LEAFLET 29

ITEMS AND COMPONENTS CONTAINING THORIUM

CONTENTS

SCOPE

1 Thorium, which is a naturally occurring radioactive material, is widely used within MOD in magnesium alloy aircraft components, optical lenses and some laboratory compounds. Less widely used, now, but still in service in some areas are thoriated gas mantles and thoriated welding rods. Thorium is not used for its radioactive properties but rather because of its physical properties such as a hardening agent in lightweight magnesium alloys, for the optical qualities it imbues when incorporated in lenses or lens coatings and for its incandescence properties.

2 This Leaflet describes the radiological requirements for keeping, using and disposing of such items and components. General information and instruction on the hazards associated with thorium, personnel duties and responsibilities and statutory and MOD mandatory requirements is provided in the body of the Leaflet. Further information and guidance on each major type of item or component and the risks posed is provided at the Annexes. The RPA is to be consulted for detailed advice on specific applications involving thorium.

STATUTORY REQUIREMENTS AND PARALLEL ARRANGEMENTS

3 In addition to the general requirements of the Health and Safety at Work etc Act 1974 and the Management of Health and Safety at Work Regulations 1999, the following specific legislation applies directly or is applied indirectly through parallel arrangements designed to achieve equivalent standards:

- Ionising Radiations Regulations 1999 (IRR99) (apply directly);
- Radioactive Substances Act 1993 (RSA93) (parallel arrangements);
- Radioactive Substances (Uranium and Thorium) Exemption Order 1962 (parallel arrangements);
- Radioactive Substances (Prepared Uranium and Thorium Compounds) Exemption Order 1962 (parallel arrangements);
- Carriage of Dangerous Goods and Transportable Pressure Equipment Regulations 2007 (apply directly).

DUTIES

Commanding Officer and Head of Establishment (CO/HoE)

4 The CO/HoEhas a duty to the Secretary of State, and a personal responsibility, to protect the environment and secure the health, safety and welfare of their staff at work. The CO/HoE is also required to protect persons not in MOD employment (e.g. members of the public) against risks to their health and safety arising from the MOD work activities. This includes radiation safety. The CO/HoE's authority (but not responsibility) for radiation safety management arrangements may be delegated to appropriate personnel, such as a Radiation Safety Officer (RSO).

Radiation Safety Officer (RSO)

5 The Radiation Safety Officer (RSO) is to ensure that:

- They are familiar with the specific radiation hazards of work involving thorium items or components at their unit or establishment and that an appropriate risk assessment has been carried out;
- Local orders include the requirements for keeping, using and disposing of thorium items and components as detailed in this Leaflet;
- Staff are appointed, instructed and trained in their duties relating to this Leaflet;
- The requirements stemming from this Leaflet are subject to audit.

Radiation Protection Supervisor (RPS)

6 An RPS must be appointed where it is necessary to designate areas as controlled or supervised – for further details see Table 2. Where an RPS is appointed, they are to ensure that work is carried out in accordance with the local orders for radiation safety which are to include the requirements of this Leaflet.

Workplace Supervisor (WPS)

7 In units holding thorium items and components but where it is unnecessary to appoint an RPS, a WPS is to be appointed with duties to ensure that work is carried out in accordance with the local orders for radiation safety which are to include the requirements of this Leaflet.

Employees

8 It is the responsibility of all employees to ensure that they are familiar with the relevant parts of local orders to ensure that these items and components are handled safely and correctly. Any incidents are to be reported to the appropriate supervisor or line manager.

NATURE OF THORIUM

9 The major source of thorium in nature is monazite sand containing up to 12% by weight of thorium oxide. Thorium occurs in nature as thorium-232 (Th-232) which has an extremely long half-life (many millions of years). Th-232 has 10 radioactive daughters (which include Th-228) of much shorter half-lives which exist in equilibrium with the parent nuclide and contribute to the overall radioactivity of natural thorium. The activity of natural thorium is 4.1 kBq g^{-1} of Th-232 together with similar activity levels of each daughter (including Th-228). Th-232 together with its daughters emit alpha, beta and gamma radiation.

10 Thorium and thorium/magnesium alloys are prone to corrosion if allowed to weather, resulting in a loose powdery oxide which can pose a contamination hazard.

11 Specialised chemical processing, such as that used to prepare laboratory compounds, can separate Th-232 (and Th-228) from other daughter nuclides resulting in a rather different nuclide and radiation profile. For bulk solids containing processed thorium, the full equilibrium is slowly restored over about 30 years. Finely divided thorium (e.g. a powder) can allow the release of the gaseous daughter product radon-220 (also called thoron) which can affect the equilibrium and change the nuclide and radiation profile.

12 Detailed advice on the radioactive nature and properties of thorium can be sought from the RPA.

HAZARDS

Table 1 Hazards associated with items and components containing thorium

Radiation type		Emitted	Comments
Alpha		✓	High energy alpha radiation is emitted by Th-232 and 6 of its 10 radioactive daughter products. Alpha radiation is absorbed effectively by a thin layer of all materials including the dead surface layer of skin or a few cm of air and hence is not normally considered an external radiation hazard. However, in the case of **some optical lenses** containing or coated with thorium material, **a significant alpha dose could be received by the eye** (surface of the cornea) if the eye is placed close to the thoriated lens. Alpha radiation poses a potential internal hazard e.g. inhalation of airborne thorium material (machining, gas mantles, welding), ingress through or via the skin of loose thorium arisings and ingestion of contamination. Finely divided thorium (powders etc) can allow some Radon-220 (daughter product) gas to reach atmosphere – this leads to an additional internal radiation hazard.
Beta	Direct	✓	Beta radiation is emitted by 5 of the 10 radioactive daughters of Th-232. Beta radiation penetrates through thin layers of material and travels up to a few metres in air. Beta will contribute to the external radiation dose received by the eye from some thoriated lenses (see above). Beta will also contribute to the external radiation dose where personnel are in close proximity to thorium items and components containing thorium alloys. In the latter case, only beta radiation from surface layers (a few mm in depth) contributes to dose due to self absorption of beta emitted within the bulk material. Beta radiation poses a potential hazard from inhalation, ingress through or via the skin and ingestion as indicated for alpha above.
	Bremsstrahlung	✓	Low levels of Bremsstrahlung radiation (X-rays) are emitted from items and components containing thorium.
Gamma		✓	Gamma radiation is emitted by thorium and its daughter products. This gives rise to an external radiation hazard. Dose rates are dependent on concentration and quantity of thorium and also the design and structure of the equipment. Dose rates can be sufficient to require areas to be designated as controlled or supervised (see annexes to this leaflet).
X-rays		×	
Neutrons		×	

RISK ASSESSMENTS FOR ITEMS AND COMPONENTS CONTAINING THORIUM

13 A risk assessment is to be carried out by units and establishments, in consultation with the RPA, on each new or existing activity using equipment containing thorium. The assessment must take account of local factors and recommended control measures. Leaflet 2 describes the process to be followed in carrying out a radiological risk assessment. The general legal and MOD mandatory requirements for work with thorium are given in Table 2. Specific hazard and risk information for the following applications is given at Annexes A to E respectively:

- Thoriated magnesium alloy components (e.g. aircraft engine components);
- Thoriated lenses;
- Thoriated Gas Mantles;
- Thoriated welding electrodes.

Risk assessments for work involving laboratory compounds of thorium

14 Work with thoriated laboratory compounds invariably involves work with open sources of radioactivity. The hazards and risks of this work and the necessary control measures vary widely depending on the application. For this reason, the RPA must always be consulted prior to the work commencing in regard to the prior risk assessment, the need for area designation, contingency plans and the control measures necessary for safe management of the work and use and disposal of the radioactive materials.

LEGAL AND MOD MANDATORY REQUIREMENTS

15 Table 2 below summarises the legal and MOD mandatory requirements for work involving thorium items and components. Further guidance for the thorium in optical lenses, thoriated engine components, thoriated welding electrodes and radioactive gas mantles is given at the Annexes to this leaflet. For other applications of thorium or in cases of doubt, the RPA is to be consulted for advice.

Table 2 Legal and MOD mandatory requirements for items and components containing thorium

Requirement	Applicable	Comments	Related leaflet*
HSE Authorisation	✗		
HSE Notification	✓	In general, work carried out involving thorium items and components is to be notified to HSE in accordance with Leaflet 3. Exceptionally, where the concentration of thorium is less than 10 Bq g^{-1}, HSE need not be notified.	3
EA Notification**	✗ (but see comment)	Items and components containing 4% by weight or less of natural thorium are exempt from notification (this includes most MOD applications). Incandescent mantles are exempt from notification. Items containing more than 4% of natural thorium are exempt from notification provided that the total weight of thorium present on the premises at any one time does not exceed 2 kg.	3
Risk Assessment	✓	This is required for work with thorium items and components in accordance with Leaflet 2. Basic information on the major MOD applications is provided at the Annexes to this leaflet.	2

Table 2 Legal and MOD mandatory requirements for items and components containing thorium (continued)

Requirement	Applicable	Comments	Related leaflet*
Restriction of exposure	✓	Gas mantles are to re-stocked using non-radioactive variants. Use of thoriated welding electrodes is to be avoided if practicable. Alternatives to thoriated lenses are to be considered in the design of equipment. Stocks of spares of thoriated items and components are to be kept to the minimum necessary to meet operational requirements. See Annexes to this leaflet for further specific information on the control measures advised for restriction of exposure and also Leaflet 4 for general information on restriction of exposure.	4
PPE	✓	See Annexes for specific information.	4
Maintenance of radiation engineering controls	✗	Not applicable.	
Contingency plans	✓	Leaflet 40 describes the general requirements for contingency plans.	40
Designated areas	✓	Thorium items and components can give rise to external radiation dose rates exceeding the levels requiring areas to be designated as controlled or supervised (see Leaflet 4). Similarly, work which can give rise to airborne or surface contamination e.g. machining of thoriated alloys may require area designation. An RPA must always be consulted as to the requirements in designated areas. Designated areas are not required where only thoriated gas mantles are stored or used or for storage of thoriated welding electrodes.	4
Monitoring	✓	Where designated areas are required or where areas need to be kept under review or where there is a potential for contamination, then monitoring will be required in accordance with Leaflets 4 and 8.	4, 8
Training for users	✓	Information and instruction is required.	15
Local orders	✓	See Leaflet 16 for guidance. Some specific information which may be considered for inclusion in local orders is provided at the Annexes to this leaflet.	16
Appointed person	✓	An RPS is required where areas require to be designated as controlled or supervised. Where an RPS is not required, a WPS needs to be appointed in accordance with Leaflet 39.	39

Table 2 Legal and MOD mandatory requirements for items and components containing thorium (continued)

Requirement	Applicable	Comments	Related leaflet*
Storage	✓	Smaller items and components not in use are to be kept in a segregated fire resistant secure store/container/cupboard marked with radiation trefoil warning sign and stored in accordance with Leaflet 9. Larger components are to be stored in fire resistant containers or double bagged and stored on metal racking or in an area set aside for their storage. Appropriate warning signs and access controls (for designated areas) are to be in place.	9
Accounting	✓	Mustered monthly, recorded on a radioactive source list which is to be retained for 2 years. Recorded on Dstl Annual Holdings Return, copy retained for 1 year.	9
Leak testing	✗	Thorium items and components do not require to be leak tested.	
Personal dosimetry	✓	Personal dosimetry may be required, as advised by the RPA, if there is a requirement for a designated area.	6
Classified persons	✓	Personnel working in designated controlled areas may need to be classified in accordance with Leaflet 4.	4, 6, 38
Reporting procedures	✓	All losses and certain other incidents require to be reported to MOD authorities. Reporting to external regulatory authorities may also be required. See Leaflet 14 for details.	14
Transport	✓	Items and bulk quantities may be transported as Excepted Packages in accordance with JSP 800 Vol. 4b (road, rail, sea) or JSP 800 Vol. 4a (air) provided the only radioactive content is natural thorium and the dose rate on the external surface of the package does not exceed 5 μSv h^{-1}. It is also a requirement that the outer surface of the thorium is fully enclosed in an inactive sheath made of metal or other substantial substance. Items containing less than 10 Bq g^{-1} of Th-232 are exempt from the above requirement.	10 JSP 800 Vol. 4a & Vol. 4b
Marking	✓	All thoriated items and components and equipment, stores and containers holding such items are to be marked appropriately with the radiation warning sign and description of content.	-
Sale/Transfer	✓	See Leaflet 11	11
Disposal of redundant items and waste arisings	✓	A number of exemptions are in place for disposal of items and components containing thorium. Details are provided for specific applications at the annexes to this leaflet. For other applications, the RPA is to be consulted. Leaflet 12 also refers. Keep records of disposal for 2 years.	12

*JSP 392, unless otherwise stated
**Environment Agency (EA) for England and Wales, Scottish Environment Protection Agency (SEPA) for Scotland and Environment and Heritage Service for Northern Ireland (EHSNI)

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LEAFLET 29 ANNEX A

THORIATED MAGNESIUM ALLOY COMPONENTS – HAZARD AND RISK INFORMATION

Thoriated Magnesium Alloy Components	
Description	Thorium can be incorporated into engine components to instil creep resistance at elevated temperatures. Typically up to 4% by weight of thorium is present.
Radionuclide	Thorium-232 (Th-232) and 10 radioactive daughter products including Ra-228, Th-228, Ra-224 and Rn-220.
Ionising radiation	Alpha, beta and gamma radiation from mix of parent and daughter nuclides.
Half life	1.4×10^{10} years (Th-232)
Activity	4% w/w alloys contain approximately 160 Bq g^{-1} of Th-232 and up to 1500 Bq g^{-1} of daughter products.
External radiation hazard	Gamma radiation is emitted from thoriated engines, beta radiation from surface layers up to a few mm deep and alpha radiation from the immediate surface layer. 4% w/w alloys give whole body contact dose rates of up to 20 µSv h^{-1} and skin dose rates of up to 160 µSv h^{-1} skin. Dose rates fall off rapidly with distance such that significant exposure is only likely for those who work in close proximity for extended periods.
Internal radiation hazard	Drilling or machining can create radioactive dust. Corrosion generates white powdery thorium oxide which can be released as contamination during handling, maintenance and refurbishment. The radioactive dust emits alpha, beta and gamma which can be an internal hazard via inhalation, ingestion, skin contamination and ingress through cuts or abrasion in the skin. Working (unprotected) on a 4% alloy and generating dust levels of a few mg/m^3 could lead to an inhalation dose rate of up to 40 µSv h^{-1}.
Local orders	Details of the control measures taken from this leaflet are to be included in the local orders for radiation safety (Leaflet 16 refers).
Control measures during use	Local shielding (e.g. lead rubber) is to be applied wherever practicable to reduce the dose to personnel working for long periods in close proximity to engines or other components containing thoriated alloys. Rubber gloves are to be worn, where practicable, during routine handling of these items. Small scale drilling or refurbishment can be undertaken with operator wearing suitable RPE and gloves but a strict clean up must be followed on completion. The advice of the RPA must be sought where more major work involving machining or refurbishment of corroded components is required. Standard control measures for work involving contamination are to be followed (see Leaflet 4). Components found to have loose surface activity are to be double bagged and advice taken on their decontamination or disposal.
Accounting	These items are to be accounted for on a Radioactive Source List or in equivalent locally produced documentation. Leaflet 9 refers.
Radioactive Substances Act 1993	Thoriated alloy components containing up to 4% w/w thorium are exempt from formal RSA93 notification to the relevant environment agency but these items are to be included in the Annual Holdings Return to Dstl – Leaflet 3 refers. Where components contain more than 4% w/w thorium, notification to EA is required unless the total weight of thorium held on the premises at any one time is 2 kg or below.

Thoriated Magnesium Alloy Components	
Storage and labelling	If uninstalled, these items are to be stored in a dedicated area for radioactive materials – see Leaflet 9. Equipment is to display the appropriate radiation warning label on it. The storage/installed area is also to have a sign showing radioactive material within. i.e. a radiation warning trefoil including the contact name and telephone number of the RPS or WPS and stating the nature of the radiological hazard. Larger components can be stored in fire resistant containers or double bagged and stored on metal racking or in an area set aside for their storage. Thoriated aircraft engines are to be stored in conditions which prevent their deterioration, in their transit boxes if practicable and in an area set aside for them.
Contingency Plans Fire/Contamination/ **Loss/Incident**	In the event of fire, thorium components can oxidise to thorium oxide but both thorium and its oxide are not volatile. Contingency arrangements for a fire involving radioactive material are to be followed (see Leaflet 40). Significant contamination is likely to be present on thoriated components affected by the fire. Small amounts of corrosion products or arisings from drilling can be cleaned up using the methods outlined for dealing with breakages at Annex D to Leaflet 17. Reporting of loss and certain other incidents are to be carried out in accordance with procedures described in Leaflet 14.
Transport	Items and bulk quantities can be transported within an excepted package provided the dose rate on the external surface of the package does not exceed 5 μSv h^{-1} and the item is fully enclosed in an inactive sheath.
Disposal	Small amounts of waste arisings (e.g. from clean up of contamination) can be disposed of (in an unmarked polythene bag) with ordinary refuse providing the total weight of thorium disposed is less than 100 g in any one day. Equipments containing thoriated alloys incorporating less than 4% thorium by weight can be disposed to a local authority tip. Alternatively, they can be returned to the manufacturer of such equipments, through a MOD establishment or to an external contractor having an authorisation to dispose of thorium waste. In general thoriated alloys have been found to be below 4% thorium but, where possible, clarification is to be sought from the manufacturer or IPT, or otherwise from the RPA.

LEAFLET 29 ANNEX B

THORIATED LENSES – HAZARD AND RISK INFORMATION

Thoriated Lenses	
Description	Thorium oxide ($Th0_2$) can be added to molten glass during lens manufacture to promote its optical quality. These lenses, termed homogenous thorium oxide lenses, have been found to contain up to 17% Thorium by weight. Germanium lenses, for example those used in thermal imaging equipment, can be coated with thorium fluoride (ThF_4) to reduce surface reflections.
Radionuclide	Thorium-232 (Th-232) and 10 radioactive daughter products including Ra-228, Th-228, Ra-224 and Rn-220.
Ionising radiation	Alpha, beta and gamma radiation from mix of parent and daughter nuclides.
Half life	1.4×10^{10} years (Th-232).
Activity	Homogenous thorium oxide lenses, containing 17% Th-232 w/w, contain approximately 0.7 kBq g^{-1} of Th-232 and up to 6.5 kBq g^{-1} of daughter products. Thorium fluoride coated lenses contain a total of between 0.8 and 3.3 kBq of Th-232 thinly coated around the lens surface plus between 7 and 30 kBq of daughter products.
External radiation hazard	Gamma radiation is emitted from thoriated lenses, beta radiation from layers within a few mm of the surface and alpha radiation from the immediate surface layer. Homogenous thorium oxide lenses (17% w/w) give external beta/gamma dose rates of ~ 100 µSv h^{-1} and for an eye placed close to an unprotected lens, ~ 3 mSv h^{-1} alpha dose rate to the surface of the cornea. Thorium fluoride coated lenses can only give up to a few µSv h^{-1} beta/gamma dose rate but, as above can give an alpha dose rate to the cornea of ~ 3 mSv h^{-1}. Dose rates fall off rapidly with distance such that significant exposure is only likely for those who work in close proximity for extended periods or those handling bulk quantities.
Internal radiation hazard	The internal hazard from homogenous thorium oxide lenses is negligible unless breakage occurs and shards of glass penetrate the skin, leading to only a minor hazard to the local tissue (due to the insolubility of the thorium oxide present in the glass). Thorium fluoride coatings, on the other hand, are prone to flaking leading to contamination which could potentially be taken into the body. Additionally, a shard of glass from a breakage could penetrate the skin leading to uptake of soluble thorium fluoride and a more significant internal radiation dose, possibly of the order of 1 mSv.
Local orders	Details of the control measures taken from this leaflet are to be included in the local orders for radiation safety (Leaflet 16 refers).
Control measures during use	Rubber gloves are to be worn, where practicable, during routine handling of these items, particularly thorium fluoride coated lenses. If thoriated lenses must be used for eye-pieces, they are to be covered with a thin sheet of glass or Perspex to minimise the alpha and beta radiation dose to the eye.
Accounting	These items are to be accounted for on a Radioactive Source List or in equivalent locally produced documentation. Leaflet 9 refers.

Thoriated Lenses	
Radioactive Substances Act 1993	Holdings of small quantities of lenses are exempt from notification providing the total weight of thorium at the premises at any one time is 2 kg or below. These items are to be included in the Annual Holdings Return to Dstl – Leaflet 3 refers.
Storage and Labelling	Equipments containing thorium lenses are to be marked with a radiation warning sign unless this is not possible for operational or safety reasons. When uninstalled, these items are to be stored in a dedicated area for radioactive materials – see Leaflet 9. The storage/installed area is also to have a sign showing radioactive material within. i.e. a radiation warning trefoil including the contact name and telephone number of the RPS or WPS and stating the nature of the radiological hazard. Strong metal, fire resistant storage cabinets can be used, marked as above providing no more than 400 lenses are contained within and the dose rate on the exterior of the cabinet is < 2.5 μSv h^{-1}.
Contingency Plans Fire/Breakage/ **Loss/Incident**	In the event of fire, thoriated lenses are unlikely to lead to an airborne hazard but there may be some spread of surface contamination. Contingency arrangements for a fire involving radioactive material are to be followed (see Leaflet 40). Breakage is to be dealt with by using the methods outlined for dealing with breakages at Leaflet 40. Glass fragments entering the skin are to be removed immediately and the wound cleaned under running water – RPA and medical advice is to be sought. RPA advice is to be sought regarding disposal of the arisings from clean up. Reporting of loss and certain other incidents is to be carried out in accordance with procedures described in Leaflet 14.
Transport	Items and bulk quantities can be transported within an excepted package provided the dose rate on the external surface of the package does not exceed 5 μSv h^{-1} and the item is fully enclosed in an inactive sheath.
Disposal	Thoriated lenses or fragments of lenses can be disposed of to a local authority tip providing that the total weight of thorium does not exceed 100g in any one day. Alternatively, they can be returned to the manufacturer of such equipments, through a MOD establishment or to an external contractor having an authorisation to dispose of thorium waste. For larger quantities, the RPA is to be consulted.

LEAFLET 29 ANNEX C

THORIATED GAS MANTLES – HAZARD AND RISK INFORMATION

CONTENTS

THORIATED GAS MANTLES – HAZARD AND RISK INFORMATION

<table>
<tr><th colspan="2">Thoriated Gas Mantles</th></tr>
<tr><td>Description and activity</td><td>Gas mantles are used in portable lanterns and Tilley ® lamps to provide lighting in field conditions. Thoriated gas mantles are being phased out of service (being replaced by non-radioactive variants) but 4 different types of thoriated gas mantle currently remain in service:

<table>
<tr><th>Type</th><th>NATO Stock Number</th><th>Estimated Thorium-232 Content</th></tr>
<tr><td>Veritas (Valor)</td><td>6260-99-129-6561</td><td>1.3 kBq</td></tr>
<tr><td>Coleman</td><td>6260-21-107-4859</td><td>0.7 kBq</td></tr>
<tr><td>Coleman</td><td>6260-99-910-6822</td><td>1.6 kBq</td></tr>
<tr><td>Coleman</td><td>6260-99-107-4860</td><td>1.9 kBq</td></tr>
</table>

Gas mantles are to be restocked using the non-radioactive variant identified by a crossed out radiation trefoil on the packaging and by a green thread running through the gas mantle.

The information below is based on the highest activity (1.9 kBq per mantle).</td></tr>
<tr><td>Radionuclide</td><td>Thorium-232 (Th-232) and 10 radioactive daughter products including Ra-228, Th-228, Ra-224 and Rn-220.</td></tr>
<tr><td>Ionising radiation</td><td>Alpha, beta and gamma radiation from mix of parent and daughter nuclides.</td></tr>
<tr><td>Half life</td><td>1.4×10^{10} years (Th-232).</td></tr>
<tr><td>External radiation hazard</td><td>The contact dose rate from a single thoriated mantle is < 1 μSv h^{-1}. A large consignment of 2500 mantles held in a cardboard box gives a dose rate of ~ 20 μSv h^{-1} at the surface of the container falling off rapidly with distance to < 1 μSv h^{-1} at 1 m.</td></tr>
<tr><td>Internal radiation hazard</td><td>Rn-220 (Thoron) is emitted in small quantities from gas mantles in storage but it is very short lived and does not escape from the heat sealed cellophane wrapping.
The most significant internal hazard arises from mantle ash during replacement. Potential committed effective doses of 9 μSv from inhalation, 5 μSv from ingestion and up to 270 μSv from injection through the skin. Emissions of airborne contamination during operation of the mantle are very small – however, a fire at a gas mantle storage facility, holding large numbers of mantles, could present an inhalation hazard from thorium oxide dust and aerosols containing daughter products.</td></tr>
<tr><td>Local orders</td><td>Details of the control measures taken from this leaflet are to be included in the local safety orders or radiation safety orders if held (Leaflet 16 refers).</td></tr>
</table>

Thoriated Gas Mantles	
Control measures during use	Stocks are to be kept to a minimum and older mantles are to be used first. Gas mantles are to not be removed from their wrapping until required for use. When first lit (or relit after a period greater than 2 days), ensure a well ventilated environment where practicable. Guidance on the procedure for changing gas mantles, wearing rubber gloves, is provided at the end of this Annex. Where large quantities are stored, RPA advice is to be taken on the need for additional control measures.
Accounting	Mantles installed in lamps and holdings of less than 50 uninstalled mantles need not be entered in the radioactive source list. Where more than 50 of these items are held, they are to be accounted for on a Radioactive Source List or in equivalent locally produced documentation. Leaflet 9 refers. Holdings of more than 50 are to be included in the Annual Holdings Return to Dstl – Leaflet 3 refers.
Radioactive Substances Act 1993	These items are exempt from notification under RSA93.
Storage and labelling	Small quantities of gas mantles, not exceeding 400, can be stored in a building other than a specially designed store. Gas mantles are to be segregated from non-radioactive materials and, where practicable, stored separately from the lanterns in which they are used. Quantities greater than 400 are to be stored in containers or on racks constructed of fire resistant material in a purpose built fire resistant store with ventilation to atmosphere. Advice on fire precautions are to be obtained from the local fire authority. Storage areas are to have a sign indicating that there is radioactive material within. i.e. a radiation warning trefoil including the contact name and telephone number of the RPS or WPS and stating the nature of the radiological hazard.
Contingency Plans Fire/Loss/Incident	In the event of fire, affecting stores where thoriated gas mantles are held, there may be an airborne hazard and firefighters are to use self contained breathing apparatus. Contingency arrangements for a fire involving radioactive material are to be followed (see Leaflet 40). RPA advice is to be sought regarding clean up after a fire. Loss of a small number of these mantles need not be reported. However, if more than 50 mantles are involved, reporting procedures described in Leaflet 14 are to be followed.
Transport	Items and bulk quantities can be transported within an excepted package provided the dose rate on the external surface of the package does not exceed 5 μSv h^{-1}.
Disposal	Used gas mantles or waste arising from mantle usage is to be placed in an unmarked polythene bag, mixed with normal refuse and disposed of to a local authority tip.

PRECAUTIONS TO BE TAKEN WHEN REMOVING AND REPLACING GAS MANTLES

1 Thoriated gas mantles are to be removed in the open air or in a well ventilated environment whenever practicable, crushing the used mantle into a damp cloth or tissue to reduce airborne contamination. Rubber gloves are to be worn when removing old gas mantles, and a damp cloth is to be used to keep down any mantle ash.

NOTES

(1) Gas mantles must not be changed in areas used for eating drinking or smoking.

(2) Mantle ash is not to be blown away from a lamp as this will increase the hazard due to inhalation.

2 The mantle ash is to be placed in a plastic bag and disposed of in the general rubbish. Surfaces that have become contaminated are to be wiped down with a damp cloth and the cloths placed in the disposal bag.

3 On completion hands are to be washed thoroughly.

4 Any cuts or abrasions are to be reported to the medical officer. If this is not possible the cut is to be allowed to bleed and be rinsed with clean water. The medical officer is to be informed at the earliest opportunity. If radiation medicine advice is required, contact is to be made with the Duty Radiation Medicine Officer on 023 9276 8085 during working hours or 023 9276 8020 during silent hours.

5 If mantle ash is blown into the eyes, the eye is to be irrigated with clean water for at least 10 minutes and medical assistance sought.

6 The RPA is to be informed if any mantle ash is believed to have been inhaled.

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LEAFLET 29 ANNEX D

THORIATED WELDING ELECTRODES – HAZARD AND RISK INFORMATION

Thoriated Welding Electrodes	
Description and activity	Thoriated tungsten welding electrodes are still used in plasma cutting and welding processes but are generally now being replaced by non radioactive electrodes. The non-radioactive variants are to be used wherever practicable. Thoriated welding electrodes typically contain up to a maximum of ~ 7 kBq of Th-232. **The information below is based on the upper bound of 7 kBq per electrode.**
Radionuclide	Thorium-232 (Th-232) and 10 radioactive daughter products including Ra-228, Th-228, Ra-224 and Rn-220.
Ionising radiation	Alpha, beta and gamma radiation from mix of parent and daughter nuclides.
Half life	1.4×10^{10} years (Th-232).
External radiation hazard	The contact dose rate from an electrode is ~ 1 µSv h^{-1} falling off rapidly with distance.
Internal radiation hazard	Despite the high temperatures generated, welding and cutting processes produce only very small quantities of loose airborne or surface radioactivity. Grinding and regrinding of electrode tips, on the other hand, does lead to the production of loose airborne and surface contamination. Potential committed effective doses from grinding operations in the absence of control measures (see below) are estimated as follows: • Inhalation of dust up to 5 µSv per grinding activity. • Ingestion via contamination transferred from hand to mouth < 1 µSv per grinding activity. • Injection through a wound or skin abrasion 7 µSv. **All of the above doses can be substantially reduced by following the control measures (below).**
Local orders	Details of the control measures taken from this leaflet are to be included in the local safety orders or radiation safety orders if held (Leaflet 16 refers).
Control measures during use	Use non thoriated welding electrodes wherever practicable. Keep non-essential personnel clear of welding and grinding activities – no eating, drinking smoking rule in place in areas where welding or grinding takes place. Wherever practicable, a grinding wheel is to be reserved for the grinding of thoriated electrodes, local exhaust ventilation is to be provided at the site of the grinding wheel; welders are to wear suitable gloves to prevent grinding dust coming into contact with the skin and wash hands thoroughly after grinding is complete. Any cuts or wound are to be covered before carrying out grinding operations. Any cuts becoming contaminated with grinding dust are to be allowed to bleed and thoroughly washed in running water.

Thoriated Welding Electrodes	
Control measures during use (continued)	In areas where more than 50 grinding operations per week are undertaken, and in units where training is carried out, in addition to extractors venting to the external atmosphere, surface dust is to be frequently removed using a vacuum cleaner fitted with an absolute dust filter. The vacuum cleaner is to be kept solely for the removal of thorium dust and is to be marked with a radiation warning label. Removal of the dust collection bag or replacement of the absolute filter is to be carried out in accordance with local orders and procedures (using adequately trained personnel wearing gloves, coverall and respiratory protection). In areas where less than 50 grinding operations a week take place, a routine clean-up programme is to be adopted. The grinding dust is to be dampened down and then removed using a damp cloth. The cloth is to be placed in a plastic bag or container displaying no radiation markings and disposed of with normal refuse.
Accounting	These items are to be accounted for on a Radioactive Source List or in equivalent locally produced documentation. Leaflet 9 refers. These items are to also be included in the Annual Holdings Return to Dstl – Leaflet 3 refers.
Radioactive Substances Act 1993	These items are exempt from notification under RSA93.
Storage and labelling	The number of welding electrodes held in a welding store is to be kept to a minimum. When not in use welding electrodes other than those fitted into arc welding equipment are to be segregated from non-radioactive items and are to be stored together in bundles in a drawer, a locked steel cabinet or metal container. The container is to be marked with a radiation warning sign. The number of welding electrodes held outside the store is to be kept to a minimum and is not to exceed one month's supply where practicable.
Contingency Plans Fire/Loss/Incident	In the event of fire in a welding shop, it is extremely unlikely that any release of radioactive material will occur from the welding electrodes. Loss of a small number of these consumable electrodes need not be reported. However, if more than 10 electrodes are involved, reporting procedures described in Leaflet 14 are to be followed.
Transport	Items and bulk quantities can be transported within an excepted package provided the dose rate on the external surface of the package does not exceed 5 $\mu Sv\ h^{-1}$.
Disposal	Arisings from grinding operations are to be placed in a plastic bag or container displaying no radiation markings and disposed of with normal refuse.