

WASTE STREAM**2D35/C****Encapsulated Retrieved Magnox Cladding**

SITE Sellafield
SITE OWNER Nuclear Decommissioning Authority

WASTE CUSTODIAN Sellafield Limited

WASTE TYPE ILW

Is the waste subject to Scottish Policy: No

WASTE VOLUMES

		Conditioned	Packaged
Stocks:	At 1.4.2022.....	1209.3m ³	1414.9m ³
Total future arisings:		0m ³	0m ³
Total waste volume:		1209.3m ³	1414.9m ³
Number of waste packages in stock:	At 1.4.2022.....	2478 package(s)	

Comment on volumes: There will be no future arisings of retrieved swarf from Compartments 19-22. The total volume of encapsulated retrieved swarf is 1209.26 cubic metres. Operations to retrieve additional swarf from Compartments 19-22 are not planned. Number of drums in stock is known precisely. It is likely that one drum included in this total is not an MSSS drum.

Uncertainty factors on volumes:
 Stock (upper): x 1.01 Arisings (upper) x
 Stock (lower): x 0.99 Arisings (lower) x

WASTE SOURCE Magnox swarf from retrieval at storage silo that is then encapsulated with grout in 500 litre stainless steel drums.

PHYSICAL CHARACTERISTICS

General description: The waste is swarf from Magnox fuel decanning. The waste is encapsulated in a grout matrix comprising ground granulated Blast Furnace Slag and Ordinary Portland Cement. No items require special handling. The waste has been encapsulated in grout and is stored in 500 litre drums.

Physical components (%wt): Magnox swarf and associated debris which includes Sintox discs, Nimonic springs, etc. (16.5 wt%). Ground granulated blast furnace slag/ordinary Portland cement grout (82 wt%). Mild steel anti-flotation plate (1.5 wt%).

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m³): 1.85

Comment on density: -

CHEMICAL COMPOSITION

General description and components (%wt): (a) Cement grout matrix, which comprises 82% by weight of the waste, is composed of ground granulated blast furnace slag (57.4%), ordinary Portland cement (16.7%), and water (25.9%). (b) Encapsulated waste, which comprises 16.5% by weight of the waste, is composed of Magnox alloy (94.6%), aluminium (1.5%), stainless steel (0.15%), nimonic (0.2%), uranium (3.5%). (c) Anti-flotation plate, which comprises 1.5% by weight of the waste, is composed of mild steel.

Chemical state: Alkali

Chemical form of radionuclides:
 Cl-36: Present as trace amount of clathrate compounds of metallic salts readily lost to aqueous solution.
 I-129: Present as trace amount of clathrate compounds of metallic salts readily lost to aqueous solution.
 U: Present as metal carry-over from the decanning process, with trace quantities of hydride and small amounts of oxide.
 Pu: Associated with the uranium.

Metals and alloys (%wt): There is no sheet metal. The metal content of the waste varies in form depending on the extent of corrosion, with individual pieces of Magnox being typically 100mm long and 10mm wide.

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	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....	0		
Other ferrous metals.....	1.0	Mild steel, carbon steel.	100.0
Iron.....	0		
Aluminium.....	0.25		
Beryllium.....	<0.01		
Cobalt.....	0		
Copper.....			
Lead.....			
Magnox/Magnesium.....	15.1		
Nickel.....	~0.05		
Titanium.....	TR		
Uranium.....	1.4		
Zinc.....	0		
Zircaloy/Zirconium.....	0		
Other metals.....	~0.10		
Organics (%wt):		Hydrogenated nitrile rubber and/or polyurethane.	
	(%wt)	Type(s) and comment	% of total C14 activity
Total cellulose.....	0		
Paper, cotton.....	0		
Wood.....	0		
Halogenated plastics	0		
Total non-halogenated plastics.....	TR		
Condensation polymers.....	TR		
Others.....	TR		
Organic ion exchange materials....	0		
Total rubber.....	0		
Halogenated rubber	0		
Non-halogenated rubber.....	TR		
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): Matrix grout makes approx 82% total package volume.

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	(%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.....	~82.1		
Sand.....	0	No sand is added to the grout mix.	
Glass/Ceramics.....	0		
Graphite.....	0		
Desiccants/Catalysts.....	0		
Asbestos.....	0	No known asbestos content.	
Non/low friable.....	0		
Moderately friable.....	0		
Highly friable.....	0		
Free aqueous liquids.....	0		
Free non-aqueous liquids.....	0		
Powder/Ash.....	0		

Inorganic anions (%wt): Chlorides, iodides and carbonates may be present in trace amounts. Chlorides, sulphates and sulphides are associated with the grout solids.

	(%wt)	Type(s) and comment
Fluoride.....	0	
Chloride.....	<0.05	
Iodide.....	TR	
Cyanide.....	NE	
Carbonate.....	TR	
Nitrate.....	0	
Nitrite.....	TR	
Phosphate.....	0	
Sulphate.....	<0.50	
Sulphide.....	<0.95	

Materials of interest for waste acceptance criteria: The waste contains uranium and magnesium alloy. Uranium hydride is also present in trace amounts. These materials are encapsulated and present no hazard.

	(%wt)	Type(s) and comment
Combustible metals.....	15.1	Magnox swarf considered as combustible.
Low flash point liquids.....	0	
Explosive materials.....	0	
Phosphorus.....	0	
Hydrides.....	P	Trace amount of uranium hydride may be present.
Biological etc. materials.....	0	
Biodegradable materials.....	0	
Putrescible wastes.....	0	

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Non-putrescible wastes.....	0	
Corrosive materials.....	P	Cement grout is strongly alkaline.
Pyrophoric materials.....	P	Present only in trace amounts.
Generating toxic gases.....	P	Chronic low level evolution of hydrogen.
Reacting with water.....	0	
Higher activity particles.....	P	Small fraction only released in the event of a drop.
Soluble solids as bulk chemical compounds.....	P	Various sodium and magnesium compounds.

Hazardous substances /
non hazardous pollutants: -

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

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Complexing agents (%wt): No

	(%wt)	Type(s) and comment
EDTA.....	0	
DPTA.....	0	
NTA.....	0	
Polycarboxylic acids.....	0	
Other organic complexants.....		There are no complexing agents present in the waste.
Total complexing agents.....	0	

Potential for the waste to contain discrete items: No.

PACKAGING AND CONDITIONING

Container type:	Container	Waste packaged (%vol)	Waste loading (m ³)	Payload (m ³)	Number of packages
	500 l drum	100.0	0.488	0.488	2478

Container type comment: Packaging factor is 1.17, conditioning factor is 1.

Range in container waste volume: -

Other information on containers: 1192mm high x 800mm diameter stainless steel drum. Stainless Steel is essentially 316L type and is nominally 3mm thick, the lid contains a filter. Approximately 130 kgs assembled weight.

Conditioned density (t/m³): 1.85

Conditioned density comment: -

Other information on conditioning: -

RADIOACTIVITY

Source: Mixed fission products and reactor fuel carry-over. The main sources of activity are Ce-144, Pm-147, Ru-106, Nb-95, Zr-95, Cs-137 in proportions typical for outer layer of irradiated uranium fuel rods.

Uncertainty: Activities are derived best estimates within a factor of 3, and assume an average 1% fuel carry over.

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: -

Other information: Short-lived daughters are included in "other" beta/gamma activity.

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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	1.03E-02	BB 2			Gd 153				
Be 10	8.85E-08	BB 2			Ho 163				
C 14	4.03E-03	BB 2			Ho 166m				
Na 22					Tm 170				
Al 26					Tm 171				
Cl 36	1.67E-05	CB 2			Lu 174				
Ar 39					Lu 176				
Ar 42					Hf 178n				
K 40					Hf 182				
Ca 41	1.30E-04	BB 2			Pt 193				
Mn 53					Tl 204				
Mn 54	2.12E-13	BB 2			Pb 205				
Fe 55	5.39E-04	BB 2			Pb 210	1.93E-10	BB 2		
Co 60	6.93E-02	BB 2			Bi 208				
Ni 59	4.84E-03	BB 2			Bi 210m				
Ni 63	4.50E-01	BB 2			Po 210	1.85E-10	BB 2		
Zn 65	7.67E-16	BB 2			Ra 223	2.79E-09	BB 2		
Se 79	7.31E-06	BB 2			Ra 225	6.41E-12	BB 2		
Kr 81					Ra 226	6.62E-10	BB 2		
Kr 85					Ra 228	3.72E-14	BB 2		
Rb 87					Ac 227	2.80E-09	BB 2		
Sr 90	4.40E+00	BB 2			Th 227	2.76E-09	BB 2		
Zr 93	2.65E-04	BB 2			Th 228	3.30E-14	BB 2		
Nb 91					Th 229	6.43E-12	BB 2		
Nb 92					Th 230	8.27E-08	BB 2		
Nb 93m	1.69E-04	BB 2			Th 232	4.97E-14	BB 2		
Nb 94	1.55E-07	BB 2			Th 234	2.64E-04	BB 2		
Mo 93	2.98E-06	BB 2			Pa 231	6.52E-09	BB 2		
Tc 97					Pa 233	1.64E-05	BB 2		
Tc 99	2.17E-03	BB 2			U 232				
Ru 106	7.10E-09	BB 2			U 233	2.60E-09	BB 2		
Pd 107	1.91E-05	BB 2			U 234	2.33E-04	BB 2		
Ag 108m	9.58E-11	BB 2			U 235	5.70E-06	BB 2		
Ag 110m					U 236	3.04E-05	BB 2		
Cd 109					U 238	2.64E-04	BB 2		
Cd 113m					Np 237	1.65E-05	BB 2		
Sn 119m					Pu 236				
Sn 121m	8.09E-06	BB 2			Pu 238	6.66E-02	BB 2		
Sn 123					Pu 239	1.49E-01	BB 2		
Sn 126	5.74E-05	BB 2			Pu 240	1.90E-01	BB 2		
Sb 125					Pu 241	4.06E+00	BB 2		
Sb 126	8.04E-06	BB 2			Pu 242	1.46E-04	BB 2		
Te 125m					Am 241	5.70E-01	BB 2		
Te 127m					Am 242m	9.37E-04	BB 2		
I 129	4.53E-06	BB 2			Am 243	3.27E-04	BB 2		
Cs 134	6.86E-05	BB 2			Cm 242	7.73E-04	BB 2		
Cs 135	1.10E-04	BB 2			Cm 243	1.70E-04	BB 2		
Cs 137	6.89E+00	BB 2			Cm 244	2.34E-03	BB 2		
Ba 133					Cm 245	1.83E-07	BB 2		
La 137					Cm 246	1.54E-08	BB 2		
La 138					Cm 248				
Ce 144	1.56E-11	BB 2			Cf 249				
Pm 145					Cf 250				
Pm 147	4.40E-03	BB 2			Cf 251				
Sm 147	6.20E-11	BB 2			Cf 252				
Sm 151	4.58E-02	BB 2			Other a	6.00E-07	BB 2		
Eu 152	2.36E-04	BB 2			Other b/g	2.02E+01	BB 2		
Eu 154	2.71E-02	BB 2			Total a	9.80E-01	BB 2	0	
Eu 155	3.63E-03	BB 2			Total b/g	3.62E+01	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