS

| II.4 | For each of the technical analyses in paras II.14 to II.17 and II.19 of this table, the following considerations apply. |

## REFERENCE TO PACKAGE DESIGN

| II.5 | The package design which is evaluated should be precisely referenced by mentioning the drawing (see para. I.6 in this table) including revision state, and the specification of contents (see paras I.3 to I.5 in this table) including revision state. |

## ACCEPTANCE CRITERIA AND DESIGN ASSUMPTIONS

| II.6 | Acceptance criteria and design assumptions. The acceptance criteria for the technical analyses and the package design assumptions in terms of geometry or performance characteristics should be defined and justified when necessary. The acceptance criteria are the quantitative limits specified by the designer derived from the regulatory criteria and other applicable standards to meet the regulatory requirements. The design assumptions include the design specification provided in paras I.3 to I.6 of this table and other assumptions derived from the design specification and used in the technical analyses. The design assumptions should take into account ageing mechanisms, as necessary (see also paras 613A.1 to 613A.4 in [2]). Example: |

   - For dose rate analysis, one acceptance criterion could be the regulatory dose rate limits around the package;  
   - For thermal analysis, one acceptance criteria could be the melting temperature of lead, as melting could lead to loss of lead and the presence of lead could be a design assumption for the dose rate analysis. |
APPENDIX VI - TYPE B(U), TYPE B(M) AND TYPE C PACKAGES

DESCRIPTION AND JUSTIFICATION OF ANALYSIS METHODS

II.7 The safety demonstration of a package design can be accomplished by a combination of the following as appropriate (see para. 701 in [1]):

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

When a programme of tests is implemented for a specific design to be approved by the competent authority, the competent authority should be notified of the programme in advance of the testing and the competent authority should be allowed to witness testing. When such a programme of tests is done without competent authority approval, but is part of the safety analysis, its validity is to be determined by the competent authority.

(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 specified in paras II.14 to II.19 of this table should include a description of the analysis technique used, its limitations and accuracy, together with the demonstration of the correct application of the technique 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. This may include sensitivity analysis.

ANALYSIS OF PACKAGE DESIGN

II.10 The performance characteristics of the package design should be assessed. When determined to be necessary, the results of sensitivity analyses and levels of accuracy should be stated.

More than one sequence of tests might 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.

COMPARISON BETWEEN ACCEPTANCE CRITERIA AND RESULTS OF ANALYSES
II.13 The results of the technical analyses should be compared with the acceptance criteria. The package design assumptions for subsequent analyses should be justified and regulatory compliance should be demonstrated accordingly.

**TECHNICAL ANALYSES**

**STRUCTURAL ANALYSIS**

II.14 The general considerations for all technical analyses have to be taken into account when performing the structural analysis.

The mechanical behaviour (including thermal stresses, fatigue, brittle fracture, creep, if applicable) under routine, normal and accident conditions of transport should be assessed, for:

(a) The components of the containment system (this may be supported by special form radioactive material, if applicable (para. 642 in [1]));
(b) The package components that provide radiation shielding;
(c) Any other package components for which their performance may have a consequential effect upon (a) and (b);

Additionally, the mechanical resistance (including fatigue, brittle fracture, creep, if applicable) should be assessed, for:

(d) The packaging attachments used for lifting the package (paras 608 and 609 in [1]);
(e) The packaging attachments used for restraining the package to the conveyance (analysis for routine conditions of transport).

If the package is to be transported by air (paras 619 to 621 in [1]), structural analysis of the containment system 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 addition, 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 paras 621.2, 621.3 and 613.1 in [2].

The following remarks should be taken into account.

(i) **General remarks**

1) 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 (or another specified temperature for Type B(M) packages) and +70°C (see para. 639 in [1]) and the temperature range of the respective package components in normal conditions of transport (see para. 653 in [1]).

The following points should be considered:

2) 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 (or another specified
temperature for Type B(M) packages as agreed by the competent authority) to
the maximum temperature in normal conditions of transport, or moisture
should be analysed;
3) The safety against brittle fracture at -40°C (or another specified temperature
for Type B(M) packages) of components of the containment system made of
potentially brittle materials (e.g., ferritic steels, cast iron) should be analysed;
4) Strength of lid bolts should be justified for all drop orientations;
5) Any excursion in the plastic domain should be avoided as possible for
containment system components such as bolts and gasket seats (which would
require additional complex proofs concerning the mechanics of the rupture or
the maintenance of sufficient gasket seating);
6) Possible damage of metallic seals after drops due to vibrations or sliding of
the lid should be evaluated;
7) It should be verified that internal components (content, basket, cage…) are not
liable to damage the containment system. For the evaluation of the impact of
internal components onto the packaging lid, the maximum possible gap
between these components and the lid before the drop should be considered;
8) The condition of the containment system should be determined to enable the
requirements of I.3 of this table to be demonstrated within the temperature
range concerned (-40°C (or another specified temperature for Type B(M)
packages as agreed by the competent authority), maximum temperature in
accident conditions of transport);
9) Retention of sufficient thermal protection, after the mechanical tests for
accident conditions of transport, to guarantee the containment or other
components safety function during the thermal test should be demonstrated.
10) The effect of the thermal test on the mechanical behaviour of the package;
components should be considered (e.g. thermal stresses and strains, thermo-
mechanical interactions between package components, and interactions of the
package components with contents);
11) If the shielding includes components made from lead, the consolidation height
of lead (lead slump) after the 9 m drop test should be determined, taking into
account environmental conditions of paras 656 and 657 in [1];
12) The maximum pressure should consider phenomena such as radiolysis
(internal pressure elevation, internal inflammation or explosion), physical
changes, chemical reactions, and accident conditions of transport (including
the thermal test);
13) The appropriate water immersion test depending on the content activity of the
package should be considered.

(ii) Experimental mechanical testing
1) The package orientations, in accordance with paras 722.6 and 727.5 in [2],
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.) and of the protection objectives
(containment and shielding) should be determined;

For instance, the following aspects should be considered:
APPENDIX VI - TYPE B(U), TYPE B(M) AND TYPE C PACKAGES

- Tests which maximise the stresses and acceleration (flat, slap down ...): the greater the impact area, the harder the impact (constant stiffness per unit area assumed);
- Tests which maximise the deformation (on corner, on edges ...): in contrast, the smaller the impact area, the greater the crushing;
- 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;
- 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 is much higher.

2) For reduced scale models, similar or conservative geometry and material properties are to be used as with the original design;
3) 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;
4) Representativeness of drop tests performed with reduced scale models should be demonstrated for the following:
   - Drop heights: 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;
   - Appropriate geometry scaling of all components (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 in accordance with 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;
   - Welding seams should be similar for scale model and package design;
   - In case of reduced scale model drop testing with significant deformations of impact limiters, the original package performance should be carefully justified.

The tests should be conducted and reported in accordance with a management system. The test report should address the verification of the package before testing, the description of the test site, the measurement equipment used and its calibration, the results of performed measurements. This report should also contain pictures showing and explaining the performing conditions of the tests and their results.

(iii) Calculation
   1) See point 1 under (ii) above;
2) Validated computer codes should be used. It should be justified that input parameters (material laws, characteristic values, boundary conditions etc.) describe sufficiently and precisely the real 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;
4) Data used (material laws, boundary conditions, load assumptions etc.) and calculation results are to be documented comprehensively.

**THERMAL ANALYSIS**

II.15 The general considerations for all technical analyses have to be taken into account when performing the thermal analysis.

The surfaces temperatures under the conditions defined in paras 654 or 655 in [1] should be determined.

The temperatures of the package components should be assessed in normal (see para. 653 in [1]) and accident (see para. 659 (b) in [1]) conditions of transport, including the thermal behaviour of the following:

(a) The components of the containment system;
(b) The components of shielding;
(c) The package components for which their performance will have a consequential effect upon (a) and (b).

The following remarks should be taken into account:

- Consideration of the effects of insolation on a period of 12 hours in accordance with para. 657 in [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 (e.g. containers, boxes), if applicable;
- Justification of simplifying assumptions used for calculation under normal and accident conditions of transport (for example: absence of trunnions);
- Analysis of the package in accident conditions of transport under the position more penalizing (horizontal or vertical);
- Consideration of the solar insolation before and after the thermal test as defined in para. 728 in [1];
- Absorptivity coefficient of the external surface of the package not lower than 0.8, without additional justification (see para. 728 (a) in [1]), during and after the thermal 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;
- Evaluation of the minimum / maximum temperatures of the various components of the packaging, taking account of all the possible positions for the radioactive contents;
APPENDIX VI - TYPE B(U), TYPE B(M) AND TYPE C PACKAGES

- Consideration of a profile of heat power in accordance with burnup distribution in irradiated fuels taken into account in the thermal analysis;
- When thermal analysis for conditions specified in paras 654 and 655 in [1] is based on test results, justification that the temperature measurements were performed at thermal equilibrium;
- When the thermal test is made in a furnace and when it is noted that some package components burn, justification that the concentration of oxygen present in the furnace is controlled and in conformity with that obtained in a hydrocarbon fuel-air fire. In addition, control of heat input should be considered thoroughly;
- Consideration of the influence of combustible materials which generate additional heat input and affect the fire duration beyond the thermal test;
- Safety margins on temperature results derived using numerical modelling commensurate with the uncertainty associated to the numerical model;
- Demonstration that the spare volume in the gasket grooves allows for gasket thermal expansion in conditions specified in paras 654 and 655 in [1] and accident conditions of transport, unless appropriate justification is provided.

CONTAINMENT DESIGN ANALYSIS

II.16 The general considerations for all technical analyses have to be taken into account when performing the containment analysis.

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 have been assessed, in para. II.14 of the PDSR. The risk of rupture due to creep of the rods under the effect of the internal pressure should be evaluated, taking into account the mechanical properties of the fuel cladding for the temperature conditions in normal conditions of transport and for the burnup 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 have been included in para. II.14 of the PDSR, if necessary for safety demonstration;
- Fission gas release fraction out of fuel material should be justified;
- The presence of debris and of aerosols in the package cavity for irradiated fuels in the case of 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 (see para. I.7 of this table);
• A reduction of ambient pressure to 60 kPa should be considered for evaluation of activity release.

DOSE RATE ANALYSIS

II.17 The general considerations for all technical analyses have to be taken into account when performing the dose rate analysis.

The dose rates under routine and accident conditions of transport and the dose rate increase ratio for normal conditions of transport should be assessed, to such an extent that it provides evidence that requirements are met.

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 Transport Regulations.

The assessment should take into account the appropriate ICRP recommendations.

The maximum dose rate and the dose rate increase ratio under normal conditions of transport should be determined, taking into account potential amplifying phenomena such as movement of the radioactive contents, or, in the case of packages containing liquids, change in the state of the contents, including segregation and/or precipitation of the radionuclides.

See paras 624.4 and 523.7 in [2].

The following remarks should be taken into account:

• Dose rate analysis should be based on the maximum radioactive contents of the package design, which should be defined by various methods and parameters such as nuclide specific activities, source terms for gamma and neutron emitters and others as appropriate;

• The dose rate limits can be shown to be met by calculations or measurements. If calculation methods are used, the calculations of source terms should take into account the interactions, secondary emissions and neutron multiplication factors when relevant;

• Dose rate analysis should be performed in such a way that in particular package surface areas with maximum dose rates are identified and analysed such as trunnion areas, areas containing gaps which give rise to “radiation passes” and other areas with the potential of increased dose rates due to the design of the package;

• If measurements are applied to demonstrate compliance with the dose rate 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;

• 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 (for instance, in the irradiators) (under drop test sequence conditions) should be provided in the structural analysis, if applicable;
• Local melting or combustion during the thermal test of the materials providing radiation shielding should be considered, as determined by the thermal analysis, and the thermal analysis should take into account also the effects of penetration or deformation of components by the bar in the mechanical test.

CRITICALITY SAFETY ANALYSIS

II.18 See Appendix VII.

OTHER ANALYSES

II.19 The general considerations for all technical analyses have to be taken into account when performing additional analyses, e.g. analyses regarding radiolysis and thermolysis. Radiolysis and thermolysis phenomena can affect and can be affected by the structural analysis, the thermal analysis, the containment design analysis and the dose rate analysis.

If the package contains wet contents, the internal pressure built-up inside the package should be assessed and considered under regulatory transport conditions. For the assessment of effects concerning radiolysis and/or thermolysis on the performance characteristics of the package design (internal pressure elevation, internal inflammation or explosion) the following should be considered:

• In all cases where water or hydrocarbonated materials is/are present (cellulose, polymers, aqueous or organic solutions, absorbed humidity), the absence of the risk of accumulation of combustible gases exceeding the limiting concentration for inflammability should be demonstrated;
• When the radiolysis phenomenon limits the maximum safe duration of transport, any specified limit for the duration of transport should necessarily integrate margins for incidents and emergency response operations;
• If leaking fuel rods are allowed as contents, contained water should be taken into account if absence of water is not demonstrated.

In addition, if applicable, the risk of chemical or physical reactions for materials which react with water or oxygen, e.g., sodium, UF₆, plutonium and metallic uranium should be assessed. Moreover, the potential change of phase (freezing, melting, boiling), precipitation or segregation should be considered.
APPENDIX VII
ADDITIONAL INFORMATION
FOR PACKAGES CONTAINING FISSILE NUCLIDES

This appendix provides specific additional guidance about the information recommended in Part 1 and 2 of the PDSR for packages containing fissile nuclides defined in para. 222 of the Transport Regulations.

They apply in addition to those items belonging to the package type defined by the radioactive properties of the contents, see Appendices III to VI.

Further guidance is also available in SSG-26 (Rev. 1) [2] and IAEA-TECDOC-1768 [6].

For packages containing 0.1 kg or more of uranium hexafluoride, see in addition APPENDIX VIII.

The Transport Regulations comprise four groups of provisions for the transport of radioactive material containing fissile nuclides, as shown in the bottom row of Figure 2.

<table>
<thead>
<tr>
<th>Non-fissile or fissile-excepted UN Number</th>
<th>FISSILE UN Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>222</td>
<td>417(a) to 417(f)</td>
</tr>
<tr>
<td>674 &amp; 675</td>
<td>Others</td>
</tr>
</tbody>
</table>

- **May be transported in packages whose designs are not approved by CA for fissile material (or in certain circumstances may be transported unpackaged)**
- **Transported in a CA approved fissile package design**
- **Defines the fissile nuclides, and fissile material as material containing those nuclides**
- **Excludes certain materials from being defined as fissile**
- **Defines limits on the mass, form and isotopic composition of fissile nuclides that except the package or material from further criticality safety consideration**
- **Material specification required to ensure sub-criticality set out in a CA “FE” certificate (802(a)(iii))**
- **Defines limits on the mass and isotopic composition of fissile nuclides in a package and requirements on the package design that allows transport as a fissile package**
- **Package design specified in a CA fissile “F” certificate (802(a)(v)) (including Special Arrangements)**
- **Not defined as fissile material**
- **Exception from UN FISSILE Classification and CSI control**
- **CSI control with exception from CA approval of package**
- **CSI control with CA approval of package design**
FIG. 2. Overview of the provisions for the transport of fissile material (from IAEA TECDOC 1768 [6]).

**Group No 1.** Transport where the material is excluded from the definition of fissile material;

**Group No 2.** Transport with exception from UN “FISSILE” classification and criticality safety index (CSI) accumulation control;

**Group No 3.** Transport with UN “FISSILE” classification and CSI control but without Competent Authority (CA) approval as a package design for fissile material;

**Group No 4.** Transport in a package for which the design is approved by the CA to contain fissile material.

Those group numbers will be referred to in the table in this Appendix.

The same package may be assigned to different groups for different consignments. This should be reflected in the PDSR. For each group, the complete information as specified below should be given in the PDSR.

The numbers in the first column of the table below refer to paragraph numbers in Appendices I and II of this safety guide.

<table>
<thead>
<tr>
<th>Part 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTENTS OF THE PDSR</td>
</tr>
<tr>
<td>I.1</td>
</tr>
</tbody>
</table>

**ADMINISTRATIVE INFORMATION**

| Group No 1: Nothing to be added. |
| Group No 2: Reference to one of the subparagraphs 417 (a) to 417 (f) in the Transport Regulations applied to be added. When para. 417 (f) is applied, multilateral approval is required. |
| Group No 3: Reference to the paras 674 (a) to 674 (c) or 675 applied to be added. |

The following administrative information should be added, when necessary:

- Colloquial name of package, if applicable.

**Group No 4:** The following administrative information should be added, when necessary:

a) Colloquial name of package, if applicable;

b) Package design specified in a competent authority fissile “F” certificate.

**SPECIFICATION OF CONTENTS**
APPENDIX VII - ADDITIONAL INFORMATION FOR PACKAGES CONTAINING
FISSILE NUCLIDES

| I.3 | The description of the contents and of their physical, and chemical forms and radionuclides should be sufficiently precise to allow the demonstration of compliance with the requirements for prevention of criticality. The following information should be added, as necessary. Group No 1: Nothing to be added. Group No 2: Mass of fissile nuclides and enrichment if applicable to be added. Group No 3: Following information to be added:  
  (a) Mass of fissile nuclides and enrichment if applicable;  
  (b) Other limitations to the contents as described in para. 674 (d) or 675 (c) in [1];  
  (c) The formula for calculating the criticality safety index (CSI) in accordance with para. 674 or 675 in [1]. Group No 4: Following information to be added:  
  (a) Mass of fissile nuclides, enrichment if applicable;  
  Also description of quantities of nuclides able to sustain chain reaction whereas not defined as fissile should be included, e.g. 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.  
  (b) The criticality safety index (CSI) and the value of “N”;  
  (c) Safety relevant limits for non-radioactive materials (e.g. moderators, reflectors) should be stated, for example by material composition, density, form, location within package, restrictions of relative quantities of materials. 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). |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I.4</td>
<td>Safety relevant limits for non-radioactive materials (e.g. materials subject to radiolysis) should be stated, for example by material composition, density, form, location within package, restrictions of relative quantities of materials.</td>
</tr>
<tr>
<td>I.5</td>
<td>Nothing to be added.</td>
</tr>
</tbody>
</table>

SPECIFICATION OF PACKAGING
### APPENDIX VII - ADDITIONAL INFORMATION FOR PACKAGES CONTAINING FISSILE NUCLIDES

**Group No 3:** The following information to be added, if necessary:

- (a) A list of packaging components important to safety and their materials, including their specifications;
- (b) The packaging body, lid (closure mechanism and tamper-indicating features) and inserts;
- (c) The shock absorbing components;
- (d) Testing requirements and controls before first use to transport radioactive material (acceptance tests to ensure compliance of the fabrication to the design).

**Group No 4:** The following information should be added, when necessary:

- (a) The overall dimensions and the maximum (fully loaded) mass and minimum (empty) mass (additional configurations may be included, depending on the operation conditions);
- (b) A list of packaging components important to safety and their material, including their specifications and methods of manufacture, requirements for material procurement, welding, other special processes, non-destructive evaluation and testing;
- (c) The maximum normal operating pressure (MNOP);
- (d) The packaging body, lid (closure mechanism and tamper-indicating features) and inserts, and components for lifting and tie-down;
- (e) The package components of the confinement system (such as neutron poisons, moderators, flux traps and spacer);
- (f) The packaging components for thermal protection;
- (g) The packaging components for heat dissipation;
- (h) The protection against corrosion;
- (i) The shock absorbing components;
- (j) Testing requirements and controls before first use to transport radioactive material (acceptance tests to ensure compliance of the fabrication to the design). See also para. 501 in [1].

### AGEING CONSIDERATION

Depending on the package design, the information expected in this section can be provided by the designer directly in the table recommended in para. I.10 of this table. In this case, this section should be left blank.

This section of the PDSR should include:

- (a) Those intended conditions of use of the package which may influence ageing;
- (b) A list of potential ageing mechanisms which are relevant for the package design, taking into account its intended conditions of use;
APPENDIX VII - ADDITIONAL INFORMATION FOR PACKAGES CONTAINING FISSILE NUCLIDES

(c) Operational measures (including maintenance and inspection before shipment) to monitor and limit the ageing effects;
(d) Analysis on the influence of the ageing of packaging and contents on the design assumptions for demonstration of compliance with the regulations including the technical analyses in Part 2 of the PDSR, considering the specified intended use conditions, ageing mechanisms and operational measures. See paras 613A.1 to 613A.4 of SSG-26 (Rev. 1) [2].

PACKAGE PERFORMANCE CHARACTERISTICS

Groups No 1, No 2 and No 3: nothing to be added.

Group No 4: This section should describe the main design principles and performance characteristics of the package design to meet the criticality safety requirements of the Transport Regulations.

Furthermore, this section should summarize the analyses performed in Part 2 and describe how analysis assumptions and data used for the criticality safety analysis are derived from the design and the behaviour of the package under routine, normal and accident conditions of transport, also taking into account ageing mechanisms (see para. 1.7 of this table).

This should help to ensure that the design and the various parts of the safety demonstration are compatible with one another.

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, 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.

COMPLIANCE WITH REGULATORY REQUIREMENTS

The PDSR should also include a complete list of all paragraphs of the Transport Regulations and other international or national regulations applicable to packages containing fissile nuclides for the relevant group.

Demonstration of compliance with these paragraphs should be by reference to where in the PDSR compliance is demonstrated, or other justification. Annex I provides
references to applicable paragraphs of the Transport Regulations for packages containing fissile nuclides.

OPERATION

Group No 1: Nothing to be added.

Group No 2: The following information to be added, if necessary:
- Any operational controls to be applied during transport including consignment and conveyance limits.

Group No 3: The following information to be added, if necessary:
- Requirements for assembling of the packaging components (including compliance with para. 637 in [1]).

Group No 4: The following information to be added, if necessary:
- Testing requirements and controls before each shipment;
- The methods used for operational controls and tests, in particular those required in paras 502 and 503 in [1], should be detailed;
- For drying operations, method used should prevent formation of ice;
- For leak tightness testing, qualified methods should be implemented (see para. 2.3 of this table). For packages which are, or which have been in contact with water, it should be demonstrated that the presence of water does not impair the validity of the leak tightness testing by sealing the leakage paths;
- The check for the presence of absorber rods or selection of inner equipment with the correct neutron absorber content should be specified, if applicable;
- The control of tightening torques of the bolts and of the correct position of the lid should be specified;
- Requirements for assembling of the packaging components (including compliance with para. 637 in [1]).

Details of the package operations may be included in more exhaustive written procedures to which reference may be made in this part of the PDSR.

MAINTENANCE

Groups No 1, No 2 and No 3: Nothing to be added.

Group No 4: The following information to be added, if necessary:
Periodic maintenance and inspection activities should be detailed. They may include, depending on the package design:
(a) Visual inspections and measurements (including tie-down and handling attachments);
(b) The control of all void spaces of the package (cavity and other spaces), in particular regarding water penetration, should be specified;
(c) Weld examinations;
APPENDIX VII - ADDITIONAL INFORMATION FOR PACKAGES CONTAINING FISSILE NUCLIDES

| (d) Structural and pressure tests (including internal enclosures, tie-down and handling attachments);  
| (e) Component and material tests (screws, bolts, welds, neutron absorbers, basket etc.).  
| The definition of the periodicity of replacement of the packaging components should take into account any reduction in efficiency due to wear, corrosion, ageing etc.  
| The justification of the periodicity of activities, when needed, may take place in this section.  

GAP ANALYSIS PROGRAMME

| I.13 Groups No. 1, No. 2 and No. 3: Nothing to be added.  
| Group No. 4: Additional information about the systematic procedure for a periodic evaluation of changes in technical knowledge should be provided, if necessary.  

MANAGEMENT SYSTEM

| I.14 Groups No 1, No 2 and No 3: Nothing to be added.  
| Group No 4: The following information to be added, if necessary:  
| The management system should cover:  
| (a) Design, PDSR, documentation, records;  
| (b) Manufacture and testing;  
| (c) Operation (loading, transport, storage in transit, receipt, and unloading);  
| (d) Maintenance, repair and inspection.  
| The actions to be performed to check the compliance of the operational documents with the PDSR and the management of deviations detected in the framework of any transport activity should be described in the management system.  
| For all components significant for safety, the PDSR should define the parameters to be guaranteed and the level of controls during manufacturing and maintenance.  

PACKAGE ILLUSTRATION

| I.15 Groups No 1 and No 2: Nothing to be added.  
| Group No 3: A reproducible illustration should be provided showing the make-up of the package, including shock absorbers and packaging inserts, if applicable.  
| The illustration should indicate at least the overall outside dimensions and the masses for empty and loaded conditions.  
| Group No 4: A reproducible illustration should be provided showing the make-up of the package, including shock absorbers, devices for thermal protection and packaging inserts, if applicable.  

|
The illustration should indicate at least the overall outside dimensions and the masses for empty and loaded conditions.

### Part 2

#### GENERAL INFORMATION

| II.1 | 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 para. I.7 of this table. The level of detail of the analysis should consider the complexity of the package design and the existing safety margins. |  |
| II.2 | Depending on the way of demonstration, for some of the technical analyses of Part 2, demonstration of compliance can be provided by the designer directly in the table recommended in para. I.7 of this table. Conversely, the complexity of some analyses may require that the relevant section of the PDSR be divided in several documents or includes appendices. |  |

#### GENERAL CONSIDERATIONS

| II.4 | For each of the technical analyses in paras II.14 to II.16 and II.18 of this table, the following considerations apply. |  |

#### REFERENCE TO PACKAGE DESIGN

| II.5 | The package design should be precisely referenced by mentioning a design drawing or packaging drawing list (see para. I.6 of this table), including revision number, and the specification of the contents (see paras I.3 to I.5 of this table), including revision number, as appropriate. |  |

#### ACCEPTANCE CRITERIA AND DESIGN ASSUMPTIONS

| II.6 | The acceptance criteria for the technical analyses and the package design assumptions in terms of geometry or performance characteristics should be defined and justified when necessary. |  |
| | The acceptance criteria are the quantitative limits specified by the designer derived from the regulatory criteria and other applicable standards to meet the regulatory requirements. |  |
| | The design assumptions include the design specification provided in paras I.3 to I.6 of this table and other assumptions derived from the design specification and used in the technical analyses. |  |
| | The design assumptions should take into account ageing mechanisms, as necessary (see also paras 613A.1 to 613A.4 in [2]). |  |

#### DESCRIPTION AND JUSTIFICATION OF ANALYSIS METHODS
APPENDIX VII - ADDITIONAL INFORMATION FOR PACKAGES CONTAINING FISSILE NUCLIDES

### II.7 II.8 II.9

The safety demonstration of a package design can be accomplished by a combination of the following as appropriate (see para. 701 in [1]):

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

When a programme of tests is implemented for a specific design to be approved by the competent authority, the competent authority should be notified of the programme in advance of the testing and the competent authority should be allowed to witness testing. When such a programme of tests is done without competent authority approval, but is part of the safety analysis, its validity is to be determined by the competent authority.

(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 specified in paras II.14 to II.19 of this table should include a description of the analysis technique used, its limitations and accuracy, together with the demonstration of the correct application of the technique 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. This may include sensitivity analysis.

### ANALYSIS OF PACKAGE DESIGN

<table>
<thead>
<tr>
<th>II.10</th>
<th>II.11</th>
<th>II.12</th>
</tr>
</thead>
<tbody>
<tr>
<td>The performance characteristics of the package design should be assessed. When determined to be necessary, the results of sensitivity analysis and levels of accuracy should be stated.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>More than one sequence of tests might 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.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### COMPARISON BETWEEN ACCEPTANCE CRITERIA AND RESULTS OF ANALYSES
### APPENDIX VII - ADDITIONAL INFORMATION FOR PACKAGES CONTAINING FISSILE NUCLIDES

#### II.13
The results of the technical analyses should be compared with the acceptance criteria. The package design assumptions for subsequent analyses should be justified and regulatory compliance should be demonstrated accordingly.

#### TECHNICAL ANALYSES

#### STRUCTURAL ANALYSIS

#### II.14
The general considerations for all technical analyses have to be taken into account when performing the structural analysis.

**Groups 1 and 2:** There is no need for an additional structural analysis.

An additional structural analysis is necessary for:

**Group 3** (for Industrial Packages only): if the demonstration of compliance with para. 674 (b) or (c) in [1] relies on the performance of the package under normal conditions of transport and is not otherwise assessed for the package design.

**Group 4:** if the criticality safety assessment relies on the performance of the package under normal or accident conditions of transport and is not otherwise assessed for the package design.

The mechanical behaviour (including thermal stresses, fatigue, brittle fracture, creep, if applicable) under routine, normal and accident conditions of transport should be assessed, for:

- (a) The components of the confinement system;
- (b) Any other package components for which their performance may have a consequential effect upon (a);
- (c) The structural analysis should include 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 water leaking into or out of the package (totally or partially), the rearrangement of the fissile material and the degradation of neutron traps.

See also the remarks in para. I.6 of this table.

The following remarks should be taken into account:

(i) **General remarks**

1) 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 the temperature range of the respective package components for an ambient temperature of -40°C to +38°C (or another temperature range as agreed by the competent authority: para. 679 in [1]);

2) 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 (e.g. wood, polymers,
plaster, concrete) with an ambient temperature of -40°C to +38°C (or another temperature range as agreed by the competent authority: para. 679 in [1]) or moisture should be analysed;

- The safety against brittle fracture at -40°C (or another temperature as agreed by the competent authority: para. 679 in [1]) of components of the confinement 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;
- Any excursion in the plastic domain should be avoided as possible for confinement system components such as bolts and gasket seats (which would require additional 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;
- It should be verified that internal components (content, basket, cage) are not liable to damage the confinement system. For the evaluation of the impact of internal components onto the packaging lid, the maximum possible gap between these components and the lid before the drop should be considered;
- The condition of the confinement system should be determined to enable the requirements of 1.5 of this table to be demonstrated for an ambient temperature range from -40°C to +38°C (or another temperature range agreed by the competent authority: para. 679 in [1]);
- Retention of sufficient thermal protection, after the mechanical tests for accident conditions of transport, to guarantee the confinement system during the thermal tests should be demonstrated;
- The effect of the thermal test on the mechanical behaviour of the package components should be considered (e.g. thermal stresses and strains, thermo-mechanical interactions between package components, and interactions of the package components with contents);
- The appropriate water immersion test should be considered.

(ii) **Experimental mechanical testing**

1) The package orientations, in accordance with paras 722.6 and 727.5 in [2], 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.) and of the protection objective (criticality safety) should be determined.

For instance, the following aspects should be considered:

- Tests which maximise the stresses and acceleration (flat, slap down): the greater the impact area, the harder the impact (constant stiffness per unit area assumed);
- Tests which maximise the deformation (on corner, on edges): in contrast, the smaller the impact area, the greater the crushing;
APPENDIX VII - ADDITIONAL INFORMATION FOR PACKAGES CONTAINING FISSILE NUCLIDES

- 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;
- 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 is much higher.

2) For reduced scale models, similar or conservative geometry and material properties are to be used as with the original design.

3) 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.

4) Representativeness of drop tests performed with reduced scale models should be demonstrated for the following:
   - Drop heights: 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;
   - Appropriate geometry scaling of all components (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 in accordance with 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;
   - Welding seams should be similar for scale model and package design;
   - In case of reduced scale model drop testing with significant deformations of impact limiters, the original package performance should be carefully justified.

The tests should be conducted and reported in accordance with a management system. The test report should address the verification of the package before testing, the description of the test site, the measurement equipment used and its calibration, the results of performed measurements. This report should also contain pictures showing and explaining the performing conditions of the tests and their results.

(iii) Calculation

1) See point 1 in para. II.14 (ii) in this table;
2) Validated computer codes should be used. It should be justified that input parameters (material laws, characteristic values, boundary conditions etc.) describe sufficiently and precisely the real 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;

4) Data used (material laws, boundary conditions, load assumptions etc.) and calculation results are to be documented comprehensively.

**THERMAL ANALYSIS**

II.15 The general considerations for all technical analyses have to be taken into account when performing the thermal analysis.

Additionally, the temperatures of the package components should be assessed in accident (see para. 659 (b) in [1]) conditions of transport, including the thermal behaviour of the following:

(a) The components of the confinement system;

(b) The package components for which their performance will have a consequential effect upon (a).

The following remarks should be taken into account:

- Consideration of the effects of insolation on a period of 12 hours in accordance with para. 657 in [1]. Averaging on 24 hours should not be accepted;
- Justification of simplifying assumptions used for calculation in normal and accident conditions of transport (for example: absence of trunnions);
- Analysis of the package in accident conditions of transport under the position more penalizing (horizontal or vertical);
- Consideration of the solar insolation before and after the thermal test as defined in para. 728 in [1];
- Absorptivity coefficient of the external surface of the package not lower than 0.8, without additional justification (see para. 728 (a) in [1]), during and after the thermal 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;
- Evaluation of the minimum / maximum temperatures of the various components of the packaging, taking account of all the possible positions for the radioactive contents;
- Consideration of a profile of heat power in accordance with burnup distribution in irradiated fuels taken into account in the thermal analyses;
- When the thermal test is made in a furnace and when it is noted that some package components burn, justification that the concentration of oxygen present in the furnace is controlled and in conformity with that obtained in a hydrocarbon fuel-air fire. In addition, control of heat input should be considered thoroughly;
- Consideration of the influence of combustible materials which generate additional heat input and affect the fire duration beyond the thermal test;
### CONTAINMENT DESIGN ANALYSIS

**II.16** The extent of the additional containment design analysis depends on the hypothesis which are used when demonstrating criticality safety, as regards the fissile material which escapes from the package (para. 685 (c) of the Transport Regulations) and the quantity of water that leak into or out of all void spaces of the package (para. 680 of the Transport Regulations).

### DOSE RATE ANALYSIS

**II.17** Nothing to be added.

### CRITICALITY SAFETY ANALYSIS

**II.18** The general considerations for all technical analyses have to be taken into account when performing the criticality safety analysis.

For packages designed to transport fissile material not excepted by para. 417, 674 or 675 of the Transport Regulations (Group No. 4), assessment of criticality safety for routine, normal and accident conditions of transport, for the isolated package and for the arrays of packages is required to be performed.

The following items, if applicable, should be taken into account in the criticality safety analysis.

(a) **Contents:**
   
   (i) Within the range set by the description of the contents and the packaging, see paras I.3 to I.6 of this table, all possible configurations with any possible geometrical and physical characteristics (dimensional tolerances, positions of the components, density of powders in normal or accident conditions of transport);
   
   (ii) Materials with hydrogen concentration higher than that of water which may be present in the package;
   
   (iii) Natural or depleted uranium which may be present in the package, with appropriate assumptions relative to quantities and localisation.

(b) **Configurations to be analysed:**
   
   (i) For packages where special features preventing water leakage are considered for the criticality safety analysis for a package in isolation (para. 680 (a) of the Transport Regulations): The criterion for water tightness 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 para. 680 of the Transport Regulations should be taken into account as well as a single error;

(ii) For packages to be transported by air, subcriticality of the isolated package should be assessed under conditions consistent with Type C package tests, assuming reflection by at least 20 cm of water but no water leakage. If the behaviour of the package under these conditions is not assessed, typical envelope configurations should be considered, such as:

- The fissile material contained in one package (without consideration of water ingress from outside the package) in spherical shape reflected by 20 cm of water;
- The fissile material contained in one package (without consideration of water from outside the package), pure or mixed with all or part of the moderating materials of the package, in spherical shape, surrounded by the reflecting materials (steel, lead…) of the package and reflected by 20 cm of water.

(iii) In modelling, all the elements of structures that could increase the neutron multiplication should be taken into account;

(iv) The designer should check the qualification of criticality calculation tools and should specify the critical experiments used for benchmarking of the calculation tool, which should be representative for the single package in isolation as well as the applicable arrays of packages. Special attention should be paid to systems (low-moderation systems, 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;

(v) 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;

(vi) 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;

(vii) The heterogeneous nature of the fissile material as transported should be considered;

(viii) In case of the assumption of a homogeneous enrichment equal to the average enrichment for BWR UOX assemblies, this assumption should be proven to be conservative, especially if the assembly geometry may change under test conditions specified in the Transport Regulations;

(ix) For spent fuel initially containing plutonium, a conservative irradiation level that takes into account the possible evolution of reactivity during irradiation should be considered.

Helpful advice on criticality safety assessments is given in Appendix VI of SSG-26 (Rev. 1) [2]. Guidance on the application of burnup credit in criticality safety
assessments of spent nuclear fuel is provided in IAEA Safety Standards Series No. SSG-27, Criticality Safety in the Handling of Fissile Material [7]. Additional information can be found in ISO 27468 [8] and in publications from the Expert Group on Burn-up Credit Criticality Safety of the OECD/NEA Working Party on Nuclear Criticality Safety (WPNCS, see https://www.oecd-nea.org/science/wpncs/buc/index.html).

<table>
<thead>
<tr>
<th>OTHER ANALYSES</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>II.19</td>
<td>Nothing to be added.</td>
</tr>
</tbody>
</table>
APPENDIX VIII
ADDITIONAL INFORMATION FOR PACKAGES CONTAINING 0.1 KG OR MORE OF URANIUM HEXAFLUORIDE

This appendix provides specific additional guidance about the information recommended in Part 1 and 2 of the PDSR for packages containing 0.1 kg or more of uranium hexafluoride. They apply in addition to those items belonging to the package type defined by the radioactive properties of the contents, see Appendices IV to VI.

Further guidance is also available from SSG-26 (Rev. 1) [2].

For packages containing fissile nuclides, see in addition APPENDIX VII.

The numbers in the first column of the table below refer to paragraph numbers in Appendices I and II of this safety guide.

<table>
<thead>
<tr>
<th>Part 1</th>
<th>CONTENTS OF THE PDSR</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.1</td>
<td>Nothing to be added.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ADMINISTRATIVE INFORMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.2</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SPECIFICATION OF CONTENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.3</td>
</tr>
<tr>
<td>I.4</td>
</tr>
<tr>
<td>I.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SPECIFICATION OF PACKAGING</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.6</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
### APPENDIX VIII - ADDITIONAL INFORMATION FOR PACKAGES CONTAINING 0.1 KG OR MORE OF URANIUM HEXAFLUORIDE

| (b) | The packaging body and closure mechanism; |
| (c) | The packaging components for thermal protection; |
| (d) | The protection against corrosion; |
| (e) | The protection against contamination; |
| (f) | The shock limiting components; |
| (g) | Testing requirements and controls before first use to transport uranium hexafluoride. |

### AGEING CONSIDERATION

Depending on the package design, the information expected in this section can be provided by the designer directly in the table recommended in para. I.10 of this table. In this case, this section should be left blank.

This section of the PDSR should include:

- (a) Those intended conditions of use of the package which may influence ageing;
- (b) A list of potential ageing mechanisms which are relevant for the package design taking into account its intended conditions of use;
- (c) Operational measures (including maintenance and inspection before shipment) to monitor and limit the ageing effects;
- (d) Analysis on the influence of the ageing of packaging and contents on the design assumptions for demonstration of compliance with the regulations including the technical analyses in Part 2 of the PDSR, considering the specified intended use conditions, ageing mechanisms and operational measures. See para 613A.5 of SSG-26 (Rev. 1) [2].

### PACKAGE PERFORMANCE CHARACTERISTICS

The following information should be added, when necessary:

This section should describe the main design principles and performance characteristics of the package design to meet the different safety requirements in the Transport Regulations (e.g. leakage, stress, rupture).

Furthermore, this section should summarize the analyses performed in Part 2 and describe how analysis assumptions and data used for the safety analysis – especially regarding leakage, stress, rupture - are derived from the design and the behaviour of the package under routine, normal and accident conditions of transport, also taking into account ageing mechanisms (see para. I.7 of this table).

This should help to ensure that the design and the various parts of the safety demonstration are compatible with one another.

### COMPLIANCE WITH REGULATORY REQUIREMENTS

The PDSR should also include a complete list of all paragraphs of the Transport Regulations and other international or national regulations applicable to packages containing 0.1 kg or more of uranium hexafluoride.
Demonstration of compliance with these paragraphs should be by reference to where in the PDSR compliance is demonstrated, or other justification. Annex I provides references to applicable paragraphs of the Transport Regulations for packages containing 0.1 kg or more of uranium hexafluoride.

**OPERATION**

| I.11 | The PDSR should also include the measures to be implemented to assure compliance with para. 420 in [1]. |

**MAINTENANCE**

| I.12 | The PDSR should also include the measures to be implemented to assure compliance with ISO 7195 Standard, as required by para. 631 in [1]. |

**GAP ANALYSIS PROGRAMME**

| I.13 | Additional information about the systematic procedure for a periodic evaluation of changes in technical knowledge should be provided, if necessary. |

**MANAGEMENT SYSTEM**

| I.14 | The PDSR should include the specification of the management system as requested in para. 306 in [1] to ensure compliance with the relevant provisions. The management system should cover:  
(a) Design, PDSR, documentation, records;  
(b) Manufacture and testing;  
(c) Operation (loading, transport, storage in transit, receipt, and unloading);  
(d) Maintenance, repair and inspection.  
The management system should be appropriate to the complexity of the design of the package to ensure that the package is designed to demonstrate it meets the regulatory requirements. This should include a reliable document control system.  
The actions to be performed to check the compliance of the operational documents with the PDSR and the management of deviations detected in the framework of any transport activity should be described in the management system.  
For all components significant for safety, the PDSR should define the parameters to be guaranteed and the level of controls during manufacturing and maintenance.  
More detailed guidance is available in TS-G-1.4 [4]. |

**PACKAGE ILLUSTRATION**

| I.15 | A reproducible illustration should be provided showing the make-up of the package, including shock absorbers, devices for thermal protection and packaging inserts, if applicable. |
### Part 2

**GENERAL INFORMATION**

<table>
<thead>
<tr>
<th>II.1 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 para. I.7 of this table. The level of detail of the analysis should consider the complexity of the package design and the existing safety margins. Depending on the way of demonstration, for some of the technical analyses of Part 2, demonstration of compliance can be provided by the designer directly in the table recommended in para. I.7 of this table. Conversely, the complexity of some analyses may require that the relevant section of the PDSR be divided in several documents or includes appendices.</th>
</tr>
</thead>
</table>

**GENERAL CONSIDERATIONS**

<table>
<thead>
<tr>
<th>II.4 For each of the technical analyses in paras II.14 to II.16 of this table, the following considerations apply.</th>
</tr>
</thead>
</table>

**REFERENCE TO PACKAGE DESIGN**

<table>
<thead>
<tr>
<th>II.5 The package design should be precisely referenced by mentioning a design drawing or packaging drawing list (see para. I.6 of this table), including revision number, and the specification of the contents (see paras I.3 to I.5 of this table), with revision number, as appropriate.</th>
</tr>
</thead>
</table>

**ACCEPTANCE CRITERIA AND DESIGN ASSUMPTIONS**

<table>
<thead>
<tr>
<th>II.6 The acceptance criteria for the technical analyses and the package design assumptions in terms of geometry or performance characteristics should be defined and justified when necessary. The acceptance criteria are the quantitative limits specified by the designer derived from the regulatory criteria and other applicable standards to meet the regulatory requirements. The design assumptions include the design specification provided in paras I.3 to I.6 of this table and other assumptions derived from the design specification and used in the technical analyses. The design assumptions should take into account ageing mechanisms, as necessary (see also para. 613A.5 in [2]).</th>
</tr>
</thead>
</table>

**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 para. 701 in [1]):

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

When a programme of tests is implemented for a specific design to be approved by the competent authority, the competent authority should be notified of the programme in advance of the testing and the competent authority should be allowed to witness testing. When such a programme of tests is done without competent authority approval, but is part of the safety analysis, its validity is to be determined by the competent authority.

(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 specified in paras II.14 to II.19 of this table should include a description of the analysis technique used, its limitations and accuracy, together with the demonstration of the correct application of the technique 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. This may include sensitivity analysis.

The performance characteristics of the package design should be assessed. When determined to be necessary, the results of sensitivity analysis and levels of accuracy should be stated.

More than one sequence of tests might 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.

The results of the technical analyses should be compared with the acceptance criteria. The package design assumptions for subsequent analyses should be justified and regulatory compliance should be demonstrated accordingly.
## TECHNICAL ANALYSES

### STRUCTURAL ANALYSIS

| II.14 | The general considerations for all technical analyses have to be taken into account when performing the structural analysis, in order to demonstrate compliance with paras 632 (a) and (b) in [1].

The mechanical behaviour (including thermal stresses, fatigue, brittle fracture, creep, if applicable) under routine, normal and accident conditions of transport should be assessed, for

(a) The components of the containment system;
(b) Any other package components for which their performance may have a consequential effect upon (a).

The following remarks should be taken into account:

(i) **General remarks**

1) 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 the temperature range applicable to the type of package.

2) 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 considering the temperature range applicable to the type of package, or moisture should be analysed;
   - The safety against brittle fracture, considering the temperature range applicable to the type of package, should be analysed;
   - It should be verified that content is not liable to damage the containment system;
   - The condition of the containment system should be determined to enable the requirements of I.3 of this table to be demonstrated within the temperature range applicable to the type of package;
   - The ability to withstand the maximum pressure during the thermal test (elevation of pressure of UF₆) should be demonstrated.

(ii) **Experimental mechanical testing**

1) The package orientations, in accordance with para. 722.6 in [2], 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.) and of the protection objective (containment) should be determined.

For instance, the following aspects should be considered:

- Tests which maximise the stresses and acceleration (flat, slap down): the greater the impact area, the harder the impact (constant stiffness per unit area assumed);
Tests which maximise the deformation (on corner, on edges): in contrast, the smaller the impact area, the greater the crushing;
Tests which maximise the damages to valves, notably by a puncture bar;
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 is much higher.

2) For reduced scale models, similar or conservative geometry and material properties are to be used as with the original design.

3) 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.

4) Representativeness of drop tests performed with reduced scale models should be demonstrated for the following:
   • Drop heights: 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;
   • Appropriate geometry scaling of all components;
   • 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;
   • Welding seams should be similar for scale model and package design;
   • In case of reduced scale model drop testing with significant deformations of impact limiters, the original package performance should be carefully justified.

The tests should be conducted and reported in accordance with a management system. The test report should address the verification of the package before testing, the description of the test site, the measurement equipment used and its calibration, the results of performed measurements. This report should also contain pictures showing and explaining the performing conditions of the tests and their results.

(iii) Calculation

1) See point 1 under (ii) above;
2) Validated computer codes should be used. It should be justified that input parameters (material laws, characteristic values, boundary conditions etc.) describe sufficiently and precisely the real 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;
4) Data used (material laws, boundary conditions, load assumptions etc.) and calculation results are to be documented comprehensively.
### APPENDIX VIII - ADDITIONAL INFORMATION FOR PACKAGES CONTAINING 0.1 KG OR MORE OF URANIUM HEXAFLUORIDE

| II.15 | The general considerations for all technical analyses have to be taken into account when performing the thermal analysis. Additionally, the temperatures of the package components should be assessed in accident (see para. 659 (b) in [1]) conditions of transport, including the thermal behaviour of the following:  
|       | (a) The components of the containment system;  
|       | (b) The package components for which their performance will have a consequential effect upon (a).  
|       | The demonstration is limited to show compliance with para. 632 (c) in [1].  
|       | The following remarks should be taken into account:  
|       | • Consideration of the effects of insolation on a period of 12 hours in accordance with para. 657 in [1]. Averaging on 24 hours should not be accepted;  
|       | • Justification of simplifying assumptions used for calculation in normal and accident conditions of transport;  
|       | • Analysis of the package in accident conditions of transport under the position more penalizing (horizontal or vertical);  
|       | • Consideration of the solar insolation before and after the thermal test as defined in para. 728 in [1];  
|       | • Absorptivity coefficient of the external surface of the package not lower than 0.8, without additional justification (see para. 728 (a) in [1]), during and after the thermal 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;  
|       | • Evaluation of the minimum / maximum temperatures of the various components of the packaging, taking account of all the possible positions for the radioactive contents;  
|       | • When the thermal test is made in a furnace and when it is noted that some package components burn, justification that the concentration of oxygen present in the furnace is controlled and in conformity with that obtained in a hydrocarbon fuel-air fire. In addition, control of heat input should be considered thoroughly;  
|       | • Consideration of the influence of combustible materials which generate additional heat input and affect the fire duration beyond the thermal test;  
|       | • Safety margins on temperature results derived using numerical modelling commensurate with the uncertainty associated to the numerical model. |

### CONTAINMENT DESIGN ANALYSIS

| II.16 | Compliance with para. 632 in [1] is usually demonstrated in the structural analysis. |

### DOSE RATE ANALYSIS

| II.17 | Nothing to be added. |
# CRITICALITY SAFETY ANALYSIS

| II.18 | Nothing to be added. |

# OTHER ANALYSES

| II.19 | Nothing to be added. |
REFERENCES


[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Methodology for a Safety Case for a Dual Purpose Cask for Storage and Transport of Spent Fuel, IAEA-TECDOC-****, IAEA, Vienna (201*) (under publication)


## ANNEX I

### MATRIX OF APPLICABLE REQUIREMENTS OF THE TRANSPORT REGULATIONS FOR DIFFERENT PACKAGE TYPES AND ADDITIONAL PROVISIONS

<table>
<thead>
<tr>
<th>SSR-6 (Rev. 1) [1]</th>
<th>Package Type</th>
<th>Additional provisions</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exected</td>
<td>IP-1</td>
<td>IP-2</td>
<td>IP-3</td>
</tr>
<tr>
<td>408-411</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>412-414</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>415, 416</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>417, 418</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>419, 420</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>422-427</td>
<td>x</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- LSA classification and activity limits, §410: transport by air
- SCO classification and activity limits
- If special form radioactive material or LDRM is present, add reference to approval certificate
- Classification as fissile material, exceptions and restrictions
- Classification as uranium hexafluoride and restrictions
- Classification as excepted package
## ANNEX I – REGULATORY REQUIREMENTS AND PACKAGE TYPE

<table>
<thead>
<tr>
<th>SSR-6 (Rev. 1)</th>
<th>Package Type</th>
<th>Additional provisions</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exected IP-1</td>
<td>IP-2 IP-3 A B(U), B(M) C Fissile UF6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>429-430</td>
<td>x</td>
<td></td>
<td>Activity limit for type A package</td>
</tr>
<tr>
<td>431, 432</td>
<td>x</td>
<td></td>
<td>Classification as type C package and activity limits</td>
</tr>
<tr>
<td>433</td>
<td>x</td>
<td></td>
<td>Activity limits for type B(U) and B(M) packages by air</td>
</tr>
<tr>
<td>501</td>
<td>x x x x x x x</td>
<td></td>
<td>Requirements before 1st shipment</td>
</tr>
<tr>
<td>502, 503</td>
<td>x x x x x x x</td>
<td></td>
<td>Requirements before each shipment</td>
</tr>
<tr>
<td>504</td>
<td>x x x x x x x</td>
<td></td>
<td>Additional items in the package</td>
</tr>
<tr>
<td>507</td>
<td>x x x x x x x</td>
<td></td>
<td>Other dangerous properties</td>
</tr>
<tr>
<td>515-516</td>
<td>x</td>
<td></td>
<td>Excepted package requirements</td>
</tr>
<tr>
<td>517</td>
<td>x x x</td>
<td></td>
<td>Dose rate of unshielded LSA or SCO</td>
</tr>
<tr>
<td>521</td>
<td>x x x</td>
<td></td>
<td>Package for LSA material and SCO</td>
</tr>
<tr>
<td>522</td>
<td>x x x</td>
<td></td>
<td>Activity limit for LSA and SCO</td>
</tr>
</tbody>
</table>
# ANNEX I – REGULATORY REQUIREMENTS AND PACKAGE TYPE

<table>
<thead>
<tr>
<th>SSR-6 (Rev. 1)</th>
<th>Package Type</th>
<th>Additional provisions</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exected</td>
<td>IP-1</td>
<td>IP-2</td>
<td>IP-3</td>
</tr>
<tr>
<td>526</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>527, 528</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>533-536</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>575</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>578</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>606-607-618</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>619-621</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>622-624-625</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>626-630</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>631-634</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## ANNEX I – REGULATORY REQUIREMENTS AND PACKAGE TYPE

<table>
<thead>
<tr>
<th>SSR-6 (Rev. 1) [1]</th>
<th>Package Type</th>
<th>Exected</th>
<th>IP-1</th>
<th>IP-2</th>
<th>IP-3</th>
<th>A</th>
<th>B(U), B(M)</th>
<th>C</th>
<th>Fissile</th>
<th>UF6</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>635 636</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>Minimal dimensions</td>
</tr>
<tr>
<td>637</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>Seal</td>
</tr>
<tr>
<td>638-647</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Type A</td>
</tr>
<tr>
<td>648</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>b) only</td>
<td>b) only</td>
<td>Type A – release criteria</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>649</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Type A - liquids</td>
</tr>
<tr>
<td>650</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Type A - liquids</td>
</tr>
<tr>
<td>651</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Type A - gases</td>
</tr>
<tr>
<td>652</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Type B(U)</td>
</tr>
<tr>
<td>653-657</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Type B(U)</td>
</tr>
<tr>
<td>658-660</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Type B(U)</td>
</tr>
<tr>
<td>661-666</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Type B(U)</td>
</tr>
<tr>
<td>667, 668</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B(M) only</td>
</tr>
<tr>
<td>669-672</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Type C</td>
</tr>
<tr>
<td>673</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fissile material</td>
</tr>
</tbody>
</table>
## ANNEX I – REGULATORY REQUIREMENTS AND PACKAGE TYPE

<table>
<thead>
<tr>
<th>SSR-6 (Rev. 1) [1]</th>
<th>Package Type</th>
<th>Additional provisions</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exected IP-1 IP-2 IP-3 A B(U), B(M) C Fissile UF6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>674, 675</td>
<td></td>
<td>x</td>
<td>CSI control with exception from CA approval of package design for fissile material</td>
</tr>
<tr>
<td>676 - 686</td>
<td></td>
<td>x</td>
<td>Packages containing fissile material</td>
</tr>
<tr>
<td>701</td>
<td>x x x x x x x x x</td>
<td>Demonstration of compliance</td>
<td></td>
</tr>
<tr>
<td>702</td>
<td>x x x x x x x x</td>
<td>Assessment after tests</td>
<td></td>
</tr>
<tr>
<td>713-715</td>
<td>x x x x x x x</td>
<td>Preparation of a package for testing</td>
<td></td>
</tr>
<tr>
<td>716</td>
<td>x x x x x x x x</td>
<td>Integrity of containment, shielding and assessing criticality safety</td>
<td></td>
</tr>
<tr>
<td>717</td>
<td>x x x x x x x x</td>
<td>Target for drop tests</td>
<td></td>
</tr>
<tr>
<td>718</td>
<td></td>
<td>x</td>
<td>Structural test</td>
</tr>
<tr>
<td>719-720</td>
<td>x x x x x x x</td>
<td>General provisions for normal conditions tests</td>
<td></td>
</tr>
<tr>
<td>721</td>
<td>x x x x x</td>
<td>Water spray test</td>
<td></td>
</tr>
</tbody>
</table>
## ANNEX I – REGULATORY REQUIREMENTS AND PACKAGE TYPE

<table>
<thead>
<tr>
<th>SSR-6 (Rev. 1) [1]</th>
<th>Package Type</th>
<th>Additional provisions</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excluded</td>
<td>IP-1</td>
<td>IP-2</td>
<td>IP-3</td>
</tr>
<tr>
<td>722</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>723</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>724</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>725</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>726</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>727 (a)</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>727 (b)</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>727 (c)</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>728</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>729</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>730</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>731-733</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>734</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
## ANNEX I – REGULATORY REQUIREMENTS AND PACKAGE TYPE

<table>
<thead>
<tr>
<th>SSR-6 (Rev. 1)</th>
<th>Package Type</th>
<th>Additional provisions</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Excepted IP-1 IP-2 IP-3 A B(U), B(M) C Fissile UF6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>735</td>
<td></td>
<td>x</td>
<td>Puncture/tearing test</td>
</tr>
<tr>
<td>736</td>
<td></td>
<td>x</td>
<td>Enhanced thermal test</td>
</tr>
<tr>
<td>737</td>
<td></td>
<td>x</td>
<td>Impact test</td>
</tr>
</tbody>
</table>
## ANNEX II

### REFERENCE DOCUMENTS USED BY COMPETENT AUTHORITIES FOR TECHNICAL ASSESSMENTS

<table>
<thead>
<tr>
<th>Country</th>
<th>Reference Documents</th>
</tr>
</thead>
</table>
| **Canada** | * ISO 2919 “Sealed radioactive sources - General requirements and classification”  
* ISO 9978 “Sealed Radioactive Sources - Leak Test Methods”  
* ISO 7195 “Packaging of uranium hexafluoride for transport”  
* ANSI N14.1 “Uranium Hexafluoride – Packaging for Transport”  
* ISO 12807 “Safe transport of radioactive materials - Leakage testing on packages”  
* ANSI N14.5 “Leakage Tests on Packages for Shipment of Radioactive Materials”  
* ANSI N14.7, Guidance for Packaging Type A - Quantities of Radioactive Materials  
* RD-364, Joint Canada - United States Guide for Approval of Type B(U) and Fissile Material Transportation Packages  
* ISO 9001, Quality management systems — Requirements |
| **France** | *ASN Guide N°7 – Transport – Transport of packages or radioactive materials for civil use on public domain  
Vol. 1: Applications for package design and shipment approvals : legal context, required documentation, approval certificate template, applicant obligations, reference demonstration methods and parameters, experience feedback of assessment key issues) – Vol. 2: European PDSR (Package Design Safety Reports) – Vol.3: Conformity of package designs that do not require a certificate of approval  
* ISO 2919 « Sealed radioactive sources - General requirements and classification»  
* ISO 9978 « Sealed Radioactive Sources - Leak Test Methods »  
* ISO 7195 « Packaging of uranium hexafluoride for transport »  
* ANSI N14.1 « Uranium Hexafluoride – Packaging for Transport »  
* ISO 12807 « Safe transport of radioactive materials - Leakage testing on packages»  
* ISO 10276 «Trunnions for packages used to transport radioactive material »  
* NF EN 25-030 – « Éléments de fixation - Assemblages vissés - Partie 1 : règles générales de conception, de calcul et de montage » |
<table>
<thead>
<tr>
<th>Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td>* VDI 2230 – “Systematic calculation of high duty bolted joints”</td>
</tr>
<tr>
<td>* ROARK’s Formulas for stress and strain; 7th edition, Warren C. YOUNG</td>
</tr>
<tr>
<td>* Catalogue PMDS, CEA, Tome I « Ecrans de protection contre les rayonnements ionisants »</td>
</tr>
<tr>
<td>* NF EN 10228-3, «Essais non destructifs des pièces forgées en acier - contrôle par ultrasons des pièces forgées en aciers ferritiques et martensitiques »</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td>* ANSI N14.1 “Uranium Hexafluoride – Packaging for Transport”</td>
</tr>
<tr>
<td>* BAM-GGR 007 “Leitlinie zur Verwendung von Gusseisen mit Kugelgraphit für Transport- und Lagerbehälter für radioaktive Stoffe“</td>
</tr>
<tr>
<td>* BAM-GGR 008 “Richtlinie für numerisch geführte Sicherheitsnachweise im Rahmen der Bauartprüfung von Transport- und Lagerbehältern für radioaktive Stoffe“</td>
</tr>
<tr>
<td>* BAM-GGR 011 “Quality Assurance Measures of Packagings for Competent Authority Approved Package Designs for the Transport of Radioactive Material”</td>
</tr>
<tr>
<td>*BAM-GGR 012 “Leitlinie zur Berechnung der Deckelsysteme und Lastanschlagsysteme von Transportbehältern für radioaktive Stoffe“</td>
</tr>
<tr>
<td>* DIN 25415 part 1 “Radioactively contaminated surfaces - Method for testing and assessing the ease of decontamination”</td>
</tr>
<tr>
<td>* FKM Guideline “Fracture Mechanics Proof of Strength for Engineering Components”</td>
</tr>
<tr>
<td>* FKM Richtlinie “Rechnerischer Festigkeitsnachweis für Maschinenbauteile”</td>
</tr>
<tr>
<td>* ISO 2919 “Sealed radioactive sources - General requirements and classification”</td>
</tr>
<tr>
<td>* ISO 7195 “Packaging of uranium hexafluoride for transport”</td>
</tr>
<tr>
<td>* ISO 9978 “Sealed Radioactive Sources - Leak Test Methods”</td>
</tr>
<tr>
<td>* ISO 12807 “Safe transport of radioactive materials - Leakage testing on packages”</td>
</tr>
<tr>
<td>* KTA 3905 “Load Attaching Points on Loads in Nuclear Power Plants”</td>
</tr>
<tr>
<td>* R6 - Assessment of the Integrity of Structures Containing Defects. British Energy Generation Ltd.</td>
</tr>
<tr>
<td>* VDI 2230 “Systematic calculation of high duty bolted joints”</td>
</tr>
<tr>
<td>* DIN 25712 “Criticality safety taking into account the burnup of fuel for transport and storage of irradiated light water reactor fuel assemblies in casks”</td>
</tr>
<tr>
<td>United States of America</td>
</tr>
<tr>
<td>-------------------------</td>
</tr>
</tbody>
</table>
* ANSI N14.1 “Uranium Hexafluoride – Packaging for Transport”  
* ISO 2919 “Sealed Radioactive Sources – General Requirements and Classification”  
* ISO 9978 “Sealed Radioactive Sources – Leak Test Methods” |