

WASTE STREAM	5B32	Irradiated Thorium Fuel Pin Pieces
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SITE Dounreay

SITE OWNER Nuclear Decommissioning Authority

WASTE CUSTODIAN Dounreay Site Restoration Limited

WASTE TYPE ILW

WASTE VOLUMES

		Reported
Stocks:	At 1.4.2019.....	< 0.1 m ³
Total future arisings:		0 m ³
Total waste volume:		< 0.1 m ³

Comment on volumes: There will be no further arisings.

Uncertainty factors on volumes:

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

WASTE SOURCE The pins were irradiated in research reactors in Germany and were later shipped to Dounreay and have subsequently become an NDA liability.

PHYSICAL CHARACTERISTICS

General description: Clad fuel pins stored in cans with dimensions of 1m long x 0.25m diameter.

Physical components (%wt): Irradiated thorium fuel pin pieces consisting of aluminium clad thorium metal pins (62%) and zirconium clad thorium oxide pins (38%).

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m³): 3.23

Comment on density: -

CHEMICAL COMPOSITION

General description and components (%wt): Thorium metal and oxide (97.22%), uranium (0.76%), plutonium (0.44%), aluminium (0.86%), zirconium (0.73%).

Chemical state: Neutral

Chemical form of radionuclides: Cl-36: Not likely to be present.
I-129: Present at low levels.
Th: Thorium is present as both metal and oxide.
U: Uranium is present as oxide.

Metals and alloys (%wt): The metal is in the form of pin cladding approximately 1mm thick.

Stainless steel.....	0
Other ferrous metals.....	0
Iron.....	
Aluminium.....	0.85
Beryllium.....	0
Cobalt.....	0
Copper.....	
Lead.....	0
Magnox/Magnesium.....	0
Nickel.....	
Titanium.....	
Uranium.....	0.76
Zinc.....	0
Zircaloy/Zirconium.....	0.73
Other metals.....	97.7

Thorium (97.22%) and plutonium (0.44%).

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Organics (%wt):

-	
Total cellulose	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):

-	
Inorganic ion exchange materials	0
Inorganic sludges and flocs	0
Soil	0
Brick/Stone/Rubble	0
Cementitious material	0
Sand	0
Glass/Ceramics	
Graphite	0
Desiccants/Catalysts	
Asbestos	0
Non/low friable	
Moderately friable	
Highly friable	
Free aqueous liquids	0
Free non-aqueous liquids	0
Powder/Ash	0

Inorganic anions (%wt):

-

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Fluoride.....	0
Chloride.....	0
Iodide.....	0
Cyanide.....	0
Carbonate.....	0
Nitrate.....	0
Nitrite.....	0
Phosphate.....	0
Sulphate.....	0
Sulphide.....	0

Materials of interest for waste acceptance criteria:

-	
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.....	0
Pyrophoric materials.....	0
Generating toxic gases.....	0
Reacting with water.....	0
Active particles.....	NE
Soluble solids as bulk chemical compounds.....	0

Hazardous substances / non hazardous pollutants:

-	
Acrylamide.....	
Benzene.....	NE
Chlorinated solvents.....	
Formaldehyde.....	
Organometallics.....	
Phenol.....	NE
Styrene.....	
Tri-butyl phosphate.....	NE
Other organophosphates.....	
Vinyl chloride.....	NE
Arsenic.....	NE
Barium.....	
Boron.....	NE

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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):

EDTA.....
 DPTA.....
 NTA.....
 Polycarboxylic acids.....
 Other organic complexants.....
 Total complexing agents.....

PACKAGING AND CONDITIONING

Conditioning method: It is likely that the waste will be encapsulated and packaged into 500 litre drums. Prior to encapsulation the pins will be cut into suitable lengths.

Plant Name: Not yet known

Location: Dounreay

Plant startup date: Not yet known

Total capacity (m³/y incoming waste): -

Target start date for packaging this stream: -

Throughput for this stream (m³/y incoming waste): ~

Other information: The waste processing timetable is yet to be established. The waste may be packaged into dedicated drums or it may be co-packaged with other RHILW (5B03).

Likely container type:

Container	Waste packaged (%vol)	Waste loading (m ³)	Payload (m ³)	Number of packages
500 l drum	100.0	0.007	0.5	6

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Likely container type comment: -

Range in container waste volume: The container loading is not yet finalised and there may be considerable variability.

Other information on containers: -

Likely conditioning matrix: Cement;PFA/OPC
Other information: A typical PFA/OPC grout, comprised of a nominal powder ratio of 3:1 by weight, with a nominal waste to solids ratio by weight of 0.42 is considered to be suitable.

Conditioned density (t/m³): 2.12
Conditioned density comment: -

Other information on conditioning: -

Opportunities for alternative disposal routing: No

Treatment	Stream volume (%)	Comment
-	-	-

RADIOACTIVITY

Source: The material consists of several pieces of cut pins of aluminium clad thorium metal and zirconium clad thorium/plutonium oxide pellets. The pins were irradiated in German research reactors in the 1960s/70s and transported to Dounreay under a commercial contract, NDA has taken over the liability.

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 original consignment data comprised burnup data and masses for Th232, U233 and Pu content. Subsequently FISPIN calculations have been performed to give more indicative radionuclide inventories. Approximate FISPACT calculations have been performed for the cladding materials.

Other information: No other radionuclides are expected to be present at significant concentrations.

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Nuclide	Mean radioactivity, TBq/m ³				Nuclide	Mean radioactivity, TBq/m ³			
	Waste at 1.4.2019	Bands and Code	Future arisings	Bands and Code		Waste at 1.4.2019	Bands and Code	Future arisings	Bands and Code
H 3	9.95E-01	BB 2			Gd 153				
Be 10	5.6E-06	BB 2			Ho 163				
C 14	2.75E-04	BB 2			Ho 166m	7.22E-05	BB 2		
Na 22					Tm 170				
Al 26					Tm 171	1.12E-08	BB 2		
Cl 36					Lu 174	4.54E-14	BB 2		
Ar 39					Lu 176	1.85E-19	BB 2		
Ar 42					Hf 178n				
K 40					Hf 182	1.25E-13	BB 2		
Ca 41					Pt 193				
Mn 53					Tl 204				
Mn 54					Pb 205	2.22E-21	BB 2		
Fe 55					Pb 210	1.05E-06	BB 2		
Co 60	1.36E-12	BB 2			Bi 208				
Ni 59					Bi 210m	5.54E-15	BB 2		
Ni 63	1.94E-06	BB 2			Po 210	1.01E-06	BB 2		
Zn 65					Ra 223	9.76E-02	BB 2		
Se 79	2.16E-04	BB 2			Ra 225	7.05E-02	BB 2		
Kr 81					Ra 226	3.13E-06	BB 2		
Kr 85					Ra 228	9.49E-03	BB 2		
Rb 87	4.66E-07	BB 2			Ac 227	9.77E-02	BB 2		
Sr 90	4.92E+02	BB 2			Th 227	9.63E-02	BB 2		
Zr 93	3.42E-02	BB 2			Th 228	8.56E+00	BB 2		
Nb 91					Th 229	7.06E-02	BB 2		
Nb 92					Th 230	3.03E-04	BB 2		
Nb 93m	2.85E-02	BB 2			Th 232	9.52E-03	BB 2		
Nb 94	8.05E-06	BB 2			Th 234	1.20E-09	BB 2		
Mo 93	5.07E-15	BB 2			Pa 231	1.28E-01	BB 2		
Tc 97	2.64E-11	BB 2			Pa 233	3.58E-03	BB 2		
Tc 99	2.78E-01	BB 2			U 232	8.31E+00	BB 2		
Ru 106					U 233	1.58E+01	BB 2		
Pd 107	3.86E-03	BB 2			U 234	6.83E-01	BB 2		
Ag 108m	5.04E-07	BB 2			U 235	1.75E-05	BB 2		
Ag 110m					U 236	5.77E-05	BB 2		
Cd 109	1.83E-15	BB 2			U 238	1.21E-09	BB 2		
Cd 113m	1.20E-01	BB 2			Np 237	3.59E-03	BB 2		
Sn 119m					Pu 236	1.41E-09	BB 2		
Sn 121m	5.05E-01	BB 2			Pu 238	1.1E+02	BB 2		
Sn 123					Pu 239	1.14E+01	BB 2		
Sn 126	6.70E-03	BB 2			Pu 240	2.65E+01	BB 2		
Sb 125	1.40E-02	BB 2			Pu 241	1.67E+03	BB 2		
Sb 126	9.37E-04	BB 2			Pu 242	1.62E-01	BB 2		
Te 125m	3.52E-03	BB 2			Am 241	3.76E+02	BB 2		
Te 127m					Am 242m	1.40E+00	BB 2		
I 129	1.05E-03	BB 2			Am 243	1.37E+00	BB 2		
Cs 134	1.27E-03	BB 2			Cm 242	1.15E+00	BB 2		
Cs 135	1.63E-02	BB 2			Cm 243	4.81E-01	BB 2		
Cs 137	8.61E+02	BB 2			Cm 244	4.19E+01	BB 2		
Ba 133	3.39E-07	BB 2			Cm 245	1.72E-02	BB 2		
La 137	6.34E-07	BB 2			Cm 246	1.37E-03	BB 2		
La 138	6.58E-12	BB 2			Cm 248	3.19E-09	BB 2		
Ce 144					Cf 249	2.39E-08	BB 2		
Pm 145	5.94E-08	BB 2			Cf 250	1.16E-08	BB 2		
Pm 147	7.31E-02	BB 2			Cf 251	4.36E-10	BB 2		
Sm 147	1.64E-07	BB 2			Cf 252	6.58E-13	BB 2		
Sm 151	9.51E+00	BB 2			Other a				
Eu 152	1.14E-02	BB 2			Other b/g				
Eu 154	4.23E+00	BB 2			Total a	6.03E+02	BB 2	0	
Eu 155	2.35E-01	BB 2			Total b/g	3.04E+03	BB 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