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THE R80 PACKAGE: A NEW TYPE B(U), TYPE A AND INDUSTRIAL PACKAGE FOR MULTIPLE RADIOACTIVE WASTE STREAMS

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ABSTRACT

Background

ROBATEL and Transnubel partnered in the development of a new package to cover the need of the nuclear industry for transportation of legacy and other miscellaneous wastes from operation or decommissioning of nuclear facilities.

ROBATEL Industries is a worldwide nuclear turnkey services provider, especially regarding bespoke radioactive material transportation casks. For decades it has designed numerous package models, type B ones especially which require regulators approvals. Based on such a broad experience, the company acquired a comprehensive knowledge of the technical issues related to safety and to international regulations.

R80: a modular package to fit diverse needs

ROBATEL Industries delivered two R80 packages and their ancillary equipment early 2019. This package has been specifically thought from the beginning to carry all forms and very diverse waste streams using all transportation modes (road, rail, sea, air).
It can be used as an industrial or type A package without the impact limiters where 3 packages can be shipped at a time on the same trailer. In type B(U) configuration, the license allows 2 packages to be shipped at a time on the same trailer (1 shipment).
The cask comes in different configurations with different shielding thicknesses with or without drainage system, with the same overall dimensions (Height 2.11m, Diameter 1700mm, Gross weight 11000kg).

The aim of this paper is to present this new R80, industrial, type A and type B(U) package, design and licensing strategy implemented by ROBATEL Industries and Transnubel to include a maximum of different content types and forms, and describing the challenges and focusing on its specificities, making it a very versatile cask design.

INTRODUCTION

The CAROLINE-R80 cask is designed as a flexible solution, the safety case has been submitted to the FANC (Belgium Nuclear Safety Authority) in spring 2017 and we submitted our responses to the final RAIs mid-2018. ROBATEL has manufactured and delivered two cask bodies and two sets of impact limiters (as of July 2019).

Transnubel and ROBATEL Industries have designed a new transportation package, "CAROLINE-R80" dedicated to the transport of radioactive material.
This package is dedicated to the transportation of:

- 400 L standard barrels which contain solid materials from nuclear facilities processes.
- Baskets which contain activated or contaminated materials from the nuclear industry.

Two different designs of the body of the package are available (CAROLINE-R80/ST and CAROLINE-R80/ES). The main difference between these two configurations is the thickness of the radiological shielding. The shock absorbers are identical:

- CAROLINE-R80/ST provides less radiological shielding and a wider cavity (ST stands for standard),
- CAROLINE-R80/ES provides a stronger shielding (ES stands for Extra Shielding) and a narrower cavity.

According to the European Agreement [Ref. 1], the CAROLINE-R80 transport package model is of type B(U) non-fissile (UN 2916). The design of the package model and the safety file take into account the specifications of road, rail, maritime, inland waterways and air transport regulation [Ref. 1 to Ref. 6].
The design, welding qualification and nondestructive examination rules for the CAROLINE-R80 cask are determined in accordance with the ASME requirements.

DESCRIPTION OF R80 DESIGN

The CAROLINE-R80 package model will be available in two distinct designs:

- One with a wide cavity and less radiological shielding (CAROLINE-R80/ST);
- the other one with a narrower cavity and a stronger radiological shielding (CAROLINE-R80/ES). These two designs of the same package model are described below in this chapter.

The CAROLINE-R80 package is of cylindrical shape. It is used and transported vertically and is composed of the following components:

- A body which comprises:
  - a cylindrical body made of stainless steel, lead and ROBATEL compound PNT7™,

  - a thick plug made of stainless steel which is put in place on the flange,
  - a lid closed by 16 bolts which is put in place over the thick plug,
  - 1 pin for the orientation of the lid.

- An upper shock absorber which comprises:
  - phenolic foam (FENOSOL^{TM}) dedicated to impact effect limitation and fire protection,
  - a stainless steel casing,
  - a circular anti-puncture stainless steel plate (thickness 15 mm),
  - a cylindrical stainless steel shell on which are welded the stowage components.

- A lower shock absorber which comprises:
  - phenolic foam (FENOSOL^{TM}) dedicated to impacts effects limitation and fire protection,
  - a stainless steel casing,
  - a cylindrical stainless steel shell

Illustrations of the CAROLINE-R80 packaging are presented in following figure:

Figure 1. general view and picture of the R80 package.

The main masses and dimensions[1] are:

Nominal dimensions (mm)	***CAROLINE-R80/ST***	***CAROLINE-R80/ES***
overall height	2 111	2 111
overall external diameter	1 700	1 700
body height (with its lid; without impact limiters)	1 485	1 485
external diameter of the body	1 054	1 004
internal height of the cavity (closed by the lid)	1 163	1 008

[1] Masses and dimensions are likely to change during the design process

internal diameter of the cavity	788	670

Nominal masses (kg)	***CAROLINE-R80/ST***	***CAROLINE R80/ES***
total mass of the empty body	4 780	6 900
mass of the upper shock absorber	1 030	1 030
mass of the lower shock absorber	790	790
mass of the equipped lid	370	270
Mass of the plug	735	695
maximal mass of the empty package	7 700	9 700

The two casks ES and ST versions have been designed with an additional bottom drain port for wet loading/unloading conditions. These two options take the same features as the ST and ES version and are named STW and ESW respectively.

SHIPMENT CONFIGURATIONS

The package will be shipped in different configurations depending on the classification of the shipment. Either as IP, type A or Type B shipment.

In case of Type B shipment, the R80 will be shipped by 2 at a time with the impact limiters and installed on a specific trailer. Furthermore, for this more demanding shipments, Transnubel have developed a specific autonomous loading and unloading system (presented by Transnubel in this PATRAM Conference 2019). This special system allows to significantly reduce the dose uptake by workers during the operations. The figure 3 below show the testing of this system having been performed. Further details are presented in article #1262.

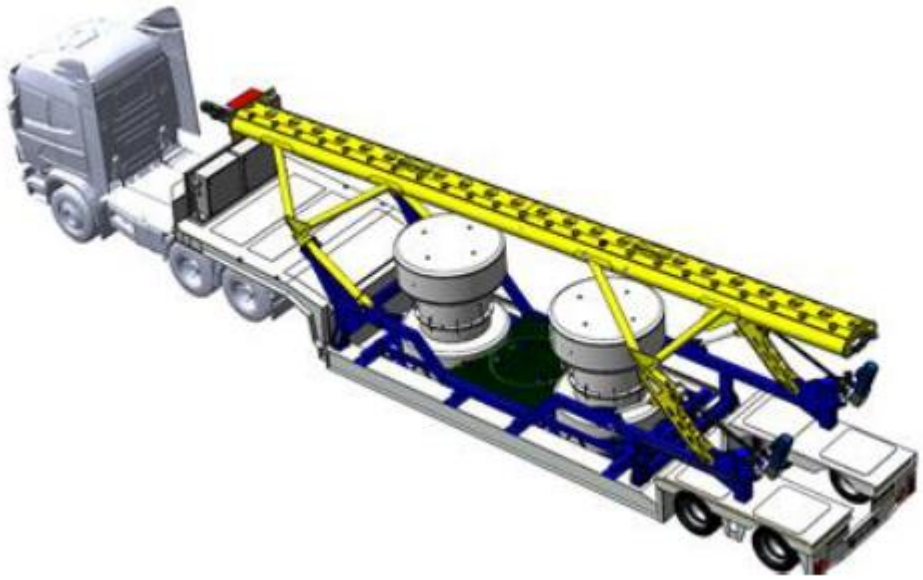

Figure 2. CAROLINE-R80 autonomous loading/unloading system.

IP-2 and Type A shipments do not require the use of impact limiter and can be loaded 3 at a time on a trailer for one shipment as shown in Figure 2 hereafter.

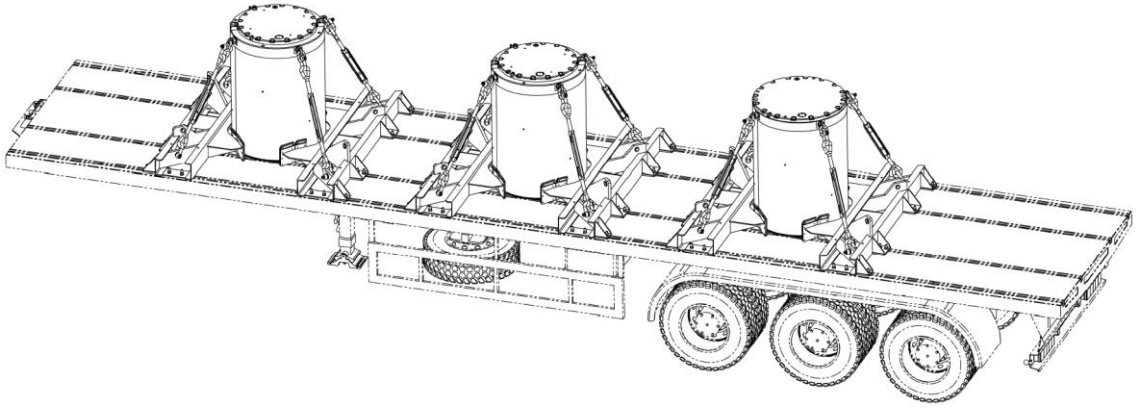

Figure 3. R80 tie-down configuration for IP-2/Type A shipments

DESCRIPTION OF THE CONTENTS

The challenge with trying to license a type B(U) cask for generic contents resides in that the unknown of the contents like their specific activities, their distributions etc. shall be modelled in a representative and conservative way in the Safety File. However, generic implies that we are trying to allow for the shipment of very diverse radioactive waste forms, leading to many unknown about contents at the design stage and making the shielding model very conservative to cover all future potential waste streams shipped in the R80.

To overcome the need for excessive conservatism and to keep the cask efficient, ROBATEL built several content models representing several secondary container configurations, thus

allowing more representative shielding models in NCT and HAC, and maximizing the authorized activity transported within the package.

CAROLINE-R80 packages are dedicated to the transport of generic contents from different nuclear facilities. Spacers are foreseen to limit the movements of the content.

1.1. Content 1

is solid activated and/or contaminated radioactive material from nuclear facilities which may be packed into either:

1. a metallic basket, or
2. a 200L drum, or
3. a 400L drum.

The package, when loaded with this content, is excepted from fissile regulatory requirements:

- either because the content does not contain fissile material,
- or because the content contains fissile material but that are excepted under §417 of IAEA [Ref. 2],
- or because the package is excepted from application of the fissile requirements (§676-686 of IAEA [Ref. 2]) under §674 or 675 of IAEA [Ref. 2].

The content no.1 is radioactive material that may be packed into either:

↳ a **metallic basket** which is then directly loaded inside the packaging's cavity;
Several designs of metallic basket can be used depending on the operating needs (for instance: adaptation of the lifting devices, draining system for wet loading/unloading, etc...).

↳ a **200L drum** which must be loaded inside the packaging's cavity when equipped with a dedicated internal device (made of stainless steel) in order to wedge it vertically and horizontally (centering it in the cavity);
Several designs of such an internal wedging device can be used depending on operating needs.

↳ a **400L drum** which must be loaded inside the packaging's cavity when equipped with a dedicated internal device (made of stainless steel) in order to wedge it vertically.
Several designs of such an internal wedging device can be used depending on operating needs.

The maximum weights of the content no.1 (i.e. radioactive material + internal devices: drum, basket, wedging) shall conform to the following limits (depending on the loading configuration):

Using a metallic basket:	**Maximum total weight:**	**≤ 2 145 kg**
Using a 200L drum:	**Maximum total weight:**	**≤ 350 kg**
Using a 400L drum:	**Maximum total weight:**	**≤ 2 145 kg**

Content 1 is dedicated to CAROLINE-R80/ST packages.

1.2. Content 2

The content no.2 is solid activated and/or contaminated radioactive material from nuclear facilities which is packed into a TV400/80 drum.

The package, when loaded with this content, is excepted from fissile regulatory requirements:

- either because the content does not contain fissile material,
- or because the content contains fissile material but that are excepted under §417 of IAEA [Ref. 2],
- or because the package is excepted from application of the fissile requirements (§676-686 of IAEA [Ref. 2]) under §674 or 675 of IAEA [Ref. 2].

The content no.2 is radioactive material that is packed into TV400/80 drum. This is a shielded drum whose main radiological protections must meet the following requirements:

- Radial thickness ≥ 121 mm (steel)
- Bottom thickness ≥ 67 mm (steel)
- Top thickness ≥ 15 mm (steel) + 62 mm (lead)

In addition, the maximum weight of the content no.2 (i.e. radioactive material + TV400/80 drum + wedging devices) shall conform to the following limit:
Maximum total weight: ≤ 2 145 kg

Content 2 is dedicated to CAROLINE-R80/ST packages.

1.3. Content 3

The content no.3 is solid activated and/or contaminated radioactive material from nuclear facilities which is packed into a TV400/200 drum.

The package, when loaded with this content, is excepted from fissile regulatory requirements:

- either because the content does not contain fissile material,
- or because the content contains fissile material but that are excepted under §417 of IAEA [Ref. 2],
- or because the package is excepted from application of the fissile requirements (§676-686 of IAEA [Ref. 2]) under §674 or 675 of IAEA [Ref. 2].

The content no.3 is radioactive material that is packed into TV400/200 drum. This is a shielded drum whose main radiological protections must meet the following requirements:

- Radial thickness **≥ 24 mm (steel)**
- Bottom thickness **≥ 21 mm (steel)**
- Top thickness **≥ 15 mm (steel)**

In addition, the maximum weight of the content no.3 (i.e. radioactive material + TV400/200 drum + wedging devices) shall conform to the following limit:

- **Maximum total weight: ≤ 2 145 kg**

Content 2 is dedicated to CAROLINE-R80/ST packages.

1.4. Content 4

The content no.4 is solid activated and/or contaminated radioactive material from nuclear facilities which may be packed into either:

1. a **metallic basket** or
2. a **200L drum**.

The package, when loaded with this content, is **excepted from fissile regulatory requirements**:

- either because the content does not contain fissile material,
- or because the content contains fissile material but that are excepted under §417 of IAEA [2],

or because the package is excepted from application of the fissile requirements (§676-686 of IAEA [2]) under §674 or 675 of IAEA [2].

The content no.4 is radioactive material that may be packed into a either:

↳ a **metallic basket** which is then directly loaded inside the packaging's cavity;
Several designs of metallic basket can be used depending on the operating needs (for instance: adaptation of the lifting devices, draining system for wet loading/unloading, etc...).

a **200L drum** which must be loaded inside the packaging's cavity when equipped with a dedicated internal device (made of stainless steel) in order to wedge it vertically and horizontally (centering it in the cavity).
Several designs of such an internal wedging device can be used depending on operating needs.

The maximum weight of the content no.4 (i.e. radioactive material + internal devices: drum, basket, wedging) shall conform to the following limits (depending on the loading configuration):

- **Using a metallic basket: Maximum total weight: ≤ 600 kg**
- **Using a 200L drum: Maximum total weight: ≤ 350 kg**

Content 2 is dedicated to CAROLINE-R80/ES packages.

1.5. Content current limitations

The gamma emitters activity in the contents is limited in order to lower the dose rate around the CAROLINE-R80 package and respect the regulatory limitations.

- Shielding point of view:

A maximum allowable gamma/neutron spectrum providing the limiting dose rates from was defined for both designs of the CAROLINE-R80 package model.

Compliance of the contents with this limitation will be verified by the consignor/shipper.

- Criticality point of view:

The contents of CAROLINE-R80 are non-fissile or fissile excepted for now.

CAROLINE-R80 contents may contain fissile material but shall meet the requirements of IAEA §674 [Ref. 2]. The contents of the CAROLINE-R80 are excepted from the requirements of §676-686. Contents limitations concerning fissile material are defined and compliance of the contents with these limitations will be verified by the consignor.

- Radiolysis point of view

Radiolysable materials may be part of the contents of the CAROLINE-R80 package.

A radiolysis analysis was performed to determine the maximum allowable gas production limit, in order to limit the production of hydrogen and ensure a concentration below the limit of inflammability.

Compliance of the contents with this limitation will be verified by the consignor.

CONCLUSION

ROBATEL Industries and TNB have combined their strengths & experience to provide solutions to the market to safely load, transport and unload radioactive waste drums as either industrial packages, Type A or Type B.
We are expecting to receive the Certificate of Compliance from the Belgium FANC in 2019
The content definitions have been thought to make this cask versatile while optimizing the payload. For more versatility, The R80 was evaluated internally for fissile content shipped inside the R80-ES and the R80-ST versions. This next step is currently ongoing and will offer in the future, the possibility to transport major actinides like U^{235} and Pu^{239}.

REFERENCES

Ref. 1 ADR – European Agreement Concerning the International Carriage of Dangerous Goods by Road. Applicable as from 1 January 2015.

Ref. 2 IAEA – Specific Safety Requirements SSR-6
Regulations for the Safe Transport of Radioactive Material – 2012 edition.

Ref. 3 European PDSR Guide Issue 3 (December 2014)
Technical Guide – Package Design Safety Reports for the Transport of Radioactive Material

Ref. 4 RID – Convention Concerning International Carriage by Rail (COTIF).
Appendix C – Regulations concerning the international Carriage of Dangerous Goods by Rail – January 2015.

Ref. 5 IMDG – International Maritime Dangerous Goods Code – 2014 Edition.

Ref. 6 ICAO – Annex 18 to the convention on international civil aviation: The Safe Transport of Dangerous Goods by Air.