# OPTIMIZATION OF ALPHA CONTAMINATED WASTE TRANSPORTATION IN FRANCE

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## ABSTRACT

Drums of waste contaminated with plutonium and uranium oxides generated by MELOX plant are transported to AREVA NC La Hague plant by TN International in TN GEMINI™ and RD26 packages. Up to 60 118-liter drums can be loaded in the TN GEMINI™ packaging, a 20-foot ISO container like packaging. One 118-liter drum can be loaded in the RD26 packaging. Up to 12 RD26 packages are shipped together inside a 20-foot ISO container. The TN GEMINI™ packaging was initially designed for medium level waste contamination and the RD26 packaging high level waste contamination. **This paper describes the main characteristics of these wastes and of these two packages**.

So as to optimize the waste transportation while MELOX is increasing its MOX fuel production, **TN International has implemented a strategy of sustainable development which is detailed in this paper.** This is based on the one hand on the modular design of the TN GEMINI™ packaging:

- the allowable amount of fissile material per drum and per package has been increased (criticality issue), hence a reduced number of drums and packages,
- the allowable heat power of waste per drum and per package has been increased (radiolysis issue), hence a reduced number of drums and packages,
- the RD26 payload has been included in the TN GEMINI™ package, hence an increased number of drums per shipment from 12 to 20.

while warranting the safety of the package. On the other hand, the limitation of fissile materials per shipment due to security issue has also been discussed with the French authorities, in case of waste contaminated with plutonium and uranium oxides.

Consequently, the decrease of the number of transports and of the number of packages led to:

- economic development with cost optimization for MELOX as consignor, AREVA NC La Hague as consignee and TN International as carrier,
- an environmentally friendly logistics plan, with a reduced greenhouse gas generation with decreasing transports for more circulating wastes,
- social development with reduced radiation exposure for workers.

## INTRODUCTION

TN International transports alpha waste packed in TN GEMINI™ and RD26 packages from MELOX to AREVA NC La Hague plant. So as to optimize the waste transportation while MELOX increases its MOX fuel production, TN International has implemented a strategy of sustainable development which is detailed in this paper.

## ALPHA CONTAMINATED WASTE DESCRIPTION

MELOX plant

The AREVA plant MELOX produces MOX fuel assemblies intended to power light-water reactors in different countries. Created from a mixture of uranium and plutonium oxides, MOX fuel enables the recycling of plutonium issuing from spent fuel recovered during treatment operations executed at the AREVA NC La Hague plant. MELOX is the world leader in this production. To keep in step with market developments, MELOX was granted authorization in April 2007 to progressively increase its production from 145 MTHM (metric tons of heavy metal) to 195 MTHM per year

Waste description

Two types of alpha waste are generated during MOX fuel manufacturing:

- Medium level waste: they consist of miscellaneous technological wastes,
- High level waste: they consist of ventilation filters.

These wastes are contaminated with plutonium and uranium oxides. They are packed in 118-liter drums before transportation to AREVA NC La Hague site.

Evolution of waste

While MELOX increases its MOX fuel production, the quantity of wastes is optimized at source. The loading of each drum is optimized, hence an increase of the quantity of plutonium and uranium oxides inside a drum.

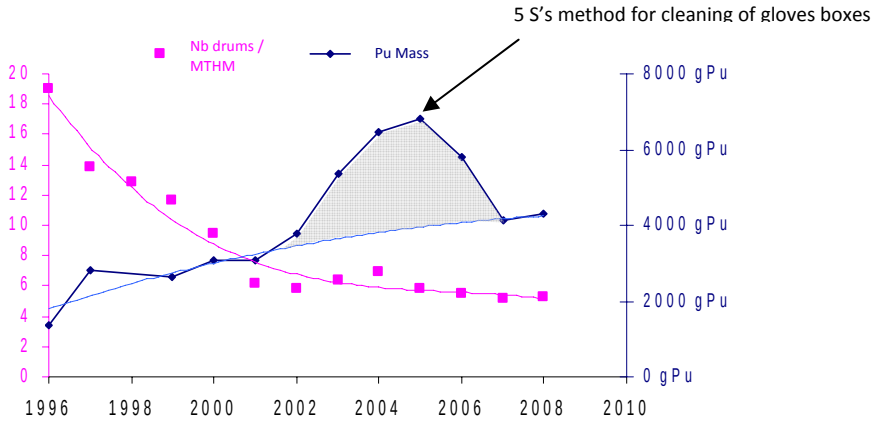


**Figure 1. Evolution of medium level wastes production**

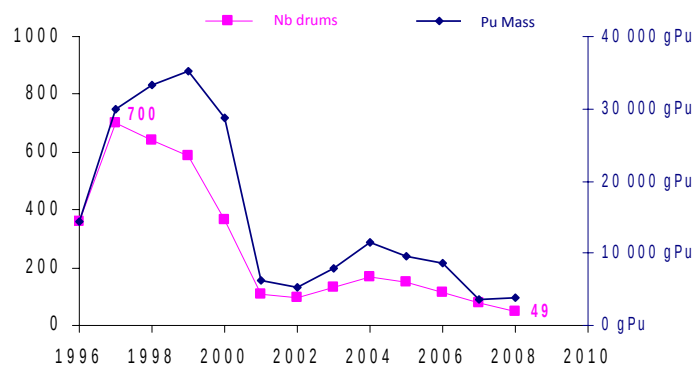


**Figure 2. Evolution of high level wastes production**

Moreover, from now on, the $^{238}$Pu content tends to increase. The higher the $^{238}$Pu content is, the higher the heat power of plutonium and of the wastes is.

## ALPHA CONTAMINATED WASTE TRANSPORTATION

Drums of waste contaminated with plutonium and uranium oxides generated by MELOX plant are transported to AREVA NC La Hague plant by TN International in TN GEMINI™ and RD26 packages. The TN GEMINI™ packaging was initially designed for medium level waste drums and the RD26 packaging for high level waste drums.

TN GEMINI™ packaging

The TN GEMINI™ packaging is a 20-foot ISO container like packaging.

The dimensions of this parallelepipedic shaped packaging are as follows:

Overall dimensions:

- length : 6,058 mm
- width : 2,500 mm
- height : 2,650 mm

Useful cavity dimensions:

- length : 4,510 mm
- width : 1,840 mm
- height : 2,000 mm

Its maximum mass is:

– empty: 24,200 kg maximum
– with its load: 30,000 kg maximum

This packaging is characterised by:

- a rectangular cavity in which the internal arrangements is designed to receive the packed waste;
- a body made entirely by assembling welded stainless steel plates, flats and round bars. This body is surrounded by shock-absorbing and heat insulating materials, confined in stainless steel compartments welded to the body;
- a closure system (or lid) secured to the body by screws and manufactured, with respect to the same principles as the walls of the containment;
- a semi-flush-mounted shock-absorbing cover filled with shock-absorbing and heat-insulating materials,
- eight standard-size anchor points, called "ISO corner anchors" for handling and tie-down.

**Figure 3. TN GEMINI™ packaging**

Up to 60 118-liter drums can be loaded inside a TN GEMINI™ packaging.

The TN GEMINI™ packaging loaded with drums is licensed as a type B(M) package containing fissile material.

Until 2009, the payload of the package was limited by the following requirements:
- the mass of plutonium per package is not higher than 374 g,
- the mass of plutonium per drum is not higher than 40 g,
- the heat power per package is not higher than 10 W,
- the heat power per drum is not higher than 0.55 W.

RD26 packaging

The RD26 packaging is a cylindrical shaped packaging with a vertical axis.

The dimensions of this packaging are as follows:

Overall dimensions:

- length : 900 mm
- width : 900 mm
- height : 1,145 mm

Useful cavity dimensions:

- diameter : 513 mm
- height : 780 mm

Its maximum mass is:

– empty: 460 kg maximum
– with its load: 610 kg maximum

This packaging consists of:

– a cylindrical cavity designed to receive the packed waste;

– a body made entirely by assembling welded stainless steel plates. This body is surrounded by neutron-absorbing materials, confined in stainless steel compartments welded to the body;

– a closure system (or lid) secured to the body by studs and manufactured, with respect to the same principles as the body;

– a shock-absorbing cover filled with shock-absorbing and heat-insulating materials,

– a handling pallet secured to the body by screws.

**Figure 4. RD26 packaging**

One 118-liter drum can be loaded in the RD26 packaging. Up to 12 RD26 packages are shipped together inside a 20-foot ISO container.

The RD26 packaging loaded with one drum is licensed as a type B(M) package containing fissile material.

The payload of the package is limited by the following requirements:
– the mass of plutonium per package is not higher than 100 g,
– the heat power per package is not higher than 1 W.

## TRANSPORTATION OPTIMIZATION

So as to optimize the waste transportation while MELOX increases its MOX fuel production, TN International has implemented a strategy of sustainable development based on the one hand on the modular design of the TN GEMINI™ packaging, on the other hand on discussion with the French authority about the security issue.

The modular design of the TN GEMINI™ packaging

The safety analysis report of the TN GEMINI™ package was first based on the characteristics of the wastes produced by MELOX at that time. The whole capability of this packaging was not used and authorized because there was no need for.

In 2009, the safety analysis report has been revised so as to optimize the payload of the package.

With regard to the criticality issue, the allowable amount of plutonium has been increased from 40 g to 70 g per drum and from 374 g to 640 g per package, while warranting the safety of the package, hence a reduced number of drums and packages.
- The modelling has been updated thanks to the progress of computer codes: uncertainties are narrowed and the reactivity coefficient calculations are less pessimistic.
- The realistic isotopic composition of plutonium has been taken into account.

With regard to the radiolysis issue, the allowable heat power of waste has been increased from 0.55 W to 0.7 W per drum and from 10 W to 42 W per package, while warranting the safety of the package, hence a reduced number of drums and packages.
- The thermal modelling has been updated thanks to the progress of computer codes: the temperatures are less pessimistic, hence a less pessimistic calculation of the amount of flammable gas generated by radiolysis.

These two first steps of optimization are approved by the French authorities since March 2010. Therefore, MELOX is no more restricted by the certificate of approval of the TN GEMINI™ for conditioning alpha waste in drums.

In the light of the updated safety analysis report of the TN GEMINI™ package, the third step of optimization could consist in including the RD26 payload in the TN GEMINI™ package, which would lead to an increased number of drums per shipment from 12 to 20.

Security issue

The limitation of fissile materials per shipment due to security issue has been discussed with the French authorities, in case of waste contaminated with plutonium and uranium oxides.

The TN GEMINI™ and the RD26 packages contained plutonium and uranium oxides classified in category III in terms of loss, theft and misappropriation. Until September 2009, the following requirements had to be met:
– maximal mass of plutonium per shipment: 400 g,
– unlimited mass of natural or depleted uranium.

And yet the new certificate of approval of the TN GEMINI™ package authorized up to 640 g of plutonium per package. Until September 2009, such material is classified in category II and need reinforced measures of security compared to category III materials. These measures cannot be implemented in case of transport of TN GEMINI™ packages because of mass and dimension requirements of the French traffic rules. Moreover, plutonium oxides scattered in waste are not easily liable to recovery unlike 400 g of plutonium oxides in powder form. Therefore TN International discussed with the French authorities and was granted a deviation so as to transport waste contaminated with plutonium oxides inside TN GEMINI™ packaging in the same conditions as for category II irradiated materials in case of a plutonium weight percentage not higher than 0,1 %. These conditions meet the constraints relating to the TN GEMINI™ packaging.

Since September 2009, the definition of category III materials has been extended to waste in which the weight percentage of nuclear materials is not higher than 0.1 %.

## CONCLUSIONS

The alpha waste transportation optimization leads to the following consequences:
– the capability of the TN GEMINI™ packaging is doubled,
– the number of transports of alpha waste, filters excepted, is reduced by 30 %, from 18 transports to 12 transports per year, for more circulating wastes,
– the drums loaded with filters could be shipped in TN GEMINI™ packages instead of RD26 packages:
    - 10 shipments of 12 RD26 packages per year could be replaced by 6 shipments of one TN GEMINI™ packaging,
    - the number of packages needed would be reduced: only one TN GEMINI™ packaging instead of one TN GEMINI™ packaging and 12 RD26 packages.

The decrease of the number of transports and of the number of packages led to:

- economic development with cost optimization:
  - the profit for MELOX as consignor is proportionate to the reduction of the number of waste drums and of transports,
  - the profit for AREVA NC La Hague as consignee is proportionate to the reduction of the number of transports,
  - the profit for TN International as carrier is linked to the number of packages to be maintained, and to the number of types of packages needed (licensing cost).

- an environmentally friendly logistics plan:
  - the cancellation of 10 transports per year saves 25000 km, 9000 liters of fuel and then 25 tons of $CO_2$.
  - the reduction of the number of maintenance operations saves the consumption of spare parts and the generation of effluents.

- social development:
  - the reduction of the number of transports by public highway meets the recommendations of the French authorities,
  - the reduction of the number of transports reduced proportionally the radiation exposure for workers.