STANDARD FOR URANIUM ORE CONCENTRATE TRANSPORT DRUM

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ABSTRACT

A large number of mines located throughout the world provide only few converters with uranium ore concentrate (UOC). Worldwide UOC transport, which uses multiple modes, employs conventional commercial lines to optimize transportation costs.

To comply with regulations of both mining and conversion facilities, UOC is often packaged in 210-L steel drums stowed in dry sea ISO containers. A drum's technical features and stowage system vary widely relative to the country of origin. Transport efficiency varies as well in terms of:

- Transportation costs: drum stacking – a very efficient way to reduce cost – is not widely used.
- Internal contamination: transportation conditions are rough on the drums, thus the containment of UOC powder is challenged.
- Environmental impact and decommissioning: some producers use 800 kg of wood per container to restrain drums; this material needs to be decommissioned at the arrival site.

Since 2007, AREVA has been reviewing its transport of UOC on its most difficult route from the mines in Niger to the conversion sites in France.

The purpose of this article is to share AREVA experience in this field. After a presentation of the transportation constraints and current practices in the industry, this article will focus on the technical solution defined for drums and stowage inside the 20-foot ISO container. It will also include the description of the validation process which involved both laboratory and field tests.

This proven solution could be considered as a reference for optimizing UOC transportation and eventually become an industry-wide standard.

INTRODUCTION

Uranium production is a rising market reaching 50,000 tons of uranium today and is expected to grow in 2010 by 10%. Canada, Kazakhstan, Australia and Niger rank among the largest producers of uranium. Mines provide converters with uranium ore concentrate (UOC). Although mines are located throughout the world, converters are only found in the USA, Canada, Russia, France and China. To comply with regulations of both mining and conversion facilities, UOC is often packaged in 210-L steel drums stowed in dry sea ISO containers. AREVA extracts uranium from two mines in Niger, Cominak and Somaïr, which provide nearly 7% of the worldwide uranium production. Since 2007, AREVA has been improving its UOC shipments from mines in Niger to conversion sites in France.

This article presents UOC transportation constraints and current practices, and shares AREVA experience in this field.

CONSTRAINTS AND CURRENT PRACTICES

Industry practices

The use of drums (210 liters) is widespread since drums are affordable and can be supplied easily. As most UOC shipments require multiple modes of transport, including sea, drums are loaded in twenty-foot containers. Drum features and stowage designs are not standardized, therefore different practises have been adopted by mines and loaders. The following figures give an overview of different industry practices of drum-loading configurations in the twenty-foot containers:

Figure 1: Stowage with lashings, 8 stacked drums, open head drums with a center hole in the lid

Figure 2: Wood frame restraints, no stacking

Figure 3: 8 stacked drums, open head drums with a center hole in the lid, drums supported by spacers of different thicknesses

Figure 4: Wood frame restraints, no stacking

Constraints

- Regulations

As UOC is natural uranium, 210-L drums are mostly considered as industrial packages (IP-1). However, some drums are qualified as type A packages. Therefore, regulations require that drums resist strains of routine transport conditions, and that UOC containment is ensured . In addition, for type A packages, such containment must be guaranteed under drop-test conditions.

One of the main issues concerning UOC transport is the contamination left inside the container. As containers are usually reused by conventional commercial lines for flexibility reasons, contamination requires costly and time-consuming cleansing. Regulations impose the non-contamination criterion at 0.4 Bq/cm^2 for beta and gamma emitters and low toxicity alpha emitters, and 0.04 Bq/cm^2 for all other alpha emitters. [1]

In some countries, regulations specify acceleration for road transport and shipment by sea, up to 2 g in the vertical direction.

- Environment

As drums and stowage components are disposable, a significant amount of waste is produced. In particular, waste treatment for wood frame restraints is expensive. In some cases, the amount of wood used for stowage can reach 800 kg per container.

- Transport

UOC is shipped from mines distributed all over the world, and usually located in remote places, to conversion facilities which are concentrated in the northern hemisphere. This geographical repartition is a constraint for UOC shipments : transports are multi modal, over long distance with numerous transhipments. In addition, as UOC quantities are relatively low, the use of specially reserved ships cannot be justified. Therefore, UOC containers are carried on conventional shipping lines. The following map illustrates the routes of the main UOC shipments to the Areva Malvesi conversion site in France.

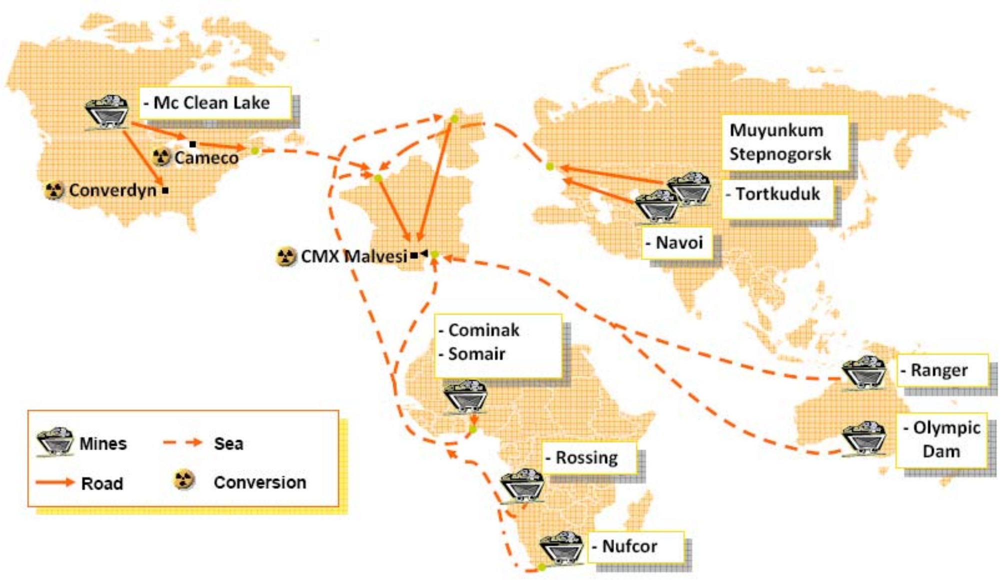

Figure 5: UOC shipments to the Areva Malvesi conversion site in France

TECHNICAL SOLUTION

Since 2007, AREVA has been improving UOC shipments from mines in Niger to its conversion site in France. Currently, two mines in Niger, Cominak (underground mine) and Somaïr (open pit mine), send nearly 300 containers per year to the Malvesi conversion site. These mines provide nearly 7% of the worldwide uranium production. The route is composed of 2,000 km of dilapidated roads between Arlit (Niger) and Cotonou (Benin), and a shipment by sea from Cotonou to a port in France (Fos sur Mer or Sète).

Initial configuration in Niger

Initially, containers were loaded with 36 drums secured by a wooden frame. UOC was packed into standard 210-L drums. In 2007, several incidents of contamination in containers at the Malvesi conversion site put in question this method of securing of drums into the container. Analysis showed that drums were not restrained efficiently. Moreover, nails used for the fabrication of the wood frame could penetrate the drum body.

Drum design

Drums are made with steel sheets usually manufactured with trapezoidal corrugations which improve the resistance of the structure. However, this kind of drum, under the load strain during transport, tends to shift up over the corrugation of the neighboring drums, as shown in Figure 6.

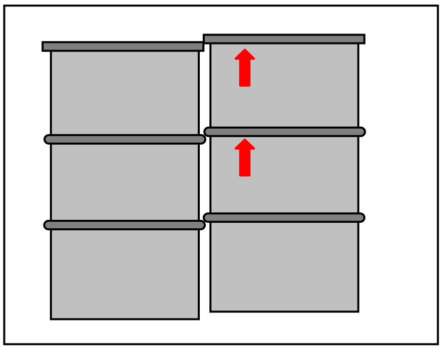

Figure 6

This vertical displacement creates a gap between the drums. As a result, the drums can easily jostle during transport and can, consequently, be damaged due to shocks with neighboring drums. An easy solution to prevent drums from shifting up is to enlarge the corrugations. Figures 7 and 8 show the modifications on the Niger drums. Contact stresses are lower and loading is more stable with the wider corrugations.

Figure 7: First design

Figure 8: New design

Contact between closing rings of neighboring drums should be avoided. Indeed, transfers during transport could lead to the opening of the drum.

To avoid such contact, Niger drums were modified in 2008:

- the corrugation diameter was increased
- the closing ring size was reduced

The size of the corrugation has an impact on the number of the drums which can be loaded into a container. The diameter was chosen for the loading of 36 drums. Figure 9 shows an example of a closing ring with a reduced diameter:

Figure 9: Ring with a reduced diameter

Drums are usually closed with simple lids. However, a lid with a hole in the center, as shown in Figure 10, is a practical alternative : The lid and the closing ring are mounted on the drum prior to the filling. Once filled, the top cover is sealed to the lid. The lid should have a water proof seal on the centre hole.

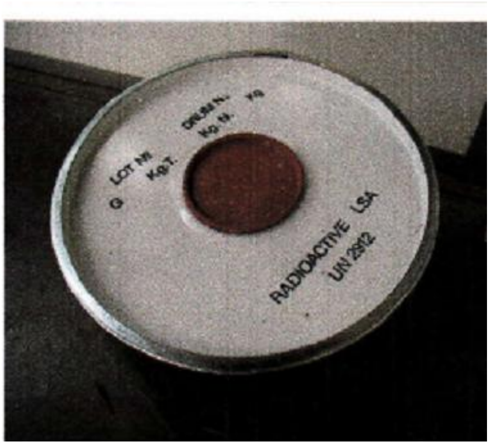

Figure 10 : lid with a hole in the center

Securing

In 2008, the wood frame was replaced by stowage with lashings. Lashings secure groups of 4 drums. Each drum belongs to two groups of four drums so as to improve the stowage stability. Transversal lashings linked to vertical lashings further restrain groups of 8 drums. The lashing is manufactured from high-tenacity polyester yarn (lashing capacity: 2,300 daN). This lashing is closed by specially developed buckles, and tightened with a manually operated tool. Figure 11 illustrates the new stowage system:

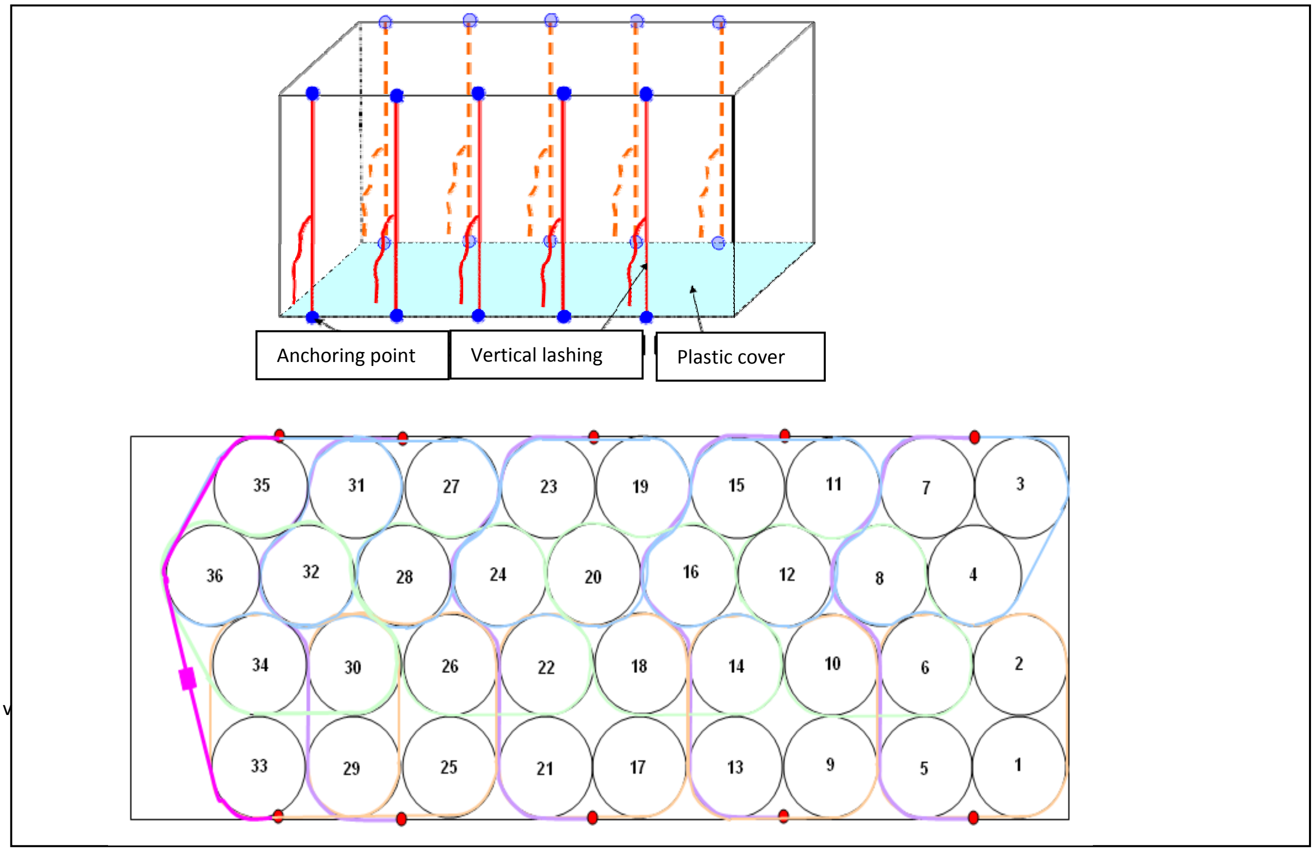

Figure 11: Lashing diagram

The following figures shows the evolution of the securing system:

Figure 12: Previous securing

Figure 13: New securing

Lashing and buckles per container weigh nearly 30 kg, whereas a wood frame is nearly 400 kg. Therefore, 10 times less waste is produced with the new stowing method. The reduction in purchase and decommissioning costs is about 100,000 € per year for the UOC from Niger.

Stacking

The gross weight of the container varies with UOC density. For low UOC density, the container weight is often under the maximum gross weight of 30,480 kg [3]. Staking is a practical solution for optimizing loading configurations and for reducing transportation costs.

Qualification of the securing

As lashing is a new securing method for UOC shipments in Niger, a field transport test was performed. 36 drums filled with concrete were lashed into a container according to the new stowage drawing. The container was shipped from Le Havre (France) to Cotonou (Benin) and then carried on a truck to the mines of Arlit (Niger). Upon arrival, drum positions and lashing tightness were satisfactory.

Qualification of the closing ring

As the closing ring is part of the containment system, any change had to be carefully qualified. The closing ring was tested under both vibratory and static conditions.

- Vibratory conditions

Vibration tests were performed in the SOPEMEA facilities. A drum with the new closing ring was secured to an electrohydraulic actuator which reproduced load strain during a shipment between Arlit (Niger) and Cotonou (Benin).

In 2009, a series of field acceleration measurements was taken so as to define a range for the vibration tests. Sensors monitored acceleration on the frame of the container and on the drum closing rings during a shipment by road between Arlit (Niger) and Cotonou (Bénin). Figure 14 shows a tri-axial sensor fixed on a drum.

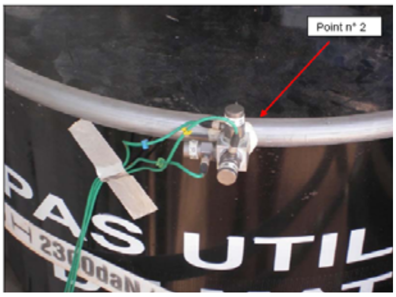

Figure 14 : sensor position

Acceleration measurement description: The 2,000 km route was divided into 48 road categories. For each category, one measurement gave the corresponding acceleration, composed of random accelerations and shocks. A resulting signal was built with the envelope of each signal. At this point, the signal duration was equal to the monitoring duration. In order to perform a field test compliant with laboratory conditions, the signal duration had to be reduced to a 15-minute test for each axis (X, Y and Z).

SOPEMEA used a method of personalization based on the equivalence of energy and fatigue. The drum used for the vibration test was filled with silica powder, whose granulometry was equivalent to that of UOC, wrapped in a plastic cover. The test was considered satisfactory if:

- no powder was found on the plastic cover or the external side of the drum
- no powder was found on the gasket once the lid was removed

The following figures show a drum on the electrohydraulic actuator and a drum filled with silica powder:

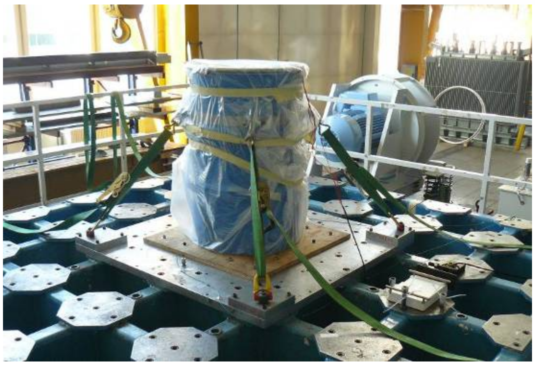

Figure 15: Drum on the electrohydraulic actuator **Figure 16: Drum filled with silica powder**

- Static conditions

The tightness of the closing device under static conditions was tested in the Somaïr mine (Niger), according to the norm [2]. The gas bubble technique, as described in Figure 17, was adopted. An empty drum was immersed in water heated at 90°C. Leaks were indicated by the appearance of bubbles in the water. The test sensitivity is between 10^{-4} and 10^{-7} Pa.m^3/s SLR.

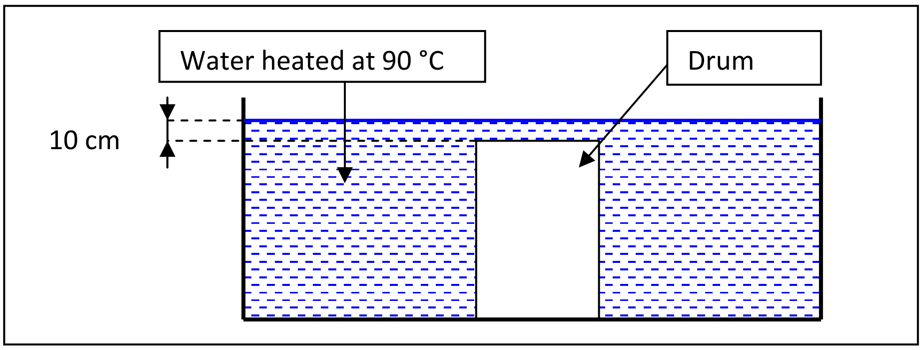

Figure 17: Tightness test

CONCLUSIONS

AREVA feedback on UOC shipments highlights good practices which can be easily applied to the drum design and the drum securing method in the ISO container. As no standard currently provides guidelines, the solution described in this paper could be considered as an optimization for UOC transport in the following ways:

- Improvement in the securing of drums in ISO containers
- Reduction of transport costs
- Environmentally favorable

We hope this feedback will contribute to an industry-wide benchmark for UOC shipments and demonstrates the need for sharing good practices.

REFERENCES

[1] AIEA TS-R-1 Regulations for the safe transport of radioactive material, 2009 Edition.

[2] ISO 12807 Safe transport of radioactive material – Leakage testing on packages, 1996 Edition.

[3] ISO 668 Freight containers – Classification, dimensions and ratings.