The CAROLINE-R80 Package: A new Type B(U), Type A and Industrial Package for multiple radioactive waste streams

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Summary

1. Introduction
   - ROBATEL presentation
   - Context presentation

2. Presentation of the R80 package
   - Design overview
   - Loading capabilities (Content)
   - Operation overview

3. Status of manufacturing and availability

4. Conclusions
ROBATEL Industries presentation

- French firm founded in 1830
- Working for the nuclear industry for over 60 years
- ~ 130 employees
- 3 plants in France (Genas / La Hague / Cadarache)
  - ROBATEL Industries (www.robatel.fr)
- 1 sister company in the USA (Roanoke, Virginia USA)
  - ROBATEL Technologies (www.robateltech.com)

Activities:
- Study / Design / Manufacture / Technical support
- On-site interventions

Fields:
- Shielded cells
- Glove boxes
- Miscellaneous equipment for nuclear industry
- Radioactive Material Transportation Packages:
  - Design of over 80 type B models of package
  - Manufacture of over 1000 packaging specimens
Robatel’s recent Type B designs

Typical ROBATEL Industries cask designs of type B:

<table>
<thead>
<tr>
<th>Name / Type</th>
<th>Content</th>
<th>Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>R72 Type B</td>
<td>R&amp;D Spent Fuel Rods</td>
<td>France</td>
</tr>
<tr>
<td>R73 Type B</td>
<td>Activated Dismantling Waste</td>
<td>France</td>
</tr>
<tr>
<td>R74 Type B</td>
<td>Cemented drums</td>
<td>Belgium/Scotland</td>
</tr>
<tr>
<td>R75 Type B</td>
<td>Activated NPPs Cluster Guides</td>
<td>France</td>
</tr>
<tr>
<td>R76 Type B</td>
<td>Waste Drums; hydrogenous materials</td>
<td>France</td>
</tr>
<tr>
<td>R79 Type B</td>
<td>Waste Drums</td>
<td>Netherlands</td>
</tr>
<tr>
<td>R80 Type B</td>
<td>Waste Drums</td>
<td>Belgium</td>
</tr>
<tr>
<td>RT100 Type B</td>
<td>LLW Class B &amp; C waste (spent resins &amp; filters, irradiated hardware)</td>
<td>USA</td>
</tr>
</tbody>
</table>
The CAROLINE-R80 is a type B package for Multiple, Diverse Nuclear Waste streams

- **Partnership:**
  - TRANSNUBEL
  - ROBATEL Industries

- **Multiple Wastes:**
  - Solid activated and/or contaminated radioactive material from nuclear facilities packed in different kinds of secondary containers
    - Type B(U)
    - Type A
    - Industrial Package

- **ROBATEL’s scope:**
  - Design a new cask, make the PDSR, obtain the certificate of approval, manufacture and deliver 2 casks
The CAROLINE-R80 is a type B package for Multiple, Diverse Nuclear Waste streams

Caroline R80: Flexible solution

- **Multiple Wastes:**
  - Solid activated and/or contaminated radioactive material

- **Multiple primary packaging**
  - Drums of various size, with or without additional shielding
  - Basket

- **Package type:**
  - Type B(U)
  - Type A
  - Industrial Package

- **Mode of transport**
  - Road, rail, sea, air

- **Two main designs**
  - Standard or extra-shielded

- **Option**
  - Drain port for wet loading
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CAROLINE-R80 Design

R80 main parts

- Cylindrical body
  (made of stainless steel, lead and PNT7™ compound)
  - Lead equivalent thickness: 90 or 140 mm

- Shielded plug
  (stainless steel + lead, secured by special lockers)

- Closure lid
  (stainless steel + lead, secured by special lockers)

- Basket, shoring (stainless steel)
  or secondary containers

- Impact limiters
  (stainless steel casing filled with FENOSOL™ foam)
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CAROLINE-R80 Design

Table: Nominal dimensions (mm)

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Standard</th>
<th>Extra shielded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall height</td>
<td>2 111</td>
<td></td>
</tr>
<tr>
<td>Overall external diameter</td>
<td>1 700</td>
<td></td>
</tr>
<tr>
<td>Body height (with its lid; without impact limiters)</td>
<td>1 485</td>
<td></td>
</tr>
<tr>
<td>External diameter of the body</td>
<td>1 054</td>
<td></td>
</tr>
<tr>
<td>Internal height of the cavity (closed by the lid)</td>
<td>1 163</td>
<td>1 008</td>
</tr>
<tr>
<td>Internal diameter of the cavity</td>
<td>788</td>
<td>670</td>
</tr>
<tr>
<td>Total mass of the empty body (kg)</td>
<td>4 780</td>
<td>6 900</td>
</tr>
<tr>
<td>Mass of the upper shock absorber (kg)</td>
<td>1030</td>
<td></td>
</tr>
<tr>
<td>Mass of the lower shock absorber (kg)</td>
<td>790</td>
<td></td>
</tr>
<tr>
<td>Mass of the equipped lid (kg)</td>
<td>370</td>
<td>270</td>
</tr>
<tr>
<td>Mass of the plug (kg)</td>
<td>735</td>
<td>695</td>
</tr>
<tr>
<td>Maximal mass of the loaded package (kg)</td>
<td>10 000</td>
<td>10 300</td>
</tr>
</tbody>
</table>
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CAROLINE-R80 Design summary

- **R80 main characteristics:**
  - Dimensions:
    - Height: 2110 mm
    - Diameter: 1700 mm
  - Gross weight: 10 tons
  - Max payload: 2145 kg
  - **Dry** or **Wet** Loading / Unloading
  - Two Shielding thicknesses available
    - ST Standard
    - ES Extra Shielding
  - Available with Drain ports
    - STW Standard
    - ESW Extra Shielding

**Type B(U)**
CAROLINE-R80 Contents

R80 Contents transported in the CAROLINE-R80/ST and STW versions:
Solid, activated and/or contaminated radioactive materials from nuclear facilities

<table>
<thead>
<tr>
<th>Additional shoring</th>
<th>Basket</th>
<th>200L DRUM</th>
<th>400L DRUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL payload weight</td>
<td>NO</td>
<td>Yes (stainless steel)</td>
<td>Yes (stainless steel)</td>
</tr>
<tr>
<td>weight</td>
<td>2145 KG</td>
<td>350 KG</td>
<td>2145 KG</td>
</tr>
<tr>
<td>Max payload diameter</td>
<td>788 mm</td>
<td>572 mm</td>
<td>760 mm</td>
</tr>
<tr>
<td>Max payload height</td>
<td>1163 mm</td>
<td>851 mm</td>
<td>1040 mm</td>
</tr>
</tbody>
</table>

- 200L equivalent to 55 gal. US
- 400L equivalent to 110 gal. US
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CAROLINE-R80 Contents

- R80 Contents, shipped in the CAROLINE-R80/ES and ESW versions:
  Solid, activated and/or contaminated radioactive materials from nuclear facilities

<table>
<thead>
<tr>
<th></th>
<th>Basket</th>
<th>200L DRUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional shoring</td>
<td>NO</td>
<td>Yes (stainless steel)</td>
</tr>
<tr>
<td>TOTAL payload weight</td>
<td>600 KG</td>
<td>350 KG</td>
</tr>
<tr>
<td>Max payload diameter</td>
<td>600mm</td>
<td>572 mm</td>
</tr>
<tr>
<td>Max payload height</td>
<td>1008 mm</td>
<td>851 mm</td>
</tr>
</tbody>
</table>

- 200L equivalent to 55 gal. US
CAROLINE-R80 Operations

- IP-2 and Type A shipments
  - Up to 3 casks loaded on a trailer at a time
  - 3 x 9200 KG (Loaded cask without impact limiters)
  - Facilitated tie down using ratchet binders
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CAROLINE-R80 Operations

- **Type B shipments**
  - Up to 2 casks loaded onto a dedicated trailer at a time
  - 2 x 11000 KG Max
  - Autonomous loading/unloading system to facilitate cask operations and reduce operators received dose.
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**R80 Safety analysis**

- **Mechanical**
  - Stowage, pressure, thermal elongation, ...

- **Thermal**
  - Heat dissipation, fire test: finite element analysis (ANSYS)

- **Criticality**
  - Monte Carlos simulation: CSAS6 (SCALE)

- **Dose rate evaluation**
  - Monte Carlos simulation: MAVRIC (SCALE)

- **Containment**
  - Double O-ring system
Drop test simulations

- LS-Dyna Finite Element model
- Specific behavior law for the FENOSOL™ foam
- Used to find the most penalizing drops and to define the drop test program
Focus on the FENOSOL™ Foam

- Acquired by ROBATEL with its partner the CEA in 2013

- Use in new ROBATEL packages designs: R79, R80, R83

- Temperature range of use from -180°C to +120°C
- Good shock absorbing efficiency
- High thermal insulation properties
- Classified M1 and F1 according to French standards (safety)
Focus on the FENOSOL™ Foam

- Very good firewall as it doesn’t melt and keeps its structure and geometry when submitted to flames
Focus on the FENOSOL™ Foam

- An isotropic material
- Low mechanical properties temperature dependence
- A large range of densities from 50 kg/m³ to 500 kg/m³
  - Adjustable Mechanical properties depending on needs
- Extensive mechanical and thermal characterization have been done and are constantly improved (R&D),
  - Accurate modeling of drop tests using dynamic FEA codes like LS-dyna
CAROLINE-R80 Status of the project

Project beginning: Jan-2016

PDSR submittal: Jan - 2018

Delivery of 2 casks + associated tools: March 2019

Certificate of Approval issuance: Expected 2019

Total duration for design, safety analysis, certificate of approval, manufacturing of 2 casks and their ancillary equipment: Expected Less than 4 years
Conclusion and future contents

ROBATEL Industries and TRANSNUBEL have combined their strengths & experience to provide the CAROLINE-R80 solutions to the market to safely load, transport and unload radioactive waste drums as either industrial packages, Type A or Type B offering a versatile and complete service.

Future Contents:
The R80 was evaluated internally for fissile contents shipped inside the R80-ES and the R80-ST versions. This next step of evaluation is currently ongoing and will offer in the future, the possibility to transport major actinides like U$^{235}$ and Pu$^{239}$ in addition to the current contents.
THANK YOU FOR ATTENTION