

WASTE STREAM**2D07****Pile Fuel Cladding and Miscellaneous Solid Waste**

SITE Sellafield
SITE OWNER Nuclear Decommissioning Authority

WASTE CUSTODIAN Sellafield Limited

WASTE TYPE ILW

WASTE VOLUMES

		Reported
Stocks:	At 1.4.2019.....	~3231.0 m ³
Total future arisings:		0 m ³
Total waste volume:		3231.0 m ³

Comment on volumes: Arisings have ceased. "Stock volume" uncertainty factors taken from the Pile Fuel Cladding Silo - Retrievals Feed Specification, RP/PFCS-PROG/PROJ/00001/D, A Khan, Aug 2018. The feed specification indicates the maximum 'as tipped volume' of 3800m³ and the observed volume of 3231m³.

Uncertainty factors on volumes:	Stock (upper):	x 1.2	Arisings (upper)	x
	Stock (lower):	x 1.0	Arisings (lower)	x

WASTE SOURCE

The wastes have predominately arisen from Windscale, Calder Hall and Chapelcross operations carried out between 1951 and 1965. Source of information is the Pile Fuel Cladding Silo - Retrievals Feed Specification, RP/PFCS-PROG/PROJ/00001/D, A Khan, Aug 2018.

PHYSICAL CHARACTERISTICS

General description: The waste contains swarf, principally aluminium and magnesium, from early reprocessing programmes. Other materials include graphite, organics, steel, ash, gravel and uranium residues. There may be some items that require special handling. The waste has been stored in a silo for ~60 years. Whilst the silo is nominally dry, it is known to be damp in parts with potential for discrete volumes of free liquor. The extent of any physical/chemical changes will be established on retrieval.

Physical components (%wt): Metal swarf, graphite, organics (e.g. wood, cloth, paper), scrap metal, ash, lead and uranium, as follows: Magnesium alloy swarf and magnesium hydroxide (41%), aluminium swarf (5.8%), graphite (18%), uranium (0.6%), uranium oxide (0.04%), gravel (7.6%), lead (2.2%), scrap metal - predominantly steel (20%), others - organics, ash, filters, etc. (4.4%).

Sealed sources: The waste contains sealed sources. A number of isotope cartridges have been confirmed to have been disposed to the Silo. The radioactivity in these cartridges will have decayed away to negligible levels.

Bulk density (t/m³): 0.53

Comment on density: The quoted value is the average bulk density of the undisturbed waste in the silo. Upon retrieval the average bulk density is expected to decrease. The retrieved volume is expected to have an average bulk density of 0.45 t/m³

CHEMICAL COMPOSITION

General description and components (%wt): Metal swarf, graphite, organics (e.g. wood, cloth, paper), scrap metal, ash, lead and uranium, as follows: Magnesium alloy swarf and magnesium hydroxide (41%), aluminium swarf (5.8%), graphite (18%), uranium (0.6%), uranium oxide (0.04%), gravel (7.6%), lead (2.2%), scrap metal - predominantly steel (20%), others - organics, ash, filters, etc. (4.4%).

Chemical state: Alkali

Chemical form of radionuclides:
H-3: Present as part of spent fuel components (predominantly trapped as gas within spent fuel).
C-14: Present as part of spent fuel components (trapped as gas within spent fuel components).
Cl-36: Present as part of spent fuel components (trapped as gas within spent fuel components).
Se-79: Present as part of spent fuel components (fission product within spent fuel).
Tc-99: Present as part of spent fuel components (associated with fission products within spent fuel).
I-129: Present as part of spent fuel components (fission product within spent fuel).
Ra: Present within spent fuel.
Th: Present within spent fuel.
U: Uranium metal and uranium corrosion products (associated with spent fuel).
Np: Present within spent fuel.

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Pu: Both present within spent fuel and associated with Plutonium Contaminated Material.

Metals and alloys (%wt):

Approximately 20% of the waste is present as scrap metal or cans. It is unknown how much is present as sheet. A normal limit of between 460 mm and 610 mm in any dimension was applied to items disposed in the Silo. However there are known to be many items larger than this. There are many metal rods, some up to 7 metres long. Approximately 25 mild steel boxes up to a maximum length of 1 metre in each dimension. Approximately 50 x 200 litre drums. There are sections of aluminium decking up to 2.8 m long and 0.6 m wide, totalling 15 m in length. There are 4 sections of steel cover plate measuring approximately 1830 mm x 915 mm x 5 mm and 2 folded aluminium cover plates originally measuring 1830 mm x 1830 mm x 5 mm. There will also be sections of mild steel plate up to 1 m x 1 m, totalling 2 plates (1.8 m x 2.4 m) per compartment

Stainless steel.....	P
Other ferrous metals.....	20.0
Iron.....	P
Aluminium.....	6.0
Beryllium.....	0
Cobalt.....	0
Copper.....	NE
Lead.....	2.2
Magnox/Magnesium.....	41.0
Nickel.....	TR
Titanium.....	NE
Uranium.....	0.60
Zinc.....	NE
Zircaloy/Zirconium.....	TR
Other metals.....	NE

Predominantly depleted/natural uranium.

Organics (%wt):

The waste contains a variety of organics and cellulosic materials including wood and paper. Rubber may be present in small amounts. Detailed organics inventory uncertain, total listed as "other organics". Most of the plastics are likely to be Bakelite, high density polythene or PVC, although there is photographic evidence of more modern ABS piping on top of the waste.

Total cellulosics.....	P
Paper, cotton.....	P
Wood.....	P
Halogenated plastics	NE
Total non-halogenated plastics.....	NE
Condensation polymers.....	NE
Others.....	NE
Organic ion exchange materials....	0
Total rubber.....	NE
Halogenated rubber	NE
Non-halogenated rubber.....	NE
Hydrocarbons.....	P
Oil or grease	P
Fuel.....	NE
Asphalt/Tarmac (cont.coal tar)...	NE
Asphalt/Tarmac (no coal tar)....	0
Bitumen.....	NE

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	Others.....	
	Other organics.....	1.9
Other materials (%wt):	The gravel at bottom of silo compartments is listed as rubble. Fibreglass is present in pile filters. Incinerator ash (2.4%). Controls have been put in place for asbestos, which maybe have been disposed in the form of lagging, etc. Amounts/types not known.	
	Inorganic ion exchange materials.	NE
	Inorganic sludges and flocs.....	P
	Soil.....	NE
	Brick/Stone/Rubble.....	7.6
	Cementitious material.....	NE
	Sand.....	P
	Glass/Ceramics.....	P
	Graphite.....	18.4
	Desiccants/Catalysts.....	NE
	Asbestos.....	P
	Non/low friable.....	NE
	Moderately friable.....	NE
	Highly friable.....	NE
	Free aqueous liquids.....	P
	Free non-aqueous liquids.....	P
	Powder/Ash.....	~2.3
Inorganic anions (%wt):	If present, the listed anions are likely to be present only in small or trace quantities.	
	Fluoride.....	NE
	Chloride.....	NE
	Iodide.....	NE
	Cyanide.....	NE
	Carbonate.....	NE
	Nitrate.....	NE
	Nitrite.....	NE
	Phosphate.....	NE
	Sulphate.....	NE
	Sulphide.....	NE
Materials of interest for waste acceptance criteria:	The waste contains uranium, magnesium, graphite, aluminium and combustible organics. It may also contain uranium hydride and alkali metals. During retrievals, disturbed magnox may come into contact with, and react with, free water to produce hydrogen gas. There may also be a very small number of sealed cans (<30) containing either uranium hydride or sodium, which may present an ignition source.	
	Combustible metals.....	P Approx 30% of the waste is Magnesium alloy. A small number of canned items may contain sodium or uranium hydride.
	Low flash point liquids.....	P Expected to be trace amounts.
	Explosive materials.....	0
	Phosphorus.....	0
	Hydrides.....	P Very small amounts of uranium hydride in sealed cans.

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	Biological etc. materials.....	0	
	Biodegradable materials.....	P	Approximately 2% w/w of the waste is organic.
	Putrescible wastes.....	P	
	Non-putrescible wastes.....		
	Corrosive materials.....	0	
	Pyrophoric materials.....	P	Very small amounts of sodium and uranium hydride.
	Generating toxic gases.....	0	
	Reacting with water.....	P	Magnox reacts with water to form hydrogen.
	Active particles.....	P	10% w/w of the silo waste is expected to be particulate.
	Soluble solids as bulk chemical compounds.....	0	
Hazardous substances / non hazardous pollutants:	Lead is present and the presence of asbestos is suspected.		
	Acrylamide.....	NE	
	Benzene.....	NE	
	Chlorinated solvents.....	NE	
	Formaldehyde.....	NE	
	Organometallics.....	NE	
	Phenol.....	P	Present within disposed plastics.
	Styrene.....	NE	
	Tri-butyl phosphate.....	NE	
	Other organophosphates.....	NE	
	Vinyl chloride.....	P	Present as PVC.
	Arsenic.....	NE	
	Barium.....	P	As Barium 137.
	Boron.....	NE	
	Cadmium.....	NE	
	Caesium.....	P	As Caesium 137
	Selenium.....	NE	
	Chromium.....	P	Present in disposed stainless steel .
	Molybdenum.....	P	Potentially present in disposed stainless steel.
	Thallium.....	NE	
	Tin.....	P	Present in disposed scrap metal.
	Vanadium.....	NE	May be present in scrap steel.
	Mercury compounds.....	NE	
	Others.....		
	Electronic Electrical Equipment (EEE)		
	EEE Type 1.....	0	
	EEE Type 2.....	P	

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EEE Type 3..... P

EEE Type 4..... NE

EEE Type 5..... NE

Complexing agents (%wt): Not yet determined

EDTA..... NE

DPTA..... NE

NTA..... NE

Polycarboxylic acids..... NE

Other organic complexants.....

Total complexing agents..... NE

PACKAGING AND CONDITIONINGConditioning method: Waste will be placed in 3m³ boxes for interim storage and subsequent conditioning and packaging.

Plant Name: Treatment options and plants under development.

Location: Sellafield.

Plant startup date: Under review.

Total capacity (m³/y incoming waste): -

Target start date for packaging this stream: -

Throughput for this stream (m³/y incoming waste): -

Other information: -

Likely container type:	Container	Waste packaged (%vol)	Waste loading (m ³)	Payload (m ³)	Number of packages
	Sellafield enhanced 3m ³ box	100.0	1.469	2.15	2200

Likely container type comment: -

Range in container waste volume: The waste loading has been calculated based on an estimated 2,200 final packages being produced at the PFCS Treatment Plant (note that this also includes any POCO waste from the silos). The actual waste container loading is uncertain and will depend greatly on achievable packing fractions.

Other information on containers: Stainless steel. Interim waste container will be re-used for disposal if possible.

Likely conditioning matrix: Not Specified

Other information: -

Conditioned density (t/m³): NE

Conditioned density comment: -

Other information on conditioning: -

Opportunities for alternative disposal routing: Not yet determined

Treatment	Stream volume (%)	Comment
-	-	-

RADIOACTIVITY

Source:	The waste contains contaminated fuel cladding, residual uranium fuel from decanning operations and reactor structural components. The main sources of radioactivity are Cs-137, Sr-90, Pu-239, C14, Pu-241.
Uncertainty:	Actual Silo wall dose readings have been used to calculate the specific activities. The underlying assumptions in the calculation lead to uncertainties. These uncertainties are expected to be less than an order of magnitude.
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:	Specific activities have been predominately based on Silo dose reading and estimates of plutonium associated with PCM. All specific activities have been decayed to expected values in 2019.
Other information:	-

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Nuclide	Mean radioactivity, TBq/m ³				Nuclide	Mean radioactivity, TBq/m ³			
	Waste at 1.4.2019	Bands and Code	Future arisings	Bands and Code		Waste at 1.4.2019	Bands and Code	Future arisings	Bands and Code
H 3	5.02E-05	CC 1			Gd 153				
Be 10	2.27E-08	CC 1			Ho 163	7.18E-14	CC 1		
C 14	4.72E-03	CC 1			Ho 166m	1.01E-10	CC 1		
Na 22					Tm 170				
Al 26					Tm 171	1.44E-15	CC 1		
Cl 36	1.14E-06	CC 1			Lu 174				
Ar 39					Lu 176				
Ar 42					Hf 178n				
K 40					Hf 182				
Ca 41	1.06E-05	CC 1			Pt 193				
Mn 53	1.51E-15	CC 1			Tl 204				
Mn 54					Pb 205				
Fe 55	5.89E-08	CC 1			Pb 210	7.19E-11	CC 1		
Co 60	1.74E-04	CC 1			Bi 208				
Ni 59	4.56E-05	CC 1			Bi 210m				
Ni 63	3.73E-03	CC 1			Po 210	7.00E-11	CC 1		
Zn 65					Ra 223	1.99E-09	CC 1		
Se 79	1.52E-07	CC 1			Ra 225	1.68E-13	CC 1		
Kr 81	1.62E-15	CC 1			Ra 226	2.17E-10	CC 1		
Kr 85	8.68E-04	CC 1			Ra 228	1.13E-16	CC 1		
Rb 87	2.74E-12	CC 1			Ac 227	8.61E-10	CC 1		
Sr 90	6.13E-02	CC 1			Th 227	8.47E-10	CC 1		
Zr 93	5.07E-06	CC 1			Th 228	6.54E-10	CC 1		
Nb 91					Th 229	1.69E-13	CC 1		
Nb 92					Th 230	1.96E-08	CC 1		
Nb 93m	3.67E-06	CC 1			Th 232	2.07E-15	CC 1		
Nb 94	1.35E-10	CC 1			Th 234	4.20E-05	CC 1		
Mo 93	2.06E-09	CC 1			Pa 231	1.93E-09	CC 1		
Tc 97	2.70E-18	CC 1			Pa 233	1.59E-07	CC 1		
Tc 99	3.84E-05	CC 1			U 232	6.36E-10	CC 1		
Ru 106	4.12E-17	CC 1			U 233	5.12E-11	CC 1		
Pd 107	1.37E-07	CC 1			U 234	4.14E-05	CC 1		
Ag 108m	1.76E-11	CC 1			U 235	1.76E-06	CC 1		
Ag 110m					U 236	8.25E-07	CC 1		
Cd 109					U 238	4.20E-05	CC 1		
Cd 113m	5.91E-08	CC 1			Np 237	1.59E-07	CC 1		
Sn 119m					Pu 236	2.37E-14	CC 1		
Sn 121m	6.84E-07	CC 1			Pu 238	4.88E-05	CC 1		
Sn 123					Pu 239	1.28E-02	CC 1		
Sn 126	1.28E-06	CC 1			Pu 240	2.41E-03	CC 1		
Sb 125	2.15E-08	CC 1			Pu 241	4.04E-03	CC 1		
Sb 126	1.84E-07	CC 1			Pu 242	5.79E-08	CC 1		
Te 125m	5.25E-09	CC 1			Am 241	1.66E-03	CC 1		
Te 127m					Am 242m	1.91E-07	CC 1		
I 129	7.22E-08	CC 1			Am 243	2.08E-08	CC 1		
Cs 134	1.76E-10	CC 1			Cm 242	1.58E-07	CC 1		
Cs 135	1.93E-06	CC 1			Cm 243	3.18E-09	CC 1		
Cs 137	7.56E-02	CC 1			Cm 244	1.24E-08	CC 1		
Ba 133	2.93E-13	CC 1			Cm 245	5.71E-13	CC 1		
La 137	5.88E-14	CC 1			Cm 246	9.29E-15	CC 1		
La 138	8.70E-17	CC 1			Cm 248				
Ce 144					Cf 249				
Pm 145	3.26E-17	CC 1			Cf 250				
Pm 147	4.69E-07	CC 1			Cf 251				
Sm 147	1.15E-12	CC 1			Cf 252				
Sm 151	2.55E-03	CC 1			Other a				
Eu 152	5.45E-07	CC 1			Other b/g				
Eu 154	1.05E-05	CC 1			Total a	1.70E-02	CC 1	0	
Eu 155	4.28E-06	CC 1			Total b/g	1.53E-01	CC 1	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