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THE USE OF URANIUM AND THORIUM COMPOUNDS

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DOCUMENT QUALITY CONTROL

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BACKGROUND

8) Compounds of natural uranium and thorium have found widespread use in industry and research, notably as pre-treatment agents, in electron microscopy and in *in-vitro* tracer studies. In the past safety measures were focussed on the toxicity of uranium, which needed to be assessed in compliance with the Control of Substances Hazardous to Health Regulations 1988 (COSHH). The radiation hazards associated with these compounds were only fully addressed with the enactment of the Ionising Radiations Regulations 1985 (now the Ionising Radiations Regulations 1999; IRR99).

Ionising Radiations Regulations 1999

9) The IRR99 require that, without exception, **prior risk assessments** be carried out for **all uses of all sources** of ionising radiation. Furthermore, the IRR99 are explicit in requiring that the risk assessments are then used as a basis for doing all that is reasonably practicable to minimise the risks such that radiation exposures are As Low As Reasonably Practicable, this is known as the ALARP principle. To this end, the University of Leeds has requires that all radiation work be controlled such that under normal operational conditions, no person can receive a radiation exposure in excess of a **dose constraint[1] of 1mSv per year**. This means that the University believes that, given the nature of teaching and research work undertaken at Leeds, it is reasonably practicable to restrict all radiation exposures to an intrinsically safe constraint[2]. This has the benefit of protecting all employees, students, visitors, the unborn foetus or breast feeding infants, and will ensure that any person working in accordance with the instructions of local rules and other written procedures will not become exposed to doses of radiation that exceed the variation in natural background radiation levels experienced across Great Britain.

10) This information sheet presents generic data and derived radiation exposures that may be used in the completion of prior risk assessments.

Radioactive Substances Act 1993

11) The use of the naturally occurring (unprocessed) isotopes of uranium and thorium are

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[1] An internally imposed dose limit based on the ALARP principle.

[2] By way of comparison, a member of the public receives, on average, an annual dose of 2mSv per year due to natural background radiation, and a person who takes a return air flight to Spain can expect to receive a radiation dose of up to 0.1 mSv.

subject to regulatory control by virtue of The Radioactive Substances (Prepared Uranium and Thorium Compounds) Exemption Order 1962. The Exemption Order excludes certain specified classes of radionuclides from the full requirements of the Radioactive Substances Act 1960 (now the Radioactive Substances Act 1993; RSA93), while still placing certain specific conditions of use on 'radiation employers'. This Information Sheet gives guidance on compliance with the Exemption Order and the Act.

OCCUPATIONAL EXPOSURE PATHWAYS AND RISK ASSESSMENT

12) Although the specific activities of unprocessed uranium and thorium are sufficiently low for the substances to be controlled by an Exemption Order, the risks associated with exposure are high, very high if the exposure pathway is the inhalation of suspended dusts and aerosols. The reason why these radionuclides are so hazardous is because they are alpha emitting radionuclides, and if inhaled would decay in the lungs via a chain of daughters that are themselves alpha emitters: alpha emitting radionuclides deposit large quantities of energy into surficial tissues.

13) The following tables give derived data that quantify the hazards posed by intakes of uranium/thorium compounds through the two exposure pathways of concern[3].

Isotope	Specific Activity	DPUI[a] µSv/Bq	
Natural uranium (99.3% ^{238}U, 0.7% ^{235}U)	26 Bq/mg	Ingestion	0.05
		Inhalation	7.3
Natural thorium (100% ^{232}Th)	8 Bq/mg	Ingestion	0.22
		Inhalation	42

[a]DPUI - The Dose Per Unit Intake is the dose to the most radiosensitive organ that would be irradiated via a given exposure pathway, i.e. inhalation or ingestion (including skin absorption).

[3] The exposure to external radiation doses emanating from gamma emissions is insignificant for gram-level uses of uranium/thorium compounds.

Isotope	Pathway (route of intake)	Derived dose[b] from an intake of 1 mg	Intake required to deliver a dose of 1 mSv[c]	Dose following the ingestion of 1 ml of a 1% v/v sol'n[d]
Natural uranium	Ingestion	1.2 μSv	833 mg	0.1 mSv
	Inhalation	190 μSv	5.3 mg	n/a[e]
Natural thorium	Ingestion	1.8 μSv	556 mg	0.2 mSv
	Inhalation	336 μSv	3.0 mg	n/a[e]

[b]Derived dose is the product of the specific activity and the DPUI.

[c]The intake required to reach the **dose constraint** in terms of mass of the isotope via the inhalation or ingestion (skin absorption) pathways.

[d]It is assuming the intake is via ingestion of a drop of the solution spilt onto the skin, which is then taken in orally. *Uranium and thorium are not readily absorbed through the skin on account of their large atomic weight & the molecular mass of the compound. For risk assessment purposes assume 10% absorption.*

[e]n/a = not applicable to this pathway; the appropriate pathway for intakes of solution is ingestion.

14) Using the derived exposure data presented above, and given knowledge of the uses of uranium and thorium compounds, it is possible to use these data to determine the level of risk 'under normal operational conditions'. The following risk assessments are based on the assumption that users will adhere to good laboratory practice[4].

GENERIC RISK ASSESSMENT FOR THE USE OF URANIUM AND THORIUM COMPOUNDS IN *IN VITRO* STUDIES

Procedure

15) Uranium/thorium compounds are made into aqueous solution. The solid is weighed out using

[4] Good Laboratory Practice (GLP).

- Workers wear laboratory coats, latex (or similar) gloves, and eye protection.
- Instruction on eating and drinking (etc.) in laboratories is followed and users thoroughly wash their hands before leaving the laboratory.
- Work is undertaken in specified areas, drip trays are lined with Benchkote® (or similar), contamination monitors are used (and the users know how to use them).

a balance fitted a measurement chamber, or in a balance sited in a fumecupboard. The solid is transferred into glass in a fumecupboard where it is made up to volume.

16) The labelled stock solution is kept on a drip tray in a cupboard or in some other location where it is unlikely to be knocked over. Precautions are also taken to minimise the effect of potential spillages.

17) Aliquots are dispensed either in a fumecupboard or on the open bench. All aqueous wastes are disposed of via a **designated (radiation) sink**; solid wastes are disposed of via the **green tag** waste route.

Major risks

18) Inhalation of dusts during weighing out powders.

- **Route of Intake** → Inhalation.
- **Risk Prevention** → Weighing out powders using a balance fitted with a measurement chamber or by working in a fume cupboard.

19) Contamination of hands during wet work, or following a spillage.

- **Route of Intake** → Ingestion of contamination transferred from hands to food, drink, cigarettes, etc. *Uranium/thorium will not pass through unbroken skin.*
- **Risk Prevention** → Use of latex (or similar) gloves to prevent contamination of hands & washing hands thoroughly at appropriate times during work and after work.

20) Intake by others persons exposed to contaminated work surfaces, equipment or through the spread of contamination (cross contamination).

- **Route of Intake** → Ingestion of contamination inadvertently picked up as a result of exposure to cross contamination; then transfer from hands to food, drink, cigarettes, etc.
- **Risk Prevention** → Work carried out under (appropriate) containment, i.e. in designated areas surfaces marked out and laid with Benchkote® (absorbent surface uppermost) and using lined drip trays. Work surfaces and hands are monitored for contamination during and after work. User changes gloves frequently or if contamination suspected.

GENERIC RISK ASSESSMENT FOR THE USE OF URANIUM COMPOUNDS AS ELECTRON MICROSCOPY STAINING AGENTS

Procedure

21) Uranium compounds are made into aqueous solution. The solid is weighed out using either a balance fitted with a measurement chamber, or a balance sited in a fumecupboard. The solid is transferred into glass in a fumecupboard, where it is made up to volume (usually to a solution strength of between 1 and 3%v/v; occasionally as a saturated solution).

22) The labelled stock solution is kept on a drip tray in a cupboard or in some other location where it is unlikely to be knocked over. Precautions are also taken to minimise the effect of potential spillages.

23) Slides bearing microscopy specimens are stained by immersing in the uranium solution and air-dried. All aqueous wastes are disposed of via a **designated (radiation) sink**; solid wastes are disposed of via the **green tag** waste route.

Major risks

24) Inhalation of dusts during weighing out powders.

- **Route of Intake** → Inhalation.
- **Risk Prevention** → Weighing out powders using a balance fitted with a measurement chamber or by working in a fume cupboard.

25) Contamination of hands during staining, or following a spillage.

- **Route of Intake** → Ingestion of contamination transferred from hands to food, drink, cigarettes, etc.
- **Risk Prevention** → Use of latex (or similar) gloves to prevent contamination of hands & washing hands thoroughly at appropriate times during work and after work. Thereafter, only handling slides when wearing gloves.

26) Intake by others persons exposed to contaminated work surfaces, stained slides, equipment or through the spread of contamination (cross contamination).

- **Route of Intake** → Ingestion of contamination inadvertently picked up as a result of exposure to cross contamination; then transfer from hands to food, drink, cigarettes, etc.
- **Risk Prevention** → Work carried out under (appropriate) containment, i.e. in designated areas surfaces marked out and laid with Benchkote® (absorbent surface

uppermost) and using lined drip trays. Work surfaces and hands are monitored for contamination during and after work. User changes gloves frequently or if contamination suspected.

ARRANGEMENTS FOR WORK WITH URANIUM AND THORIUM COMPOUNDS

Scope of Arrangements

27) These arrangements apply to the use of natural uranium/thorium compounds that are in secular equilibrium, and which contain

- 99.3% ^{238}U, 0.7% ^{235}U and 0.005% ^{234}U
- depleted uranium (though nature of the source must be confirmed with the Radiation Protection Service prior to purchase)
- 100% ^{230}Th or ^{232}Th.

28) Most 'off the shelf' compounds of uranium and thorium in secular equilibrium, e.g. uranium nitrate and uranium acetate will be formulated from 'natural' uranium.

29) Uranium and thorium products that have been physically produced (e.g. by milling) or chemically produced (e.g. by reaction) from naturally occurring minerals may not be covered by these arrangements; check with the Radiation Protection Service. *The keeping and use of geological specimens are subject to other arrangements.*

30) Other isotopes of thorium and uranium are subject to the full scope of the RSA93 and to further prescriptive requirements of the IRR99.

Control of Substances

31) An Academic Unit may only use uranium/thorium compounds if the Unit has been issued with a Certificate of Registration and Authorisation[5] explicitly states compound to be used.

32) The maximum quantity permitted in one Academic Unit is two bottles and a maximum of 100g of compound (unless otherwise indicated on a Certificate of Registration). Excess quantities or spare stocks can be lodged with the Radiation Protection Service for safekeeping.

33) When not being used, the solid stock and any sub stocks should be kept in a locked

[5] Registration Certificates are issued by the Radiation Protection Service (Safety Advisory Services) on behalf of the Vice Chancellor of the University.

radioactive source store that is appropriately labelled (Figure 1).

34) Aqueous stocks should be held in a secure location, which could be a locked cupboard (Figure 1) or locked laboratory, and they must be stored such that the risk of spillage is minimised.

35) Stained electron microscopy slides must be kept in a safe location, i.e. in a suitable container that is kept in a lockable cupboard or a cupboard in a locked laboratory. The store and the container must be marked with a suitable hazard-warning device (Figure 1).

36) A usage log must be kept that shows the

- compound(s) and chemical formulae
- date of purchase or receipt
- quantity (mass) of material held
- mass of material withdrawn from the stock at any time, and the date of removal.

Working with uranium and thorium compounds

37) Work must be carried out using a **workstation** that has been created in either a **Supervised Area** (registered radiation workers only) or preferably in an **Undesignated Area** (Figure 2) (any approved worker).

38) A 'workstation' must be created as follows:

- A suitably sized area of workbench should be covered with Benchkote® (absorbent surface uppermost) and taped down using appropriate hazard warning tape. All work, equipment, labware, solutions, etc. must be contained within this defined area.
- The workstation must be provided with drip trays fitted with either disposable liners or Benchkote®, and uranium/thorium compounds or solutions may only be handled in these trays.

39) The workstation must be cleaned (decontaminated) and dismantled immediately after use unless it is in regular use. If the latter is the case, the workstation must be checked for contamination **prior** to and **after** use. The local rules give further instruction.

40) Uranium/thorium compounds may only be handled by persons who have received **local instruction** in the safe uses of these materials[6]. A person who has been approved to do so

[6] In particular, the user must know how to monitor for radioactive contamination and how to decontaminate any contaminated areas.

by the Radiation Protection Supervisor would normally give this training. *In particular, the user must know how to monitor for radioactive contamination.*

41) Uranium/thorium powders may only be handled in a fume cupboard. The only exception to this where weighing out is to be done using a balance fitted with a measurement chamber. *Any spillages must be wiped up using damp tissues.*

42) Work must be carried out in accordance with the instructions given in the Academic Unit's 'Local Rules for the Safe Uses of Uranium and Thorium Compounds'.

Waste Disposal

Aqueous waste

43) All aqueous waste, including spare stock solution, must be disposed of by decanting into running water in a **designated sink** (Figure 3). *Small volumes of aqueous waste (i.e. less than 50 mls), such as generated by dipping slides into uranium solutions, may be washed down a normal sink: copious quantities of water must be run down the sink after use.*

Solid waste

44) All solid waste, i.e. small quantities (i.e. less than 1 gram) of solid uranium/thorium compounds, suppliers stock bottles, Benchkote® (contaminated or not), gloves, wipes, swabs, tissues, disposable labware, etc. must be disposed of through the **green tag** radioactive waste disposal route (Figure 4).

45) Scalpel blades, broken glassware and unwanted electron microscope slides must also be disposed of via the solid waste route, though such items must first be placed in a sealed cardboard box.

46) Before disposing of **radiation hazard warning tape** it must first be screwed into a ball so that the radiation trefoils etc. can no longer be seen.

Green Tag Waste Route

47) All solid radioactive waste must be disposed of to the Radiation Protection Service (Wayne Harrison ☎ 34204, w.f.harrison@leeds.ac.uk), who will provide the bags and black bag ties (the Academic Unit must provide a suitable rigid bin in which to stand the disposable waste bags). When a bag is full or at monthly intervals, whichever is the soonest; the waste must be transferred to the Radiation Protection Service.

48) A waste collection bag comprises a heavy-duty paper sack inside a clear heavy gauge polythene bag.

- the inner paper sack must be sealed using a black bag tie,
- the outer polythene bag must then sealed using a black bag tie,
- the outer black tie must also be threaded through a green tag onto which the disposal details must be written,
- the bag must be taken to The Radiation Protection Service. Deliveries should be made on Thursday mornings, phone before leaving.

recycled items

49) All laboratory glassware used for uranium/thorium work may be returned to general circulation once it has been decontaminated by soaking in Decon® or similar.

Needles and sharps

50) Needles and other sharps (other than scalpel blades, contaminated broken glass and microscope slides - see above) must be decontaminated and then disposed of via appropriate routes for such items, e.g. sharp cinbins.

FIGURES

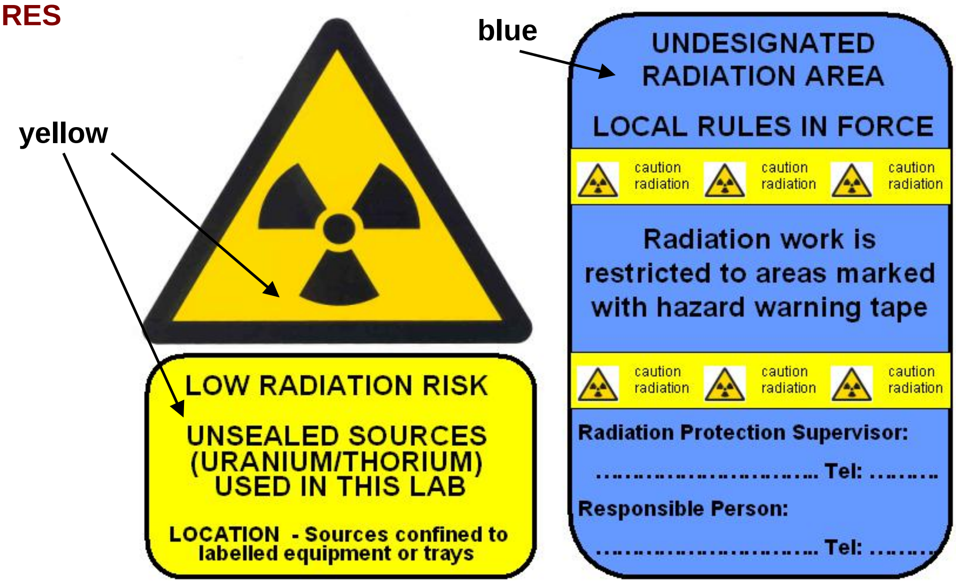

Figure 2 Door sign for laboratories in which uranium and thorium compounds are used

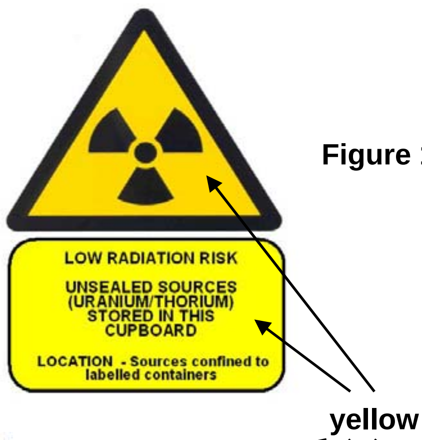

Figure 1 Sign to be affixed to the radiation source store and other storage cupboards as appropriate

Figure 3 Sign to be posted to indicate which sink may be used for the disposal of aqueous radioactive waste

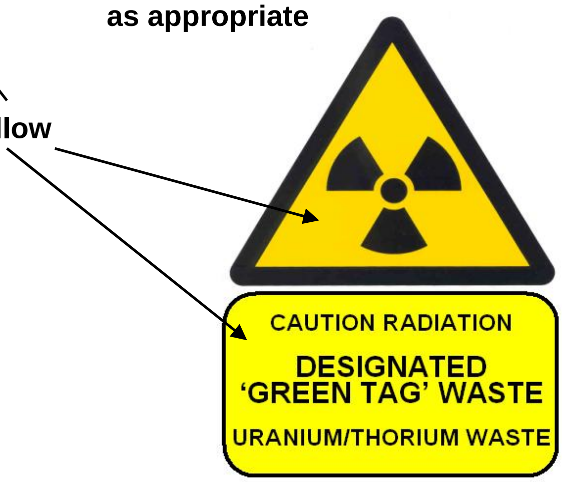

Figure 4 Sign to be posted on the bin that is to be used for the disposal of solid radioactive waste