

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

Is the waste subject to Scottish Policy: Yes

WASTE VOLUMES

		Reported
Stocks:	At 1.4.2022.....	< 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 (%vol): Aluminium (0.20%), Plutonium (1.84%), Thorium (97.96%),

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): Aluminium (0.04%), Plutonium (3.08%), Thorium (96.87%),

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: Present at low levels.
 Pu: Plutonium present as oxides

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

	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....	0		
Other ferrous metals.....	0		
Iron.....			
Aluminium.....	0.05	+0.01 to correct to 100%	
Beryllium.....	0		
Cobalt.....	0		
Copper.....			
Lead.....	0		
Magnox/Magnesium.....	0		
Nickel.....			
Titanium.....			
Uranium.....	TR	U233 from irradiation of thorium	

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Zinc.....	0		
Zircaloy/Zirconium.....	P	Cladding is known to be zirconium - unspecified quantity	
Other metals.....	100.0	Thorium (96.87%) and plutonium (3.08%).	
Organics (%wt):	-		
	(%wt)	Type(s) and comment	% of total C14 activity
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):	-		
	(%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.....			
Graphite.....	0		
Desiccants/Catalysts.....			
Asbestos.....	0		
Non/low friable.....			
Moderately friable.....			
Highly friable.....			
Free aqueous liquids.....	0		

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Free non-aqueous liquids..... 0

Powder/Ash..... 0

Inorganic anions (%wt): -

(%wt) Type(s) and comment

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: -

(%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..... 0

Pyrophoric materials..... 0

Generating toxic gases..... 0

Reacting with water..... 0

Higher activity particles..... NE

Soluble solids as bulk chemical
compounds..... 0Hazardous substances /
non hazardous pollutants: -

(%wt) Type(s) and comment

Acrylamide.....

Benzene..... NE

Chlorinated solvents.....

Formaldehyde.....

Organometallics.....

Phenol..... NE

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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):

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

Potential for the waste to contain discrete items: Not yet determined.

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: RHILW Repackaging Plant

Location: Dounreay

Plant startup date: 2028

Total capacity (m³/y incoming waste): NE

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Target start date for packaging this stream: 2027

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

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

Baseline Management Route	Opportunity Management Route	Stream volume (%)	Estimated Date that Opportunity will be realised	Opportunity Confidence	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: Re-assessment of Specific Activity using Letter of Compliance radionuclide data from August 2004 which has been decayed to 2022.

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Nuclide	Mean radioactivity, TBq/m ³				Nuclide	Mean radioactivity, TBq/m ³			
	Waste at 1.4.2022	Bands and Code	Future arisings	Bands and Code		Waste at 1.4.2022	Bands and Code	Future arisings	Bands and Code
H 3	1.59E-01	BB 2			Gd 153				
Be 10	2.10E-06	BB 2			Ho 163				
C 14	6.77E-05	BB 2			Ho 166m	1.95E-04	BB 2		
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	1.66E-06	BB 2		
Co 60					Bi 208				
Ni 59					Bi 210m				
Ni 63	4.80E-06	BB 2			Po 210	1.63E-06	BB 2		
Zn 65					Ra 223	6.19E-02	BB 2		
Se 79	1.01E-03	BB 2			Ra 225	8.34E-02	BB 2		
Kr 81					Ra 226	3.18E-06	BB 2		
Kr 85	1.23E+00	BB 2			Ra 228	1.54E-02	BB 2		
Rb 87	7.33E-08	BB 2			Ac 227	6.22E-02	BB 2		
Sr 90	1.66E+02	BB 2			Th 227	6.12E-02	BB 2		
Zr 93	3.16E-02	BB 2			Th 228	4.01E+00	BB 2		
Nb 91					Th 229	8.35E-02	BB 2		
Nb 92					Th 230	2.86E-04	BB 2		
Nb 93m	2.68E-02	BB 2			Th 232	1.54E-02	BB 2		
Nb 94	4.20E-06				Th 234	5.54E-09	BB 2		
Mo 93					Pa 231	1.45E-01	BB 2		
Tc 97					Pa 233	3.51E-02	BB 2		
Tc 99	3.43E-01	BB 2			U 232	3.89E+00	BB 2		
Ru 106					U 233	1.84E+01	BB 2		
Pd 107	7.98E-03	BB 2			U 234	6.15E-01	BB 2		
Ag 108m	2.06E-08	BB 2			U 235	1.33E-05	BB 2		
Ag 110m					U 236	2.84E-05	BB 2		
Cd 109					U 238	5.55E-09	BB 2		
Cd 113m	4.00E-02	BB 2			Np 237	3.52E-02	BB 2		
Sn 119m					Pu 236				
Sn 121m	3.77E-01	BB 2			Pu 238	2.32E+02	BB 2		
Sn 123					Pu 239	9.44E+00	BB 2		
Sn 126	2.19E-02	BB 2			Pu 240	7.84E+00	BB 2		
Sb 125	2.25E-06	BB 2			Pu 241	2.40E+03	BB 2		
Sb 126	2.19E-02	BB 2			Pu 242	7.99E-01	BB 2		
Te 125m	5.33E-07	BB 2			Am 241	3.48E+03	BB 2		
Te 127m					Am 242m	1.13E+01	BB 2		
I 129	1.20E-03	BB 2			Am 243	2.64E+00	BB 2		
Cs 134	2.62E-09	BB 2			Cm 242	9.42E+00	BB 2		
Cs 135	2.43E-02	BB 2			Cm 243	7.33E-01	BB 2		
Cs 137	4.28E+02	BB 2			Cm 244	8.26E+00	BB 2		
Ba 133					Cm 245	5.69E-03	BB 2		
La 137					Cm 246	1.55E-04	BB 2		
La 138					Cm 248				
Ce 144					Cf 249				
Pm 145					Cf 250				
Pm 147	6.69E-06	BB 2			Cf 251				
Sm 147	1.74E-14	BB 2			Cf 252				
Sm 151	2.04E+01	BB 2			Other a	1.51E+01	BB 2		
Eu 152	4.79E-03	BB 2			Other b/g	5.94E+02	BB 2		
Eu 154	1.40E-01	BB 2			Total a	3.79E+03	BB 2		0
Eu 155	3.97E-03	BB 2			Total b/g	3.63E+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