Abstract

ROBATEL is a major actor in the French Nuclear Industry since the 1950s, with a clear focus on international development as a driver of new growth for the group. It is present in France with four ROBATEL Industries sites (Genas, La Hague, Cadarache, Marcoule) and in the USA with Robatel Technologies (Roanoke, VA). ROBATEL develops, licenses, manufactures and maintains transportation and storage casks for radioactive wastes/sources, spent fuels; LLW, ILW and HLW. We also provide custom design and fabrication of equipped Glove Boxes, Hot Cells, Shield Doors and Hatches for the nuclear industry and nuclear medicine. Adding to these products a long experience in the back end, we thus supply waste management lines, including sorting, cementation, incineration, repackaging. This activity makes of ROBATEL a major supplier for the MOX and MELOX plants (France). These activities have lead ROBATEL to develop neutron and thermal shield compounds and shock absorbing foam that are now used around the world: PNT3™, PNT7™, Compound 9™, Compound 10™, Compound 21™, Compound 22™, FENOSOL™. The following article will focus on presenting our hot cells and type B casks for Research Reactor Spent Fuels capabilities and recent solutions that have been implemented.

1. Introduction

ROBATEL Industries has been a supplier of design engineering and fabricated components to the nuclear industry for more than sixty years. During this time, ROBATEL has developed a comprehensive range of skills and experience. Our corporate resume is built on:

• Design and manufacture of hot cells and glove boxes;
• Design and manufacture of process equipment in nuclear environment, such as conveyors, elevators, waste sorting and conditioning units, shield doors and hatches, airlock systems;
• Design and manufacture of gamma and neutron shielding panels;
• Design and manufacture of transportation flasks / casks (Type B);
• Turn-key projects, such as design and manufacture of research laboratory, design, manufacture and supply of waste conditioning plants.

ROBATEL is an international engineering and manufacturing company experienced with deploying projects throughout the world. As early as the 1970’s, ROBATEL was delivering equipped hot cells overseas, in Taiwan, Belgium, Egypt, and Korea in addition to the French national hot cell projects. More recently, ROBATEL Industries has been a strategic supplier in France to the CEA Saclay “LECI” Post irradiation examination facility (see figure 1) and pursuing its international development by supplying major projects in Europe and lately for example to ANSTO in Australia.
The company was also the first one in France to design and manufacture radioactive material transportation cask in 1953 for the French Zoe reactor, using lead material for radiation shielding. Now reaching over 80 designs of type B cask projects for radioactive wastes and nuclear fuels, and counting; The variety of designed and licensed casks for multiple nature of materials and activities, and the constantly evolving regulations lead ROBATEL’s experience to be able to provide fit for purpose solutions to the nuclear industry’s transport and storage challenges. Some recent cask design and supply give a representative overview of the range of solutions that can be offered.

2. Recent Hot cell projects

2.1 The CEA Cadarache VERDON project:

The Verdon installation is unique in the world, it allows fuel samples to be brought to their fusion temperature in a controlled atmosphere, thus reproducing nuclear reactor accident scenarios (See figure 2).

The hot cell structures are composed of stainless steel containment enclosures, lead walls for gamma radiation shielding and ROBATEL PNT7™ Compound as a neutron and thermal shield.

The fuel pins are loaded thought a docking system allowing the connection of spent fuel transportation casks like the R72 type B(f) package.

The Installation is equipped with an induction furnace, gamma spectrometers, micro-chromatography, temperature gradient tubes, iodine filters … to allow scientists to study and analyze accidental configurations on freshly irradiated fuel and the release of fission products.

The purpose of this research program is to identify released fission product and to increase
the knowledge on their physical and chemical forms, in order to improve mitigation pieces of equipment and avoid any potential release in the environment in case of accident.

Principle for fission product release test:
The fuel sample is brought to a temperature of up to 2700°C in an atmosphere mixing variable proportions of water vapor, helium and hydrogen. The released fission products are trapped close to their point of release in an aerosol filter heated at around 150°C. Beyond this filter, gaseous forms of iodine are trapped in a selective filter. Then only the non-condensable injected gases and fission gases are collected in a glovebox outside the hot cell [1].

ROBATEL Industries was appointed for the design manufacturing and commissioning of this complex hot cell system.
This project mobilized multiple discipline skills from the company’s engineering and technical services. They were responsible for:
- Civil Engineering,
- Structural engineering,
- Seismic Calculation,
- Risk analyses
- Radiation shielding (gamma + Neutron)
- Containment enclosures
- Electricity (high and low voltage), Controls & Instrumentation, and automation,
- Ventilation systems,
- Lifting and handling equipment,
- Mechanical inners
- Operation and maintenance Manuals
- On site assembling and testing

2.2 The OPAL’s materials surveillance program from ANSTO (Australia):

ANSTO’s OPAL research reactor is mainly dedicated to medical isotope production. In order to launch their examination and testing of materials from the OPAL materials surveillance program and from research programs, ANSTO awarded a contract to design and manufacture and supply new hot cells (see figure 3).

This program aimed at monitoring changes in structural materials for advanced nuclear power generation systems, in particular to monitor the changes in the properties of the OPAL reactor core materials to ensure changes are as predicted, principal materials are zirconium, and aluminum alloys.

The hot cell structure is made of lead walls and stainless steel containment boundaries. They were design to handle contaminated materials and to contain up to 200GBq of Co60 each.
3. Recent type B cask projects

3.1 Transport of Spent fuel rods for research & development programs – R72:

See below figure 4 showing the R72 cask on its transportation chassis.

This cask has been ordered for R&D purpose by EDF for spent fuel rods transportation. It contains up to 10 rods type UOX or MOX of a total thermal power of 1250 W. The loaded weight is 21.5 tons. The cask is shielded with lead and ROBATEL PNT7™ compound. The rods are put into a canister which is placed into a sealed casing. The casing can be horizontally transferred into the examination hot cells.

Characteristics and design

The R72 package, which general form is cylindrical, is composed of three main parts: its body (closed with two lids at each of its extremities) which is equipped with two shock absorbers. The package is designed to be transported in an horizontal position. See figure 5.

Concerning the R72's inner layout, the package is equipped with a basket placed inside a canister including a shielded plug.

The R72 package ensures all the safety functions required by the transportation regulation:
- Its closing system is ensured by the two lids linked to the body with respectively 21 and 8 screws.
- From a regulatory standpoint the confinement is ensured by the body and its two lids, which are both equipped with a airtight joint. However the canister is also airtight and can be considered as a second confinement system for user operations.
- The biological protection is ensured by the cask body and by the extremity of the canister. It is made of stainless steel, lead and neutron shielding compound. The equivalent gamma shielding is 180 mm of lead.
- The neutron and thermal protection is 210 mm of compound ROBATEL PNT7. It is both an efficient neutron absorbing material and thermal switch protecting the cavity in case of fire.
The body of the cask is equipped with 4 trunnions at the front end and 2 trunnions at the rear end. It could be handled horizontally by 4 trunnions or vertically (front end on top) by 2 or 4 trunnions.

The package is designed in order to be loaded/unloaded under water, or under a loading pool, as well as horizontally, in hot labs cells.

The main dimensions and masses of the package are consigned into the following table:

<table>
<thead>
<tr>
<th>R72's main dimensions</th>
<th>R72's main masses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package length: 6254 mm</td>
<td>Package weight: 21 kg</td>
</tr>
<tr>
<td>Package diameter: Ø1680 mm</td>
<td>Body weight: 19 kg</td>
</tr>
<tr>
<td>Body length: 5445 mm</td>
<td>Front lid weight: 155 kg</td>
</tr>
<tr>
<td>Body diameter: Ø950 mm</td>
<td>Rear lid weight: 25 kg</td>
</tr>
<tr>
<td>Cavity diameter: Ø140 mm</td>
<td>Front shock absorber weight: 1100 kg</td>
</tr>
<tr>
<td>Cavity length: 5330 mm</td>
<td>Rear shock absorber weight: 1100 kg</td>
</tr>
</tbody>
</table>

Figure 5. R72 package
The R72 package can be filled with up to ten fuel rods. Those are placed in a basket introduced into the airtight canister loaded in the cask's cavity. The characteristics of the content of the R72 package are consigned into the following table:

<table>
<thead>
<tr>
<th></th>
<th>UOX</th>
<th>MOX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of fuel rods</td>
<td>≤10</td>
<td>≤10</td>
</tr>
<tr>
<td>Fuel weight</td>
<td>≤25.6 kg</td>
<td>≤25.6 kg</td>
</tr>
<tr>
<td>Burn-up</td>
<td>≤120 000 MWd/tM</td>
<td>≤120 000 MWd/tM</td>
</tr>
<tr>
<td>U235 enrichment (% weight)</td>
<td>≤10 %</td>
<td>≤1.5 %</td>
</tr>
<tr>
<td>Pu rate (% weight)</td>
<td></td>
<td>≤15 %</td>
</tr>
<tr>
<td>Cooling time</td>
<td>≥6 month</td>
<td></td>
</tr>
<tr>
<td>Residual linear thermal power</td>
<td>≤310 W/m</td>
<td>≤310 W/m</td>
</tr>
<tr>
<td>Residual thermal power</td>
<td>≤1250 W</td>
<td></td>
</tr>
<tr>
<td>Maximal activity</td>
<td>≤4.19 x 10^5 A^2</td>
<td></td>
</tr>
</tbody>
</table>

3.2 Transport of legacy radioactive wastes in the R76 type B cask:

The R76 is a type B(M) package which may transport fissile material. It is a cylindrical package transported by road in a vertical position whose external dimensions are about Ø 2.2 m x H 2.2 m and whose total payload is around 20 tons (see Figure 1 below).

Its main strengths lie primarily in:
- its large useful volume of load (Ø 1100 mm x H 655 mm: about 620 L)
- its important biological protection (around 165 mm. minimum of lead equivalent) and
- its robust containment system with regard to its mechanical resistance: made entirely of stainless steel, it has for example a thickness of 30 mm. at its cylindrical wall and more than 100 mm. at its background and closing lid.

In addition to these special performances that its design offers, R76 packaging also includes all the elements needed for safe transport in compliance with regulatory requirements. For instance, it is equipped with specific thermal protections (in particular with PNT3™ compound which is a material specifically developed by ROBATEL Industries for these applications) allowing it to withstand the thermal regulatory test, especially in case of fire.

The R76 is made up of a body, shielded plugs, a closure lid and two shock absorbers fixed to its lower and upper faces. It can carry from one to five drums of waste according to their geometry, their physicochemical properties and their radiological features. To do this, it can be equipped with different internal devices as needed, especially with different stainless steel baskets that have cylindrical cavities to load the drums and to maintain them in the package during transport (see Figure 6 hereafter).
Figure 6 - Overview of the TIRADE / R76 packaging

TIRADE / R76
Packaging
(Transport of HILW drums)
4. Conclusions

With the development of new hot cells and packages, ROBATEL Industries is able to propose several approaches for design and safety assessments capitalizing on past experiences and solving new challenges for compliance with customer and regulatory requirements, integration of innovative technologies.

The hot cells, gloveboxes, type B and storage casks developed through the years provide the company a valuable expertise in these fields that translates by allowing personal responses to client needs, high quality ensuring all safety aspects using diverse construction codes, quality standards and international and local regulations.

References