wnti

Fact Sheet

Media and Communications – Uranium Ore Concentrates (UOC)

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Introduction

The World Nuclear Transport Institute (WNTI) is a Non-Governmental Organisation (NGO) that represents the nuclear transport industry focusing on the needs of its members.

One of the ways WNTI does this is through its Observer Status role at the International Atomic Energy Agency (IAEA). The WNTI actively participates in IAEA discussions around the content and meaning of the radioactive materials transport regulations, contributing to the development of IAEA guidance documents and helping develop IAEA technical reports. WNTI also has Consultative status at the International Maritime Organisation (IMO) where is it the only NGO recognised as an industry expert in transport of radioactive material. The WNTI is also a Category A Liaison Organization to the International Organization for Standardization (ISO) representing the radioactive material transport industry.

The WNTI utilizes its extensive network of contacts to act on behalf of its members to represent and advocate with industry groups and regulators to promote safe and secure radioactive material transport. The WNTI endeavours to achieve resolution to issues which impede such transport. The development of this fact sheet has resulted from issues transporting uranium ore concentrate (UOC) raised by its members.

Our vision is for the transport of nuclear (radioactive) materials to be regarded as safe and secure and as a model for the transport of all dangerous goods/hazardous materials.

We provide up to date information and educational tools to promote safe and secure transportation of radioactive materials.

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Purpose of this Fact Sheet

This fact sheet focusses on UOC, including its hazards and risks and how UOC fits within the broader nuclear fuel cycle. Its purpose is to provide communicators and educators with clear and concise information that can be shared broadly. The information is intended to be understood by both technical and non-technical people and is aimed at persons having little or no knowledge about the nuclear fuel cycle industry or the transport of radioactive materials. This fact sheet also provides basic information on the chemical and radiological protection requirements relating to any incident response.

As well as being radioactive, UOC is a metal concentrate, and like other metal concentrates (such as copper and lead), the heavy metal toxicity characteristics are also important.

Additional information can be found in the WNTI fact sheet entitled “Safe Transport of Uranium Ore Concentrates” [Ref 1] which offers further information on what Uranium is, along with its uses, giving details of the Front-End Fuel Cycle and explaining why this material needs to be transported.

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The Hazards of Uranium

Uranium is a naturally occurring element that exists in varying concentrations throughout the Earth's crust. Trace amounts of uranium can be found in almost everything; rocks, soil, streams, food and in the human body. It is the heaviest naturally occurring element and is classified as a heavy metal. It is naturally radioactive, emitting radiation as it decays into other radioactive elements, which themselves decay over time. This is known as a decay chain and in nature, uranium exists with equilibrium with 13 other decay products which contribute to natural background radiation. About 0.7% of natural uranium is the fissile uranium-235 isotope, with the remainder being non-fissile uranium-238. The term 'fissile' means that under very specific conditions, the uranium atom can split and produce a burst of heat energy. This heat energy is the basis of a nuclear power reactor, however the naturally occurring 0.7% concentration cannot sustain a nuclear chain reaction. Therefore, UOC is categorised as non-fissile when transported.

The radiological hazards from uranium can be the result of external (outside the body) or internal (inside the body) radiation exposure. External exposure refers to gamma radiation from uranium which is generally low energy and presents a minimal hazard. Internal exposure results from the uranium being ingested or inhaled, however the risk to health is low, provided simple safety precautions are observed.

While uranium is radioactive, its primary hazard is usually associated with its heavy metal properties with its radiological properties being the secondary hazard. Therefore, controlling exposure in a similar way to any other heavy metal will adequately control the radiological impact as well as toxicity.

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Uranium Ore as a Resource

Uranium is one of a range of radioactive elements found in mineralised ore bodies that are commonly known as Naturally Occurring Radioactive Materials (NORM). It is as common as tin and tungsten and about forty times as common as silver. Uranium occurs naturally everywhere in varying concentrations averaging 3 parts per million, but it is not economic to recover uranium when it is in low concentrations. The average uranium ore concentrations of many world mines is 0.10% uranium, or 1,000 parts per million, whilst in Canada there are some mines having abundant amounts of uranium ore with grades up to 20% uranium. Research continues on trying to economically extract uranium from seawater, which exists naturally at approximately 3 parts per billion.

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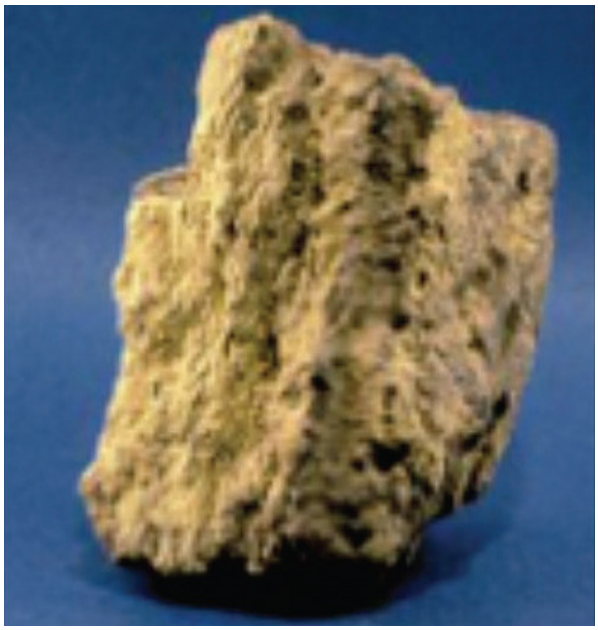
What is Uranium Ore Concentrate (UOC)?

UOC, is the generic term for the concentrated uranium product that is produced from the milling, grinding, leaching and other extractive chemical processes of uranium bearing ores. The resultant UOC is either a dark khaki olive green to a blackish, brown coloured powder or granular material as U_3O_8, or a pale-yellowish to orangish coloured peroxide of uranium as UO_4, depending on the manufacturing process being employed.

Both products (U_3O_8 and UO_4), are chemically and physically stable forms of uranium powder packaged in steel drums to be shipped for further refining and processing to produce uranium trioxide (UO_3), uranium tetrafluoride (UF_4) or uranium hexafluoride (UF_6) ahead of further processing for eventual use as a fuel source in nuclear reactors.

There are well established international standards covering the specification for UOC material. ASTM International, formerly known as the American Society for Testing and Materials is an international standards organization that develops and publishes voluntary consensus technical standards for a wide range of materials. A copy of the ASTM norm C967-13 specification for UOC can be found in Appendix 11 of the WNTI Standard for Packaging and Transport of Uranium Concentrates [Ref 2] on the WNTI website.

Whilst UOC specifications typically require a minimum of 65% U by weight; the concentration of uranium in the UOC will generally fall around 80% U depending on the form of the final product, U_3O_8 or UO_4.



Natural ore

Drum of UOC (U_3O_8)

Drum of UO_4 (Uranyl Peroxide)

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The Different Types of UOC

The extractive processing method applied to the treatment of the uranium ore determines the final chemical form of uranium produced and referred to as UOC.

UOC as triuranium octoxide (U_3O_8), is a dark khaki olive green to a blackish, brown coloured powder or granular material. It is the product resulting from the high temperature (800 deg C) decomposition of ammonium or sodium diuranate precipitate.

UOC as uranium peroxide hydrate (UO_4) is generally a pale-yellowish to orangish coloured peroxide of uranium. It is the product resulting from processes that utilize ion exchange or strong acid solvent extraction purification processes, is precipitated with the use of hydrogen peroxide and dried at substantially lower temperatures to UOC as U_3O_8.

UOC as uranium dioxide or uranium oxide (UO_2), is also known as urania or uranous oxide, being an oxide of uranium, in the form of a black, radioactive, crystalline powder.

It is important to note that the term ‘Yellowcake’ is an often incorrectly used as a general terminology for UOC. This was the form of uranium product produced at mines up until about 1970. Since then, yellowcake has become the name associated with and generally applied to the product at the point where the uranium is chemically separated from the treated ore using ammonia to form Ammonium Diuranate (ADU) in the form of a yellowcake (sludge). This is further processed to form UOC before transport.

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Dangerous Goods and Hazardous Materials

Dangerous Goods or Hazardous Materials are classified as materials that from either their physical or chemical properties may have an adverse effect on people, property and/or the environment, leading to such situations as fires, explosions, corrosion and poisoning. Adverse health effects can be either immediate or long term.

UOC is classified and referred to as being either a Dangerous Good or Hazardous Material depending on the applicable country, jurisdiction or regional location through which it is being transported.

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Proper Shipping Name

The Proper Shipping Name comprises the universally understood standard technical name for a range of dangerous goods/hazardous materials along with additional words describing the nature, properties and composition of that material.

Every category of dangerous goods or hazardous material has a corresponding United Nations Identification Number (UN number) associated with the Proper Shipping Name. This information is used by transporters and emergency response personnel to identify the nature of the dangerous goods or hazardous material being transported.

The Proper Shipping Name for UOC is 'UN 2912 RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-I)'.

Both the UN number and the Proper Shipping Name are displayed on the outside of packages and freight containers as well as on shipping and transport documents providing important safety related information to transporters, first responders and members of the public.

Radioactive material

Many materials contain radioactive elements. When the concentration or quantity exceeds an internationally agreed level, the material is then defined as being radioactive and therefore subject to regulatory control. The transport of radioactive material must comply with internationally agreed regulations published by the IAEA [Ref 3].

Low specific activity (LSA-I)

The IAEA Regulations for the Safe Transport of Radioactive Materials [Ref 3] provides a list of different classifications. UOC is classified as a 'Low Specific Activity' material, specifically 'LSA-1'. This means that it is in the lowest classification of radioactive materials.

'Non-fissile or fissile-excepted'

UOC is also classified as 'non-fissile or fissile excepted'. This means that the package does not contain significant quantities of fissile radioactive material, such as U-235.

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Characteristics of UOC

The main properties of Uranium Ore Concentrates are as follows:

- Uranium like other heavy metals, is toxic and should not be inhaled or ingested.
- UOC is a mildly radioactive (natural) material that has not been enriched.
- It is not explosive, nor is it flammable or combustible.
- No fissile reaction can be initiated with this material (non-fissile material).
- It is not a marine pollutant having limited solubility in water whilst remaining stable in air and water.

The amount of external radiation exposure received by any person relates to the time a person spends near to a source of radioactive material and the intensity of the radiation emitted by that material with the radiation emitted by UOC being low.

External radiation dose rate levels are practically undetectable four or five meters away from a truck loaded with UOC, merging into normal background radiation dose rate levels. Background radiation is present everywhere, comprising radiation from naturally occurring materials in the rock and soil as well as cosmic rays. Average annual background radiation varies depending on local geology from 1 to 10 milli-Sievert (mSv) per year around the world [ref 4].

Radiation exposure can be easily managed by implementing simple steps such as minimising the time of exposure to the material, maximizing distance away from the material and by the use of shielding.

The maximum dose rate level measured at a distance of 1 metre from a 20' freight container of UOC is 0.02 mSv/h. The dose for drivers transporting freight containers of UOC between Olympic Dam and Port Adelaide, estimated from actual dose rate measured in the driver's cabin before shipment, averages about 1µSv/h. Therefore, a driver who makes 100 eight-hour trips (two trips per week) with UOC per year, would receive a total dose of about 0.8 mSv per year [Ref 5]. This is below the 1 mSv public dose limit and the normal background annual dose of 1-10mSv [Ref 4].

In comparison, the dose on a transatlantic flight is about 0.08mSv and a chest CT scan dose is around 6.6mSv [ref 6].

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Packages, Freight Containers and Transport

UOC is prepared for transport in accordance with strict internationally agreed regulations published by the IAEA: The Regulations for the Safe Transport of Radioactive Material [Ref 3].

UOC is packaged in standard 210 litre steel drums, suitable for repeated handling, stacking and storage for extended periods of time.

For road, rail and maritime transport, UOC drums are stowed and secured in 20-foot ISO freight containers (standard dry containers) and shipments can consist of several ISO freight containers. Typical transit times from mine sites to overseas conversion facilities can range from a few weeks to several months depending on the distance travelled.

UOC drums are also stowed and secured for road transport in 53-foot dry van trailers across North America. In these instances, typical transit times are generally only a few days.

Drums of UOC as U_3O_8

Drums of UOC as UO_4

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Markings, Labels and Placards

Markings provide specific information describing the material and its radioactive content.

Labels provide transporters, first responders and members of the public with important safety related information identifying the hazards and the precautions required for handling.

Placards contain basic textual information along with the applicable UN identifier indicating the presence of radioactive material associated with the package or freight container.

Collectively, markings, labels and placards provide an effective internationally recognised means of communicating information about radioactive materials that are being transported by road, rail, sea or air transport.

Category labelling

The transport of radioactive material requires the shipper to determine and assign a Category Label to the package or freight container which relates to the dose rate measured on the surface and at a distance of one metre from the external surface of the package or freight container.

Category labels which provide information about the radioactive material and dose rates are required to be applied to the outside of packages and freight container to assist transporters, emergency response personnel and members of the public to identify the nature of the dangerous goods or hazardous material being transported. Class 7 placards are placed on the outside of the freight container or conveyance to indicate that the material being transported is radioactive material.

The IAEA transport regulations require packages and freight containers to be assigned a Category depending on the external dose rate. UOC is a Category III-YELLOW radioactive material.

Drums of UOC have Category III-YELLOW labels affixed to two opposite sides of the outside of the drum, indicating the nature of the content (LSA-I), its activity (in Becquerels) and the value of the Transport Index (TI) (a TI of 2 corresponds to a dose rate of 0.02mSv/h at 1 metre from the drum).

Two factors determine the category label of a package or freight container, that is the highest radiation level on the external surface, and the Transport Index (TI) (which is determined by the highest radiation level at 1 meter from the external surface). Category I-WHITE is the lowest category.

Drum label

Freight Container Label

UOC freight containers have radioactive III-YELLOW category labels and placards affixed to the four sides of the container. The labels indicate the nature of the content (LSA-I), its activity (in Becquerels) and the value of the Transport Index (TI) for the total load. The UN number 2912 is also displayed on the four sides of the shipping container either on a rectangular orange sticker or on the radioactive placard.

Radioactive placard

UN placard

Freight Container placarding

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Safety Precautions

Undamaged packages are quite safe to handle. However, when handling or dealing with loose (unpackaged material), gloves and respirators should be worn to avoid direct contact, inhalation and ingestion.

Like other heavy metals such as lead etc. UOC should be handled carefully as uranium is toxic and should not be inhaled or ingested. If UOC is ingested or inhaled it is also possible that internal organs could receive a small radiation dose, but it is highly unlikely that a member of the public would receive an internal dose that exceeds the regulatory limit.

The external radiation risks associated with uranium ore concentrate can be easily managed by simple steps such as minimising the time of exposure to the material, maximizing distance from the material, using shielding and the use of basic Personal Protection Equipment (PPE).

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Protection During Incident Response

In the event of a spillage involving UOC during transport, the normal incident management response procedures for dangerous goods/hazardous materials should be followed. Whilst some material may be released from packages during incidents of moderate severity, the risks to people are small.

A spillage of UOC does not pose any immediate radiological danger and can be managed by implementing simple steps such as minimising the time of exposure to the material, maximizing distance from the material and using shielding to protect against external radiation (for example using a parked vehicle to protect responders approaching the material). Standard protective equipment and containment, such as applying a tarpaulin, can prevent the spread of uranium and the potential for inhalation or ingestion of the material.

The first priority should always be to provide first aid to any injured persons; staying upwind of any spillage as far as possible and then to cordon off the area to limit any exposure. In order to minimise the dispersal of any spillage, the material can be covered and contained awaiting clean-up by trained emergency responders. Assistance should be sought by contacting the local emergency services telephone number.

Cleaning up a spillage

The clean-up of a UOC spillage is similar to that of other industrial chemicals or heavy metal compounds and first responders and transporters, will have familiarity with the requisite processes. Basic PPE of disposable coveralls, PVC, rubber or cotton gloves and dust mask or respirator are all that is required for responders cleaning up a spillage.

Use brooms, shovels or specialist vacuum equipment to sweep up and collect spillage repatriating the collected materials into sealable receptacles.

Radiation and chemical risks are reduced by limiting the time of direct exposure and by avoiding direct contact, inhalation and ingestion.

The repatriation of collected spillage material should be undertaken in conjunction with local regulatory authority requirements.

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Key Messages

Many materials contain radioactive elements. When the concentration or quantity exceeds an internationally agreed level, the material is then defined as being radioactive, becoming subject to regulatory control.

UOC is radioactive material, however it presents a very low external hazard. The primary health hazard associated with an intake of natural uranium comes from its chemical heavy metal properties, with its radiological properties being the secondary hazard.

The toxicity of uranium will vary according to its chemical form and exposure route (inhalation or ingestion) and is only a hazard if the UOC is loose or spilled.

The transport of radioactive material must comply with internationally agreed regulations published by the IAEA.

Markings, Labels and Placards provide transporters, first responders and members of the public with important safety related information allowing them to identify the hazards and precautions required.

In the event of a spillage involving UOC during transport, the normal incident management response procedures for dangerous goods/hazardous materials should be followed. Basic PPE is adequate to respond to and clean up spills.

The radiation risks associated with handling and or transporting UOC can be easily and effectively managed by implementing simple steps such as minimising the time of exposure to the package or freight container, maximizing distance from the package or freight container, using shielding and the use of basic Personal Protection Equipment.

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References

1 Safe Transport of Uranium Ore Concentrates, WNTI, 2020, **www.wnti.co.uk**

2 Packaging and Transport of Uranium Concentrates, WNTI, version 3, 2019, **www.wnti.co.uk**

3 Regulations for the Safe Transport of Radioactive Material, IAEA SSR-6 (Rev. 1), 2018, **www.ieae.org**

4 Sources and Effects of Ionizing Radiation, United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 2000, **www.unscear.org**

5 BHP Billiton Olympic Dam Expansion Draft Environmental Impact Statement DEIS 2009, Appendix S Uranium and Radiation, S2.4 Doses from Transportation, **www.bhp.com**

6 UK Government Guidance Ionising Radiation: dose comparisons, March 2011, **www.gov.uk**

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The WNTI offers the use of this Fact Sheet freely to members and non-members of the transport community. Where any interpretation of the information has been made, it has been done so with the interests of the wider transport community. Although the standard has been extensively reviewed by industry experts, if you have any issues in use or content, please contact the WNTI so we can rectify the issues and conflicts in systems etc.

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