A NEW OVERPACK FOR THE TRANSPORT OF UF_6 IN 30B CYLINDERS

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ABSTRACT

Facing the difficulties met in the United States to obtain a durable certificate of approval for the existing overpacks, COGEMA wished to free itself from the constraints imposed by these packagings for the transport of enriched UF_6.
Transnucléaire therefore initiated, on behalf of COGEMA, the design of a new type B(U)F overpack for use with the 30B cylinders containing hexafluoride uranium enriched up to 5% in U235, obtained from natural or reprocessed uranium.
The external aspect of the new overpack is quite standard (two cylindrical halves closed with ten toggles) and it keeps the same stowing system so that it can be used with the transportation means that already exist.
The main features of Transnucléaire's overpack are a reinforced internal structure to protect the 30B cylinder's skirt against bending, and a better absorption of the drop energy in order to limit the acceleration under impact.
The drop tests and a fire test have been performed successfully in February and March 1997 and the Safety Analysis Report has been submitted to the French Competent Authority, with a view to obtain the corresponding approval mid 1998.

INTRODUCTION

This paper deals with the problems surrounding the protective overpacks needed to transport enriched uranium hexafluoride (UF_6) from enrichment plants to fuel fabrication facilities. Throughout the world, enriched UF_6 is conditioned under solid form for transport in the well known 30B cylinders. These strongly built steel containers with an empty weight of 640 kg can carry an uranium payload up to 2,277 kg. Because of the fissile nature of enriched UF_6, a 30B cylinder must be protected by an overpack to conform with IAEA regulations.

Furthermore, when dealing with reprocessed uranium, a type B package may be required, depending on the isotopic composition of the uranium, which, compared with a type A package, implies additional requirements.

This presentation describes the existing overpacks, outlines the problems which have arisen during their operation and their following consequences. An overview is then given of the various solutions studied in different countries, among which the new overpack designed by Transnucléaire on behalf of COGEMA.

THE EXISTING OVERPACKS

Altogether 4 different models of overpacks are used around the world to protect 30B cylinders during transport, which are known as:

- DOT-21PF-1A
- DOT-21PF-1B
- NCI-21PF-1
- UX30.

DOT-21PF-1A

Designed originally on behalf the US Department of Transportation, the DOT-21PF-1 has been the first overpack used to transport 30B cylinders. During the course of their operation, all of them have been modified and renamed DOT-21PF-1A. Their main components consist of carbon steel, oak wood, and phenolic foam. The closure system relies upon the use of conventional bolts and nuts. These early overpacks are no longer allowed to be manufactured and only a few of them are still in operation. From a regulatory standpoint, these overpacks constituted type A packages and for this reason, their content was limited to UF_6 enriched from commercial natural uranium, or reprocessed uranium under certain restrictive conditions related to its isotopic composition. The corresponding original certificate of approval was USA/4909/AF.

DOT-21PF-1B

Regardless of its reference number, the DOT-21PF-1B is not a mere evolution of the previous model, but a new design based on the DOT-21PF-1A overpack. This new overpack was manufactured from stainless steel instead of carbon steel plates, but kept the same protection materials as the previous DOT-21PF-1A, which are oak wood and phenolic foam. Its closure system still relied upon conventional bolts and nuts. This type of overpack has been supplied by NCI (Nuclear Containers Inc.) in the United States under certificate of approval USA/4909/AF. An equivalent overpack exists in Japan, where it has been manufactured.

NCI-21PF-1

The NCI-21PF-1 overpack has then been designed and manufactured by NCI. In this model, like in the DOT-21PF-1B, all the metallic parts are in stainless steel, the shock absorbers are made of oak wood, and the thermal protection consists of a phenolic foam. However, the closure system is designed for faster operations, relying on the use of quick-release toggles. A supporting system allows stacking several overpacks. It was licensed as a type B package, which allowed the transportation of either commercial natural uranium or reprocessed uranium. The corresponding certificate of approval was USA/9234/B(U)F.

UX-30

A new model appeared when VECTRA designed and supplied the UX-30 overpack in the United States. The UX-30 is a type AF package made of stainless steel and of a polyurethane foam material. Its closure system consists in ten cross locking ball lock pins, providing a fast and high strength package assembly. The certificate of approval is USA/9196/AF.

PROBLEMS ENCOUNTERED

The problems started in 1986, when Union Carbide decided to stop the production of the phenolic foam used as fire protection in the NCI overpacks. NCI was forced to select another type of foam manufactured by a different source in October 1987. But after a few years of operation, corrosion pitting points started to appear on many overpacks, due to the high chloride level present in the new foam.

Thus, in 1991, NCI had once again to change the type of foam for another one with equivalent fire protection properties, but with a lower chloride level. Nevertheless, the specification concerning the foam, called SP-9, part of 49 CFR 178.359, referenced Union Carbide's resin BRL-2760, and no substitutions were allowed.

In November 1994, the U.S. Nuclear Regulatory Commission (NRC) and the U.S. Department of Transportation (DOT) which assessed the problems related to the pitted overpacks and the new foam, issued a certificate of approval for a single year associated to several restrictive conditions:

- The DOT-21PF-1B and the NCI-21PF-1 overpacks manufactured by NCI prior to November 30, 1991 were no longer authorized for transportation. The reason put forward was that the defects in the stainless steel shells (pitted points) could reduce the effectiveness of the overpacks under accident conditions.

- The overpacks manufactured by NCI subsequent to November 30, 1991 were authorized for transportation for one year. The purpose of the one-year certificate was to allow enough time to NCI to demonstrate that the new foam with a low chloride level is equivalent in all respects to DOT's specification SP-9.

But during the year 1995 a difficulty of a different nature appeared when drop tests performed on the NCI overpacks revealed that the skirt of the cylinder could hit the valve when subjected to a nine-metre corner drop. A leak of this valve was then possible. Then, the US authorities extended in October 1995 the certificate of approval of NCI-21PF-1 and DOT-21PF-1B overpacks for another year, giving time to find back-up solutions to pursue the transportation of UF_6 with these overpacks or other systems. Thus, in 1996, several organizations belonging to various countries began to study and test a variety of solutions to guarantee the transportability of enriched uranium.

PROPOSED SOLUTIONS

Among the various solutions offered to alleviate the problems, the main achievements are:

- a valve protection device designed by the consortium of overpack owners,
- a complementary protection developed by NCI and applied to the existing DOT-21PF-1B and NCI-21PF-1 overpacks,
- a valve protection device designed by Transnucléaire,
- a new overpack design developed by Transnucléaire on behalf of COGEMA.

The Consortium Valve Protection Device (VPD)

The Consortium VPD has been developed and tested in 1996. It consists of five metallic parts including three triangular aluminum blocks placed inside the cylinder skirt, one spacer between the three blocks, and a spreader. The spacer and the spreader are made of carbon steel and maintain the VPD anchored in the cylinder skirt. This VPD has a weight of 77 kg.
The last tests were performed successfully in October 1996 and demonstrated the efficiency of this new valve protection system under accident conditions. It can be supplied by each member of the overpack owners consortium to be fitted on the existing 30B cylinders.

NCI modified overpacks

The NCI modification consists of an overprotection made of phenolic foam contained in a stainless steel shell welded externally on the valve side of the overpack. The design also provides for a recess in the internal shell in front of the valve to prevent it from being damaged by the overpack internal shell.

Transnucléaire valve protection device

Because of the uncertainties faced on the design of the Consortium's VPD, Transnucléaire and COGEMA launched the design of a new valve protection device based on a project already successfully tested by Transnucléaire in 1988. A second series of tests was carried out in October 1996 on an improved version of the previous project.

The Transnucléaire VPD consists of a single-piece aluminum block that includes its own stainless steel locking system. Its use has been approved by the French authorities (a special arrangement has been delivered May 5th 1997 expiring April 15th 1998) until the new overpacks have been granted their own licence and can be put in operation.

COGEMA OP-30B OVERPACK

Concerned with the difficulties met in the United States to obtain a durable certificate of approval for the existing overpacks, COGEMA feared to see the deliveries of enriched uranium from the Eurodif plant hampered by the lack of adequate licenses of the transport equipment. It was therefore decided in the beginning of 1996 to master a package design for the transport of enriched UF_6 and Transnucléaire initiated the design of a new type B(U)F overpack for 30B cylinders containing hexafluoride uranium enriched up to 5% in U235, produced either from commercial natural uranium or reprocessed uranium.

Basic specification of the new overpack

After consulting the organizations which have the widest use of the overpacks, the operational specification of the new package was defined as follows:

- It should remain possible to transport six loaded 30B cylinders on a lorry. With an allowable payload of 25,000 kg per vehicle, the maximum weight of this new overpack was then precisely limited to 1,228 kg.
- To remain easily transportable across the width of an ISO 20 ft container, the maximum length of the new overpack should not exceed 2,420 mm.
- The width of the overpack should allow to load 4 of them transversally on a 20 ft flat ISO container. This determines a maximum width of 1,340 mm.
- The closure system should not hinder the passage of a person between two 30B cylinders stowed on a lorry once the overpack is opened.
- It should be possible to stack one empty 30B cylinder on top of another one, during transportation.
- Handling of the full package should be performed using only two shackles.

These operational conditions impose technical constraints on the designer because weight and envelope dimensions are restricted, but in turn they result in attractive features from the operator's point of view because the use of the new overpack will not lead to a reduction in the number of 30B cylinders transported per lorry.

A new design

Externally, the new overpack does not differ very much from the previous models. It still consists of two cylindrical halves connected by a quick-release system fitted with 10 toggles. It keeps the same stowing system, so that it can be used with the existing transportation means and following the methods already implemented. Finally, all of the operational specifications have been respected (see figure in annex with the main outer dimensions). Internally, a number of improvements have been brought. The main features of COGEMA's OP-30B overpack are a reinforced internal structure protecting the skirt of the 30B cylinder and preventing it from bending above the valve, and a better absorption of the drop energy in order to limit the acceleration under shock.

The internal skin is made from a 5 mm stainless steel sheet, reinforced on the valve side by another stainless steel plate, 12 mm thick. The internal ends are made up of a 25 mm stainless steel sheet, with a recess designed in front of both the valve and the plug. These features are symmetrical, so that the cylinder can be placed either way inside its overpack, with the exception of the valve position which must be located in the upper part. The external envelope is manufactured from a 2 mm stainless steel sheet. The efficiency and suitability of the materials used between the two metallic shells have been checked during preliminary crush

testing. The components selected consist of wood for shock absorption and non-corrosive phenolic foam for thermal protection.

Qualification

A regulatory qualification test campaign for type B packages and for packages containing fissile materials has been performed in February and March 1997 at the drop test facility of Moronvilliers, near Reims. This facility meets all IAEA requirements for the certification of packages and is now operated on a full time basis by Transnucléaire. Testing required two full size overpack prototypes, each containing one 30B cylinder loaded with steel shot mixed with paraffin to simulate the weight of the content.

The tests included a total of 12 drops in configurations chosen with the agreement of IPSN, the French Competent Authority's technical support, corresponding to the normal and accident conditions of transport, and equally distributed on the two prototypes. These drop tests were followed by a 30-minute fire test at 800°C on the most damaged package, as called for by the IAEA Regulations. IPSN representatives attended most of this regulatory testing campaign.

Drop tests:

The 12 drops consisted in:

On the first prototype:

- drop n° 1 : 1.2-meter drop test onto the valve-side corner, with the centre of gravity above the impact point (normal conditions of transport for type B package),
- drop n° 2 : 0.3-meter drop test onto the valve-side corner, with the centre of gravity above the impact point (normal conditions of transport for packaging containing fissile material),
- drop n° 3 : 9-meter drop test onto the valve-side corner, with the centre of gravity above the impact point (accident conditions in transport for type B packages and for packagings containing fissile material),
- drop n° 4 : 1-meter puncture drop test towards the cylinder's skirt on the valve-side, with the centre of gravity above the impact point (accident conditions in transport for type B package and for packaging containing fissile material),
- drop n° 5 : 9-meter drop test onto the valve side end, with the axis of the cylinder vertical (accident conditions in transport for type B package and for packaging containing fissile material),
- drop n° 6 : 1-meter puncture drop test towards the valve, with the centre of gravity above the impact point (accident conditions in transport for type B package and for packaging containing fissile material).

On the second prototype:

- drop n° 7 : 1.2-meter drop onto the plug side corner, at an angle chosen to maximize the slap-down effect on the valve (normal conditions of transport for type B package),
- drop n° 8 : 0.3-meter drop onto the plug side corner, at an angle chosen to maximize the slap-down effect on the valve (normal conditions of transport for packaging containing fissile material),
- drop n° 9 : 9-meter drop onto the plug side corner, with the centre of gravity above the impact point (accident conditions of transport for type B package and for packaging containing fissile material),
- drop n° 10 : 1-meter puncture drop test towards the plug, with the centre of gravity above the impact point (accident conditions of transport for type B package and for packaging containing fissile material),
- drop n° 11 : 1-meter puncture drop test towards a central locking system at an angle of 20° from the vertical (accident conditions in transport for type B package and for packaging containing fissile material),
- drop n° 12 : 9-meter drop onto the closures on the same side as drop n°11, at an angle maximizing the slap-down effect on the valve (accident conditions of transport for type B package and for packaging containing fissile material).

These drop tests were cumulated in order to entail the worse damages on the weakest components of the package. The drops representative of the normal conditions in transport were followed by the drops representative of the accident conditions of transport in order to define the state of the damaged package for the criticality studies.

Fire test: The first prototype has been chosen for the fire test because of the damage caused in the thermal protection by the punch in front of the valve. The fire averaged temperature remained above 800°C during at least 37 minutes, longer than required by the IAEA regulations. All the temperatures measured on the cylinder during and after the fire test prove that the cylinder internal pressure due to the heated UF_6 is far below the maximal pressure the cylinder can bear withstand.

Leaktightness: Helium leak tests were conducted after most of the drops and after the fire test. They showed for both cylinders that their original leaktightness ($< 10^{-9}$ $Pa.m^3.s^{-1}$) was maintained after testing.

Safety Analysis Report: The full Safety Analysis Report has been submitted to the French Competent Authority at the end of 1997, with a view to obtaining the corresponding certificate of approval in the middle of 1998.

CONCLUSION

Transnucléaire's 30 year know-how has been used in the design of the first European overpack for the 30 B cylinder. This completely new design should be delivered a type B(U)F certificate of approval by the French Authorities before the end of this year, and be manufactured as soon as possible in order to be in operation early in 1998.

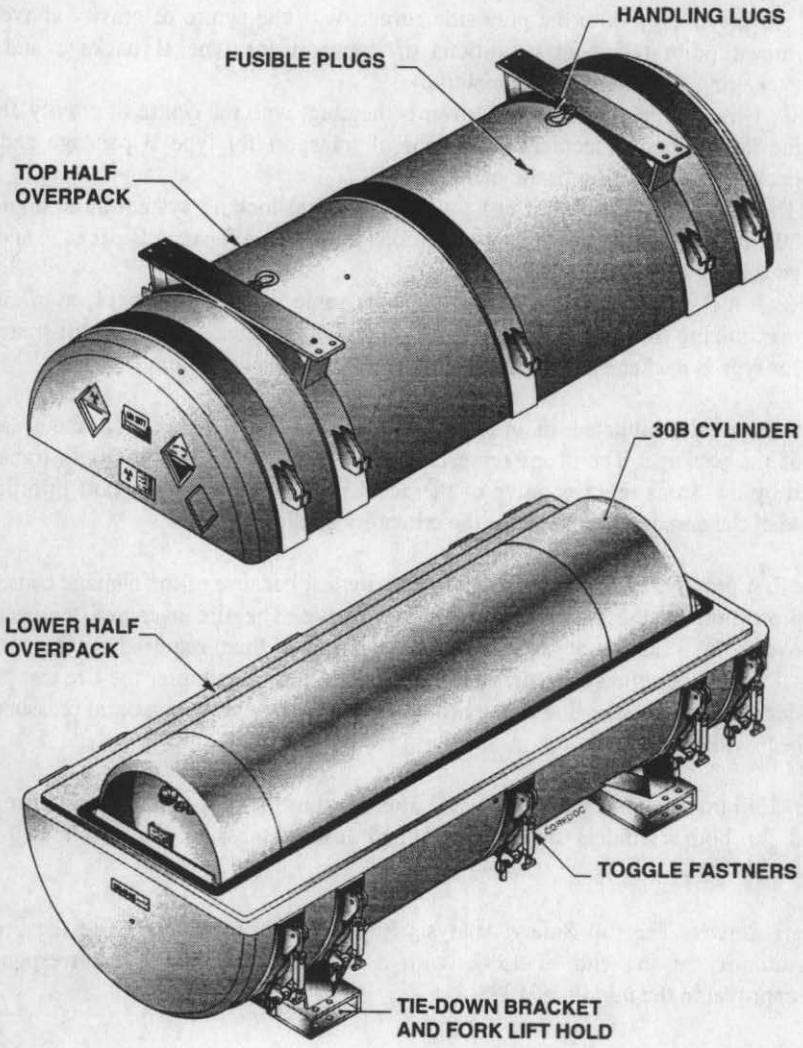

Figure 1: General view of the COG OP30B overpack