Design and Qualification Testing of the TN GEMINI

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INTRODUCTION

Alpha wastes are generated in fuel cycle facilities such as those involved in reprocessing and manufacture of mixed oxide fuel or in laboratories. For their transport, a large quantity of these wastes cannot be considered as low specific activity (LSA) material, or are combustible: a type B(U) packaging is therefore required if a significant amount of material has to be transported.

The TN GEMINI container has been developed for this application, in particular for the transport of alpha wastes in drums. Its main feature is a rectangular shape, with a rear door allowing horizontal loading. It is similar to an ISO 20 ft sea container in terms of weight, size, handling devices and tie-down capability.

The packaging offers a free volume of 4510 x 2000 x 1840 mm and a maximum payload of 5,800 kg which enables the transport of forty 200 liter drums or sixty 118 liter drums filled with alpha waste, with a maximum fissile content reaching 400 g Pu. A wide range of other contents including glove boxes or large mechanical assemblies can also be transported using specific internal arrangements.

Several issues must be resolved when designing such a container. First, due to the presence of plutonium, a high level of leaktightness is required in all conditions of transport. Second, such waste includes organic materials and is therefore combustible. The waste temperature must remain sufficiently low for all normal and hypothetical accident conditions, especially during and after the regulatory fire test. Third, the walls of a large rectangular container must be particularly well protected to withstand the regulatory punch test.

PRELIMINARY DESIGN

The packaging walls were designed to provide:

- mechanical strength for maintaining the integrity of the containment vessel in all conditions;
- a capability to uniformly absorb energy from the 9-m drop test;
- fire insulation for the thermal test;
- puncture resistance.

Therefore, a multilayered panel was selected. The layer materials were chosen for their efficiency in one or several fields listed above.

After evaluating the decelerations expected during drop tests, a light stainless steel containment wall reinforced by stiffeners was designed. Finite element calculations were performed to evaluate the behavior of the containment wall due to the deceleration from the 9-m drop tests as well as the pressure increase that may occur due to radiolysis, thermal, biological or chemical reactions, changes in temperature, reduction of the ambient pressure, and the hypothetical fire.

Several candidate materials were then tested to evaluate their ability in stopping the punch bar during the 1-m drop test.

Material tested were:

- steels;
- aluminum;
- titanium;
- woods;
- foams;

Test were performed on a half scale panel as represented on figure 1 below.

The first step was to determine the most damaging impact angle, which was found to be 30°. The energy that the structure is able to absorb in this configuration is quite less than when the surface of the wall is perpendicular to the axis of the punch bar.

The second step was to find the best arrangement of the several layers, leading to the lightest structure, since weight was the main concern. The test program included the following parameters:

- number of the layers;
- nature of the layers (material, configuration);
- arrangement of the layers;
- thickness of the layers;
- attachment of layers at edges.

Stainless steel, balsa wood and foam were finally chosen. Balsa wood and foam are efficient for their low crushing stresses and thermal insulation capability, but also assist in puncture resistance. Stainless steel was found to be the most efficient structural material.

Conceptual design was then finalized as shown on figure 2 below. The packaging includes 3 main components:

- the body;
- the containment door;
- the shock absorbing cover.

The body has overall dimensions close those of an ISO 20 ft sea container, and has a large cavity with easy access by a wide opening rear door. The design of the walls has been dictated by the result of the tests described above. The edges as well as the corners are protected by thick layers of wood.

The containment door is bolted to the body. Two concentric "O" rings made of EPDM (Ethylene Propylene Rubber) make it possible to guarantee a very low leakage rate. This can be measured by means of one of the two orifices provided at the bottom right of the door, the other being dedicated to gas sampling, pressurization whenever inert gas is necessary or depressurization.

A removable shock absorbing cover, bolted to the container body, provides protection for the closure system during transportation.

The study was then completed and the fabrication of a half scale model of the whole packaging was carried out. Except for some minor details, the model was representative of the packaging.

The qualification test program was discussed with the French Competent Authority and included:

- one 0.3-m drop test;
- four 9-m drop tests;
- three 1-m punch tests.

The thermal test was simulated by finite element analysis.

QUALIFICATION TESTING

Drop tests took place in the mid of 1994, in the French Atomic Energy Commission's CESTA test facility.

Prior to drop testing, helium tests showed that the total leakage rate of the model did not exceed 10^{-6} std cc/sec. The same helium leak tests were carried out after each drop.
The drop tests performed are shown on figure 3 below. In each case, the center of gravity was aligned with the impact point or edge so as to produce the most severe damage.

The 0.3-m drop test was performed on a short edge of the door face of the container.

The 9-m drop testing consisted of:

- drop on short edge, door face of the container,
- drop on face opposite from door,
- drop on long edge, with a slight angle for slap-down effect,
- drop on corner, door face of the container.

The punch tests were aimed at:

- the door center,
- the door flange,
- the lateral face.

Only one model was used for all tests.

RESULTS

After the whole tests, the model was not damaged in a way that would prevent it from withstanding the fire test, and its total leakage rate remained at the same level as before the first drop test. The maximum deceleration, found to be 382 g, did not cause any severe damage.

The thermal evaluation showed that the temperature in the cavity would not exceed 70°C during and after the thermal test. The test temperature was 800°C for 30 minutes. This low cavity temperature is compatible with the transport of any organic material commonly used in fuel cycle facilities or laboratories.

OPERATIONS

The design concept of the TN GEMINI provides an easy operating system. Handling and tie-down are operated by means of the eight standard ISO anchor points located on the corners of the container. They enable the use of standard lift spreader frames and trailers used for ISO 20 ft sea containers.

Horizontal loading is made possible by the design of the rear door, which provides an opening of 2,000 mm x 1,840 mm.

As shown in Figure 4, the drums are loaded with a fork truck in packs of six or twelve according to the type of pallets chosen. Currently, three different internal arrengements have been designed, one of which allows loading at the MELOX Mox fuel manufacturing facility.

CONCLUSION

The TN GEMINI packaging is a new "type B" packaging meeting the following basic design parameters:

- high capacity in terms of useful volume and payload;
- easy loading and unloading conditions;
- standard handling and tie-down;
- 30 metric tons maximum gross weight complying with the French legal limit for road transport.

Its large cavity and high payload enable the design of a variety of internal arrangements offering an answer to a wide range of specific needs such as the transport of glove boxes or large mechanical assemblies.

Table 1. Main features of the TN GEMINI packaging.

Overall dimensions	6058 x 2650 x 2500 mm
Gross weight	30,000 kg
Cavity dimensions	4510 x 2000 x 1840 mm
Payload	5,800 kg
Leak rate	10^{-6} std cc/sec
Possible contents	• 60 drums (118 liter type) • 40 drums (200 liter type) • large mechanical components
Nature of wastes	Contaminated items, including organic materials and metals
Maximum heat power of content	10 W
Maximum Pu content	400 g

Figure 1. Preliminary testing on separate panels.

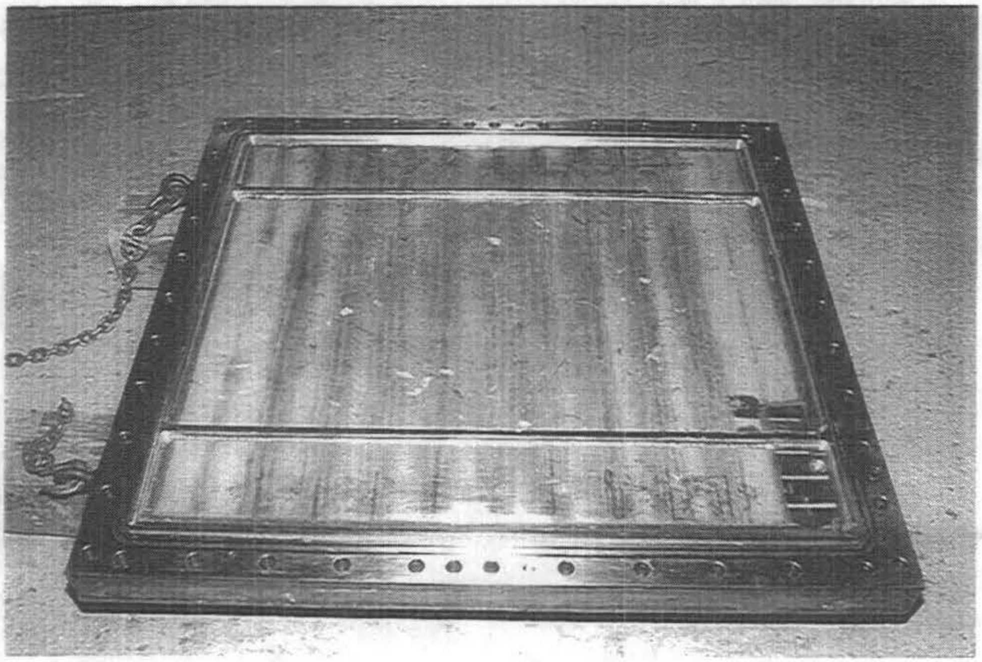


Figure 2. TN GEMINI design.

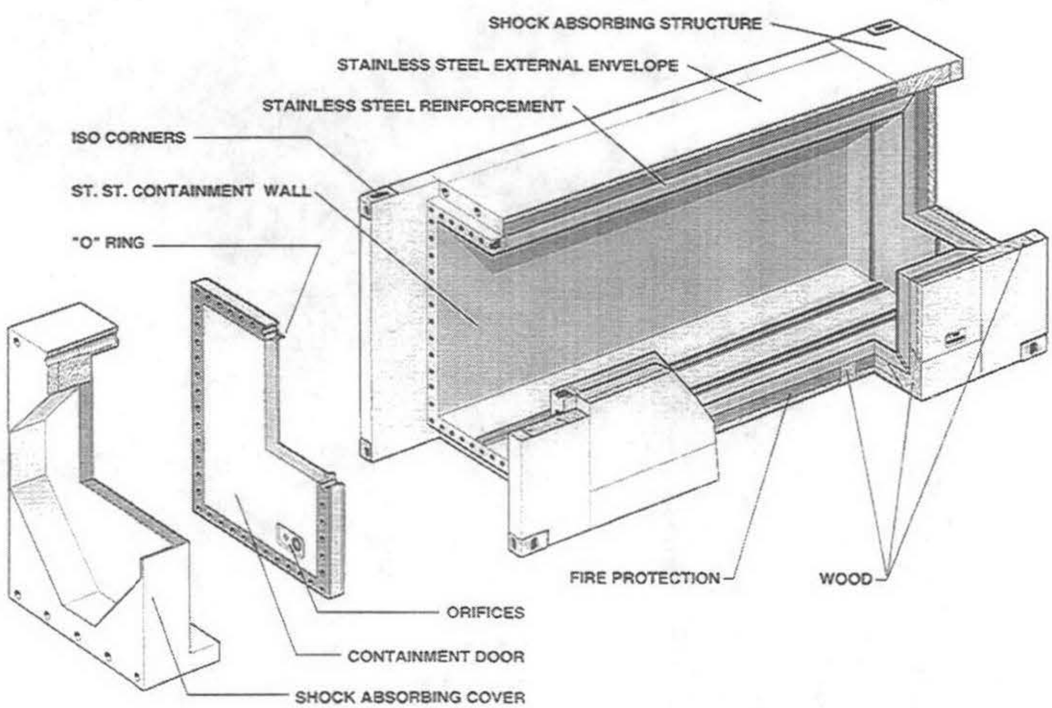


Figure 3. Qualification drop tests.

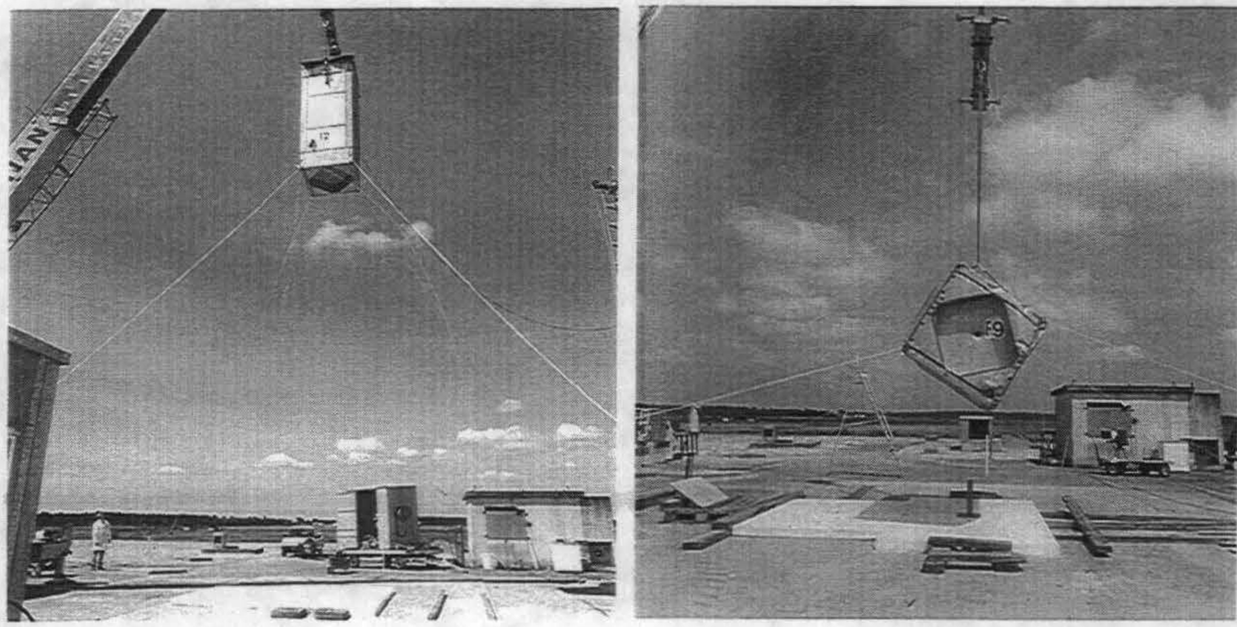
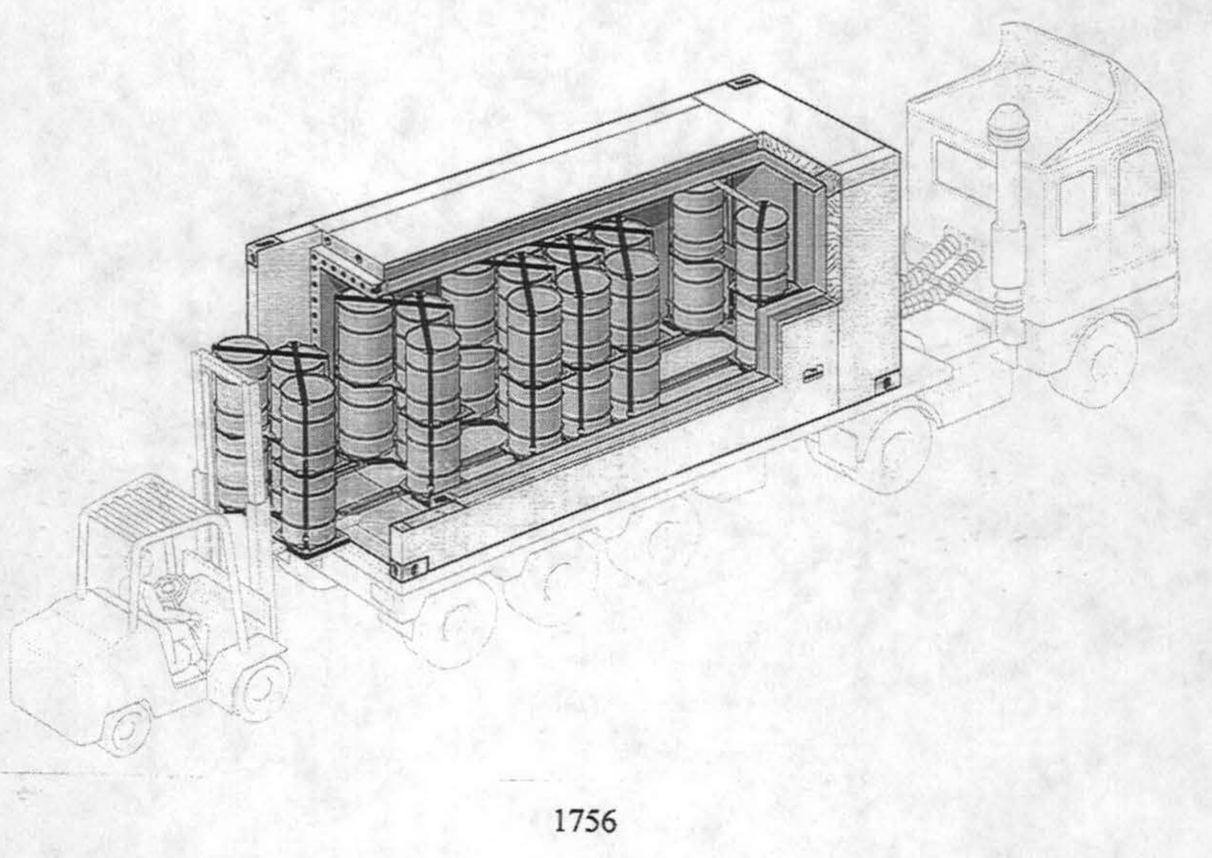


Figure 4. TN GEMINI operations



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