CURRENT PRACTISE AND EXPERIENCE OF SHIPPING BULK POWDERS AND HOW THIS IS RELEVANT TO THE TRANSPORT OF URANIUM ORE CONCENTRATES

Mr. Marc-André Charette
World Nuclear Transport Institute, Remo House, 310-312 Regent Street, London, WIB 3AX, United Kingdom

Mr. Al Stratemeyer
World Nuclear Transport Institute, Remo House, 310-312 Regent Street, London, WIB 3AX, United Kingdom

Mr. Guy Karrer
World Nuclear Transport Institute, Remo House, 310-312 Regent Street, London, WIB 3AX, United Kingdom

ABSTRACT
Natural uranium ore concentrates (UOC) have safely been transported in open-head steel drums for over 50 years. These drums are appropriate and meet the regulatory requirements for the packaging and transport of natural uranium ore concentrates. However, a review of the current practices has not been done for some time. The UOC transport industry recognises that there are many forms of bulk powders shipped all over the world and believe it to be timely, relevant and aligned with the concept of product stewardship to benchmark current practices against best practices for transporting bulk high density industrial based powders.

In order to ensure sustainable shipment of uranium concentrate, the World Nuclear Transport Institute (WNTI) commissioned a study on the current methods used for the transport of bulk powders. The study covered the shipment of powders in bulk by shipping lines, the use of ISO containers, bags, big bags, intermediate bulk containers, tote boxes, drums, special containers and pressurized tank containers.

This paper summarizes the results of Mr. Bill Brassington's study on Current Practices and Experience of Shipping Bulk Powders in Freight Containers[1] and how this relates to the transport of UOC.

INTRODUCTION
Bulk powders and granules are carried by a number of different enclosures and means; the size and type are often dictated by the characteristics of the material to be transported and by the availability of the transport means. In general there are three modes of international maritime transport for bulk cargoes:

- Bulk cargo vessels designed to carry one or more products within a hold without any other form of containment,
- Freight containers carrying bulk cargo with cargo contained in smaller enclosures,
- Freight containers without other forms of containment except for protective liners.

BULK CARRIERS
Bulk carriers are ships that are designed to carry large volumes of solid bulk cargoes. Typically solid bulk cargoes can be "automatically" loaded using conveyor gantries that deliver the cargo into the cargo holds. Conveyors are associated with larger granules or larger pieces such as coal and

road stone. It is not always possible to load dry bulk cargoes using automated methods and more manual systems are employed.

As a result of the handling operations involving the movement of solid bulk cargo, there are opportunities for the cargo to be exposed to the atmosphere and potentially lost (in corners and split).

FREIGHT CONTAINERS

Containerised transport allows the cargo to be loaded at the originating facility and remain sealed within the container until it is discharged at the consignee's facility. Not only does this simplify and reduce the number of handling operations involved, but it also reduces the cargo exposure. Freight container designs discussed included:

1. Dry freight (General Purpose) container[3];
2. Dry freight container with bulk cargo features[3];
3. Non pressurised containers for bulk[5];
4. Tank containers for pressurised dry bulk[4]

GENERAL PURPOSE FREIGHT CONTAINERS

General purpose dry-freight containers are the most common container used in international transport. The workhorse of the industry is the 20' long by 8', 6" in height container. The maximum gross mass of these 20 ft containers is 32,500 kilograms, although there are containers built with a maximum capacity in excess of this value. A 40' container is available in either standard height (8', 6") or HiCube height (9', 6") with a maximum gross mass of 32,500 to 34,000 kg.

With a high maximum gross mass, the 20 ft container is well suited to carry high density cargoes such as powders and granules. Powders and granules can be carried in standard dry freight containers in a variety of different intermediate containment methods which are explored below:

BAGS

Bags used to carry powders and granules come in a variety of sizes and materials and are generally limited to a maximum mass of 50 kg. The choice of material for the bag will depend on the product but can vary from burlap woven sacks to engineered multi-layer woven or extruded bags. Filling technology also varies depending on the product, the choice of packing material and the volume of product to be packed.

Advantages of such a system:

- Bags are inexpensive
- Lower capital cost
- Total automation and consistent packing rate - usually unattended
- Fast and compact
- Fewer moving parts
- 'Online' film printing provides readable bar code and product info.

Disadvantages of such a system:

- Not economical for short production runs of one bag size

- Cannot handle paper or multi-ply packing materials
- Not economical for packing low density, aerated powders
- Cannot remove 'trapped air' quickly or easily
- Shape of package not as efficient, safe and effective as premade sack
- Cannot self adjust for different widths of bags.

At the destination facility the bags would have to be removed from the pallet and either emptied manually or a suitable discharge system would have to be installed which would open the bag and empty the contents into the delivery receptacle for processing. Most bags are not reusable.

BIG BAGS

A Flexible Intermediate Bulk Container (FIBC), big bag, bulk bag, or super sack is a standardized container in large dimensions for storing and transporting dry products. It is most often made of thick woven polyethylene or polypropylene and normally measures around 110 × 110 cm and varies in height from 100 cm to 200 cm.

The product is typically weighed using an automated system and should be fine and free-flowing to allow easy filling of the bags. Product may be fed from a storage silo via a single screw feeder conveyor and slide valve. Unloading big bags is usually carried out by lowering the bag onto a knife edge that cuts the base of the bag allowing the contents to drop into the hopper. Hence, these bags are for single use. They are generally made from materials that can be recycled, subject to the nature of the product carried.

Big bags can be fitted with top closures to prevent the product from becoming contaminated from falling debris and to retain the product within the bag. They can be loaded into freight containers by the top loops using a suitably adapted fork lift truck; or alternatively they can be loaded onto pallets and then handled by normal pallet handling equipment.

DRUMS

Barrels, drums and pots can be made from steel, plastic or fibre (paper). They come in a wide range of sizes and are usually defined by their volumetric capacity. The largest stock size is 210ℓ (55 US gallons) but can be as small as 1ℓ (0.25 US gallons).

Drums are available in open or closed top designs:

- Closed top designs generally have two small openings and are meant for carrying liquids.
- Open top designs have a full diameter removable lid that is attached by a ring seal. They can be supplied with parallel or tapered sides.

Loaded drums are generally too heavy for manual handling so must be moved using mechanical devices. Additionally, filled drums can be palletised on simple plastic, wooden or steel pallets or, if carrying dangerous liquids, mounted on a bundled / spill pallet. To unload drums, a tipping device is required.

Drums are reusable and can be returned to the originating facility, although this is generally not practical where there is a long transport route. Nesting drums increases the financial benefit from reuse by permitting more empty drums to be loaded into the return transport unit.

INTERMEDIATE BULK CARRIERS

An intermediate bulk container (IBC) is a container used for transport and storage of fluids and bulk materials. The construction of the IBC and the materials used are chosen depending upon the application. There are various types available in the market:

- Foldable (collapsible) IBC Container
- Plastic composite IBC Container
- Steel IBC Container
- Stainless steel IBC Container

The use of IBCs has expanded and there are a number of different designs that cater to bulk liquids, powders and granules as well as food stuffs. Many designs employ a steel support frame with a tank or hopper suspended within it. These IBCs can be stacked and are generally capable of carrying a reasonable load. However the frame design, which permits the stacking capability, means that there is a reasonable amount of "wasted" space. The plan area of the IBCs are usually less than 1,200 mm square, thus permitting two units to be stowed alongside each other inside freight containers, but the height prevents stacking.

Another form of IBC is a "Tote Box" which is a 965 mm (38 inch) cube (790ℓ / 0.79 m3) of high density polyethylene, which is suitable for low density powders and granules. Such an IBC can be stacked and fitted with lids to protect the product from contamination and falling debris. These boxes can be used efficiently within a freight container. A fork truck is required to handle these boxes.

DRY FREIGHT CONTAINERS WITH BULK CAPABILITIES

It is necessary to differentiate between general purpose freight containers and freight containers designed to carry bulk cargoes. In many cases dry bulk cargo can be handled in a general purpose container, but the International Maritime Dangerous Goods (IMDG) Code[2] specifies the provisions for the design, construction, inspection and testing for bulk containers in chapter 6.9.

This section will explore dry freight containers with the following designs:

- General purpose containers being used to transport bulk cargoes
- General purpose containers with bulk container features
- Open top containers
- Half height containers

GENERAL PURPOSE CONTAINERS BEING USED TO TRANSPORT BULK CARGOES

The most common container in the world is the 20 ft general purpose dry-freight container and it is most commonly used to carry dry-bulk cargoes. However, the design requirements of these containers are not always suitable for dry bulk cargoes, especially free flowing powders and granules. For instance, extremely free-flowing materials can damage the side and end walls due to stresses induced during intermodal transport where there is high sideway acceleration.

Additionally, the rear doors are the only means of access into the container and need to be opened to load and remove the cargo. In order to transport powders and granules in general purpose containers, false walks (known as bulkheads) need to be erected at the rear end to retain the cargo

when one or both doors are opened. The introduction of dry bulk liners which are generally manufactured from virgin food-grade, co-extruded polythene film or from coated woven polypropylene, has replaced the need to construct a bulkhead.

Loading bulk powders and granules into such liners is normally carried out by a conveyor belt inserted through the open top at the rear of the liner, or pneumatically "blown" in to the liner. These loading methods have restrictions and must be evenly distributed across the entire container by gradually withdrawing the conveyor/blow pipe. When blown, powders and granules can be quite abrasive and during the loading operation care must be taken to ensure that the liner or the container are not damaged.

GENERAL PURPOSE CONTAINERS WITH BULK CONTAINER FEATURES

Many shippers of bulk commodities have developed containers based on the general purpose container with additional features to assist with loading or unloading. For deep sea routes the containers are generally 20 ft long, but are also available in 40 and 45 ft lengths. These special freight containers can be fitted with:

- Loading hatches fitted into the roof;
- Discharge hatches fitted into the container (rear) doors;
- Full-width discharge hatches incorporated into the rear end;
- Full-width discharge hatches fitted into the front wall.

Many bulk containers fitted with discharge hatches require tipping to unload as the end in which the discharge hatch is fitted is fixed and cannot be opened. Personnel access into the container, for cleaning and fitting / removal of liners, is made through a small door.

Such specialized equipment is in limited supply and will generally only be available on established bulk cargo routes. It is worth recognising that these routes often operate within a "closed loop", meaning that the container, once the bulk cargo is discharged, can be loaded with a return cargo back to its port of origin and subsequently loaded with the same or a similar cargo. Without the "closed loop" feature, the specialized bulk container could be lost to the general freight pool and end up at destinations where its special features are not required. To avoid this, empty containers may be repositioned to the port of origin which adds cost to the logistics operation and is subject to availability of empty container slots on board the container vessel.

OPEN-TOP CONTAINERS

Another type of container used for bulk powders and granules is the open-top container. Open-top containers are available in 20 ft and 40 ft lengths and can be handled in the same way as general purpose containers except that the material can be loaded through the roof. As a consequence of that access, the container is less watertight than the general purpose container. Cargoes that are susceptible to moisture should not be carried in them.

Open-top containers may be fitted with PVC covers. The hard top is easily damaged and troublesome to refitting. Open-top containers can be fitted with bulk liners, which is sealed prior to shipment. Open-top containers used for bulk dry cargoes generally carry inert materials or large particles which are not affected by moisture.

HALF-HEIGHT CONTAINERS

High density cargoes being carried in bulk in standard height (8', 6") containers can result in a large amount of empty space. To cater for these dense cargoes, half-height containers have been developed with a typical height of 4', 3" and a length of 20 ft.

Half-height containers are specialized items of equipment and are not widely available. They are generally owned by specialist companies and can be designed and built to suit the particular needs of the cargo being carried. For bulk high density powders, a hard top design with three or four loading hatches and a full-width discharge hatch could be appropriate.

Specialist containers require a closed loop trade, with the empty containers being returned with a cargo if available or empty. Half-height containers have the benefit that they can be linked together to form a standard 20 ft unit for empty return, which provides savings on repositioning costs.

NON PRESSURISED CONTAINERS FOR BULK

Box Type

The box-type, non-pressurised, dry bulk containers are very similar to 20 ft containers with increased end wall strength being the primary difference. They are also expected to be capable of withstanding a tipping operation. All of the issues identified in the section above concerning freight containers with bulk capabilities essentially apply to box type containers. .

Hopper Type

Hopper-type dry bulk containers are very specialized types of equipment and are generally built to meet the specific requirements of the cargo to be carried. The material, shape, volume and discharge of the hopper will be dictated by the dry cargo being carried and how well it flows. The loading and discharge capabilities will need to be designed to interface with the facilities at origin and destination.

Loading occurs through the top-loading hatches and the separate compartments ensure that the container can be evenly loaded and the cargo kept stable from longitudinal movement. Unloading can be either vertical discharge, where the container is positioned above receiving hoppers set below the road surface/rail bed, or by horizontal discharge to the rear mounted discharge pipe via an internal conveyor/screw.

TANK CONTAINERS FOR PRESSURISED DRY-BULK

Tank containers are generally designed to carry bulk liquids. However, many free-flowing powders and granules can be handled in much the same way. Powder tank containers come in two basic designs, one for horizontal discharge and the other for tipping. Tank containers are generally built with light-weight materials, such as aluminum, to minimize the tare weight and maximize the cargo payload.

The use of dry powder tank containers for carrying free-flowing cargos is increasing. In these containers, the cargo can be aerated to assist with horizontal discharge.

NEXT STEPS

Mr. Bill Brassington's study provided a comprehensive overview of the transport of bulk powders but did not specifically indicate if these methods would be suitable for the transport of UOC.

Although some methods to transport bulk powders would clearly not be suitable for UOC other methods may be applicable and provide a viable option. To evaluate these options, several industry members are joining forces to conduct a feasibility study. The study will assess the current practice for shipping UOC vis-à-vis the practices used to transport other bulk powders. The intent is to benchmark the current practices in the transport of UOC with those of other bulk powder transporters and identify the most efficient means for handling UOC from origin to destination.

The feasibility study will investigate UOC packaging and transport technologies, including:

- the robustness of the package,
- design for ease of use in process (filling/sampling/emptying),
- the ease of restraint during transport,
- waste from current package life,
- the ease of surface contamination control and
- the environmental impact of transporting this material.

To lend further credibility to the feasibility study, all parties involved from the manufacturing of the packages to the final disposal and all the steps in between will be invited to participate in the project. The study will examine current practices and procedures and explore the safety, environmental, and cost implications of any potential change that would result from the adoption of an alternative transport method.

The goal of the feasibility study is to identify and review the technical and commercial package design requirements and constraints required for the transport of UOC from the producers to the convertors.

ACKNOWLEDGEMENTS

The WNTI Task Force members represent both the consigning producers and the recipient converters, as well as other stakeholders such as transporters. This paper could not have been prepared without their hard work and dedication.

REFERENCES

1. Current Practices and Experience of Shipping Bulk Powders in Freight Containers, Bill Brassington, ETS Consulting.
2. INTENATIONAL MARITIME ORGANIZATION, “International Maritime Dangerous Goods (IMDG) Code”, Volumes 1 and 2, 2008 Edition, incorporating amendment 34-08, publication number IG200E, IMO, London (2008), www.imo.org
3. INTERNATIONAL ORGANISATION FOR STANDARDIZATION, “International Standard for Series 1 freight containers - Specification and testing - Part 1: General cargo containers for general purposes, ISO 1496-1:1990, ISO, Geneva (1990), www.iso.org
4. INTERNATIONAL ORGANISATION FOR STANDARDIZATION, “Series 1 freight containers -- Specification and testing -- Part 3: Tank containers for liquids, gases and pressurized dry bulk, ISO 1496-3:1995, ISO, Geneva (1995), www.iso.org
5. INTERNATIONAL ORGANISATION FOR STANDARDIZATION, “International Standard for Series 1 freight containers - Specification and testing - Part 4: Non-pressurized containers for dry bulk, ISO 1496-4:1991, ISO, Geneva (1991), www.iso.org