WASTE STREAM	5B32	Irradiated Thorium Fuel Pin Pieces

SITE Dounreay

SITE OWNER Nuclear Decommissioning Authority

WASTE CUSTODIAN Nuclear Restoration Services Ltd (NRS)

WASTE TYPE ILW

WASTE VOLUMES

	Reported (m^3)
Stocks: At 1.4.2025	< 0.1
Future arisings:	
Total future arisings:	**0.0**
Total waste volume:	**< 0.1**

OR

Conditioned (m^3)	Packaged (m^3)

Number of waste packages in stock: At 1.4.2025…… - packages

Comment on arising rates: There will be no further arisings.

Additional information on quantities: -

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.

Changes since waste generated: -

Bulk density (t/m^3): = 3.2

Comment on density: 124.72kg/0.0386m^3

CHEMICAL COMPOSITION

General description and components (%wt): Aluminium (0.04%), Plutonium (3.08%), Thorium (96.87%),

Chemical state: Neutral

Sheet metal proportion / thickness: The metal is in the form of pin cladding approximately 1mm thick.

Metals and alloys (%wt):

	(%wt)	Type(s) / Grades(s) with proportions	% of total C14 activity
Stainless steel……	= 0	-	
Other ferrous metals……	= 0	-	
Iron……	= 0	-	
Aluminium……	= 0.05	+0.01 to correct to 100%	
Beryllium……	= 0	-	
Cobalt……	= 0	-	
Copper……		-	
Lead……	= 0	-	
Magnox/Magnesium……	= 0	-	
Nickel……		-	
Titanium……	= 0	-	
Uranium……	TR	U233 from irradiation of thorium	
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 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	= 0	-	
Oil or grease	= 0	-	
Fuel	= 0	-	
Asphalt/Tarmac (cont.coal tar)	= 0	-	
Asphalt/Tarmac (no coal tar)	= 0	-	
Bitumen	= 0	-	
Others	= 0	-	
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	= 0	-	
Graphite	= 0	-	
Desiccants/Catalysts	= 0	-	
Asbestos	= 0	-	
Non/low friable	= 0	-	
Moderately friable	= 0	-	
Highly friable	= 0	-	
Free aqueous liquids	= 0	-	
Free non-aqueous liquids	= 0	-	
Powder/Ash	= 0	-	

COMPONENTS OF MATERIALS, WASTE PROPERTIES, MATERIALS NOT CONTRIBUTING TO MASS

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	= 0	-

Hazardous substances / non hazardous pollutants: -

	(%wt)	Type(s) and comment
Acrylamide	= 0	-
Benzene	NE	-
Chlorinated solvents	= 0	-
Formaldehyde	= 0	-
Organometallics	= 0	-
Phenol	NE	-
Styrene	= 0	-
Tri-butyl phosphate	NE	-
Other organophosphates	= 0	-
Vinyl chloride	NE	-
Arsenic	NE	-
Barium	= 0	-
Boron	NE	-
Boron (in Boral)	NE	-
Boron (non-Boral)	NE	-
Cadmium	NE	-
Caesium	= 0	-
Selenium	NE	-
Chromium	NE	-
Molybdenum	NE	-
Thallium	= 0	-
Tin	NE	-
Vanadium	NE	-
Mercury compounds	= 0	-
Others	NE	-

Complexing agents (%wt): No

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

Physical components:

	Number	Type(s) and comment
Sources	0	-
Electronic & Electrical Equipment (EEE)		-
EEE Type 1		-
EEE Type 2		-
EEE Type 3		-
EEE Type 4		-
EEE Type 5		-

TREATMENT, PACKAGING AND DISPOSAL

Planned on-site / off-site treatment(s):

Treatment	On-site / Off-site	Stream volume %
Size reduction	On-site	= 100.0
Decay storage		
Low force compaction		
Supercompaction (HFC)		
Incineration		
Drying/dewatering/liquid separation		
Tie down/fixatives/strippable coating/painting application		
Decontamination		
Metal treatment		
Recycling / reuse		
Thermal treatment, including vitrification		
Encapsulation	On-site	= 100.0
Polymer encapsulation		
Other physical treatment		
Other chemical treatment		
Containerisation		
Treatment not yet determined		
None		

Comments on planned treatments: It is likely that the waste will be encapsulated and packaged into 500 L drums. Prior to encapsulation, the pins will be cut into suitable lengths.

Conditioning method: Waste will be conditioned using a grout matrix into 500L drums. This will be done through a dedicated ILW repackaging facility which will handle RHILW and CHILW 200L drums. This facility will produce conditioned 500L drums.

Conditioning plants:

Plant Name	Location
Combined ILW Repackaging Facility	Dounreay

Likely conditioning matrix: Non-standard

Further information on the conditioning matrix: A typical PFA/OPC grout, comprised of a nominal powder ratio of 3:1 by weight with 42% water is considered to be suitable.

Waste Packaging:

Likely container type:

Container	Waste packaged (vol%)	Waste loading (m^3)	Payload (m^3)	Number of packages	Estimated start date for packaging
500 l drum (basket for waste)	100.0	0.01	0.50	6	-

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

Other information on packaging and conditioning: -

Conditioned density (t/m^3): = 2.1
Conditioned density comment: -

Management Routes:

Disposal Route	Stream volume %	Raw density t/m^3	Start date
Expected to be consigned to a Near Site, Near Surface Disposal Facility (Scotland)			
Expected to be Non-NSD HAW managed under Scottish Government's policy	= 100.0		
Expected to be disposed to LLW Vaults NRS Dounreay			
Expected to be consigned to the Geological Disposal Facility			
Expected to be consigned to a Near Surface Disposal Facility			
Expected to be consigned to the LLW Repository			
Expected to be consigned to a Landfill Facility			
Expected to be disposed On-Site			
Expected to be managed by In-Situ Disposal			
Expected to be consigned to an Incineration Facility			
Expected to be consigned to a Metal Treatment Facility			
Expected to be Out of Scope			
Expected to be recycled / reused			
Disposal route not known			

Classification codes for waste expected to be consigned to a landfill facility:

Opportunities for alternative disposal routing: No

Baseline Management Route	Opportunity Management Route	Stream volume (%)	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: -

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 indicitive radionuclide inventories. Approximate FISPAC calculations have been performed for the cladding materials.

Chemical form of radionuclides:

H-3: -
C-14: -
Cl-36: Not likely to be present.
Se-79: -
Tc-99: -
I-129: Present at low levels.
Ra: -
Th: Thorium is present as both metal and oxide.
U: Present at low levels.
Np: -
Pu: Plutonium present as oxides.

WASTE STREAM **5B32** **Irradiated Thorium Fuel Pin Pieces**

Nuclide	Mean radioactivity, TBq/m³ Waste at 1.4.2025	Bands and Code	Future Arisings	Bands and Code	Nuclide	Mean radioactivity, TBq/m³ Waste at 1.4.2025	Bands and Code	Future Arisings	Bands and Code
H 3	= 2.95E-02	B B 2			Gd 153				
Be 10	= 2.02E-07	B B 2			Ho 163				
C 14	= 6.54E-06	B B 2			Ho 166m	= 1.89E-05	B B 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	= 1.22E-07	B B 2		
Co 60					Bi 208				
Ni 59					Bi 210m				
Ni 63	= 5.02E-07	B B 2			Po 210	= 1.21E-07	B B 2		
Zn 65					Ra 223	= 2.38E-03	B B 2		
Se 79	= 9.78E-05	B B 2			Ra 225	= 6.10E-03	B B 2		
Kr 81					Ra 226	= 1.84E-07	B B 2		
Kr 85	= 2.51E-01	B B 2			Ra 228	= 1.49E-03	B B 2		
Rb 87	= 7.07E-09	B B 2			Ac 227	= 2.43E-03	B B 2		
Sr 90	= 2.13E+01	B B 2			Th 227	= 2.37E-03	B B 2		
Zr 93	= 3.05E-03	B B 2			Th 228	= 4.30E-01	B B 2		
Nb 91					Th 229	= 6.11E-03	B B 2		
Nb 92					Th 230	= 2.13E-05	B B 2		
Nb 93m	= 2.33E-03	B B 2			Th 232	= 1.49E-03	B B 2		
Nb 94	= 4.05E-07	B B 2			Th 234	= 3.95E-10	B B 2		
Mo 93					Pa 231	= 1.40E-02	B B 2		
Tc 97					Pa 233	= 2.12E-03	B B 2		
Tc 99	= 3.31E-02	B B 2			U 232	= 4.22E-01	B B 2		
Ru 106					U 233	= 1.77E+00	B B 2		
Pd 107	= 7.70E-04	B B 2			U 234	= 5.85E-02	B B 2		
Ag 108m	= 2.03E-09	B B 2			U 235	= 1.27E-06	B B 2		
Ag 110m					U 236	= 2.49E-06	B B 2		
Cd 109					U 238	= 3.96E-10	B B 2		
Cd 113m	= 6.86E-03	B B 2			Np 237	= 2.13E-03	B B 2		
Sn 119m					Pu 236				
Sn 121m	= 4.22E-02	B B 2			Pu 238	= 2.45E+01	B B 2		
Sn 123					Pu 239	= 9.11E-01	B B 2		
Sn 126	= 2.11E-03	B B 2			Pu 240	= 7.57E-01	B B 2		
Sb 125	= 4.08E-06	B B 2			Pu 241	= 4.08E+02	B B 2		
Sb 126	= 2.11E-03	B B 2			Pu 242	= 7.71E-02	B B 2		
Te 125m	= 9.64E-07	B B 2			Am 241	= 3.36E+02	B B 2		
Te 127m					Am 242m	= 1.15E+00	B B 2		
I 129	= 1.16E-04	B B 2			Am 243	= 2.55E-01	B B 2		
Cs 134	= 1.27E-08	B B 2			Cm 242	= 9.63E-01	B B 2		
Cs 135	= 2.35E-03	B B 2			Cm 243	= 9.26E-02	B B 2		
Cs 137	= 5.40E+01	B B 2			Cm 244	= 1.25E+00	B B 2		
Ba 133					Cm 245	= 5.50E-04	B B 2		
La 137					Cm 246	= 1.50E-05	B B 2		
La 138					Cm 248				
Ce 144					Cf 249				
Pm 145					Cf 250				
Pm 147	= 1.41E-05	B B 2			Cf 251				
Sm 147	= 1.35E-15	B B 2			Cf 252				
Sm 151	= 2.15E+00	B B 2			Unsp a				
Eu 152	= 8.41E-04	B B 2			Unsp b/g				
Eu 154	= 3.45E-02	B B 2			**Total a**	**3.68E+02**	*	**0**	*
Eu 155	= 2.10E-03	B B 2			**Total b/g**	**4.87E+02**	*	**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 the 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
* Total calculated from the 114 declared radionuclides