## WASTE STREAM 5B27 Thorium Nitrate

| | |
|---|---|
| **SITE** | Dounreay |
| **SITE OWNER** | Nuclear Decommissioning Authority |
| **WASTE CUSTODIAN** | Dounreay Site Restoration Limited |
| **WASTE TYPE** | ILW |
| Is the waste subject to Scottish Policy: | Yes |

**WASTE VOLUMES**

| | | Reported |
|---|---|---|
| Stocks: | At 1.4.2022..... | 25.5 $m^3$ |
| Total future arisings: | | 0 $m^3$ |
| Total waste volume: | | 25.5 $m^3$ |

Comment on volumes: The number of tanks, contents including Raschig rings as well as drums are fixed. They will be packaged “as is”.

Uncertainty factors on volumes:

| | | | |
|---|---|---|---|
| Stock (upper): | x 1.02 | Arisings (upper) | x |
| Stock (lower): | x 0.98 | Arisings (lower) | x |

**WASTE SOURCE** Recovery of thorium from THTR spheres by crushing and rolling the spheres, followed by density based air-separation of graphite from fuel, which could then be disposed of separately. Fuel particles were dissolved in HNO3/NH4F solution, then separated by solvent extraction in mixer-settler boxes. The thorium nitrate was evaporated to concentration of around 400 g/l, then allowed to cool and settle.

### PHYSICAL CHARACTERISTICS

General description: Thorium nitrate was formed by the dissolution of the fuel oxide in nitric acid (with the aid of aqueous fluoride ions), forming the hydrated compound, Th(NO3)4.12H2O. Thorium nitrate is very soluble in water to the extent of 65.6 g Th(NO3)4 (the commercially available nitrate) in 100 g of solution at 20 deg C and can be readily crystallised from solution.

Physical components (%vol): The waste consists of thorium nitrate solution (47.5%) and glass Rashig rings (48.2%) plus the stainless steel tank(4.3%)

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/$m^3$): ~1.85

Comment on density: The density is an estimate.

### CHEMICAL COMPOSITION

General description and components (%wt): Glass (59.75%), Other Liquid (23.56%), Stainless steel (16.69%),

Chemical state: Acid

Chemical form of radionuclides: Ra: Present as nitrate.
Th: Present as nitrate.
U: Present as nitrate.

Metals and alloys (%wt): -

| | (%wt) | Type(s) / Grade(s) with proportions | % of total C14 activity |
|---|---|---|---|
| Stainless steel..... | 16.7 | | |
| Other ferrous metals..... | 0 | | |
| Iron..... | | | |
| Aluminium..... | | | |
| Beryllium..... | | | |
| Cobalt..... | 0 | | |
| Copper..... | | | |
| Lead..... | 0 | | |

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| | |
|---|---|
| Magnox/Magnesium | 0 |
| Nickel | |
| Titanium | |
| Uranium | |
| Zinc | 0 |
| Zircaloy/Zirconium | 0 |
| Other metals | 0 |

Organics (%wt): -

| | (%wt) | Type(s) and comment | % of total C14 activity |
|---|---|---|---|
| Total cellulosics | 0 | | |
| Paper, cotton | 0 | | |
| Wood | 0 | | |
| Halogenated plastics | 0 | | |
| Total non-halogenated plastics | 0 | | |
| Condensation polymers | 0 | | |
| Others | 0 | | |
| Organic ion exchange materials | 0 | | |
| Total rubber | 0 | | |
| Halogenated rubber | 0 | | |
| Non-halogenated rubber | 0 | | |
| Hydrocarbons | | | |
| Oil or grease | | | |
| Fuel | | | |
| Asphalt/Tarmac (cont.coal tar) | | | |
| Asphalt/Tarmac (no coal tar) | | | |
| Bitumen | | | |
| Others | | | |
| Other organics | 0 | | |

Other materials (%wt): Raschig rings of standard borosilicate glass composition, originally occupying 59.75% of the available tank volume.

| | (%wt) | Type(s) and comment | % of total C14 activity |
|---|---|---|---|
| Inorganic ion exchange materials | 0 | | |
| Inorganic sludges and flocs | 0 | | |
| Soil | 0 | | |
| Brick/Stone/Rubble | 0 | | |
| Cementitious material | 0 | | |
| Sand | 0 | | |
| Glass/Ceramics | 59.8 | | |
| Graphite | 0 | | |
| Desiccants/Catalysts | | | |
| Asbestos | 0 | | |
| Non/low friable | | | |

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| | | |
|---|---|---|
| Moderately friable..... | | |
| Highly friable..... | | |
| Free aqueous liquids..... | 23.6 | |
| Free non-aqueous liquids..... | 0 | |
| Powder/Ash..... | 0 | |

Inorganic anions (%wt): -

| | (%wt) | Type(s) and comment |
|---|---|---|
| Fluoride..... | P | |
| Chloride..... | 0 | |
| Iodide..... | 0 | |
| Cyanide..... | 0 | |
| Carbonate..... | 0 | |
| Nitrate..... | 23.6 | |
| Nitrite..... | 0 | |
| Phosphate..... | 0 | |
| Sulphate..... | 0 | |
| Sulphide..... | 0 | |

Materials of interest for waste acceptance criteria: -

| | (%wt) | Type(s) and comment |
|---|---|---|
| Combustible metals..... | 0 | |
| Low flash point liquids..... | 0 | |
| Explosive materials..... | 0 | |
| Phosphorus..... | 0 | |
| Hydrides..... | 0 | |
| Biological etc. materials..... | 0 | |
| Biodegradable materials..... | 0 | |
| Putrescible wastes..... | 0 | |
| Non-putrescible wastes..... | 0 | |
| Corrosive materials..... | P | 23.56 |
| Pyrophoric materials..... | 0 | |
| Generating toxic gases..... | P | 23.56 |
| Reacting with water..... | 0 | |
| Higher activity particles..... | NE | |
| Soluble solids as bulk chemical compounds..... | 0 | |

Hazardous substances / non hazardous pollutants: -

| | (%wt) | Type(s) and comment |
|---|---|---|
| Acrylamide..... | | |
| Benzene..... | NE | |
| Chlorinated solvents..... | | |

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|---|---|
| Formaldehyde..... | |
| Organometallics..... | |
| Phenol..... | NE |
| Styrene..... | |
| Tri-butyl phosphate..... | NE |
| Other organophosphates..... | |
| Vinyl chloride..... | NE |
| Arsenic..... | NE |
| Barium..... | |
| Boron..... | NE |
| Boron (in Boral)..... | |
| Boron (non-Boral)..... | |
| Cadmium..... | NE |
| Caesium..... | |
| Selenium..... | NE |
| Chromium..... | NE |
| Molybdenum..... | NE |
| Thallium..... | |
| Tin..... | NE |
| Vanadium..... | NE |
| Mercury compounds..... | |
| Others..... | NE |
| Electronic Electrical Equipment (EEE) | |
| EEE Type 1..... | |
| EEE Type 2..... | |
| EEE Type 3..... | |
| EEE Type 4..... | |
| EEE Type 5..... | |

Complexing agents (%wt): No

| | (%wt) | Type(s) and comment |
|---|---|---|
| EDTA..... | | |
| DPTA..... | | |
| NTA..... | | |
| Polycarboxylic acids……. | | |
| Other organic complexants..... | | |
| Total complexing agents..... | 0 | |

Potential for the waste to contain discrete items: No.

### PACKAGING AND CONDITIONING

Conditioning method: Thorium nitrate in tanks will be dried and packaged into in 6m3 concrete boxes along with the tanks and the Raschig rings. This will be filled and grouted at source at the time required by mobile grouting plant. Drummed Thorium Nitrate will be dried and packaged into 500 L steel drums.

Plant Name: Temporary conditioning plant

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|---|---|
| Location: | Dounreay |
| Plant startup date: | TBC |
| Total capacity ($m^3$/y incoming waste): | 6.0 |
| Target start date for packaging this stream: | - |
| Throughput for this stream ($m^3$/y incoming waste): | 6.0 |
| Other information: | Drums and tanks may be packaged at differenttimes |

Likely container type:

| Container | Waste packaged (%vol) | Waste loading ($m^3$) | Payload ($m^3$) | Number of packages |
|---|---|---|---|---|
| 500 l drum | 26.9 | 0.2 | 0.47 | 35 |
| 6$m^3$ concrete box (SD) | 73.1 | 4.74 | 5.76 | 4 |

| | |
|---|---|
| Likely container type comment: | Drum will be a solid 500 l drum |
| Range in container waste volume: | One tank will be packaged in one 6m3 concrete box; one drum per 500 l drum. |
| Other information on containers: | - |
| Likely conditioning matrix: | PFA/OPC |
| Other information: | - |
| Conditioned density (t/$m^3$): | ~2.0 |
| Conditioned density comment: | It is expected that the density of the conditioned waste will be about 2 te/$m^3$. |
| Other information on conditioning: | |
| Opportunities for alternative disposal routing: | No |

| Baseline Management Route | Opportunity Management Route | Stream volume (%) | Estimated Date that Opportunity will be realised | Opportunity Confidence | Comment |
|---|---|---|---|---|---|
| - | - | - | - | - | - |

### RADIOACTIVITY

| | |
|---|---|
| Source: | Between July 1992 and Dec 1994, UKAEA processed 363,000 unirradiated THTR fuel spheres under a contract between UKAEA and NUKEM GmbH. |
| Uncertainty: | - |
| Definition of total alpha and total beta/gamma: | Where totals are shown on the table of radionuclide activities they are the sums of the listed alpha or beta/gamma emitting radionuclides plus 'other alpha' or 'other beta/gamma'. |
| Measurement of radioactivities: | The principal species contributing to activity will be Th-232, with contributions from daughter radionuclides in equilibrium, such as Th228, Ra228, Ac228, Bi212, Pb212, Po212, Ra224, Rn220 and Tl208. A small amount of enriched uranium is also present. |
| Other information: | There are no unlisted radionuclides present at significant concentrations.Due to high thorium content, no waste route is available that allows us to sentence this as LLW, therefore sentence as ILW.Specific Activity uses UKRWI 2019 data decayed to 2022. |

## WASTE STREAM 5B27 Thorium Nitrate

| Nuclide | Mean radioactivity, TBq/m³ Waste at 1.4.2022 | Bands and Code | Future arisings | Bands and Code | Nuclide | Mean radioactivity, TBq/m³ Waste at 1.4.2022 | Bands and Code | Future arisings | Bands and Code |
|---|---|---|---|---|---|---|---|---|---|
| H 3 | | | | | Gd 153 | | | | |
| Be 10 | | | | | Ho 163 | | | | |
| C 14 | | | | | Ho 166m | | | | |
| Na 22 | | | | | Tm 170 | | | | |
| Al 26 | | | | | Tm 171 | | | | |
| Cl 36 | | | | | Lu 174 | | | | |
| Ar 39 | | | | | Lu 176 | | | | |
| Ar 42 | | | | | Hf 178n | | | | |
| K 40 | | | | | Hf 182 | | | | |
| Ca 41 | | | | | Pt 193 | | | | |
| Mn 53 | | | | | Tl 204 | | | | |
| Mn 54 | | | | | Pb 205 | | | | |
| Fe 55 | | | | | Pb 210 | 9.98E-12 | B B 2 | | |
| Co 60 | | | | | Bi 208 | | | | |
| Ni 59 | | | | | Bi 210m | | | | |
| Ni 63 | | | | | Po 210 | 9.78E-12 | B B 2 | | |
| Zn 65 | | | | | Ra 223 | 6.32E-09 | B B 2 | | |
| Se 79 | | | | | Ra 225 | | | | |
| Kr 81 | | | | | Ra 226 | 2.22E-11 | B B 2 | | |
| Kr 85 | | | | | Ra 228 | 6.02E-04 | B B 2 | | |
| Rb 87 | | | | | Ac 227 | 6.32E-09 | B B 2 | | |
| Sr 90 | | | | | Th 227 | 6.23E-09 | B B 2 | | |
| Zr 93 | | | | | Th 228 | 6.02E-04 | B B 2 | | |
| Nb 91 | | | | | Th 229 | | | | |
| Nb 92 | | | | | Th 230 | 1.54E-09 | B B 2 | | |
| Nb 93m | | | | | Th 232 | 6.02E-04 | B B 1 | | |
| Nb 94 | | | | | Th 234 | 2.04E-08 | B B 2 | | |
| Mo 93 | | | | | Pa 231 | 7.49E-09 | B B 2 | | |
| Tc 97 | | | | | Pa 233 | | | | |
| Tc 99 | | | | | U 232 | | | | |
| Ru 106 | | | | | U 233 | | | | |
| Pd 107 | | | | | U 234 | 2.61E-06 | B B 2 | | |
| Ag 108m | | | | | U 235 | 1.77E-06 | B B 2 | | |
| Ag 110m | | | | | U 236 | 1.16E-08 | B B 1 | | |
| Cd 109 | | | | | U 238 | 2.04E-08 | B B 2 | | |
| Cd 113m | | | | | Np 237 | | | | |
| Sn 119m | | | | | Pu 236 | | | | |
| Sn 121m | | | | | Pu 238 | | | | |
| Sn 123 | | | | | Pu 239 | | | | |
| Sn 126 | | | | | Pu 240 | | | | |
| Sb 125 | | | | | Pu 241 | | | | |
| Sb 126 | | | | | Pu 242 | | | | |
| Te 125m | | | | | Am 241 | | | | |
| Te 127m | | | | | Am 242m | | | | |
| I 129 | | | | | Am 243 | | | | |
| Cs 134 | | | | | Cm 242 | | | | |
| Cs 135 | | | | | Cm 243 | | | | |
| Cs 137 | | | | | Cm 244 | | | | |
| Ba 133 | | | | | Cm 245 | | | | |
| La 137 | | | | | Cm 246 | | | | |
| La 138 | | | | | Cm 248 | | | | |
| Ce 144 | | | | | Cf 249 | | | | |
| Pm 145 | | | | | Cf 250 | | | | |
| Pm 147 | | | | | Cf 251 | | | | |
| Sm 147 | | | | | Cf 252 | | | | |
| Sm 151 | | | | | Other a | | | | |
| Eu 152 | | | | | Other b/g | | | | |
| Eu 154 | | | | | **Total a** | **1.21E-03** | **B B 2** | **0** | |
| Eu 155 | | | | | **Total b/g** | **6.02E-04** | **B B 2** | **0** | |

**Bands (Upper and Lower)**

A a factor of 1.5
B a factor of 3
C a factor of 10
D a factor of 100
E a factor of 1000

Note: Bands quantify uncertainty in mean radioactivity.

**Code**

1 Measured activity
2 Derived activity (best estimate)
3 Derived activity (upper limit)
4 Not present
5 Present but not significant
6 Likely to be present but not assessed
7 Present in significant quantities but not determined
8 Not expected to be present in significant quantity