Standard for Packaging and Transport of Uranium Concentrates Version 2

Dedicated to the safe, efficient and reliable transport of radioactive materials
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Standard for Packaging and Transport of Uranium Concentrates Version 2

2. INTRODUCTION

This document introduces and describes leading industry practice for the safe transport of natural uranium ore concentrates (UOC). It has been developed by members of the World Nuclear Transport Institute (WNTI) and is intended to share their leading practices with other industry participants. It describes the practices that Consignors should adopt in order to fulfil their obligations to ensure the security and safety of the communities and environments through which their UOC is transported. It should be read in conjunction with applicable national and international regulations for the safe transport of radioactive materials.

The transportation of UOC is a global undertaking, as producers deliver their production, on behalf of their customers, to toll Converters utilizing supply chain routes traversing international waters, ports, shipping container terminals, public roads and railways. UOC is typically packaged in open head steel drums and shipped in dry sea (ISO) containers.

This document is specific for natural UOC, which are transported as “Class 7” (radioactive) materials and identified as UN2912. UOC is a relatively weak alpha emitter of radiation and is classified as being a “low specific activity (LSA-I)” radioactive material. The management of exposure to and contamination from sources of radiation forms an essential component for the safe transport of radioactive materials.
3. PACKAGING

The packaging used for transporting any form of radioactive material must meet applicable international standards. Industry has for many years, used open head steel drums, conforming to the IAEA standard Type IP-1, as the primary containment for transporting UOC.

3.1. Drum Description

UOC is typically packed in 205 litre steel drums with a gross weight of up to 450 kg. The drums must be suitable for repeated handling, stacking and storage for extended periods of time. They must have a removable top lid secured by a bolted retaining ring to allow for filling and emptying. Drums should have smooth internal and external surfaces to facilitate emptying and cleaning. Depending on their condition, empty drums are either recycled or disposed of after use.

Drum designs vary according to local availability and are subject to applicable national and international regulations. Converter contracts will typically include a drum specification, setting out precise details of construction, dimensions and markings.

A typical drum specification can be found in Appendix 2.1.
3.2. Drum Body

3.2.1. Open head rolled steel

3.2.2. Both nesting and non-nesting types are in routine use by industry.

3.2.3. The interior of the drum should not be galvanized or have any type of coating (including organic).

3.2.4. In addition to any labelling and marking that may be required for compliance with applicable transport regulations, as best practice, drums should be marked with the following identifying information:

- Lot number,
- Drum number,
- Gross, Tare, Net weight details, and
- Producer related details

Labels should be affixed in two places, 180 degrees apart.

3.3. Drum Lids

3.3.1. Filling can be either through the open head whole lid system or a centre fill “Bung Hole”

3.3.2. Drums are emptied by removing the whole lid.

3.3.3. For drums that are filled through a centre fill “Bung Hole”, an effective waterproof seal must be applied to the fill hole, which should be capable of providing extended periods of dry storage of the UOC material sometimes in extreme climates.

![Whole lid](Image 3.d - Drum lid sketches)

![Centre fill lids with effective waterproof seals](Image 3.d - Drum lid sketches)

![Image 3.e - Drum lid showing locking ring](Image 3.e - Drum lid showing locking ring)
3.4. **Retaining Ring**

3.4.1. A bolted retaining ring should be used to secure the lid to the drum. Clip rings should not be used.

3.4.2. Galvanised retaining rings having either a “C” or “U” ring profile are preferred.

3.4.3. The rings should have sufficient strength and durability to allow for opening and closing of the lid to permit sampling at the point of delivery.

3.5. **Securing bolt**

3.5.1. The retaining ring should be secured with a removable bolt, welding should not be used on the securing bolts (to allow for opening and removal of the lid at the Consignee or Converter premises)

3.5.2. Top bolted rings should not be used (to avoid snagging when drums are stacked)

3.5.3. The use of security tags is permissible.

Appendix 2.1., provides a same of a drumpackage specification

3.6. **Drum Conformity**

Producers are encouraged to develop a close relationship with their drum suppliers, to monitor quality control and to set appropriate standards, including all required testing. Testing may include the suitability for stacking of the drums up to a height of 3 m and a drop test from 0.8 m.

Appendix 2.2., Drum Package Certification
The transport of UOC drums typically utilizes ISO shipping containers. Consignors either utilise containers supplied by the relevant maritime shipping line carrier, enter into ‘one way’ equipment leasing arrangements through major global shipping container companies, or, in some cases, elect to provide and use their own equipment.

There is a requirement for all Consignors to comply with the ‘Convention for Safe Container’s (CSC’s):

4.1.1. Shipping Container specification

- Twenty foot (20’), dry van type, full height, heavy duty ISO 1496-1 containers.


4.1.2. Containers should be compliant with the International Convention for Safe Containers (CSC), including the requirement to have a current CSC safety approval plate or ACEP marking attached to a door of the container.

  http://www.imo.org/About/Conventions/ListOfConventions/Pages/International-Convention-for-Safe-Containers-(CSC).aspx

Consignors are encouraged to conform to the requirements of the United States Customs and Border Protection, Customs-Trade Partnership against Terrorism (C-TPAT) anti-terrorism initiative when shipping cargo either into or through the USA:


4.1.3. The loaded weight must not exceed the limit stated on the container manufacturer’s plate. The combined weight of drums, dunnage and the container must conform to all applicable regulations, specifically road/rail weight restrictions, from the point of origin through the final destination.

4.1.4. As required by SOLAS chapter VI, part A, regulation 2, packed containers’ gross mass shall be verified by weighing the packed container, or by weighing and summing weights of the container and all its contents, prior to stowage aboard ship. The verified gross mass (VGM) shall be communicated in the shipping documents sufficiently in advance to be used by the ship’s master or his representative and the terminal representative in the preparation of the ship stowage plan.

CONTAINER LOADING

In determining container load configurations and securing:

Consignors should undertake a full and complete evaluation of the load restraining system that they intend to utilise to secure their drums or packages within shipping containers. The evaluation should ensure that the restraining system is in full compliance with the applicable national and international standards. Consignors should also undertake periodic reviews of their load restraint system.

Consignor should consider the relationship between maximum gross container weight and any road/rail restrictions and the limits set by the intended Consignee or Converter.

Consignors should provide loading personnel with adequate training, including written procedures and diagrams for loading drums into the shipping containers and such procedures should be followed by the facility, which is responsible for loading of the drums. Similarly, Consignees or Converters should also provide unloading personnel with adequate training including written procedures and diagrams for the unloading of shipping containers following arrival at the Consignee or Converter premises.
5.1. Loading Design

5.1.1. Drums should be evenly distributed within the shipping container and be arranged so that they are tightly nested together, using dunnage to fill any voids. Consideration should be given to preventing drums from locking and or hanging on each other during transport as this can lead to displacement of the lid and possible deformation of the drum. Drums should be placed so that their locking bolts do not touch the sides of the shipping container or other drums.

5.1.2. Drums may be secured into the container in either a single or double tier configuration. (UOC typically has a high bulk density hence the second tier is normally not fully loaded with drums due to container and/or road weight limitations). Should the loading configuration require a second (lower) tier it shall be separated from the first tier using slip resisting wafering, to minimize the possibility for any movement during transit.

5.1.3. Drums should be restrained with dunnage and or lashing in compliance with the applicable transport regulations in order to prevent longitudinal, lateral and vertical movement during transport. Particular attention should be paid to the securing of any second tier loading. Chorded polyester (or equivalent) lashing is preferred, as it minimizes the need for dunnage disposal.

5.1.4. Any void space between the cargo and the container doors, should be blocked with dunnage to prevent shifting during transport. The use of bull boards is recommended to fill this void space. It should be noted that the doors are not designed nor intended to restrain drums in case they shift.

5.1.5. Samples of UOC may be transported in the same container as the drummed UOC cargo. Samples should be packaged according to the appropriate regulations and be adequately secured within the container.

Wherever timber dunnage is used, it should be phytosanitary compliant and free of defects which impair its strength or interfere with proper nailing. Dunnage should not be nailed to the container.

5.2. Stowage of shipping containers for sea transport

5.2.1. It is suggested that containers be stowed under deck. Consignors should work closely with their Carriers who in turn should work closely with the Terminal Operators of the en route passage to achieve this outcome. However, some authorities may need to board the vessel to inspect the containers prior to final approval for transit (e.g. Suez canal) or berthing so this practice may not always be possible. In these instances the vessel owners may require the containers to be stowed on deck.

5.2.2. Containers should be stowed door to door, or alternatively with doors facing against steel bulkheads as this minimizes the risk for the doors opening should some external event trigger a significant impact or force on the container.

CTU Code: https://www.unece.org/trans/wp24/guidelinespackingctus/intro.html
6. **RADIOLOGICAL MONITORING AND CONTROL OF PACKAGING AND CONTAINERS**

Best practice requires that all packaging associated with radioactive materials be as clean as possible. Contaminants can be introduced onto packages and into shipping containers through exposure to the elements and through poor standards of housekeeping and associated work practice.

Examples of contaminants include various forms of dust, dirt, mud, residues of liquids, particulates suspended in air, etc. For example, “No muddy boots should be worn when packing or checking containers.”

The cleanliness of the package and shipping containers can be further compromised by contaminants that may include radioactive “contamination” defined in the IAEA Regulations SSR-6.

The IAEA Regulations indicate that any non-fixed contamination on the external surface of any package shall be kept as low as practicable and under routine conditions of transport shall not exceed 4 Bq/cm$^2$ for beta and gamma emitters and low-toxicity alpha emitters, such as natural uranium (averaged over any 300 cm$^2$).

Minimising the transfer of or retention and collection of contaminants on the packages or shipping containers can greatly assist in reducing the likelihood of radioactive contamination.

### 6.1. Recommended contamination limit

6.1.1. Although not a regulation, the WNTI recommends that Consignors adopt the 0.4Bq/cm$^2$ value as the applicable standard for all relevant work areas and mobile equipment used when loading drums into shipping containers (effectively reducing the admissible value for a package surface by a factor 10). This will help to ensure that the shipping containers are free of any possible contamination before leaving the Consignor’s premises and facilitate the free release of the empty shipping containers by the Consignee or Converter.

6.1.2. There are two forms of radioactive contamination fixed and non-fixed (or transferable):

Fixed radioactive contamination can come from dust or fine powder residues associated with commonly transported materials such as fertilisers, mineral sands or ceramic tiles that over time may have become embedded, impregnated and ground into relatively porous materials such as the timber flooring found in shipping containers.

Non-fixed radioactive contamination is material that can be easily removed from the surface of a package. It generally occurs in powder, dust or liquid form, which may become airborne, settle or flow anywhere, be carried away by people or equipment and transferred to people, equipment, facilities and conveyances; thus creating the potential for further contamination. Due to its greater mobility, non-fixed radioactive contamination generally creates a greater hazard than fixed radioactive contamination and therefore should be removed prior to shipment.
6.2. Measuring contamination

6.2.1. Uranium is an alpha emitter, but the immediate long-lived decay chain of U-238 contains two alpha emitters (U-238 and U-234) and two beta emitters (Th-234 and Pa-234m). Secular equilibrium of these radionuclides is generally reached within 6 to 8 months after extraction. If the UOC is to be shipped shortly after processing, then only the alpha measurements will provide meaningful results. Beta measurements should not be measured at the Consignor site. For shipment of aged material close to secular equilibrium, on arrival at the Consignee, Converter site, both alpha and beta measurements are acceptable and beta measurements usually provide greater accuracy.

6.2.2. For regular shipments, the measurement methods should be agreed between the Consignor and Consignee or Converter, occasionally comparing readings on the same items.

6.2.3. Alpha and beta contamination are measured separately and are not “additive”.

6.2.4. Surface contamination can be detected and measured using direct surface activity measurements with a surface contamination meter or by taking wipe tests.

6.2.5. Direct surface activity measurements usually measure the level of fixed plus non-fixed radioactive contamination, whereas wipe tests only measure the level of non-fixed radioactive contamination.

6.2.6. A wipe test involves wiping off some of the non-fixed radioactive contamination from a surface onto a filter (made either from paper for smooth surfaces or from fabric for rough surfaces), whose collected activity is measured using an activity counter or rate meter. This process usually involves making an assumption of the fraction of total contamination collected by the swipe. A typical value is 10% and it is important that this assumption is recorded and documented.

6.2.7. Direct surface activity is measured using a surface contamination meter. In order to measure the desired source of activity, these devices should be fitted with either an alpha or beta probe. Care must be taken as a number of beta probes are also sensitive to gamma radiation and hence will give a false positive due to direct gamma emissions from the UOC.

6.2.8. All measuring instruments should be calibrated regularly as per manufacturer’s instructions or regulatory requirements, and the calibration records should be kept.

6.2.9. Regular checks of instruments in accordance with the manufacturer’s instructions must be performed before using the equipment.

6.2.10. Measurements require the subtraction of background radiation in the measurement area. Failure to take into account subtraction of the background measurement will result in erroneous results. All readings, including the level of background radiation, should be recorded. Background for alpha contamination is usually close to zero.

6.2.11. The detection limit of the measuring instrument should be significantly below the required measuring threshold. In other words, when checking for a contamination standard of 0.4 Bq/cm², an instrument having a detection limit below 0.2 Bq/cm² should be used.
6.3. **Monitoring of drums**

6.3.1. Prior to filling, drums should undergo a visual check for suitability, focusing on any evidence of moisture or rust on the internal surfaces of the drum, any rust, corrosion, punctures and/or visible damage to the external surfaces of the drum, or defects in the seam of the drum barrel or the jointing of the barrel to the drum base and top collar which could result in a failure of the package leading to a leakage of UOC powder.

6.3.2. After filling and closing, the drums should be cleaned, e.g. vacuumed, then washed with water, dried and marked in accordance with requirements.

6.3.3. After completing the cleaning process, the external surfaces of the drums should be tested for non-fixed radioactive contamination using adequate equipment in accordance with the Consignor’s operating procedure. If the drums have been stored outside in the open, additional care is required when testing the underside of the drums to ensure that no contaminants have been caught up in or around the base of the drum.

6.3.4. The WNTI-recommended limit for surface contamination is 0.4 Bq/cm². Drums failing to meet this criterion, but which are below the regulatory limit of 4 Bq/cm² should be reviewed to determine if it is acceptable to release them for shipment. Drums exceeding the regulatory limit of 4 Bq/cm² will require remedial cleaning and re-testing prior to acceptance.

6.3.5. Best practice would ideally result in drums being transferred immediately from the drum filling plant directly into shipping containers. Where this is not possible, the drums filled with UOC and awaiting packing into shipping containers should be stored undercover in a clean area so as to minimise contaminants such as moisture or windborne dust as well as the potential for any non-fixed radioactive contamination. The failure to store loaded drums in a clean area may result in the need for the Consignor to give consideration to rewashing and retesting of the drums and associated preparatory work before packing the drums into shipping containers.

6.4. **Monitoring of shipping containers**

Shipping containers may be contaminated by other radioactive cargoes such as bulk or bagged fertilisers or ceramic tiles that can leave residual traces of fixed or non-fixed radioactive contamination.

A reliable long-term source of clean (free of dirt and contamination) structurally sound shipping containers should be secured. Nevertheless, an assessment of the quality of the shipping containers supplied should be performed before they are transported to the production site.

Once on the production site, good practice requires that the shipping containers be checked for radioactive contamination prior to moving them to clean areas within the production site and to loading them with packaged drums of UOC.

The practice of painting the flooring or any other surfaces, of the shipping container to fix the contamination is strictly forbidden and shall not be done. This results in the shipment of a contaminated shipping container which must be decontaminated, often by removing the floor, at the Converter’s site.

Appendix 4 sets out a suggested Pre-Use Inspection Checklist for Containers. The following guidelines provide details regarding industry leading practice for radiological monitoring.
6.5.  Shipping container pre loading inspection

6.5.1. Prior to checking for radioactive contamination, the inside and outside of the shipping container should be cleaned of debris. The use of water or liquids should be avoided as these may shield alpha contaminants; drying is essential before measurements.

6.5.2. After cleaning, the fixed plus non-fixed radioactive contamination levels inside the empty container should be measured. The level of natural uranium, as determined by either alpha or beta radiation measurements, should be less than the WNTI-recommended free-release contamination level of 0.4 Bq/cm² and shall be less than the regulatory limit of 4 Bq/cm². In any case, these limits are applicable when averaging over any area of 300 cm² of any part of the surface.

6.5.3. All part of the internal surfaces including walls, floor and ceiling inside the container and doors may be tested by taking measurements. Wipe tests should preferably be taken in the middle of the container walls (laterally and vertically).

6.5.4. Any shipping container found to have levels of radioactive contamination above 0.4 Bq/cm² but below the regulatory limit of 4 Bq/cm² should be reviewed to determine if it is acceptable to release them for shipment. Any shipping container exceeding the regulatory limit of 4 Bq/cm² should be thoroughly re-cleaned then retested before being loaded with drums.

6.5.5. Immediately upon completion of this pre-loading inspection, ensure that the doors of the shipping container are closed to prevent any possibility for the entry of any extraneous contaminants.

6.6.  Shipping container loading area

6.6.1. The shipping container loading area should be cleaned thoroughly to remove any extraneous materials that could be carried into the shipping container by personnel or equipment. It is preferable to have the area covered with some form of clean washable floor covering.

6.6.2. Movement by personnel or equipment within the shipping container packing area should be limited to essential traffic associated with the shipping container loading process. All other traffic should be redirected to other areas.

6.7.  Loading of drums into shipping containers

6.7.1. Care should be taken to minimise the transfer of any form of contaminant from the package storage area into the empty shipping container.

6.7.2. Workers involved in the loading of packages into shipping containers should wear appropriate clean protective clothing (e.g. gloves, full body overalls and other designated personal protective equipment that may form part of the organization's standard work safety requirements).
6.7.3. Leading practices strongly suggest that packages of UOC should not be loaded into shipping containers during extremely windy or dusty conditions.

6.7.4. The tires and wheels of any forklift or other equipment being used should be clean and free of contaminants and contamination.

6.7.5. Forklift equipment should be fitted with approved drum handling attachments. Under no circumstances should the forklift tines be used for lifting, moving or the placement of drums into shipping containers.

6.7.6. All material used for packing and securing of the packages in the shipping container including strapping, timber bracing, wedges, chipboard, plywood, etc. must be stored in a clean area prior to being used and must be checked for contamination before use.

6.8. Preparing shipping containers for transport

Appendix 5 sets out a suggested Pre Shipment Inspection Checklist

6.8.1. On completion of the drum loading and securing operations extraneous material associated with the loading process must be removed from the shipping container before it is closed and sealed. The container bolt seal reference numbers must be carefully recorded for inclusion with the shipping documentation.

6.8.2. Any area in which shipping containers are to be stored before shipment should ideally be constructed of bituminous or concrete material and be regularly inspected for cleanliness, including the presence of any radioactive contamination.

6.8.3. Before being transported from the production site, shipping containers (including their undercarriages) should be free of any contamination.

6.8.4. At the point of leaving the production site, radiation readings should be measured on all external surfaces of the shipping container to ensure conformance with radioactive contamination standards. The level of radioactive contamination averaged over 300 cm$^2$ of any external part of the shipping container should not exceed 0.4 Bq/cm$^2$.

6.8.5. Measure and record maximum dose rates and units of measurement (e.g. mSv/h) for container surface contact and one (1) meter away from the container. The one (1) meter value is used to calculate the transport index for the container. All drums loaded into a shipping container should be treated as packages and the dose rate and transport index determined according to the IMDG code and other regulations. Individual drums should only be measured separately when they are transported as non-containerised or partial loads.

6.8.6. As an alternative to measuring the maximum dose rate at 1 meter, the standard value of 0.02 mSv/h for chemical concentrates of uranium, other than uranium hexafluoride as specified in the IAEA, SSR-6 Regulations, can be used as the maximum radiation dose rate at 1 meter from the container. This value can be used to calculate the transport index of the container by multiplying by 100 and the appropriate multiplication factor for the freight container.

6.9. Determining the activity for transport

6.9.1. The specific activity is used to convert the amount of uranium in kg into an activity in Bq. It should be noted that the specific activity grows over the course of 60 to 90 days. This is due to the build in of decay products and must be considered when determining the activity for the shipment to be declared on the shipping document.

The regulations require that the maximum activity of the radioactive contents during transport be declared on the shipping documents and transport labels.
6.10. Monitoring of shipping containers during transport

6.10.1. Shipping containers should be inspected for damage at each point of transfer throughout the entire supply chain between the production site and the Consignee or Converter premises and when damage is detected photographs should be taken to record the damage. Any damage to shipping containers must be reported to the Consignor.

Temporary repairs can generally be undertaken to address minor damage, abrasions, small holes, etc. However, if spillage is suspected then radiation measurements must be performed prior to any further action. The Consignor should report details relating to the incident as per applicable regulatory and safeguards requirements, and arrange recovery.
7. UNPACKING OF CONTAINERS AT CONSIGNEE OR CONVERTER PREMISES

7.1. Preparation of the shipping container unloading area

7.1.1. The shipping container offloading area should be easy to decontaminate, providing reasonable protection against weather conditions so that contamination cannot be freely dispersed. Leading practice suggests the use of an indoor offloading area.

7.1.2. The shipping container offloading area should be prepared in a similar manner to the loading area described in Section 5. As spillage might have occurred during transport, surfaces should be easy to decontaminate; recovery equipment should be present such as protective equipment, plastic sheets, empty drums, vacuum cleaners, etc.

7.1.3. All movement by personnel and equipment within the shipping container offloading area should be limited to essential traffic associated with the package unloading process. All other traffic should be redirected elsewhere.

7.2. Unloading of shipping containers

7.2.1. After opening the shipping container doors, check for any signs of visible contamination such as spillage of UOC powder from drums. Further checks should be carried out as the container is unloaded.

7.2.2. If evidence of spillage is found it should be documented and handled as per site policy. Photographs should be taken of any spillage of UOC. An investigation should be undertaken to identify the source and cause of the spilt material and the Consignor should be informed as well as any relevant regulatory authority.

7.2.3. Workers involved in the unloading of packages from shipping containers should wear appropriate clean protective clothing (e.g. gloves, full body overalls and other designated personal protective equipment that may form part of the organisations work safety requirements).

7.2.4. Care must also be taken during the unloading of packages to ensure that any form of contamination or radioactive material from within the receiving facility is not transferred into the shipping container.

7.2.5. The tires and wheels of any forklift equipment being used should be clean and free of contaminants and contamination.

7.2.6. Forklift equipment must be fitted with approved drum handling attachments. Under no circumstances should the forklift tines be used for lifting, moving or the placing drums from shipping containers.

7.2.7. After unloading all drums, check the shipping container floor for evidence of spilt material. If spilt material is detected, it should be collected and handled as per site policy. An investigation as per 7.2.2. should then be undertaken.

7.2.8. Shipping containers should then be monitored for any radiological contamination in accordance with the guidelines in Section 6, Radiological Monitoring and Control of Packaging and Containers, so that they can be certified as being suitable for free release as detailed in Section 8, Free Release of Shipping Containers.
8. FREE RELEASE OF SHIPPING CONTAINERS

Typically shipping containers are returned to a container yard location agreed between the Consignor and the container owner, empty and certified as being free from contamination by the Consignee or by the Converter, “Free Released”. Empty shipping containers should also have all transport labels and markings removed prior to being returned to a container yard.

Alternatively, containers may be returned back to the Consignor and not be free released. This requires that the containers remain in dedicated use for the carriage of UOC and that they are transported as required under the applicable regulations for the transport of radioactive materials.

For free release as uncontaminated, the container shall be checked and certified by the Consignee or by the Converter as having levels of fixed plus non-fixed contamination totalling less than 0.4 Bq/cm².

8.1. Shipping Container Free Release Procedure

The following survey shall be conducted and the results recorded. Radiological monitoring should be carried out in accordance with Section 6, Radiological Monitoring and Control of Packaging and Containers:

8.1.1. A thorough inspection of the shipping container should be conducted including a check for visible contamination. In addition, direct fixed point measurements of total radioactivity should also be carried out at other representative surfaces. These measurements are required to determine compliance with the modal regulations, for exempted values (free release as uncontaminated). Non-compliance will result in the need for further decontamination activities including a repeat inspection survey.

8.1.2. The direct fixed point measurements of total radioactivity should be conducted in at least six (6) prescribed locations with the maximum observed total radioactivity value being recorded and documented in Bq/cm² (as averaged over 300 cm²).

The prescribed minimum locations are the floor at the front, floor at the center, floor at the back, inside wall of the container facing right, inside wall of the container facing left and an external wall of the container near the doors.

8.1.3. Wipe samples for non-fixed contamination should also be collected at the six (6) prescribed locations and analysed by either alpha or beta counting.

8.1.4. Any value showing fixed plus non-fixed contamination greater than 0.4 Bq/cm² (as averaged over 300 cm²) would require that the container undergoing appropriate decontamination activities and a repeat inspection survey.

8.1.5. Using the radiation surveyor’s documentation, the responsible person shall indicate and confirm on the release certification documentation compliance with the IMDG Code requirements. A sample release certificate form is attached in Appendix 6. The Consignee will then issue a final “Release Certificate.”

Image 8.a. - Six Minimum Prescribed Locations in an ISO Container

1. Near doors of container.
2. Centre of floor inside container.
3. Floor at back of container.
4. Inside right hand wall of container near doors.
5. Inside left hand wall of container near doors.
6. Outside of doors at lower edge.
9. RESPONSE TO INCIDENTS WHILST TRANSPORTING UOC

Consignors should have in place clear procedures to manage any incident during transport of shipping containers. Such procedures should take into account the different modes of transport and relevant host country requirements. Carriers and transport agents play an important role in managing any unplanned incidents; therefore, a close collaboration must be maintained with them and plans must be exercised and vetted in advance.

When selecting transport providers, Consignors should pay close attention to the incident response capabilities of those prospective carriers and transport agents and during the tenure of their relationship undertake regular reviews and updates.

9.1. Incident Response Action Plans

An important precursor to managing incident response is the Incident Response Action Plan (IRAP), which is a standard requirement for ensuring the safe and secure transport of dangerous goods or hazardous materials.

The transportation of UOC is generally undertaken by a number of parties often delivering services on behalf of the Consignor of the cargo. Each party should therefore develop and maintain their own individual IRAP aligned to fulfill their assigned responsibilities along with the capability to address the initial response to any unplanned incident.

An effective IRAP should contain all information needed to support the initial response to an incident, ideally sitting alongside and supporting an organisation’s overarching transport plan for managing the movement of their dangerous goods. As such the IRAP should include references to an organisations internal operating procedures including incident escalation and managing such escalation as required.

The IRAP is an effective tool designed to help those either involved in or associated with the monitoring, management or physical transportation of dangerous goods or hazardous material. The IRAP identifies specific processes, which are focused around reinstating control following an emergency event.

An effective IRAP for the transport of UOC should focus on developing procedures and processes required to minimize harm to the health and safety of people or the environment in an emergency situation. Procedures include assessment, corrective actions, response to community concern and the implementation of appropriate incident response and measures to regain control of the process.

Consignors can play an important role by educating parties involved in any handling and transportation processes about the characteristics, risks, and sensitivities associated with and transporting their UOC.

There is also a requirement to include details relating to incident response action plans within the Multimodal Dangerous Goods form for each shipping container being transported.
### 9.2. Key components of an IRAP

<table>
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<tr>
<th>Purpose</th>
<th>To provide a framework for maintaining control, managing and escalating incidents in order to regain control at the operational level, to identify the structural supporting links for managing major incidents at the corporate level.</th>
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<tbody>
<tr>
<td>Scope</td>
<td>The IRAP should follow an international approach taking into account applicable local and / or regional requirements. The IRAP applies to parties and agencies that, through their work or involvement, may be required to respond to an incident.</td>
</tr>
<tr>
<td>Alignment</td>
<td>The IRAP identifies, integrates and references international, national requirements, regulations and safety guides.</td>
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<tr>
<td>Risk assessment</td>
<td>The IRAP identifies and references any risk assessments that have been undertaken to support the IRAP.</td>
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| Incident response | Classification and assessment of incidents  
Response to each classification  
Incident reporting, escalation and management processes  
Specific instructions and technical support for emergency service responders |

Many examples of IRAP's prepared by regulators, consignors, shipping ports and transporters can be found by searching the internet.

The Australian Department of Energy Resources and Tourism have published an extensively detailed booklet entitled the Guide to Safe Transport of Uranium Oxide Concentrate. The guide is a consolidation of widely adopted and applied well practiced procedures focussed on the safe transport of UOC.

The booklet includes information relating to responding to and dealing with unexpected incidents and events that might occur during transporting of UOC and contains detailed guidance information around the development of IRAPs. It can be accessed through the following websites:


1. **APPENDIX 1**

1.1. **The following terms are used throughout this document**

Throughout this document the word “should” indicates a recommendation and the word “may” indicates permission

- **ACEP** – Approved Container Examination Program (under the CSC).
- **Activity** – Measure of radioactive disintegrations per unit time, the SI unit of activity is the becquerel.
- **Anchor Points** – Securing devices located at the base structure of the container at the top and bottom with a restraint capacity of 1000 kg in any direction.
- **Background Instrument Count Rate** – The normal level of radioactivity within the location not originating from the object to be measured.
- **Becquerel (Bq)** – The SI unit for activity. One becquerel is equal to one disintegration per second (dps).
- **Bulk Density** – Weight per unit volume for the uranium concentrate powder.
- **Chine** – Circumferential ridge(s) in a drum profile.
- **Corded Polyester Rated Strapping** – Strapping of this type with a specific strength rating.
- **Consignee** – any person, organization or government that is entitled to take delivery of a consignment. That is, the receiver of ISO container of uranium ore concentrate cargo
- **Consignor** – any person, organization or government that prepares a consignment for transport. That is, the dispatcher of ISO container of uranium ore concentrate cargo.
- **Contamination (fixed)** – This is contamination other than non-fixed contamination.
- **Contamination (non-fixed)** – This is contamination that can be removed from a surface during routine conditions of transport.
- **Converter** – Facility that processes natural uranium concentrates, typically to natural uranium hexafluoride ($\text{UF}_6$).
- **CSC** – International Convention for Safe Containers, 1172.
**Gross Cargo Weight** – The total approved weight including the ISO container and contents as marked on the CSC plate.

**IAEA** – International Atomic Energy Agency.


**IMO** – International Maritime Organization.

**ISO** – International Organization for Standardization.

**ISO Container** – A freight container constructed to the specifications of ISO 1416-1.

**Lashing Points** – Securing devices located in any part of the container other than the base structure (other than anchor points) with restraint capacity of 500 kg in any direction.

**Packaging** – one or more receptacles and any other components or materials necessary for the receptacles to perform the containment and other safety functions. That is, the receptacles in which material is contained. Both drums and ISO containers can be packaging.

**Phytosanitary Compliant** – Meets the relevant national regulations covering the import of lumber dunnage.

**Producer** – Facility (or facilities), which processes natural uranium ore to uranium concentrates. Typically this is a mill associated with a mining operation.

**Responsible Person** – Suitably authorized and qualified person, often a Radiation Protection Officer or equivalent.

**Secular Equilibrium** – Occurs when the quantity of a radioactive isotope remains constant achieving a stable level of radioactivity since its growth rate due to the decay of a parent isotope equals its decay rate. Following chemical purification, uranium concentrates achieve secular equilibrium within some 6 to 8 months after extraction.

**Single Tier Loading** – Where only a single layer of drums is loaded within the ISO container.

**SI Unit** – An internationally accepted coherent system of physical units, derived from the MKSA (meter-kilogram-second-ampere) system, using the meter, kilogram, second, ampere, kelvin, mole, and candela as the basic units (SI units) respectively of the fundamental quantities of length, mass, time, electric current, temperature, amount of substance, and luminous intensity.

**Structural Member** – Support that is a constituent part of a shipping container.

**Uranium Ore Concentrates** – Chemical compounds of natural uranium originating from natural ores. Usually produced in a dry powder form the term includes yellowcake and uranium oxide.

**Wafering** – Use of boards or equivalent materials within the ISO container to spread any point loads and to address and assist in overcoming the possibility for any movement of the cargo during transit.

**Wipe Papers** – Materials that are used to rub (wipe) surfaces that are to be measured for non-fixed contamination.

**Wipe Samples** – Wipe paper that have been used to collect contamination.

**Verified Gross Mass (VGM)** – Effective gross mass verified by weighting the packed container, or by weighting all the content of the container (all packages and cargo items, including the mass of pallets, dunnage and other packing and securing material to be packed in the container) added to the tare mass of the container.
2. APPENDIX 2

2.1. Sample of Drum Package Specification

<table>
<thead>
<tr>
<th>Type</th>
<th>Removable head steel drum</th>
<th>Designator Code</th>
<th>1A2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package marking</td>
<td>1A2/Y450/S/(Year of manufacture, two digits) / (Makers mark or name &amp; approval number issued by the Competent Authority) Metal thickness 1.15/1.15/1.15 to be applied as per IMDG Code clause 6.1.3.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td>450 kg Gross mass open head drum (1.15/1.15/1.15) with 177 mm crimped enclosure re-sealable lid and locking ring with nut and bolt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td>(Insert manufacturer details here)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product name</td>
<td>(Insert manufacturer product name here)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SPECIFICATIONS**

<table>
<thead>
<tr>
<th>Gross Mass tested</th>
<th>450 kg</th>
<th>Packing group</th>
<th>II &amp; III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal dimensions</td>
<td>608 mm (D) x 862 mm (H), effective stack height 872 mm</td>
<td>Tare mass</td>
<td>Drum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>177 mm cap</td>
<td>185 g</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lid</td>
<td>2.836 kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Locking ring</td>
<td>1.36 kg</td>
</tr>
</tbody>
</table>

**Methods and material of manufacture**

- Drum body – 1.15 mm thick cold rolled steel with plain internal and baked enamel outside, resistance welded body side seam, end piece rolled to the body
- Drum base – 1.15 mm thick cold rolled steel with plain internal and baked enamel outside
- Drum top – 1.15 mm thick cold rolled steel with Epoxy phenolic resin, baked enamel outside
- Locking ring – 2 mm galvanised steel, 600 mm diameter, with 8 mm bolt and nut

**Method of closure**

Removable head of drum which may incorporate a 177 mm crimp fit steel closure with PVC gasket. The main rim of lid is sealed using an EPDM foam gasket with the lid being secured by a steel locking ring with a nut and bolt.

**PROPOSED USE**

PGII & III Dangerous Goods solids with gross mass of no more than 450 kg
CERTIFICATE OF TEST

N.A.T.A. ACCREDITED LABORATORY NUMBER
(1234)

PACKAGE PERFORMANCE TESTS

<table>
<thead>
<tr>
<th>Date:</th>
<th>Report No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Product tested: 450 kg Gross mass open head steel drum (1.15/1.15/1.15) with 177 mm crimped closure, re-sealable lid with locking ring, nut and bolt.

Sample selection: Samples selected and identified by client or their agent.

Specification: Please refer to page 2 of this report

<table>
<thead>
<tr>
<th>Test(s) Performed</th>
<th>Sample ID</th>
<th>Orientation (as per fig 6.1 ADG Code)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>DROP TEST</td>
<td>13-6344-01</td>
<td>1</td>
<td>PASS</td>
</tr>
<tr>
<td></td>
<td>13-6344-02</td>
<td>1</td>
<td>PASS</td>
</tr>
<tr>
<td></td>
<td>13-6344-03</td>
<td>1</td>
<td>PASS</td>
</tr>
<tr>
<td></td>
<td>13-6344-04</td>
<td>6</td>
<td>PASS</td>
</tr>
<tr>
<td></td>
<td>13-6344-05</td>
<td>6</td>
<td>PASS</td>
</tr>
<tr>
<td></td>
<td>13-6344-06</td>
<td>6</td>
<td>PASS</td>
</tr>
</tbody>
</table>

Test Method: UN Recommendations on the Transport of Dangerous Goods 17th Revised Ed. 6.1.5.3

STACK TEST

Effective stack height of package = 872 mm. Number in 3 m equivalent stack 4+1=3. Three samples prepared as they would be used in transport, were placed under a common platen and subjected to a superimposed mass of 4050 kg (1350 kg gross per package) for 24 hours at ambient temperature.

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>13-6344-07</td>
<td>PASS</td>
</tr>
<tr>
<td>13-6344-08</td>
<td>PASS</td>
</tr>
<tr>
<td>13-6344-09</td>
<td>PASS</td>
</tr>
</tbody>
</table>

Test Method: UN Recommendations on the Transport of Dangerous Goods 17th Revised Ed. 6.1.5.6

"The results of the performance tests reported on this certificate only relate to the samples tested"

"Use of other packaging methods or components may render testing invalid"

Checked
Authorised Signatory

Name of Signatory
3. **APPENDIX 3**

3.1. Details of ISO Shipping Containers

![Diagram of ISO shipping container]

*Appendix Figure 3.a. - Container closed*

*Appendix Figure 3.b. - Lashing point*

*Appendix Figure 3.c. - Anchor point*
APPENDIX 4

4.1 Pre-use Inspection Checklist for Containers

4.1.1 External surface inspection

During examination of the CSC plate, check that it is securely attached, check and record the Approved Continuous Examination Program (ACEP) and CSC approval details, container type, date of manufacture, maximum gross, stacking weight of 1.8 g and container tare weight.

Check that the ACEP identification label or the validity of the CSC container safety approval plate and re-inspection date has not expired, check the last dates of examination (valid for 5 years for less 5 years old containers, valid for 30 months for more 5 years old containers).

Remove any previously applied placards, markings and associated warning or advisory labels. Undertake visual checks of all external surfaces which should be free from dents and rust and be in good overall condition, check for holes and cracks. Minor cracks in joints may be filled with silicon if required.

Ensure that any bowing or warping of the roof or wall surfaces fall within the stated Institute of International Container Lessors (IICL) limits.

4.1.2 External structural inspection

Check that the main framework (corner posts, corner fittings, bottom and top side rails, bottom and top end rails, door sills and header have no major defects such as dents, bends cracks or breaks in structural members (including under floor cross members).

Check that there is no more than one splice or an improper splice (e.g. a lapped splice) in top or bottom end rails or door headers or more than two splices in any one top or bottom side rail or any splice in a door sill or corner post.

Check the undercarriage to ensure there is no damage to the under floor timber, the container floor rails, or the box tyne channels, etc. Care must be taken to ensure worker safety when performing these checks. Never stand underneath a shipping container when performing these checks.

Check that all exterior surfaces have minimal surface and no major structural rust. The shipping container should be in good condition and have a visually pleasing appearance. Even though the shipping container is acceptable for use the general appearance of the shipping container has a significant impact on public perception.

Check to ensure both doors are capable of being securely locked and sealed in the closed position, properly secured in the open position, and that gaskets and seals are in good serviceable condition.

Check the top and bottom mounted corner fitting locking structures for serious damage to ensure that the twist locks are not seized, twisted, broken, missing or otherwise inoperative.

Check for any distortion of the overall configuration sufficient to undermine proper alignment of handling equipment, mounting and securing on a vehicle chassis, container handling equipment, or container racking slots on ocean going vessels.
4.1.3 **Internal inspection**

Check that the shipping container has been cleaned free of any previous cargo residue and that there is no dirt or debris left on the floor, and no persistent odours from previous cargoes.

 Undertake a survey of the container prior to packing to ensure that no form of contamination is present.

 Check that all interior wall and roof surfaces are free of rust. Ensure that any bowing or warping of roof or wall surfaces fall within the stated IICL limits, with no dents greater than 19 mm in depth, regardless of length. The floor shall be in good condition to facilitate its decontamination at Consignee, Converter premises, with no cracks, breaks, holes, protruding nails or screws. If being used for securing and stowage of the cargo, examine that all anchor and lashing points are fit for purpose, not twisted, broken, missing or inoperative.

 Undertake a water proof test* to ensure the integrity of the overall sealing capability of the shipping container to effectively prevent the entry or discharge of material or moisture.

 Radiological monitoring in accordance with Section 6 may be undertaken prior to loading the drums into the shipping container.

 Photographic (digital) records may be kept of the internal and external condition of the container for future reference.

 *Water proof test:*
 This involves entering into the container, having someone close the container doors. Should any indication of daylight be seen through the door seals or from elsewhere within the shipping container it must be assumed that water could gain entry and therefore the shipping container should be deemed unfit for purpose. Due to the extremes of temperature experienced at many if not most mine sites, consideration as to the total time spent inside the closed container. Additionally caution should be taken as there is always the possibility that residual potent gases from the fumigation of previous cargoes could also be present.
5. **APPENDIX 5**

5.1. **Pre-Shipment Inspection Checklist**

**Final check before shipment**

After the shipping container has been packed a final check should be undertaken, ideally by persons independent from the packing team.

A visual inspection should be undertaken to ensure stowage arrangements are in compliance with the designated loading procedures and to ensure that there is no extraneous packaging or securing material left inside the shipping container.

Check that the details on the drums match the drum, batch and lot details listed on the container packing log sheet.

Close and seal the doors, recording the container and seal numbers.

Check the external container marking and labelling.

If the container has been inside a facility area or removed from a road chassis or flatbed or a rail wagon where there is a risk of contamination before the full container leaves this area, a designated person is to ensure that container is cleaned on sides, top and bottom with high pressure cleaner or appropriate equipment. Dirt and sand shall be removed from the container bottom seams.

Inspect the empty road or rail conveyance for cleanliness before loading the container.

Place placards on road or rail conveyance (if applicable).

Radiological monitoring should be carried out according to Section 6.

Photographic (digital) records should be kept of the internal and external condition of the container for future reference.
APPENDIX 6

6.1 Sample Container Release Certificate Form

CONTAINER CERTIFICATE OF INSPECTION

Container Number: ___________________________ Date: ___________________________

The freight (sea, road, rail) container identified above has been monitored at the (insert facility company name) and was found to be free of radioactive contamination as defined in the latest applicable regulations.

CONTAMINATION means the presence of a radioactive substance on a surface in quantities in excess of 0.4 Bq/cm², fixed plus non-fixed, for beta and gamma emitters and low-toxicity alpha emitters. Natural uranium is a low-toxicity alpha emitter.

Natural uranium concentrates are comprised primarily of two (2) alpha emitters, 238U and 234U and two (2) beta emitters, 234Pa and 234Th. Once secular equilibrium is established, the total alpha activity will equal the total beta activity therefore radioactivity measurements may be conducted by either alpha measurement or by beta measurements. Contamination is measured as averaged over 300 cm², reference the applicable edition of the IAEA SSR-6 Regulations for the Safe Transport of Radioactive Material.

Signature:

Name

Title

Email

Tel

Mob
### 7. APPENDIX 7

Example of a Delivery Manifest

---

#### SUMMARISED DELIVERY, CONTAINER PACKING LIST & RADIATION DOSE RATE REPORT

<table>
<thead>
<tr>
<th>Date</th>
<th>Container No.</th>
<th>Org. Code</th>
<th>Org. Name</th>
<th>Date of Receipt</th>
<th>Time of Receipt</th>
<th>Date of Issue</th>
<th>Time of Issue</th>
<th>Date of Shipment</th>
<th>Time of Shipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/10/2023</td>
<td>TG-027629</td>
<td>24/02/23</td>
<td>XYZ Co.</td>
<td>12/03/23</td>
<td>10:00</td>
<td>13/03/23</td>
<td>14:00</td>
<td>15/03/23</td>
<td>16:00</td>
</tr>
<tr>
<td>5/10/2023</td>
<td>CL-027630</td>
<td>25/02/23</td>
<td>ABC Ltd.</td>
<td>12/03/23</td>
<td>10:00</td>
<td>13/03/23</td>
<td>14:00</td>
<td>15/03/23</td>
<td>16:00</td>
</tr>
<tr>
<td>5/10/2023</td>
<td>TG-027629</td>
<td>25/02/23</td>
<td>DEF Corp.</td>
<td>12/03/23</td>
<td>10:00</td>
<td>13/03/23</td>
<td>14:00</td>
<td>15/03/23</td>
<td>16:00</td>
</tr>
</tbody>
</table>

---

#### SUMMARY OF BATCHES IN CONTAINER LOTS

<table>
<thead>
<tr>
<th>Date</th>
<th>Container No.</th>
<th>Org. Code</th>
<th>Org. Name</th>
<th>Date of Receipt</th>
<th>Time of Receipt</th>
<th>Date of Issue</th>
<th>Time of Issue</th>
<th>Date of Shipment</th>
<th>Time of Shipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/03/2023</td>
<td>TG-027629</td>
<td>24/02/23</td>
<td>XYZ Co.</td>
<td>12/03/23</td>
<td>10:00</td>
<td>13/03/23</td>
<td>14:00</td>
<td>15/03/23</td>
<td>16:00</td>
</tr>
<tr>
<td>3/03/2023</td>
<td>CL-027630</td>
<td>25/02/23</td>
<td>ABC Ltd.</td>
<td>12/03/23</td>
<td>10:00</td>
<td>13/03/23</td>
<td>14:00</td>
<td>15/03/23</td>
<td>16:00</td>
</tr>
<tr>
<td>3/03/2023</td>
<td>TG-027629</td>
<td>25/02/23</td>
<td>DEF Corp.</td>
<td>12/03/23</td>
<td>10:00</td>
<td>13/03/23</td>
<td>14:00</td>
<td>15/03/23</td>
<td>16:00</td>
</tr>
</tbody>
</table>

---

#### Other Details

- All dose rates are in mSv/h
- All shipping dates are in March
Example of a Packing List

Material supplier Customer (account) Mine Origin (Material)

Type (U3O8, Uranate, UO3, UO4, UO2,.... (and not only yellow cake))

Weights should be presented in kg with 3 digits after comma U weight is required, not U3U8 or UO4, etc.

Depending on the country, the weight have to be specified in kg or in lbs.

**Doc 1: Dum List (Drum List pet lot)**

<table>
<thead>
<tr>
<th>Nº lot</th>
<th>Nº Drum</th>
<th>Gross weight</th>
<th>tare</th>
<th>Net weight</th>
<th>H2O%</th>
<th>Dry net weight</th>
<th>U%</th>
<th>U weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Doc 2: Packing list without samples**

<table>
<thead>
<tr>
<th>Nº lot</th>
<th>Number of drums</th>
<th>Gross weight</th>
<th>tare</th>
<th>Net weight</th>
<th>H2O%</th>
<th>Dry net weight</th>
<th>U%</th>
<th>U weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>Total</td>
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<td></td>
</tr>
</tbody>
</table>

**Doc 3: Sample Specification (sample associated to the lot)**

<table>
<thead>
<tr>
<th>Nº lot</th>
<th>Number of drums</th>
<th>Gross weight</th>
<th>tare</th>
<th>Net weight</th>
<th>H2O%</th>
<th>Dry net weight</th>
<th>U%</th>
<th>U weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Example of Chemical Specification

The minimum uranium content in the Concentrate shall not be less than 65% by weight.

Unless otherwise indicated, the contents of impurities given below are expressed as percentage of total uranium:

<table>
<thead>
<tr>
<th>Ref ASTM norm C967-13</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic (As)</td>
<td>0.05</td>
</tr>
<tr>
<td>Ammonium (NH₄)</td>
<td>0.5</td>
</tr>
<tr>
<td>Bore (B)</td>
<td>0.005</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>0.05</td>
</tr>
<tr>
<td>Carbonates (CO₃)</td>
<td>0.2</td>
</tr>
<tr>
<td>Fer (Fe)</td>
<td>0.15</td>
</tr>
<tr>
<td>Fluorine (F)</td>
<td>0.01</td>
</tr>
<tr>
<td>Halogen (Cl)</td>
<td>0.05</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>0.02</td>
</tr>
<tr>
<td>Moisture H₂O (% by weight of concentrate)</td>
<td>2</td>
</tr>
<tr>
<td>Molybdenum (Mo)</td>
<td>0.1</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>0.1</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>0.2</td>
</tr>
<tr>
<td>Silica (SiO₂)</td>
<td>0.5</td>
</tr>
<tr>
<td>Sodium (Na)</td>
<td>0.5</td>
</tr>
<tr>
<td>Sulfates (S)</td>
<td>1</td>
</tr>
<tr>
<td>Thorium(Th)</td>
<td>0.1</td>
</tr>
<tr>
<td>Titanium(Ti)</td>
<td>0.01</td>
</tr>
<tr>
<td>Vanadium (V)</td>
<td>0.06</td>
</tr>
<tr>
<td>Zirconium (en Zr)</td>
<td>0.01</td>
</tr>
<tr>
<td>Extractable organic</td>
<td>0.1</td>
</tr>
<tr>
<td>Insoluble uranium in HNO₃</td>
<td>-</td>
</tr>
<tr>
<td>²³⁴U</td>
<td>56 μg/gU</td>
</tr>
</tbody>
</table>
NB.

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