

WASTE STREAM	2D202/C	Dragon Fuel from Winfrith
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SITE Sellafield

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		= 84.0	95.9
Future arisings:	1.4.2025 - 31.3.2026		= 30.0	34.3
	1.4.2026 - 31.3.2027		= 11.5	13.1
	1.4.2027 - 31.3.2028		= 0	0.0
Total future arisings:			41.5	47.4
Total waste volume:			125.5	143.3

Number of waste packages in stock: At 1.4.2025..... 168 packages

Comment on arising rates: There are only 83 remaining packages to be received, from the PSWP 60 are due in 2025/26.

Additional information on quantities: The Dragon fuel was stored at Winfrith, but has since been repacked into stainless steel containers 1/3 the length of the original containers before being transferred to Harwell. These are referred to as third length containers (TLC). The waste occupies 251 TLCs. A single TLC is placed into a 500L drum at MEP and grouted before transferred to the Encaps Store. The TLC has been classed as part of that weight. A single non-active dummy drum was also produced during MEP commissioning hence 252 waste packages will exist across streams 2D202/C and 5C50.

Uncertainty factors on volumes: Stock (upper): x 1.00 Arisings (upper): x 1.50
Stock (lower): x 1.00 Arisings (lower): x 0.50

WASTE SOURCE Dragon reactor irradiated fuel.

PHYSICAL CHARACTERISTICS

General description: Fuel consists of uranium and uranium/thorium fuel (oxide or carbide) kernels, also including graphite and (some) ZrC, covered with carbon and SiC layers to give 0.1-0.25 mm particles. Most of the fuel particles are mixed with graphite and compressed into compacts.

Changes since waste generated: -

Bulk density (t/m³): ~ 2.0

Comment on density: The density of fuel compacts varies between ~1.7 and 2.1 t/m³.

CHEMICAL COMPOSITION

General description and components (%wt): Waste comprises graphite/pyrocarbon (91%), heavy metal oxides and carbides (U/Th/Zr) (~5%), stainless steel TLC (~4%). Conditioned product contains ~6% waste and ~94% cement.

Chemical state: Neutral

Sheet metal proportion / thickness: -

Metals and alloys (%wt):

	(%wt)	Type(s) / Grades(s) with proportions	% of total C14 activity
Stainless steel.....	= 3.8	TLC.	
Other ferrous metals.....	= 0	-	
Iron.....	0	-	
Aluminium.....	= 0	-	
Beryllium.....	= 0	-	
Cobalt.....	= 0	-	
Copper.....	= 0	-	
Lead.....	= 0	-	
Magnox/Magnesium.....	= 0	-	
Nickel.....	= 0	-	
Titanium.....	= 0	-	
Uranium.....	= 0	-	
Zinc.....	= 0	-	
Zircaloy/Zirconium.....	= 0	-	
Other metals.....	= 0.11	Uranium, thorium and zinc are present as only oxides and carbides, but not in elemental form.	

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.....	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):

	(%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.....	= 94.4	-	
Sand.....	= 0	-	
Glass/Ceramics.....	= 0	-	
Graphite.....	= 1.8	-	
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.....	TR	-	

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.....	= 0	-
Putrescible wastes.....	= 0	-
Non-putrescible wastes.....	= 0	-
Corrosive materials.....	= 0	-
Pyrophoric materials.....	= 0	-
Generating toxic gases.....	= 0	-
Reacting with water.....	= 0	-
Higher activity particles.....		-
Soluble solids as bulk chemical compounds.....		-

Hazardous substances / non hazardous pollutants:

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

Complexing agents (%wt):

No		
	(%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	On-site	= 100.0

Comments on planned treatments:

Entombment with cementitious grout in Magnox Encapsulation Plant.

Conditioning method:

Encapsulation in grout at Magnox Encapsulation Plant.

Conditioning plants:

Plant Name	Location
Magnox Encapsulation Plant (MEP)	Sellafield

Likely conditioning matrix:

Non-standard

Further information on the conditioning matrix:

Those grouted before Nov 2019 (20) will have been grouted using historic BFS/OPC 3.44:1 @ 0.33 w/s. The remaining drums will be using GGBS/CEM I 5:1 @ 0.51-0.59 w/s.

Waste Packaging:

Likely container type:

Container	Waste packaged (vol%)	Waste loading (m³)	Payload (m³)	Number of packages	Estimated start date for packaging
500 l drum	100.0	0.50	0.50	251	2025

Range in container waste loading:

Other information on packaging and conditioning:

500 l drum for Dragon Fuel has a centralised frame, 0.5m³.

Conditioned density (t/m³):

= 2.0

Conditioned density comment:

-

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) 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		2077

Classification codes for waste expected to be consigned to a landfill facility:

Opportunities for alternative disposal routing: No

Baseline Management Route	Opportunity Management Route	Stream volume (%)	Opportunity Confidence	Comment
-	-	-	-	-

RADIOACTIVITY

Source: Irradiation of enriched uranium and U/Th compact fuels.

Uncertainty: Total alpha and beta/gamma activities vary by about three orders of magnitude between cans, and some individual isotopes by more than this.

Measurement of radioactivities: Maximum and minimum activities of each radionuclide in individual cans determined by FISPIN. Average inventories for each isotope assigned to each can transferred, and total divided by the estimated volume of drum payload. Exception U235 and daughters where can-specific activities assigned.

Chemical form of radionuclides:

- H-3: -
- C-14: Present in the form of graphite and pyrolytic carbon.
- Cl-36: -
- Se-79: -
- Tc-99: -
- I-129: -
- Ra: -
- Th: -
- U: Uranium oxide and uranium carbide.
- Np: -
- Pu: Plutonium oxide and plutonium carbide.

WASTE STREAM 2D202/C Dragon Fuel from Winfrith									
Nuclide	Mean radioactivity, TBq/m ³				Nuclide	Mean radioactivity, TBq/m ³			
	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	1.05E-02	B B 2	1.05E-02	B B 2	Gd 153				
Be 10	6.31E-08	B B 2	6.31E-08	B B 2	Ho 163				
C 14	6.94E-03	B B 2	6.94E-03	B B 2	Ho 166m				
Na 22					Tm 170				
Al 26					Tm 171				
Cl 36	9.98E-06	B B 2	9.98E-06	B B 2	Lu 174				
Ar 39					Lu 176				
Ar 42					Hf 178n				
K 40					Hf 182				
Ca 41					Pt 193				
Mn 53					Ti 204				
Mn 54					Pb 205				
Fe 55					Pb 210	5.01E-10	B B 2	5.01E-10	B B 2
Co 60					Bi 208				
Ni 59					Bi 210m				
Ni 63	4.83E-09	B B 2	4.83E-09	B B 2	Po 210	4.86E-10	B B 2	4.86E-10	B B 2
Zn 65					Ra 223	5.43E-06	B B 2	5.43E-06	B B 2
Se 79	1.26E-05	B B 2	1.26E-05	B B 2	Ra 225	5.60E-06	B B 2	5.60E-06	B B 2
Kr 81					Ra 226	1.44E-09	B B 2	1.44E-09	B B 2
Kr 85					Ra 228	2.49E-06	B B 2	2.49E-06	B B 2
Rb 87					Ac 227	5.45E-06	B C 2	5.45E-06	B C 2
Sr 90	9.92E+00	B B 2	9.92E+00	B B 2	Th 227	5.36E-06	B B 2	5.36E-06	B B 2
Zr 93	6.15E-04	B B 2	6.15E-04	B B 2	Th 228	1.06E-03	B C 2	1.06E-03	B C 2
Nb 91					Th 229	5.62E-06	B B 2	5.62E-06	B B 2
Nb 92					Th 230	1.04E-07	B B 2	1.04E-07	B B 2
Nb 93m	3.69E-04	B B 2	3.69E-04	B B 2	Th 232	2.68E-06	B B 2	2.68E-06	B B 2
Nb 94	2.01E-08	B B 2	2.01E-08	B B 2	Th 234	8.37E-06	B B 2	8.37E-06	B B 2
Mo 93					Pa 231	1.08E-05	B B 2	1.08E-05	B B 2
Tc 97					Pa 233	7.87E-05	B B 2	7.87E-05	B B 2
Tc 99	4.42E-03	B B 2	4.42E-03	B B 2	U 232	1.04E-03	B B 2	1.04E-03	B B 2
Ru 106	2.78E-12	B B 2	2.78E-12	B B 2	U 233	4.96E-03	B B 2	4.96E-03	B B 2
Pd 107	1.33E-05	B B 2	1.33E-05	B B 2	U 234	1.95E-04	B B 2	1.95E-04	B B 2
Ag 108m					U 235	5.20E-05	B B 2	5.20E-05	B B 2
Ag 110m					U 236	1.66E-08	B B 2	1.66E-08	B B 2
Cd 109					U 238	8.37E-06	B B 2	8.37E-06	B B 2
Cd 113m					Np 237	7.87E-05	B B 2	7.87E-05	B B 2
Sn 119m					Pu 236				
Sn 121m	6.41E-04	B B 2	6.41E-04	B B 2	Pu 238	3.18E-01	B B 2	3.18E-01	B B 2
Sn 123					Pu 239	6.99E-02	B B 2	6.99E-02	B B 2
Sn 126	7.37E-05	B B 2	7.37E-05	B B 2	Pu 240	4.66E-02	B B 2	4.66E-02	B B 2
Sb 125					Pu 241	3.08E+00	B B 2	3.08E+00	B B 2
Sb 126	1.03E-05	B B 2	1.03E-05	B B 2	Pu 242	2.22E-04	B B 2	2.22E-04	B B 2
Te 125m					Am 241	7.86E-01	B B 2	7.86E-01	B B 2
Te 127m					Am 242m	7.44E-06	B B 2	7.44E-06	B B 2
I 129	8.70E-06	B B 2	8.70E-06	B B 2	Am 243	1.99E-03	B C 2	1.99E-03	B C 2
Cs 134	9.51E-06	B B 2	9.51E-06	B B 2	Cm 242	6.14E-06	B C 2	6.14E-06	B C 2
Cs 135	2.50E-04	B B 2	2.50E-04	B B 2	Cm 243	8.51E-04	B C 2	8.51E-04	B C 2
Cs 137	1.16E+01	B B 2	1.16E+01	B B 2	Cm 244	4.87E-02	B C 2	4.87E-02	B C 2
Ba 133					Cm 245				
La 137					Cm 246				
La 138					Cm 248				
Ce 144					Cf 249				
Pm 145					Cf 250				
Pm 147	4.87E-04	B B 2	4.87E-04	B B 2	Cf 251				
Sm 147	1.46E-14		1.46E-14		Cf 252				
Sm 151	1.75E-01	B B 2	1.75E-01	B B 2	Unsp a				
Eu 152	7.49E-05	B B 2	7.49E-05	B B 2	Unsp b/g				
Eu 154	3.87E-02	B B 2	3.87E-02	B B 2	Total a	1.28E+00	*	1.28E+00	*
Eu 155	1.22E-03	B B 2	1.22E-03	B B 2	Total b/g	2.48E+01	*	2.48E+01	*

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