

<b>WASTE STREAM</b>	<b>5C50</b>	<b>Dragon Fuel</b>
---------------------	-------------	--------------------

**SITE** Harwell

**SITE OWNER** Nuclear Decommissioning Authority

**WASTE CUSTODIAN** Magnox Limited

**WASTE TYPE** ILW

Is the waste subject to Scottish Policy: No

**WASTE VOLUMES**

Stocks:	At 1.4.2022.....	Reported 2.6 m <sup>3</sup>
---------	------------------	--------------------------------

Total future arisings:		0 m <sup>3</sup>
------------------------	--	------------------

Total waste volume:		2.6 m <sup>3</sup>
---------------------	--	--------------------

Comment on volumes: 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).

Uncertainty factors on volumes:	Stock (upper):	x 1.2	Arisings (upper)	x
	Stock (lower):	x 0.8	Arisings (lower)	x

**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.

Physical components (%wt): ~67% stainless steel, ~31% of U235 as fuel compacts (mostly 35mm od x 35mm or 45mm od x 45mm), ~2% as fuel particles

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m<sup>3</sup>): ~1.9

Comment on density: The density of fuel compacts varies between ~1.7 and 2.1 t/m<sup>3</sup>.

**CHEMICAL COMPOSITION**

General description and components (%wt): Stainless steel TLCs (~67%), Graphite/pyrocarbon (31%), heavy metal oxides and carbides (U/Th/Zr) (~2%)

Chemical state: Neutral

Chemical form of radionuclides:  
 C-14: Present in the form of graphite and pyrolytic carbon.  
 I-129: Present in fuel as fission product  
 Th: Thorium oxide and thorium carbide  
 U: Uranium oxide and uranium carbide  
 Pu: Plutonium oxide and plutonium carbide

Metals and alloys (%wt): -

	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....	67.0		
Other ferrous metals.....	0		
Iron.....			
Aluminium.....	0		
Beryllium.....	0		
Cobalt.....			
Copper.....	0		
Lead.....	0		
Magnox/Magnesium.....	0		

<b>WASTE STREAM</b>	<b>5C50</b>	<b>Dragon Fuel</b>
---------------------	-------------	--------------------

Nickel.....  
Titanium.....  
Uranium..... 0  
Zinc..... 0  
Zircaloy/Zirconium..... 0  
Other metals.....

Organics (%wt):                   The waste contains no organic materials.

	(%wt)	Type(s) and comment	% of total C14 activity
Total cellulosics.....	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.....			
Oil or grease .....			
Fuel.....			
Asphalt/Tarmac (cont.coal tar)...			
Asphalt/Tarmac (no coal tar)....			
Bitumen.....			
Others.....			
Other organics.....	0		

Other materials (%wt):                   -

	(%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.....	0		
Sand.....			
Glass/Ceramics.....	0		
Graphite.....	31.0		
Desiccants/Catalysts.....			
Asbestos.....	0		
Non/low friable.....			
Moderately friable.....			

<b>WASTE STREAM</b>	<b>5C50</b>	<b>Dragon Fuel</b>
---------------------	-------------	--------------------

Highly friable.....

Free aqueous liquids..... 0

Free non-aqueous liquids..... 0

Powder/Ash..... TR

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.....

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: None expected

(%wt) Type(s) and comment

Acrylamide.....

Benzene.....

Chlorinated solvents.....

Formaldehyde.....

<b>WASTE STREAM</b>	<b>5C50</b>	<b>Dragon Fuel</b>
---------------------	-------------	--------------------

Organometallics.....  
 Phenol.....  
 Styrene.....  
 Tri-butyl phosphate.....  
 Other organophosphates.....  
 Vinyl chloride.....  
 Arsenic.....  
 Barium.....  
 Boron..... 0  
     Boron (in Boral).....  
     Boron (non-Boral).....  
 Cadmium.....  
 Caesium.....  
 Selenium.....  
 Chromium.....  
 Molybdenum.....  
 Thallium.....  
 Tin.....  
 Vanadium.....  
 Mercury compounds.....  
 Others.....  
 Electronic Electrical Equipment (EEE)  
     EEE Type 1.....  
     EEE Type 2.....  
     EEE Type 3.....  
     EEE Type 4.....  
     EEE Type 5.....

Complexing agents (%wt): No

(%wt) Type(s) and comment

EDTA.....  
 DPTA.....  
 NTA.....  
 Polycarboxylic acids.....  
 Other organic complexants.....  
 Total complexing agents..... 0

Potential for the waste to contain discrete items: Yes. Stainless items assumed Dis

**PACKAGING AND CONDITIONING**

Conditioning method: The DRAGON fuel will be transferred to Sellafield in the GB/3358 Modular flask for processing along with similar wastes  
 Plant Name: Magnox Encapsulation Plant  
 Location: Sellafield  
 Plant startup date: -

<b>WASTE STREAM</b>	<b>5C50</b>	<b>Dragon Fuel</b>
---------------------	-------------	--------------------

Total capacity (m<sup>3</sup>/y incoming waste): -

Target start date for packaging this stream: -

Throughput for this stream (m<sup>3</sup>/y incoming waste): -

Other information: -

Likely container type:	Container	Waste packaged (%vol)	Waste loading (m <sup>3</sup> )	Payload (m <sup>3</sup> )	Number of packages
	500 l drum	100.0	0.014	0.47	192

Likely container type comment: -

Range in container waste volume: -

Other information on containers: -

Likely conditioning matrix:  
Other information: -

Conditioned density (t/m<sup>3</sup>): -

Conditioned density comment: -

Other information on conditioning: -

Opportunities for alternative disposal routing: -

Baseline Management Route	Opportunity Management Route	Stream volume (%)	Estimated Date that Opportunity will be realised	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.

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: 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 total vol of 3.4m<sup>3</sup>. Exception U235 and daughters where can-specific activities assigned.

Other information: -

**WASTE STREAM 5C50 Dragon Fuel**

Nuclide	Mean radioactivity, TBq/m <sup>3</sup>				Nuclide	Mean radioactivity, TBq/m <sup>3</sup>			
	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	3.86E-01	BB 2			Gd 153				8
Be 10	2.33E-06	BB 2			Ho 163				8
C 14	1.15E-04	BB 2			Ho 166m				8
Na 22		8			Tm 170				8
Al 26		8			Tm 171				8
Cl 36		8			Lu 174				8
Ar 39		8			Lu 176				8
Ar 42		8			Hf 178n				8
K 40		8			Hf 182				8
Ca 41		8			Pt 193				8
Mn 53		8			Tl 204				8
Mn 54		8			Pb 205				8
Fe 55		8			Pb 210	1.85E-08	BB 2		8
Co 60		8			Bi 208				8
Ni 59		8			Bi 210m				8
Ni 63	1.78E-07	BB 2			Po 210	1.79E-08	BB 2		8
Zn 65		8			Ra 223	2.01E-04	BB 2		8
Se 79	4.65E-04	BB 2			Ra 225	2.07E-04	BB 2		8
Kr 81		8			Ra 226	5.31E-08	BB 2		8
Kr 85		8			Ra 228	9.18E-05	BB 2		8
Rb 87		8			Ac 227	2.02E-04	BC 2		8
Sr 90	3.67E+02	BB 2			Th 227	1.98E-04	BB 2		8
Zr 93	2.27E-02	BB 2			Th 228	3.93E-02	BC 2		8
Nb 91		8			Th 229	2.08E-04	BB 2		8
Nb 92		8			Th 230	3.85E-06	BB 2		8
Nb 93m	1.36E-02	BB 2			Th 232	9.88E-05	BB 2		8
Nb 94	7.41E-07	BB 2			Th 234	3.09E-04	BB 2		8
Mo 93		8			Pa 231	3.97E-04	BB 2		8
Tc 97		8			Pa 233	2.91E-03	BB 2		8
Tc 99	1.63E-01	BB 2			U 232	3.82E-02	BB 2		8
Ru 106		8			U 233	1.83E-01	BB 2		8
Pd 107	4.91E-04	BB 2			U 234	7.21E-03	BB 2		8
Ag 108m		8			U 235	1.92E-03	BB 2		8
Ag 110m		8			U 236	6.12E-07	BB 2		8
Cd 109		8			U 238	3.09E-04	BB 2		8
Cd 113m		8			Np 237	2.91E-03	BB 2		8
Sn 119m		8			Pu 236				8
Sn 121m	2.36E-02	BB 2			Pu 238	1.17E+01	BB 2		8
Sn 123		8			Pu 239	2.58E+00	BB 2		8
Sn 126	2.72E-03	BB 2			Pu 240	1.72E+00	BB 2		8
Sb 125		8			Pu 241	1.14E+02	BB 2		8
Sb 126	3.81E-04	BB 2			Pu 242	8.18E-03	BB 2		8
Te 125m		8			Am 241	2.90E+01	BB 2		8
Te 127m		8			Am 242m	2.75E-04	BB 2		8
I 129	3.21E-04	BB 2			Am 243	7.35E-02	BC 2		8
Cs 134	3.51E-04	BB 2			Cm 242	2.27E-04	BC 2		8
Cs 135	9.24E-03	BB 2			Cm 243	3.14E-02	BC 2		8
Cs 137	4.27E+02	BB 2			Cm 244	1.80E+00	BC 2		8
Ba 133		8			Cm 245				8
La 137		8			Cm 246				8
La 138		8			Cm 248				8
Ce 144		8			Cf 249				8
Pm 145		8			Cf 250				8
Pm 147	1.80E-02	BB 2			Cf 251				8
Sm 147		8			Cf 252				8
Sm 151	6.45E+00	BB 2			Other a				8
Eu 152	2.76E-03	BB 2			Other b/g				8
Eu 154	1.43E+00	BB 2			<b>Total a</b>	<b>4.72E+01</b>	<b>BB 2</b>	<b>0</b>	
Eu 155	4.49E-02	BB 2			<b>Total b/g</b>	<b>9.16E+02</b>	<b>BB 2</b>	<b>0</b>	

**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