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# THE DE25 PACKAGE AND ITS OPERATING TOOLS

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## ABSTRACT

The CEA (French Alternative Energies and Atomic Energy Commission) has developed a new package (called DE25) for transportation of medium and high-level radioactive wastes. The wastes consist in a variety of solid nuclear materials (metals, papers, plastics…) with possible hydrogen production due to radiolysis phenomenon. The DE25 package complies, as a type B(M), with the regulatory requirements for road transport. It is currently being assessed by the French Nuclear Authority: if the design of the packaging is validated, the definitions of the contents need complementary assessment to take into account uncertainties of the radioactive wastes characterizations.
In order to cope with existing facilities configurations and exploitation constraints, the package mass (9.2 tons) was limited due to the mechanical strength of facilities hot cells roofs, while keeping the same quantities of transported materials (80 kilograms) as in older packages, and with much more stringent objectives in terms of safety. The DE25 package provides integral shielding with mainly stainless steel. It is 1.8 m in diameter and 2 m high. The loading operations take place vertically by the bottom of the packaging on a hot cell roof or in a pool.
As for the DE25 packaging, the development of the operating tools had to cope with the various facilities configurations, facilities stringent constraints in terms of space limitation and radiation protection. These activities have led to the definition of operating scenarios for each facility and the definition of the tools specifications with a constant concern about reliability and easy use. The main tool is called the winching set: it ensures on the one hand, wastes loading/unloading in the DE25 packaging by means of an external winch, and, on the other hand, the DE25 handling by means of facilities traveling cranes.

## MAIN DESIGN RATIONALES FOR A NEW PACKAGING

The DE25 project is part of a program to replace the old packagings for radioactive waste transportation, between the CEA facilities. These nuclear facilities are not necessarily on the same CEA Centre. The nature of the nuclear waste for the transport classification corresponds to a type B(M) package with requirements for road transport [2][3].

The nuclear facilities present different package loading/unloading configurations: on a hot cell roof, in a water pool, or in a storage well. Each facility has defined its own requirements which lead to stringent overall dimensions and mass constraints for the packaging; radioactive contents specifications; internal cavity dimensions; imposed operating conditions. These requirements have led to reducing the number of possible solutions for the design, as illustrated on figure 1. For the restricted area, the solution has to take into account the regulatory requirements.

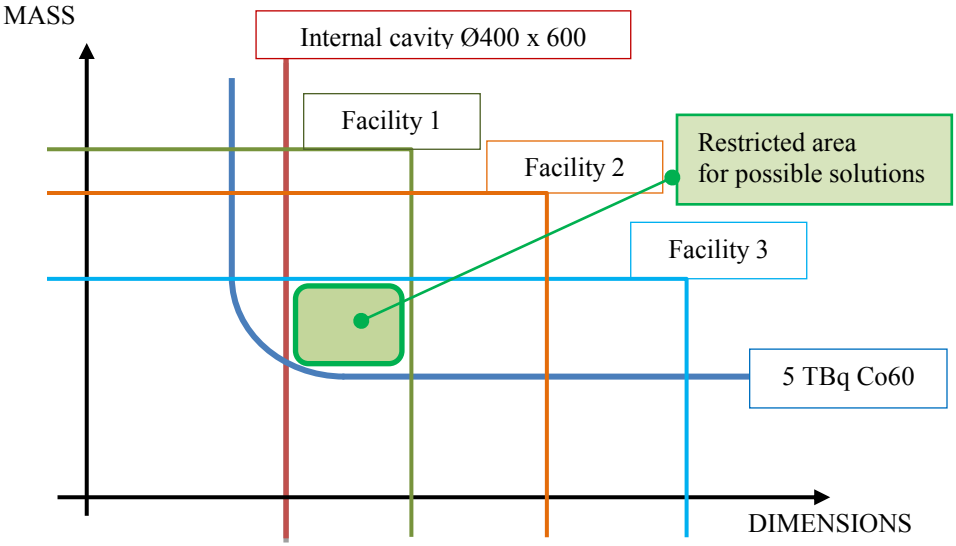



**Figure 1. An example of the DE25 package design constraints**

One of the most demanding operating constraints for the design is the need of vertical loading and unloading through the packaging bottom, either through a hot cell roof or above a pool. As a solution, the DE25 packaging has an opening/closing system which is operable while the DE25 is in loading/unloading position; the DE25 packaging provides also a high radiation protection during loading/unloading operations. The packaging systems are simple and compact. Winching and drawers driving systems have been excluded from the packaging and included in tools which equip the DE25 packaging only during corresponding operating steps inside the facilities.

## DE25 PACKAGING DESCRIPTION (FIGURE 2 AND TABLE 1)

The DE25 package provides complete shielding with mainly stainless steel, weighs 9.2 tons, and is 1.8 m in diameter and 2 m high; it holds up to 80 kilograms of medium or high-level radioactive wastes.

The DE25 packaging is made of a body (plans subset 100) and of two shock absorbers (plans subsets 200 and 300). The containment system is realized by the body (110) and closing systems: body lid (121), body removable bottom (120), and five lids. During the transport, the DE25 package is laid vertically on its lower shock absorber stowed with four lashing chains on a specific stowing structure. The handling is operated by means of four M30 tapped holes located in the upper surface of the body, and which are reached through the upper shock absorber.
The main DE25 constituting materials are

- stainless steel for structures, outer sheets, screws, and shields ;
- tungsten alloy for additional shields and drawers ;
- copper based alloys for parts undergoing friction ;
- wood for thermal insulation and shock absorption in case of an accidental fall.

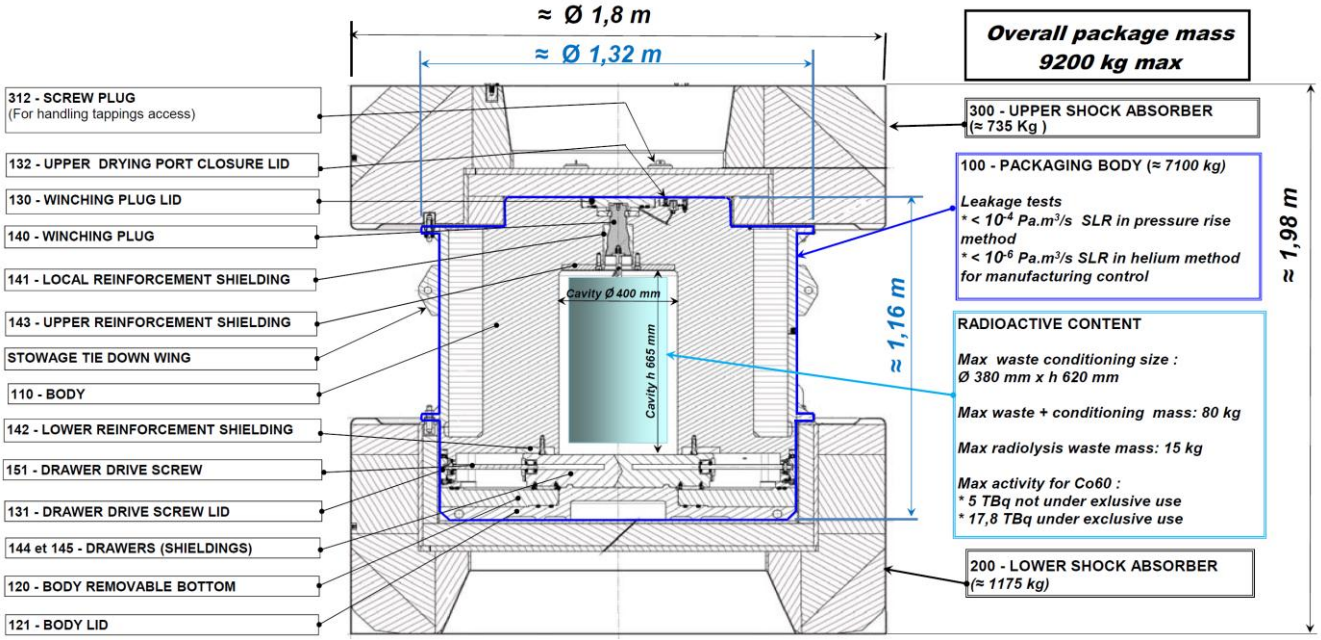



**Figure 2. DE25 packaging main characteristics**

**Table 1. Main parts and materials**

| Plan reference | Description | Material |
|---|---|---|
| 110 | Massive body with outer shielding in stainless steel and wood | Stainless steel<br>Wood |
| 140 | Winching plug for contents hanging and winching | Tungsten alloy |
| 141, 143 | Upper additional shields | Tungsten alloy |
| 142 | Drawers, serve as lower shields | Tungsten alloy |
| 151 | Drawers drive screws | Stainless steel |
| 120 | Body removable bottom | Stainless steel |
| 121 | Body tight lid, tightened by screws ; also blocks the drawers during transport | Stainless steel |
| 130, 131, 132 | Five closing lids, for various systems access | Stainless steel |
| 200, 300 | Two shock absorbers | Stainless steel<br>Wood |

## ILLUSTRATIONS OF DE25 MANUFACTURING

The manufacturing operations have been made by several manufacturers under CEA specifications [4] [5]. The massive parts, body, body removable bottom and body lid, have been forged in stainless steel. These structures are one-piece to provide the best mechanical strength. It avoids extensive controls as for complex assembled structures to demonstrate their well-done and their robustness as expected. Forging process, illustrated in Figure 3, has been realized under stringent control and final materials quality has been controlled. Forged parts have been assembled with fabricated and machined structures, and with wooden parts, as shown for the body in Figure 4. Plan specified dimensions have been controlled for each finished part, see Figure 5.

Tungsten alloy parts, shown on Figure 6, are massive parts, manufactured by sintering and machining,. Tungsten has been chosen to obtain the compactness of the packaging. The one-piece parts simplify the manufacturing and control operations compared to, for example, welded steel structures filled with lead. In addition, the safety demonstrations are easier.

The packaging comprises also more conventional parts, for closing systems, such as screws, drawers friction pads, lids ; they are shown in Figure 7.


Body forging


Body heat treatment

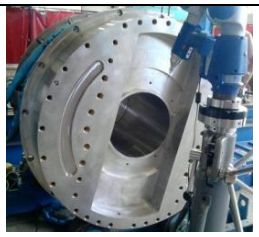

Body after first machining

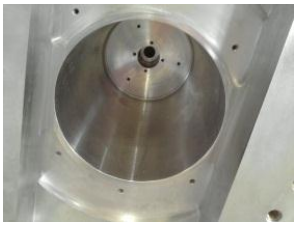
**Figure 3. Body early manufacturing steps**


Body assembly before adding wooden shields


General view of body assembly

**Figure 4. Body assembly**


Finished machined body under 3D dimensional control


Body internal cavity

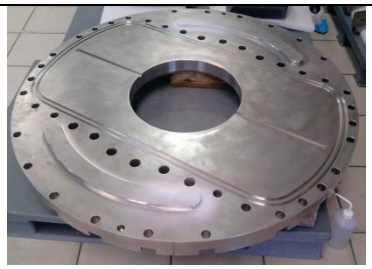
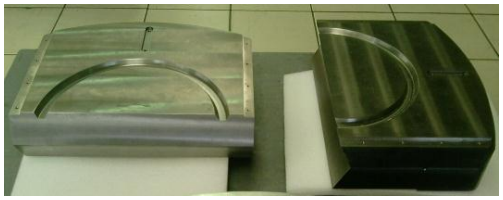

Finished body bottom

**Figure 5. Finished body and body bottom**


Right and left drawers


Shieldings


Shielding


Winching plug


Shielding


Shielding screws

**Figure 6. Machined tungsten alloy parts**

DE25 winching lid

Bronze friction parts

Drawers friction pads (Bronze mixed with carbon on stainless steel band)

**Figure 7. Machined conventional parts**

The shock absorbers are stainless steel assembled structures, filled with various wood species. Wood parts are fitted carefully, wood fibers orientation and wood humidity is stringently controlled in order to ensure mechanical cushioning properties (Figures 8 and 9). These characteristics of the woods are an important part of the safety analysis for the behavior of the shock absorbers.

Bended steel sheet

Machined wooden parts

Wooden parts in stainless steel structures

**Figure 8. Shock absorber manufacturing steps**

**Figure 9. Humidity control and shock absorber tight closing**

In order to comply with the transport requirements, each packaging part has undergone controls of its characteristics and its performance: plan specified dimensions have been checked; welds have been realized according to qualified operating procedures and controlled at least by liquid penetrant inspection; materials have undergone mechanical properties verification tests. The packaging assembly has been carefully realized, for example with torque wrenches (Figures 10, 11, 12).

Exemples of different parts before assembly

Set-up of a drawer driving nut

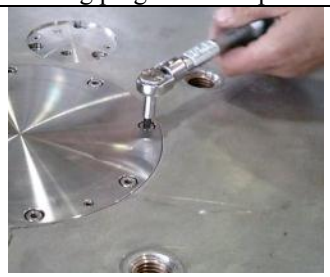
Drawers placed on the body bottom prio to body bottom and body assembly

**Figure 10. Packaging assembly**

Assembled drawer driving square

Winching plug in locked position

Body lid assembly



Torque control tightening of the winching lid

**Figure 11. Main operated organs**

Lower shock absorber set-up

Upper shock absorber set-up

Assembled packaging

**Figure 12. Final packaging assembly**

After manufacturing, the packaging has undergone successful controls with both regulatory specified tests and final use tests. Shielding capability has been assessed by gamma-ray inspection. Handling points have been tested under twice the maximum load. Static tests of stowage points have been performed. A hydraulic test under a 7.5 bar pressure has been performed. A thermal test has been realized with a 100W heat source positioned in the cavity. Leakage rates have been assessed by helium detection and by pressure variation. Final use tests have comprised testing of all packaging operating steps, such as drawers opening/closing, winching, handling…

## PREPARING THE COMMISSIONING IN THE FACILITIES

The requirements in terms of performance, operational safety, and transport regulation, as well as the wish to limit the complexity of manufacturing operations, have led to exclude from the packaging design operational functionalities leading to additional constraints. These have been taken back to the level of the packaging operating conditions.

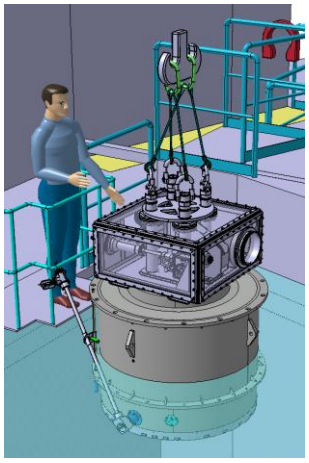
A specific project has been set up to prepare the DE25 operation in the nuclear facilities, involving several CEA units. These works at the interface between the transportation and the nuclear facility operator have consisted in:

- a definition of operational scenarios, and the specifications of the associated tools, coordinated between the different facilities; these aspects have been taken into account at the beginning of the packaging design phase, but they have been further assessed and detailed once the design finalized;
- the technical support of human and organizational factors specialists, in order to guarantee safe operations, in the scenarios definition as in the tools technical specifications; mock-ups of the packaging or tools have been used in some cases to facilitate decisions;
- the design and provision of tools compliant with specifications and allowing as much as possible similar operating conditions in the different facilities;
- the writing of safety analysis reports for the operations bringing modifications of the safety standards of the facilities;
- the organization, and follow-up of training tests for the future operators, by human and organizational factors specialists and design office; these test have been conducted with the first copies of the packaging and of the tools, in a dedicated area; for this phase, a specific platform has been designed and provided to simulate loading / unloading operations of a cell roof;
- the realization of the first loading and transport operation under real conditions, under internal authorizations;
- the writing of operational procedures, considering the feedback of the training tests and of the first transport operation;
- the sharing of the knowledge and feedback between all the involved facilities.

## DE25 OPERATING TOOLS

A complete set of specific equipment has been designed to ensure easy operating, radiation exposure for the operators as low as possible and safety protection in different configurations of use on the nuclear facilities ; two configurations are illustrated in Figure 9.

Package handled with winching set ; in the foreground, see the specific shock absorber, and behind, the cell roof platform



Package handled with winching set ; and equipped with drawer remote opening tools

**Figure 9. Hot cell roof loading and pool loading**

The main operating steps, listed in table 2, are a common basis of the various operating scenarios. The detailed operating scenarios may differ from a facility to another. The complete set of specific equipment

realized for DE25 operation is described in table 3, with the corresponding step in which each tool is used. They are ordered in decreasing effort in design studies.

**Table 2. Main operating steps**

| Step number | Step name | Step location |
|---|---|---|
| Step 1 | Shock absorbers removal/mounting | Entrance hall, main hall, ground floor |
| Step 2 | Body lid removal/mounting | Main hall, ground floor |
| Step 3 | Drawers opening/closing | Main hall, roof/pool floor |
| Step 4 | Content winching | Main hall, roof floor or above the pool |
| Step 5 | Leakage tests | Main hall, ground/pool floor |
| Step 6 | Handling | All places |
| Step 7 | Transport | Inside or outside CEA centers |
| Step 8 | Testing and training campaign | Ordinary hall in the CEA/Saclay center |

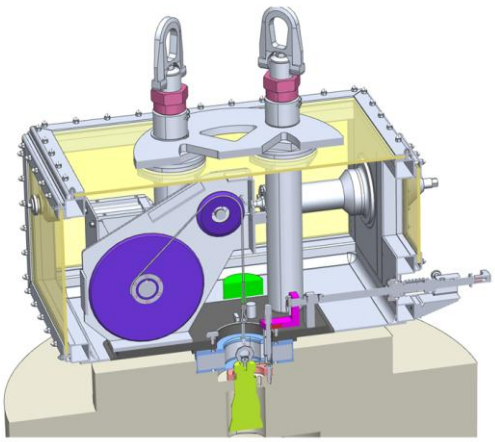
**Table 3. Operating tools list**

| Tool | Step | Design effort | Main functions and specifications |
|---|---|---|---|
| Winching set | Steps 4, 6 | High | See text |
| Specific shock absorber | Step 6 | Medium | - Drawers blockage in case of package accidental fall<br>- shock absorption<br>- easy operability (reduced size) |
| Socle and socle trolley | Step 1 | Medium | - Body lid deposit, maximum load 9000 kg<br>- easy access to lid screws<br>- Static stability with package or with lid<br>- Socle displacement without using the handling crane |
| Drawer remote opening tool | Step 2 | Medium | - Interface between packing and drill for better ergonomy and dose lowering<br>- torque limitation |
| DE25 hook+secondary packaging | Steps 4, 7 | Medium | - Contents hanging in DE25 cavity<br>- comply with DE25 safety documents<br>- easy hanging on and taking down of the payload with a remote manipulator<br>- added waste mass limitation due to secondary packaging |
| Stowage structure and carrier straps | Step 7 | Medium | - Stowage during transport<br>- comply with DE25 safety documents |
| Package spreader | Step 6 | Low | - Package handling through upper shock absorber<br>- handling with either single or double crane hooks |
| Spreader for the DE25 top shock absorber | Step 1 | Low | - Vertical handling with limited spare height |
| Three specific pallets | Steps 1,6 | Low | - For package, upper shock absorber, socle handling with a pallet truck |
| Testing platform | Step 8 | Low | - Operators training including DE25 contents winching over 1m height |
| Cell roof platform | Step 6 | Low | - Specific shock absorber removal respecting 20cm limitation in overflight height of hot cell roof<br>- operator's feet dose lowering |
| Leakage tests set | Step 5 | Low | - 7 interseal spacings to be tested by pressure drop monitoring, possibility to perform two tests at the same time |
| Tool boxes (type IP-2 industrial packagings) | Step 7 | Low | - Transportation of all tools used in nuclear facilities |
| Hand tools | All operations | Low | - All hand tools necessary for DE25 operating: 5 torque wrenches, ratchets, wrenches.<br>Well organized in the tool box, well marked as several uses for one tool, with various sockets |

The winching set (Figure 10) has demanded an important design effort as it has to fulfill different technical functions simultaneously:
1) Content loading/unloading by vertical winching,
2) Package handling during or apart from content winching operations,
3) Containment of radioactive particles, which may be brought out of the cell or pool on the winch cable,
4) Radiation protection: as the DE25 winching plug goes down when unwinding the winch, it releases an opening in the shielding which has to be filled by adequate arrangement.
The winching set is a class 4 [1] polycarbonate glove box, in slight depression in the case of hot cell roof loading, with air entrance in the box through a high efficiency filter. The box contains a 110 kg capacity winch with a 12 m long cable. It is operated either with a socket wrench or an electric drill. The winching plug lock is remotely operated; in case of a pool loading this function is mandatory. In order to ensure handling reliability, the winching set handles the package with two independent lifting ways, from DE25 handling tapped holes to the traveling crane double hook.

DE25 packaging handled by the winching set

DE25 packaging with the winching set and drawer remote opening tools



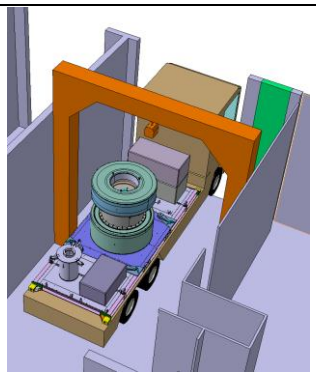
Winching set and winching plug lock remote command

**Figure 10. DE25 packaging with the winching set**

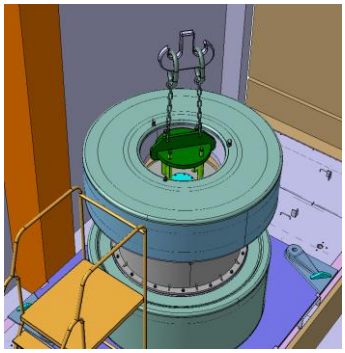
Design challenges were to ensure simultaneously winching, locking and handling the packaging, while complying with compactness, mass limitation, radiation protection levels, reliability and easy use.

## ILLUSTRATION OF THE DE25 OPERATING SCENARIO

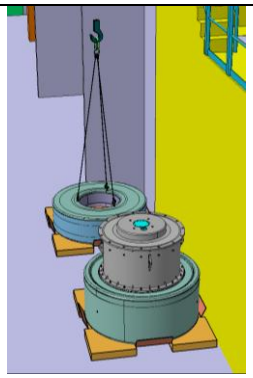
Figure 11 shows various operating steps of the DE25 package with associated operating tools.



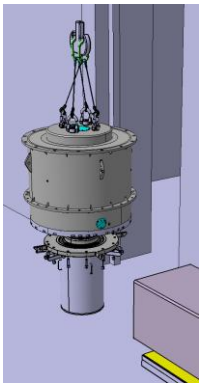
DE25 package, tools boxes and socle arrival on the truck



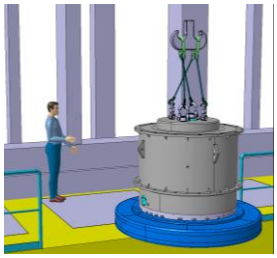
Package spreader setting up



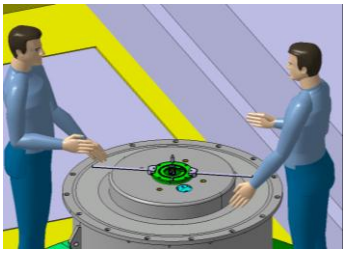
DE25 top shock absorber removal with slings



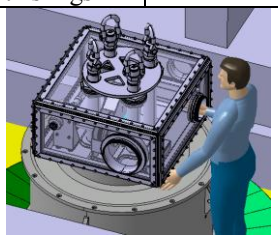
Body lid with the socle



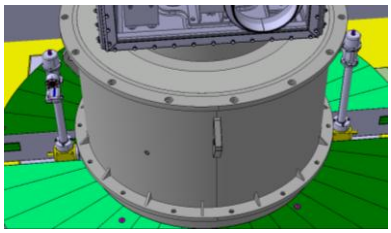
Handling with the specific shock absorber



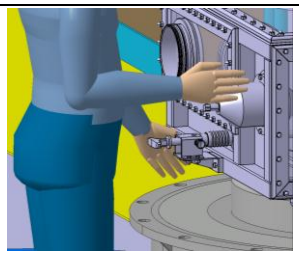
Setting up the winching set base



Setting up the winching plug lock remote command and connecting the winch cable and the packaging winching plug

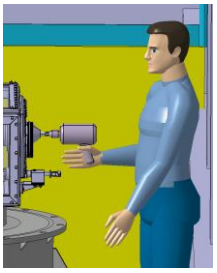


Drawers remote opening tools



Unlocking the packaging winching plug

Drawers opening



Winching operation

**Figure 11. DE25 package operating steps with associated tools**

## CONCLUSION

The DE25 package is a six-year project and initiates a new generation of design: it is a solution compatible with various CEA facilities for vertical loading by the bottom.

The safety analysis report of the type B(M) DE25 package is currently being assessed by the French Nuclear Authority (ASN) and its experts of IRSN: the definitions of the contents need complementary assessment to take into account uncertainties of the radioactive wastes characterizations. The duration of the operating steps and the number of consignments could be modified because of new types of controls on the contents

The packaging design effort was complemented with an important work on operating conditions and scenarios. Operating tools were developed in association with the users in CEA facilities (consignors and consignees). Many tests and operators training have been undertaken prior to the first in site transportation.

The first copy of the DE25 packaging has been operated for an in site transport on the CEA/Saclay center by the end of 2012. Three others copies, currently under manufacturing, are expected by the end of 2013.

## REFERENCES

[1] NF ISO 10648-2 Enceintes de confinement, Partie 2: Classification selon leur étanchéité et méthodes de contrôle associées.
[2] TS-R-1 – Safety Requirements AIEA Regulations for the Safe Transport of Radioactive Material
[3] The TMD French order of 29 May 2009, as modified, concerning the transport of dangerous goods by land.
[4] CEA internal report: Spécifications techniques de réalisation d'une ébauche forgée du corps d'emballage (Technical specifications for the realization of a forged body of DE25 packaging)
[5] CEA internal report: Spécifications techniques de réalisation d'un emballage DE25 (Technical specifications for the realization of a DE25 packaging)