WASTE STREAM	2D07	Pile Fuel Cladding and Miscellaneous Solid Waste

SITE Sellafield

SITE OWNER Nuclear Decommissioning Authority

WASTE CUSTODIAN Sellafield Ltd

WASTE TYPE ILW

WASTE VOLUMES

	Reported (m^3)
Stocks: At 1.4.2025	~ 3186.4
Future arisings:	
Total future arisings:	**0.0**
Total waste volume:	**3186.4**

OR

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

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

Comment on arising rates: Waste is currently being retrieved from the Silo into 3m3 boxes. Waste retrieved from the Silo is accounted for in waste stream 2D530.

Additional information on quantities: The feed specification indicates the maximum 'as retrieved' volume of 3790 m³ and the initial 'observed' volume of 3203 m³.

Uncertainty factors on volumes:

Stock (upper):	x 1.18	Arisings (upper):	x -
Stock (lower):	x 1.00	Arisings (lower):	x -

WASTE SOURCE The wastes have predominantly arisen from Windscale, Calder Hall and Chapelcross operations carried out between 1951 and 1965.

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.

Changes since waste generated: The waste has been stored in the 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 upon retrieval.

Bulk density (t/m³): = 0.62

Comment on density: The quoted value is the average bulk density of the undisturbed waste in the Silo (observed waste volume and 2000 te waste mass used). Upon retrieval the average bulk density is expected to decrease. The maximum as retrieved volume (3790 m³) is expected to have an average bulk density of 0.53 t/m³. Should the waste mass be 1800 te, then the in Silo density would be 0.56 t/m³ and the as retrieved density would be 0.48 t/m³. Learning from early retrievals will be used to assess the extent of bulking upon retrievals and hence the expected bulk density when containerised.

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 (assumed 750te) (36.7%), aluminium swarf (5.3%), graphite (16.47%), uranium (0.54%), gravel (6.64%), lead (1.96%), scrap metal - predominantly steel (28.35%), others - organics, ash, filters,etc. (3.96%). Note that the chemical and material composition stated here relates to the original Silo stock - no adjustment has been made for the specific composition of wastes retrieved to date.

Chemical state: Alkali

Sheet metal proportion / thickness: Approximately 28.34% 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 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

Metals and alloys (%wt):

	(%wt)	Type(s) / Grades(s) with proportions	% of total C14 activity
Stainless steel	P	-	
Other ferrous metals	= 28.3	-	
Iron	P	-	
Aluminium	= 5.2	-	
Beryllium	= 0	-	
Cobalt	= 0	-	
Copper	NE	-	
Lead	= 2.0	-	3.8
Magnox/Magnesium	= 36.7	-	
Nickel	TR	-	
Titanium	NE	-	
Uranium	= 0.54	Predominantly depleted/natural uranium.	
Zinc	NE	-	
Zircaloy/Zirconium	TR	-	0.2
Other metals	NE	-	

Organics (%wt):

	(%wt)	Type(s) and comment	% of total C14 activity
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	-	
Others	NE	-	
Other organics	= 1.9	grouted and pile filters	

Other materials (%wt):

	(%wt)	Type(s) and comment	% of total C14 activity
Inorganic ion exchange materials	NE	-	
Inorganic sludges and flocs	P	-	
Soil	NE	-	
Brick/Stone/Rubble	= 6.8	-	
Cementitious material	NE	-	
Sand	P	-	
Glass/Ceramics	P	-	
Graphite	= 16.5	-	96.1
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	~ 2.1	-	

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

Inorganic anions (%wt):

	(%wt)	Type(s) and comment
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:

	(%wt)	Type(s) and comment
Combustible metals	P	Approx 36.5% w/w 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.
Biological etc. materials	= 0	-
Biodegradable materials	P	Approximately 1.5% w/w of the waste is organic.
Putrescible wastes	P	-
Non-putrescible wastes	P	-
Corrosive materials	= 0	-
Pyrophoric materials	P	Potentially very small amounts of sodium and uranium hydride.
Generating toxic gases	= 0	-
Reacting with water	P	Magnox reacts with water to form hydrogen.
Higher activity 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: -

	(%wt)	Type(s) and comment
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	-
Boron (in Boral)	NE	-
Boron (non-Boral)	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	NE	-

Complexing agents (%wt): Not yet determined

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

Physical components:

	Number	Type(s) and comment
Sources	P	Known consignments of 29 bismuth oxide isotope cartridges for production of Po-210 and a Sb-124 source. Also suspected possible consignments of AlN, tritium, KCl and Sb/Be isotope cartridges.
Electronic & Electrical Equipment (EEE)		-
EEE Type 1	= 0	-
EEE Type 2	P	-
EEE Type 3	P	-
EEE Type 4	NE	-
EEE Type 5	NE	-

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	On-site	= 100.0

Comments on planned treatments: Waste will be placed within 3m³ boxes for interim storage (unconditioned), with encapsulation to condition the waste deferred until 2048.

Conditioning method: Waste will be encapsulated in cementitious grout within 3m3 boxes.

Conditioning plants:

Plant Name	Location
Pile Fuel Cladding Silo (PFCS) Treatment Plant	Sellafield

Likely conditioning matrix: Non-standard

Further information on the conditioning matrix: Current proposal is based on conditioning using Ground Granulated Blast Furnace Slag/CEM I 5:1 with w/s 0.55.

Waste Packaging:

Likely container type:

Container	Waste packaged (vol%)	Waste loading (m³)	Payload (m³)	Number of packages	Estimated start date for packaging
Sellafield enhanced 3 m³ box	100.0	1.4	2.2	2216	-

Range in container waste loading: The waste loading has been calculated based on an estimated 2,227 final packages being produced at the PFCS Treatment Plant (note - that this also includes 111 waste containers for residuals from the Silo and 12 waste containers being exported to EPS3). The actual waste container loading is uncertain and will depend greatly on achievable packing fractions and filling efficiencies currently assumed to be 80% with 5% of this volume being taken up by secondary ILW (CA/PFCSPROG/PROJ/00024/H, PFCS Programme PSWP Supporting Calculations, B Chapman, November 2024).

Other information on packaging and conditioning: -

Conditioned density (t/m³): NE
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 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	= 100.0		

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 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, C-14, 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.

Measurement of radioactivities: Specific activities have been predominately based on Silo dose reading and estimates of plutonium associated with PCM. All specific activies have been decayed to expected values in 2025. (CA/PFCS-PROG/PROC/00004/C, Best Estimate of PFCS Waste Specific Activity, R Fisher, March 2018)

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

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

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	3.58E-05	C C 1			Gd 153				
Be 10	2.27E-08	C C 1			Ho 163	7.17E-14	C C 1		
C 14	4.71E-03	C C 1			Ho 166m	1.01E-10	C C 1		
Na 22					Tm 170				
Al 26					Tm 171	1.65E-16	C C 1		
Cl 36	1.14E-06	C C 1			Lu 174				
Ar 39					Lu 176				
Ar 42					Hf 178n				
K 40					Hf 182				
Ca 41	1.06E-05	C C 1			Pt 193				
Mn 53	1.51E-15	C C 1			Tl 204				
Mn 54					Pb 205				
Fe 55	1.29E-08	C C 1			Pb 210	1.01E-10	C C 1		
Co 60	7.89E-05	C C 1			Bi 208				
Ni 59	4.56E-05	C C 1			Bi 210m				
Ni 63	3.57E-03	C C 1			Po 210	9.79E-11	C C 1		
Zn 65					Ra 223	1.06E-09	C C 1		
Se 79	1.52E-07	C C 1			Ra 225	1.98E-13	C C 1		
Kr 81	1.62E-15	C C 1			Ra 226	2.71E-10	C C 1		
Kr 85	5.89E-04	C C 1			Ra 228	1.19E-15	C C 1		
Rb 87	2.74E-12	C C 1			Ac 227	1.07E-09	C C 1		
Sr 90	5.31E-02	C C 1			Th 227	1.05E-09	C C 1		
Zr 93	5.07E-06	C C 1			Th 228	6.16E-10	C C 1		
Nb 91					Th 229	1.99E-13	C C 1		
Nb 92					Th 230	2.19E-08	C C 1		
Nb 93m	3.96E-06	C C 1			Th 232	2.31E-15	C C 1		
Nb 94	1.35E-10	C C 1			Th 234	4.20E-05	C C 1		
Mo 93	2.06E-09	C C 1			Pa 231	2.15E-09	C C 1		
Tc 97	2.70E-18	C C 1			Pa 233	1.62E-07	C C 1		
Tc 99	3.84E-05	C C 1			U 232	5.99E-10	C C 1		
Ru 106	6.66E-19	C C 1			U 233	5.54E-11	C C 1		
Pd 107	1.37E-07	C C 1			U 234	4.14E-05	C C 1		
Ag 108m	1.75E-11	C C 1			U 235	1.76E-06	C C 1		
Ag 110m					U 236	8.25E-07	C C 1		
Cd 109					U 238	4.20E-05	C C 1		
Cd 113m	4.36E-08	C C 1			Np 237	1.62E-07	C C 1		
Sn 119m					Pu 236	5.66E-15	C C 1		
Sn 121m	6.34E-07	C C 1			Pu 238	4.65E-05	C C 1		
Sn 123					Pu 239	1.28E-02	C C 1		
Sn 126	1.28E-06	C C 1			Pu 240	2.40E-03	C C 1		
Sb 125	4.76E-09	C C 1			Pu 241	3.03E-03	C C 1		
Sb 126	1.79E-07				Pu 242	5.79E-08	C C 1		
Te 125m	1.19E-09	C C 1			Am 241	1.68E-03	C C 1		
Te 127m					Am 242m	1.85E-07	C C 1		
I 129	7.22E-08	C C 1			Am 243	2.08E-08	C C 1		
Cs 134	2.35E-11	C C 1			Cm 242	1.53E-07	C C 1		
Cs 135	1.93E-06	C C 1			Cm 243	2.77E-09	C C 1		
Cs 137	6.59E-02	C C 1			Cm 244	9.86E-09	C C 1		
Ba 133	1.98E-13	C C 1			Cm 245	5.70E-13	C C 1		
La 137	5.88E-14	C C 1			Cm 246	9.28E-15	C C 1		
La 138	8.70E-17	C C 1			Cm 248				
Ce 144					Cf 249				
Pm 145	2.58E-17	C C 1			Cf 250				
Pm 147	9.60E-08	C C 1			Cf 251				
Sm 147	1.15E-12	C C 1			Cf 252				
Sm 151	2.44E-03	C C 1			Unsp a				
Eu 152	4.01E-07	C C 1			Unsp b/g				
Eu 154	6.50E-06	C C 1			**Total a**	**1.71E-02**	*	**0**	*
Eu 155	1.81E-06	C C 1			**Total b/g**	**1.34E-01**	*	**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