

WASTE STREAM	2S304	Windscale Piles Fuel and Isotopes
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SITE Windscale

SITE OWNER Nuclear Decommissioning Authority

WASTE CUSTODIAN Sellafield Ltd

WASTE TYPE ILW

WASTE VOLUMES

	Reported (m ³)	OR	Conditioned (m ³)	Packaged (m ³)
Stocks:	At 1.4.2025			
Future arisings:	1.4.2025 - 31.3.2032			
Total future arisings:				
Total waste volume:				

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

Comment on arising rates: While current approved schedules show Pile 1 fuel and isotopes will be removed during 2025-2032 this is likely to be deferred until a future date

Additional information on quantities: Future arisings are estimates based on what is believed to be present in the Piles. The estimated volume of material in the waste stream is approximately 5.3m³. However on recovery it is likely that this will bulk up such that the raw volume of waste generated is likely to be approximately 40 m³.

Uncertainty factors on volumes: Stock (upper): x 1.50 Arisings (upper): x 1.50
Stock (lower): x 0.50 Arisings (lower): x 0.50

WASTE SOURCE Decommissioning of Windscale Piles air-cooled graphite-moderated reactors.

PHYSICAL CHARACTERISTICS

General description: The Pile 1 fuel is uranium metal clad in an aluminium can which was sat on a graphite boat and held in place by aluminium staples. The Isotope material from both Pile 1 and 2 reactors are isotope rods that are also aluminium clad. The isotope materials are lithium magnesium, bismuth oxide, aluminium nitride, potassium chloride, thulium, thallium, lead, stainless steel and cobalt. These materials are in a range of physical and chemical states due to the fire in Pile 1.

Changes since waste generated: This waste has remained in the Pile reactors since they were shut down. The fuel and isotopes in the Pile 1 reactor were subject to fire conditions and, as a result, may be in a variety of physical and chemical conditions.

Bulk density (t/m³): ~ 0.30

Comment on density: Density is calculated based on the estimated mass and the raw recovered volume.

CHEMICAL COMPOSITION

General description and components (%wt): Uranium fuel (78.6%), Aluminium (3.3%), Aluminium Nitride (0.1%), Lead (6.7%), Bismuth Oxide (3%), Potassium Chloride (<<0.1%), Cobalt (<<0.1%), Thulium Oxide (TR), Thallium (<<0.1%), Lithium Magnesium (0.7%), Stainless Steel (2.2%), Graphite (5.4%).

Chemical state: -

Sheet metal proportion / thickness: Metal present as fuel and isotope cartridge contents and cladding.

Metals and alloys (%wt):

	(%wt)	Type(s) / Grades(s) with proportions	% of total C14 activity
Stainless steel.....	= 2.2	-	
Other ferrous metals.....	= 0	-	
Iron.....	-	-	
Aluminium.....	= 3.3	-	
Beryllium.....	-	-	
Cobalt.....	= 0	-	
Copper.....	= 0	-	
Lead.....	= 6.7	-	
Magnox/Magnesium.....	= 0	-	
Nickel.....	= 0	-	
Titanium.....	-	-	
Uranium.....	= 78.6	-	
Zinc.....	= 0	-	
Zircaloy/Zirconium.....	= 0	-	
Other metals.....	0	-	

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	-	100.0
Inorganic sludges and flocs.....	= 0	-	
Soil.....	= 0	-	
Brick/Stone/Rubble.....	= 0	-	
Cementitious material.....	= 0	-	
Sand.....		-	
Glass/Ceramics.....	= 0	-	
Graphite.....	= 5.4	-	
Desiccants/Catalysts.....		-	
Asbestos.....	NE	-	
Non/low friable.....		-	
Moderately friable.....		-	
Highly friable.....		-	
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.....	TR	-
Chloride.....		-
Iodide.....		-
Cyanide.....		-
Carbonate.....		-
Nitrate.....		-
Nitrite.....		-
Phosphate.....		-
Sulphate.....		-
Sulphide.....		-

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.....	NE	-
Putrescible wastes.....	= 0	-
Non-putrescible wastes.....	NE	-
Corrosive materials.....	= 0	-
Pyrophoric materials.....	= 0	-
Generating toxic gases.....	= 0	-
Reacting with water.....	= 0	-
Higher activity particles.....	NE	-
Soluble solids as bulk chemical compounds.....	NE	-

Hazardous substances / non hazardous pollutants:

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

Complexing agents (%wt):

No		
	(%wt)	Type(s) and comment
EDTA.....		-
DPTA.....		-
NTA.....		-
Polycarboxylic acids.....		-
Other organic complexants.....	= 0	-
Total complexing agents.....		-

Physical components:

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

TREATMENT, PACKAGING AND DISPOSAL

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

Treatment	On-site / Off-site	Stream volume %
Size reduction		
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		
Polymer encapsulation		
Other physical treatment		
Other chemical treatment		
Containerisation		
Treatment not yet determined		= 100.0
None		

Comments on planned treatments:

-

Conditioning method:

The conditioning methodology will be determined by the timing of retrieval of the materials and the facilities available.

Conditioning plants:

Plant Name	Location

Likely conditioning matrix:

-

Further information on the conditioning matrix:

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Waste Packaging:

Likely container type:	Container	Waste packaged (vol%)	Waste loading (m³)	Payload (m³)	Number of packages	Estimated start date for packaging
	Sellafield 3 m³ box	100.0	1.3	2.2	31	-

Range in container waste loading: The loading volume varies depending on the waste type.

Other information on packaging and conditioning: -

Conditioned density (t/m³): ~ 1.3

Conditioned density comment: -

Management Routes:

Disposal Route	Stream volume %	Raw density t/m³	Start date
Expected to be consigned to a Near Site, Near Surface Disposal Facility (Scotland)	= 100.0		
Expected to be Non-NSD HAW managed under Scottish Government's policy			
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: Not yet determined

Baseline Management Route	Opportunity Management Route	Stream volume (%)	Opportunity Confidence	Comment
-	-	-	-	-

RADIOACTIVITY

Source: The radionuclide activity of the waste is dominated by fission and activation products which will be present in the fuel and isotope cartridges.

Uncertainty: The data has been derived from FISPIN, FISPACT, and WIMS modelling programmes.

Measurement of radioactivities: The main uncertainties in the activation modelling stem from elemental uncertainties in the composition of the materials used to manufacture fuel and isotope cartridges and for impurities in the isotope target materials. There are also some uncertainties in the flux modelling. The radionuclide data should however be an upper bound.

Chemical form of radionuclides: H-3: Tritium isotope cartridges are present.
C-14: Product from isotope cartridges.
Cl-36: -
Se-79: Present as a fission product.
Tc-99: Present as a fission product.
I-129: -
Ra: Decay product of fuel.
Th: Present as decay product of fuel.
U: Present as fuel.
Np: Activation product of fuel.
Pu: Present due to activation of the fuel.

WASTE STREAM			2S304		Windscale Piles Fuel and Isotopes				
Nuclide	Mean radioactivity, TBq/m³				Nuclide	Mean radioactivity, TBq/m³			
	Waste at 1.4.2025	Bands and Code	Future Arisings	Bands and Code		Waste at 1.4.2025	Bands and Code	Future Arisings	Bands and Code
H 3	= 2.73E+01	B B 2	= 3.31E+01	B B 2	Gd 153				
Be 10	= 4.46E-07	B B 2	= 4.46E-07	B B 2	Ho 163	= 1.52E-05	B B 2	= 1.52E-05	B B 2
C 14	= 5.54E-02	B B 2	= 5.54E-02	B B 2	Ho 166m	= 4.90E-03	B B 2	= 4.90E-03	B B 2
Na 22					Tm 170				
Al 26					Tm 171	= 2.91E-12	B B 2	= 9.80E-12	B B 2
Cl 36	= 1.40E-04	B B 2	= 1.40E-04	B B 2	Lu 174	= 4.45E-10	B B 2	= 9.67E-10	B B 2
Ar 39	= 1.73E-03	B B 2	= 1.74E-03	B B 2	Lu 176	= 5.69E-09	B B 2	= 5.69E-09	B B 2
Ar 42	= 1.00E-09	B B 2	= 1.08E-09	B B 2	Hf 178n	= 5.43E-03	B B 2	= 5.87E-03	B B 2
K 40	= 1.12E-08	B B 2	= 1.12E-08	B B 2	Hf 182	= 2.15E-10	B B 2	= 2.15E-10	B B 2
Ca 41	= 7.51E-05	B B 2	= 7.51E-05	B B 2	Pt 193	= 5.66E-05	B B 2	= 5.94E-05	B B 2
Mn 53	= 1.76E-09	B B 2	= 1.76E-09	B B 2	Tl 204	= 8.15E-06	B B 2	= 1.53E-05	B B 2
Mn 54	= 1.73E-18	B B 2	= 2.32E-17	B B 2	Pb 205	= 6.82E-07	B B 2	= 6.82E-07	B B 2
Fe 55	= 1.05E-06	B B 2	= 2.56E-06	B B 2	Pb 210	= 1.26E-07	B B 2	= 1.09E-07	B B 2
Co 60	= 1.39E-02	B B 2	= 2.18E-02	B B 2	Bi 208	= 2.87E-07	B B 2	= 2.87E-07	B B 2
Ni 59	= 3.20E-02	B B 2	= 3.20E-02	B B 2	Bi 210m	= 1.28E-06	B B 2	= 1.28E-06	B B 2
Ni 63	= 2.42E+00	B B 2	= 2.48E+00	B B 2	Po 210	= 1.23E-07	B B 2	= 1.06E-07	B B 2
Zn 65	= 2.78E-33	B B 2	= 7.25E-32	B B 2	Ra 223	= 1.17E-06	B B 2	= 1.08E-06	B B 2
Se 79	= 4.19E-06	B B 2	= 4.19E-06	B B 2	Ra 225	= 3.90E-08	B B 2	= 3.66E-08	B B 2
Kr 81	= 6.08E-07	B B 2	= 6.08E-07	B B 2	Ra 226	= 2.69E-07	B B 2	= 2.48E-07	B B 2
Kr 85	= 7.74E-02	B B 2	= 9.70E-02	B B 2	Ra 228	= 7.62E-08	B B 2	= 7.62E-08	B B 2
Rb 87	= 1.90E-07	B B 2	= 1.90E-07	B B 2	Ac 227	= 1.17E-06	B B 2	= 1.08E-06	B B 2
Sr 90	= 1.08E+01	B B 2	= 1.17E+01	B B 2	Th 227	= 1.15E-06	B B 2	= 1.07E-06	B B 2
Zr 93	= 1.26E-03	B B 2	= 1.26E-03	B B 2	Th 228	= 2.95E-07	B B 2	= 2.98E-07	B B 2
Nb 91	= 3.52E-07	B B 2	= 3.53E-07	B B 2	Th 229	= 3.90E-08	B B 2	= 3.67E-08	B B 2
Nb 92	= 1.69E-10	B B 2	= 1.69E-10	B B 2	Th 230	= 1.24E-05	B B 2	= 1.24E-05	B B 2
Nb 93m	= 3.17E-03	B B 2	= 3.48E-03	B B 2	Th 232	= 7.62E-08	B B 2	= 7.62E-08	B B 2
Nb 94	= 3.75E-03	B B 2	= 3.75E-03	B B 2	Th 234	= 2.23E-02	B B 2	= 2.23E-02	B B 2
Mo 93	= 7.77E-05	B B 2	= 7.77E-05	B B 2	Pa 231	= 1.99E-06	B B 2	= 1.90E-06	B B 2
Tc 97	= 8.64E-11	B B 2	= 8.64E-11	B B 2	Pa 233	= 3.14E-05	B B 2	= 3.14E-05	B B 2
Tc 99	= 9.22E-03	B B 2	= 9.22E-03	B B 2	U 232	= 2.16E-07	B B 2	= 2.24E-07	B B 2
Ru 106	= 4.10E-20	B B 2	= 3.82E-19	B B 2	U 233	= 7.22E-06	B B 2	= 7.22E-06	B B 2
Pd 107	= 1.48E-05	B B 2	= 1.48E-05	B B 2	U 234	= 3.00E-03	B B 2	= 3.00E-03	B B 2
Ag 108m	= 3.13E-05	B B 2	= 3.15E-05	B B 2	U 235	= 1.27E-03	B B 2	= 1.27E-03	B B 2
Ag 110m	= 5.24E-34	B B 2	= 7.93E-33	B B 2	U 236	= 2.31E-04	B B 2	= 2.31E-04	B B 2
Cd 109	= 7.27E-21	B B 2	= 4.37E-20	B B 2	U 238	= 2.23E-02	B B 2	= 2.23E-02	B B 2
Cd 113m	= 1.83E-04	B B 2	= 2.16E-04	B B 2	Np 237	= 3.14E-05	B B 2	= 3.14E-05	B B 2
Sn 119m	= 4.05E-29	B B 2	= 6.38E-28	B B 2	Pu 236	= 2.27E-14	B B 2	= 5.14E-14	B B 2
Sn 121m	= 3.04E-03	B B 2	= 3.20E-03	B B 2	Pu 238	= 3.11E-03	B B 2	= 3.20E-03	B B 2
Sn 123					Pu 239	= 9.70E-01	B B 2	= 9.70E-01	B B 2
Sn 126	= 4.52E-05	B B 2	= 4.52E-05	B B 2	Pu 240	= 6.23E-02	B B 2	= 6.23E-02	B B 2
Sb 125	= 4.56E-08	B B 2	= 1.09E-07	B B 2	Pu 241	= 2.05E-02	B B 2	= 2.43E-02	B B 2
Sb 126					Pu 242	= 1.74E-07	B B 2	= 1.74E-07	B B 2
Te 125m					Am 241	= 2.00E-02	B B 2	= 2.00E-02	B B 2
Te 127m					Am 242m	= 5.35E-07	B B 2	= 5.44E-07	B B 2
I 129	= 1.54E-05	B B 2	= 1.54E-05	B B 2	Am 243	= 1.54E-08	B B 2	= 1.54E-08	B B 2
Cs 134	= 8.17E-10	B B 2	= 2.54E-09	B B 2	Cm 242	= 4.41E-07	B B 2	= 4.49E-07	B B 2
Cs 135	= 6.53E-04	B B 2	= 6.53E-04	B B 2	Cm 243	= 1.46E-09	B B 2	= 1.58E-09	B B 2
Cs 137	= 1.21E+01	B B 2	= 1.32E+01	B B 2	Cm 244	= 1.69E-09	B B 2	= 1.93E-09	B B 2
Ba 133	= 2.93E-05	B B 2	= 3.69E-05	B B 2	Cm 245	= 1.52E-13	B B 2	= 1.52E-13	B B 2
La 137	= 1.15E-06	B B 2	= 1.15E-06	B B 2	Cm 246	= 6.39E-15	B B 2	= 6.39E-15	B B 2
La 138	= 1.48E-10	B B 2	= 1.48E-10	B B 2	Cm 248	= 4.82E-22	B B 2	= 4.82E-22	B B 2
Ce 144	= 2.15E-25	B B 2	= 3.64E-24	B B 2	Cf 249	= 4.97E-22	B B 2	= 5.01E-22	B B 2
Pm 145	= 2.66E-07	B B 2	= 3.06E-07	B B 2	Cf 250	= 5.29E-29	B B 2	= 5.89E-29	B B 2
Pm 147	= 1.14E-06	B B 2	= 2.81E-06	B B 2	Cf 251				
Sm 147	= 6.46E-09	B B 2	= 6.46E-09	B B 2	Cf 252				
Sm 151	= 6.80E-01	B B 2	= 6.99E-01	B B 2	Unsp a				
Eu 152	= 2.79E-04	B B 2	= 3.35E-04	B B 2	Unsp b/g				
Eu 154	= 2.10E-04	B B 2	= 2.78E-04	B B 2	Total a	1.08E+00	*	1.08E+00	*
Eu 155	= 7.14E-05	B B 2	= 1.14E-04	B B 2	Total b/g	5.36E+01	*	6.15E+01	*

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