

WASTE STREAM	2S302	Windscale Pile1 and Pile 2 Graphite and Aluminium Charge Pans
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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	= 0		
Future arisings:	1.4.2025 - 31.3.2042	= 0		
	1.4.2042 - 31.3.2047	~ 964.0		
	1.4.2047 - 31.3.2052	~ 964.0		
Total future arisings:		1928.0		
Total waste volume:		1928.0		

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

Comment on arising rates: -

Additional information on quantities: The volumes provided are envelope volumes.

Uncertainty factors on volumes:

Stock (upper):	x -	Arisings (upper):	x 1.50
Stock (lower):	x -	Arisings (lower):	x 0.50

WASTE SOURCE The removal and packaging of the graphite cores of Windscale Pile 1 and Pile 2 reactors.

PHYSICAL CHARACTERISTICS

General description: The reactor cores of Pile 1 and Pile 2 are constructed from machined graphite blocks stacked in such a way as to make a horizontal cylinder approximately 15.3 m diameter and 7.4 m deep. The blocks are stacked vertically and located to the blocks above and below by graphite slats and tiles. There is no clearance vertically between blocks and tiles, though the blocks are separated horizontally from each other by a "Wigner gap" to allow for lateral expansion.

The sizes of the graphite segments are approximately: Full height blocks - 210 x 210 x 790 mm; Half height blocks - 210 x 210 x 370 mm; Slats - 400 x 26 x 90 mm; Tiles - 180 x 180 x 52 mm.

The charge pans are aluminium pressings and are fixed by self tapping screws to the adjacent graphite blocks on the charge face. The charge pans are located within the horizontal and vertical stringers and the openings align with the fuel and isotope channels. The charge pans were used to align the charge machine for the insertion of fuel and isotope cartridges.

There are 3 types of charge pans which all have same external dimensions (Length 0.392 m Width 0.392 m Height 0.121 m).

Debris contamination from the 1957 fire accident in Pile 1 is made up of the nuclide inventory of Mark X fuel. Debris and particulate removal operations are envisaged to remove 99% of the debris material. The 1% remaining (=77.85kg/ 0.01m³) will be residual surface particulate contamination and has therefore been included in this waste stream.

Changes since waste generated: Windscale Pile 1 fire accident in 1957 has left fuels debris contamination within the graphite core of Pile 1.

Bulk density (t/m³): = 1.3

Comment on density: Calculated by dividing the total mass of waste by the total envelope volume.

CHEMICAL COMPOSITION

General description and components (%wt): Graphite 99.88%; Aluminium 0.12%; Burnt Mark X fuel (assumed to be Uranium Dioxide) 0.002%.

Chemical state: Neutral

Sheet metal proportion / thickness: Not yet determined.

Metals and alloys (%wt):

	(%wt)	Type(s) / Grades(s) with proportions	% of total C14 activity
Stainless steel.....	= 0	-	
Other ferrous metals.....	= 0	-	
Iron.....		-	
Aluminium.....	= 0.12	-	
Beryllium.....		-	
Cobalt.....	= 0	-	
Copper.....	= 0	-	
Lead.....	= 0	-	
Magnox/Magnesium.....	= 0	-	
Nickel.....	= 0	-	
Titanium.....		-	
Uranium.....	P	-	
Zinc.....	= 0	-	
Zircaloy/Zirconium.....	= 0	-	
Other metals.....	= 0	-	

Organics (%wt):

	(%wt)	Type(s) and comment	% of total C14 activity
Total cellulotics.....	= 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.....	= 99.9	-	
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.....	= 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.....	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.....	= 0	-

Hazardous substances / non hazardous pollutants:

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

Complexing agents (%wt):

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

Physical components:

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

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 None		= 100.0

Comments on planned treatments:

-

Conditioning method:

While conditioning plant is not yet defined it is expected that Pile core graphite will be managed as CHILW and placed in a DCC.

Conditioning plants:

Plant Name	Location

Likely conditioning matrix:

-

Further information on the conditioning matrix:

-

Waste Packaging:

Likely container type:

Container	Waste packaged (vol%)	Waste loading (m³)	Payload (m³)	Number of packages	Estimated start date for packaging
DCC	100.0	0.54	1.5	3571	-

Range in container waste loading:

The volume of raw waste in a container can vary from 5% to 65% by volume (Note a full container of dry sharp sand would be 50% by volume).

Other information on packaging and conditioning:

Plans are under review and may change.

Conditioned density (t/m³):

= 1.0

Conditioned density comment:

The waste will not be encapsulated, therefore the density of the wasteform represents the average density of the total waste arising allowing for packing.

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: Activation of graphite and aluminium. Plus residual fuel debris contamination.

Uncertainty: It has been assumed that all the graphite components have the same radiological properties. This assumption represents the worst case, as inevitably the radionuclide inventory will vary with position in the core. The main source of uncertainty in the activation modelling is the elemental uncertainties in the material compositions. The uncertainties relate to the trace elements present within the graphite and aluminium material. Wherever possible specific compositions and trace element data was used for each component. There is also uncertainty in the inventory from the flux modelling. However, the uncertainty presented by the flux modelling is regarded to be much less than that presented by the elemental uncertainties.

Measurement of radioactivities: The principal source for the radionuclide data is the results of FISPIN modelling. In addition WIMS was used to develop a 172 group neutron flux over the graphite moderator. The neutron flux was then applied in activation calculations to derive the inventory for the waste.

Chemical form of radionuclides: H-3: H3 present in the waste material as a product of activation.
C-14: C14 present in the waste material as a product of activation.
Cl-36: -
Se-79: Se79 present in the waste material as a product of activation.
Tc-99: Te99 present in the waste material as a product of activation.
I-129: -
Ra: Radium isotopes present in the waste material as a product of activation.
Th: Thorium isotopes present in the waste material as a product of activation.
U: Uranium isotopes present in the waste material as a product of activation.
Np: Neptunium isotopes present in the waste material as a product of activation.
Pu: Plutonium isotopes present in the waste material as a product of activation.

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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			~ 1.38E-02	B B 2	Gd 153				
Be 10			~ 1.27E-06	B B 2	Ho 163			~ 6.81E-08	B B 2
C 14			~ 5.70E-03	B B 2	Ho 166m			~ 2.08E-05	B B 2
Na 22					Tm 170				
Al 26					Tm 171			~ 3.66E-12	B B 2
Cl 36			~ 7.48E-05	B B 2	Lu 174			~ 4.12E-12	B B 2
Ar 39			~ 1.45E-04	B B 2	Lu 176			~ 6.05E-13	B B 2
Ar 42			~ 2.98E-09	B B 2	Hf 178n			~ 2.76E-05	B B 2
K 40			~ 3.59E-09	B B 2	Hf 182			~ 2.13E-12	B B 2
Ca 41			~ 3.57E-04	B B 2	Pt 193			~ 1.83E-04	B B 2
Mn 53			~ 2.10E-12	B B 2	Tl 204			~ 8.37E-05	B B 2
Mn 54			~ 1.14E-23	B B 2	Pb 205			~ 9.52E-11	B B 2
Fe 55			~ 8.81E-08	B B 2	Pb 210			~ 2.24E-12	B B 2
Co 60			~ 2.09E-04	B B 2	Bi 208			~ 5.95E-12	B B 2
Ni 59			~ 1.69E-04	B B 2	Bi 210m			~ 2.65E-11	B B 2
Ni 63			~ 1.43E-02	B B 2	Po 210			~ 2.20E-12	B B 2
Zn 65					Ra 223			~ 2.78E-09	B B 2
Se 79			~ 1.27E-08	B B 2	Ra 225			~ 5.35E-08	B B 2
Kr 81			~ 5.07E-06	B B 2	Ra 226			~ 4.78E-12	B B 2
Kr 85			~ 1.41E-04	B B 2	Ra 228			~ 1.56E-08	B B 2
Rb 87			~ 1.20E-07	B B 2	Ac 227			~ 2.79E-09	B B 2
Sr 90			~ 5.53E-04	B B 2	Th 227			~ 2.74E-09	B B 2
Zr 93			~ 4.54E-08	B B 2	Th 228			~ 1.34E-07	B B 2
Nb 91			~ 4.10E-10	B B 2	Th 229			~ 5.35E-08	B B 2
Nb 92			~ 6.14E-13	B B 2	Th 230			~ 3.02E-10	B B 2
Nb 93m			~ 1.72E-05	B B 2	Th 232			~ 1.56E-08	B B 2
Nb 94			~ 2.02E-05	B B 2	Th 234			~ 3.42E-07	B B 2
Mo 93			~ 1.65E-07	B B 2	Pa 231			~ 5.75E-09	B B 2
Tc 97			~ 3.15E-10	B B 2	Pa 233			~ 1.39E-09	B B 2
Tc 99			~ 2.63E-07	B B 2	U 232			~ 1.26E-07	B B 2
Ru 106			~ 7.18E-20	B B 2	U 233			~ 1.07E-05	B B 2
Pd 107			~ 4.59E-09	B B 2	U 234			~ 2.14E-07	B B 2
Ag 108m			~ 1.13E-06	B B 2	U 235			~ 1.89E-08	B B 2
Ag 110m					U 236			~ 4.90E-09	B B 2
Cd 109			~ 2.19E-18	B B 2	U 238			~ 3.42E-07	B B 2
Cd 113m			~ 7.02E-08	B B 2	Np 237			~ 1.39E-09	B B 2
Sn 119m			~ 6.83E-28	B B 2	Pu 236			~ 1.66E-17	B B 2
Sn 121m			~ 4.24E-07	B B 2	Pu 238			~ 1.53E-06	B B 2
Sn 123					Pu 239			~ 4.96E-05	B B 2
Sn 126			~ 2.35E-09	B B 2	Pu 240			~ 2.41E-05	B B 2
Sb 125			~ 2.86E-10	B B 2	Pu 241			~ 1.34E-04	B B 2
Sb 126					Pu 242			~ 6.87E-09	B B 2
Te 125m			~ 7.16E-11	B B 2	Am 241			~ 5.93E-05	B B 2
Te 127m					Am 242m			~ 5.73E-08	B B 2
I 129			~ 5.57E-10	B B 2	Am 243			~ 5.81E-09	B B 2
Cs 134			~ 1.00E-09	B B 2	Cm 242			~ 4.73E-08	B B 2
Cs 135			~ 2.72E-08	B B 2	Cm 243			~ 9.70E-10	B B 2
Cs 137			~ 5.74E-04	B B 2	Cm 244			~ 1.66E-09	B B 2
Ba 133			~ 1.16E-05	B B 2	Cm 245			~ 7.32E-13	B B 2
La 137			~ 6.14E-08	B B 2	Cm 246			~ 3.50E-14	B B 2
La 138			~ 1.75E-12	B B 2	Cm 248			~ 2.68E-21	B B 2
Ce 144			~ 9.01E-24	B B 2	Cf 249			~ 2.62E-21	B B 2
Pm 145			~ 1.80E-06	B B 2	Cf 250				
Pm 147			~ 2.96E-09	B B 2	Cf 251				
Sm 147			~ 6.41E-12	B B 2	Cf 252				
Sm 151			~ 9.42E-05	B B 2	Unsp a				
Eu 152			~ 4.03E-05	B B 2	Unsp b/g				
Eu 154			~ 1.72E-04	B B 2	Total a	0	*	1.46E-04	*
Eu 155			~ 1.22E-06	B B 2	Total b/g	0	*	3.68E-02	*

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