

WASTE STREAM	2F01/C	Vitrified High Level Waste
---------------------	---------------	-----------------------------------

SITE Sellafield

SITE OWNER Nuclear Decommissioning Authority

WASTE CUSTODIAN Sellafield Limited

WASTE TYPE HLW

WASTE VOLUMES

		Conditioned	Packaged
Stocks:	At 1.4.2019.....	459.2 m ³	600.0 m ³
Future arisings -	1.4.2019 - 31.3.2020.....	-3.5 m ³	-4.5 m ³
	1.4.2020 - 31.3.2021.....	-13.5 m ³	-17.6 m ³
	1.4.2021 - 31.3.2022.....	-2.7 m ³	-3.5 m ³
	1.4.2022 - 31.3.2023.....	-0.9 m ³	-1.2 m ³
	1.4.2023 - 31.3.2024.....	23.1 m ³	30.2 m ³
	1.4.2024 - 31.3.2025.....	23.1 m ³	30.2 m ³
	1.4.2025 - 31.3.2026.....	7.5 m ³	9.8 m ³
	1.4.2026 - 31.3.2027.....	20.4 m ³	26.7 m ³
	1.4.2027 - 31.3.2028.....	15.0 m ³	19.6 m ³
	1.4.2028 - 31.3.2029.....	15.0 m ³	19.6 m ³
	1.4.2029 - 31.3.2030.....	4.8 m ³	6.3 m ³
Total future arisings:		88.4 m ³	115.4 m ³
Total waste volume:		547.5 m ³	715.4 m ³
Number of waste packages in stock:	At 1.4.2019.....	3061 package(s)	

Comment on volumes: Arisings are dependent on the vitrification programme. The volumes quoted are net of exports to overseas customers, and assume substitution arrangements are implemented. The reported volumes and numbers of packages are the total number of blended waste packages. Future arisings will be dependent on the adopted upstream liquor blending strategy and a degree of uncertainty is introduced as a result. However the overall uncertainty for waste package production for 2D02/C and 2F01/C is small, +/-x1.2.

Uncertainty factors on volumes:

Stock (upper):	x 1.1	Arisings (upper)	x 1.2
Stock (lower):	x 0.9	Arisings (lower)	x 0.83

WASTE SOURCE Reprocessing of spent fuel gives rise to acidic aqueous raffinate which is concentrated, then vitrified by thermally denitrating and mixing with glass formers.

PHYSICAL CHARACTERISTICS

General description: Vitrified waste is the oxide form of the fission products from spent fuel incorporated in a borosilicate lithia glass matrix. The glass blocks are cast in stainless steel product containers. Each container holds approximately 400 kg of glass. No large items are present, individual containers are approximately 430 mm diameter and 1340 mm high.

Physical components (%vol): Glass blocks in stainless steel containers (100%).

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m³): 2.65

Comment on density: -

CHEMICAL COMPOSITION

General description and components (%wt): SiO₂ (47.2%), Na₂O (8.6%), B₂O₃ (17.3%), Li₂O (2.0%), waste oxides (25%).

Chemical state: Neutral

Chemical form of radionuclides:

H-3: Not present.

C-14: Not present.

Cl-36: Present as oxide in trace quantities.

Se-79: Present as oxide.

Tc-99: Present as oxide.

I-129: Present as oxide.

Ra: Likely to be present as oxide.

Th: Likely to be present as oxide.

WASTE STREAM	2F01/C	Vitrified High Level Waste
--------------	--------	----------------------------

U: Present as oxide.
 Np: Likely to be present as oxide.
 Pu: Present as oxide.

Metals and alloys (%wt):

-
 Stainless steel..... 0
 Other ferrous metals..... 0
 Iron..... 0
 Aluminium.....
 Beryllium..... 0
 Cobalt..... 0
 Copper.....
 Lead..... 0
 Magnox/Magnesium..... 0
 Nickel.....
 Titanium.....
 Uranium..... 0
 Zinc..... 0
 Zircaloy/Zirconium..... 0
 Other metals..... 0

Organics (%wt):

No organic materials are present.
 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..... 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):

-

WASTE STREAM

2F01/C

Vitrified High Level Waste

	Inorganic ion exchange materials.	0
	Inorganic sludges and flocs.....	0
	Soil.....	0
	Brick/Stone/Rubble.....	0
	Cementitious material.....	0
	Sand.....	
	Glass/Ceramics.....	100.0
	Graphite.....	0
	Desiccants/Catalysts.....	
	Asbestos.....	0
	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):	Oxides are present.	
	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:	There are no hazardous materials in the waste.	
	Combustible metals.....	0
	Low flash point liquids.....	0
	Explosive materials.....	0
	Phosphorus.....	0
	Hydrides.....	0
	Biological etc. materials.....	0
	Biodegradable materials.....	0
	Putrescible wastes.....	0
	Non-putrescible wastes.....	
	Corrosive materials.....	0
	Pyrophoric materials.....	0
	Generating toxic gases.....	0
	Reacting with water.....	0
	Active particles.....	

WASTE STREAM**2F01/C****Vitrified High Level Waste**Hazardous substances /
non hazardous pollutants:Soluble solids as bulk chemical
compounds.....

The waste contains toxic fission products.

Acrylamide.....

Benzene.....

Chlorinated solvents.....

Formaldehyde.....

Organometallics.....

Phenol.....

Styrene.....

Tri-butyl phosphate.....

Other organophosphates.....

Vinyl chloride.....

Arsenic.....

Barium.....

Boron.....

Cadmium.....

Caesium.....

Selenium.....

Chromium.....

Molybdenum.....

Thallium.....

Tin.....

Vanadium.....

Mercury compounds.....

Others.....

Electronic Electrical Equipment (EEE)

EEE Type 1..... 0

EEE Type 2..... 0

EEE Type 3..... 0

EEE Type 4..... 0

EEE Type 5..... 0

Complexing agents (%wt):

No

EDTA..... 0

DPTA..... 0

NTA..... 0

Polycarboxylic acids.....

Other organic complexants.....

Total complexing agents.....

PACKAGING AND CONDITIONING

WASTE STREAM	2F01/C	Vitrified High Level Waste
---------------------	---------------	-----------------------------------

Container type:		Waste packaged (%vol)	Waste loading (m ³)	Payload (m ³)	Number of packages
	Container				
	HLW canister	100.0	0.15	0.15	3650

Container type comment:

-

Range in container waste volume:

-

Other information on containers:

Stainless steel grade 309.

Conditioned density (t/m³):

2.65

Conditioned density comment:

-

Other information on conditioning:

This waste is already conditioned.

RADIOACTIVITY

Source:

The main sources of activity in the waste are mixed fission products and actinides resulting from the reprocessing of irradiated Oxide and Magnox fuels.

Uncertainty:

-

Definition of total alpha and total beta/gamma:

The total alpha and beta/gamma activities are the sum of the reported nuclide activities only

Measurement of radioactivities:

The specific activity has been derived from plant records and predictions of feed stocks to the conditioning plant and a target waste incorporation of 25-28% in the conditioning matrix.

Other information:

Short-lived daughters are not included. Other radionuclides not listed represent less than 0.01% of the total activity. The specific activity data for future arisings represent a simplification in that they are reported to be the same as current stocks. In general future arisings activity will be greater at the time of vitrification, but this will be offset somewhat by the longer post-reactor cooling times of future reprocessing waste. Any underestimation is adequately covered by the uncertainty factors given for volume arisings.

WASTE STREAM

2F01/C

Vitrified High Level Waste

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		8		8	Gd 153	6.29E-06	AA 2	6.29E-06	AA 2
Be 10	1.90E-05	AA 2	1.90E-05	AA 2	Ho 163	4.63E-09	AA 2	4.63E-09	AA 2
C 14		8		8	Ho 166m	7.47E-05	AA 2	7.47E-05	AA 2
Na 22					Tm 170	1.41E-11	AA 2	1.41E-11	AA 2
Al 26					Tm 171	3.07E-04	AA 2	3.07E-04	AA 2
Cl 36	3.08E-03	AA 2	3.08E-03	AA 2	Lu 174		8		8
Ar 39		8		8	Lu 176		8		8
Ar 42		8		8	Hf 178n		8		8
K 40	3.06E-17	5	3.06E-17	5	Hf 182	1.11E-13	AA 2	1.11E-13	AA 2
Ca 41	4.58E-04	AA 2	4.58E-04	AA 2	Pt 193		8		8
Mn 53	6.69E-11	AA 2	6.69E-11	AA 2	Tl 204		8		8
Mn 54	3.61E-04	AA 2	3.61E-04	AA 2	Pb 205	8.96E-10	AA 2	8.96E-10	AA 2
Fe 55	1.45E+00	AA 2	1.45E+00	AA 2	Pb 210	2.69E-07	AA 2	2.69E-07	AA 2
Co 60	8.65E+00	AA 2	8.65E+00	AA 2	Bi 208		8		8
Ni 59	3.77E-03	AA 2	3.77E-03	AA 2	Bi 210m	2.90E-14	AA 2	2.90E-14	AA 2
Ni 63	3.95E-01	AA 2	3.95E-01	AA 2	Po 210	2.58E-07	AA 2	2.58E-07	AA 2
Zn 65	2.56E-07	AA 2	2.56E-07	AA 2	Ra 223	5.49E-06	AA 2	5.49E-06	AA 2
Se 79	2.16E-02	AA 2	2.16E-02	AA 2	Ra 225	4.23E-08	AA 2	4.23E-08	AA 2
Kr 81		8		8	Ra 226	8.71E-07	AA 2	8.71E-07	AA 2
Kr 85		8		8	Ra 228	6.62E-11	AA 2	6.62E-11	AA 2
Rb 87	8.96E-06	AA 2	8.96E-06	AA 2	Ac 227	5.51E-06	AA 2	5.51E-06	AA 2
Sr 90	1.69E+04	AA 2	1.69E+04	AA 2	Th 227	5.42E-06	AA 2	5.42E-06	AA 2
Zr 93	7.57E-01	AA 2	7.57E-01	AA 2	Th 228	1.56E-04	AA 2	1.56E-04	AA 2
Nb 91	2.38E-15	AA 2	2.38E-15	AA 2	Th 229	4.23E-08	AA 2	4.23E-08	AA 2
Nb 92	5.36E-13	AA 2	5.36E-13	AA 2	Th 230	8.81E-05	AA 2	8.81E-05	AA 2
Nb 93m	5.11E-01	AA 2	5.11E-01	AA 2	Th 232	7.36E-11	AA 2	7.36E-11	AA 2
Nb 94	3.84E-04	AA 2	3.84E-04	AA 2	Th 234	2.90E-05	AA 2	2.90E-05	AA 2
Mo 93	4.69E-04	AA 2	4.69E-04	AA 2	Pa 231	1.05E-05	AA 2	1.05E-05	AA 2
Tc 97	4.68E-12	AA 2	4.68E-12	AA 2	Pa 233	6.58E-02	AA 2	6.58E-02	AA 2
Tc 99	4.83E+00	AA 2	4.83E+00	AA 2	U 232	1.37E-06	AA 2	1.37E-06	AA 2
Ru 106	1.44E+01	AA 2	1.44E+01	AA 2	U 233	4.08E-06	AA 2	4.08E-06	AA 2
Pd 107	4.23E-02	AA 2	4.23E-02	AA 2	U 234	1.50E-04	AA 2	1.50E-04	AA 2
Ag 108m	1.23E-06	AA 2	1.23E-06	AA 2	U 235	1.38E-06	AA 2	1.38E-06	AA 2
Ag 110m	1.27E-03	AA 2	1.27E-03	AA 2	U 236	1.26E-05	AA 2	1.26E-05	AA 2
Cd 109	6.39E-07	AA 2	6.39E-07	AA 2	U 238	2.90E-05	AA 2	2.90E-05	AA 2
Cd 113m	1.79E+00	AA 2	1.79E+00	AA 2	Np 237	6.58E-02	AA 2	6.58E-02	AA 2
Sn 119m	1.39E-04	AA 2	1.39E-04	AA 2	Pu 236	1.40E-06	AA 2	1.40E-06	AA 2
Sn 121m	4.69E+00	AA 2	4.69E+00	AA 2	Pu 238	1.98E+00	AA 2	1.98E+00	AA 2
Sn 123	1.47E-06	AA 2	1.47E-06	AA 2	Pu 239	4.65E-01	AA 2	4.65E-01	AA 2
Sn 126	1.26E-01	AA 2	1.26E-01	AA 2	Pu 240	1.18E+00	AA 2	1.18E+00	AA 2
Sb 125	3.93E+01	AA 2	3.93E+01	AA 2	Pu 241	3.70E+01	AA 2	3.70E+01	AA 2
Sb 126	4.07E-02	AA 2	4.07E-02	AA 2	Pu 242	2.16E-03	AA 2	2.16E-03	AA 2
Te 125m	9.59E+00	AA 2	9.59E+00	AA 2	Am 241	5.85E+02	AA 2	5.85E+02	AA 2
Te 127m	5.53E-07	AA 2	5.53E-07	AA 2	Am 242m	1.35E+00	AA 2	1.35E+00	AA 2
I 129	1.13E-04	AA 2	1.13E-04	AA 2	Am 243	3.84E+00	AA 2	3.84E+00	AA 2
Cs 134	6.10E+01	AA 2	6.10E+01	AA 2	Cm 242	1.12E+00	AA 2	1.12E+00	AA 2
Cs 135	2.14E-01	AA 2	2.14E-01	AA 2	Cm 243	2.40E+00	AA 2	2.40E+00	AA 2
Cs 137	2.36E+04	AA 2	2.36E+04	AA 2	Cm 244	2.31E+02	AA 2	2.31E+02	AA 2
Ba 133	2.29E-07	AA 2	2.29E-07	AA 2	Cm 245	5.72E-02	AA 2	5.72E-02	AA 2
La 137	2.63E-07	AA 2	2.63E-07	AA 2	Cm 246	1.31E-02	AA 2	1.31E-02	AA 2
La 138	8.11E-12	AA 2	8.11E-12	AA 2	Cm 248	1.15E-07	AA 2	1.15E-07	AA 2
Ce 144	5.82E+00	AA 2	5.82E+00	AA 2	Cf 249	9.21E-07	AA 2	9.21E-07	AA 2
Pm 145	6.08E-05	AA 2	6.08E-05	AA 2	Cf 250	2.17E-06	AA 2	2.17E-06	AA 2
Pm 147	7.91E+02	AA 2	7.91E+02	AA 2	Cf 251	4.34E-08	AA 2	4.34E-08	AA 2
Sm 147	3.06E-06	AA 2	3.06E-06	AA 2	Cf 252	3.25E-08	AA 2	3.25E-08	AA 2
Sm 151	1.25E+02	AA 2	1.25E+02	AA 2	Other a				
Eu 152	8.03E-01	AA 2	8.03E-01	AA 2	Other b/g				
Eu 154	3.48E+02	AA 2	3.48E+02	AA 2	Total a	8.27E+02	AA 2	8.27E+02	AA 2
Eu 155	4.57E+01	AA 2	4.57E+01	AA 2	Total b/g	4.20E+04	AA 2	4.20E+04	AA 2

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