

WASTE STREAM	5G25	DRAGON High Active Components
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SITE Winfrith
SITE OWNER Nuclear Decommissioning Authority

WASTE CUSTODIAN Magnox Limited

WASTE TYPE ILW

Is the waste subject to Scottish Policy: No

WASTE VOLUMES

		Reported
Stocks:	At 1.4.2022.....	0.2 m ³
Total future arisings:		0 m ³
Total waste volume:		0.2 m ³
Comment on volumes:	Volumes based on assessment (ILW/LLW) of individual items.	
Uncertainty factors on volumes:	Stock (upper): x 1.2	Arisings (upper) x
	Stock (lower): x 0.8	Arisings (lower) x

WASTE SOURCE This waste consists of the fuel spikes from the Dragon reactor

PHYSICAL CHARACTERISTICS

General description: Fuel spikes removed from the Dragon reactor core. The fuel elements were placed on the fuel spikes which were housed within the Dragon core base plate. The spikes contained a cyclone which served the purpose of collecting dust from the purge gasses. The spikes will therefore be highly contaminated and activated as a result of the cyclone and their position within the core. Waste stream will comprise twelve 10 litre cans containing a total of 37 fuel spikes. Waste stream may also include other hotspots and anything not suitable for a 6m³ box, so isn't limited to the above.

Physical components (%wt): Stainless Steel. Constituents taken from Dragon activation model. Fe (67%), Cr (17%), Ni (9.1%), Mn (1.5%), Others (5.4%)

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m³): 7.9

Comment on density: Density taken from DRAGON iLoC submission.

CHEMICAL COMPOSITION

General description and components (%wt): Stainless Steel. Constituents taken from Dragon activation model. Fe (67%), Cr (17%), Ni (9.1%), Mn (1.5%), Others (5.4%)

Chemical state: Neutral

Chemical form of radionuclides:
 H-3: Tritium isotope present as trace element in the activated materials.
 C-14: Carbon-14 isotope present as trace element in the activated materials.
 Cl-36: Chlorine-36 isotope present as trace element in the activated materials.
 Se-79: Selenium-79 isotope present as trace element in the activated materials.
 Tc-99: Technetium-99 isotope present as trace element in the activated materials.
 I-129: Iodine-129 isotope present as trace element in the activated materials.
 Ra: Radium isotopes present as trace elements in the activated materials.
 Th: Thorium isotopes present as trace elements in the activated materials.
 U: Uranium isotopes present as trace elements in the activated materials.
 Np: Neptunium isotopes present as trace elements in the activated materials.
 Pu: Plutonium isotopes present as trace elements in the activated materials.

Metals and alloys (%wt): -

	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....	100.0	Fe (67%), Cr (17%), Ni (9.1%), Mn (1.5%), Others (5.4%)	
Other ferrous metals.....			
Iron.....			
Aluminium.....			

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Beryllium..... 0
 Cobalt.....
 Copper..... 0
 Lead..... 0
 Magnox/Magnesium.....
 Nickel.....
 Titanium.....
 Uranium.....
 Zinc..... 0
 Zircaloy/Zirconium.....
 Other metals.....

Organics (%wt): -

	(%wt)	Type(s) and comment	% of total C14 activity
Total cellulosics.....	0		
Paper, cotton.....	0		
Wood.....	0		
Halogenated plastics			
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		

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Graphite.....	0
Desiccants/Catalysts.....	
Asbestos.....	0
Non/low friable.....	
Moderately friable.....	
Highly friable.....	
Free aqueous liquids.....	0
Free non-aqueous liquids.....	0
Powder/Ash.....	0

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 / none expected
 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.....	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	

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

PACKAGING AND CONDITIONING

Conditioning method: Cement encapsulation at Harwell WEP

Plant Name: Waste Encapsulation Plant (WEP)

Location: Harwell

Plant startup date: -

Total capacity (m³/y incoming waste): -

Target start date for packaging this stream: -

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

Other information: The fuel spikes will be loaded into 12 cans (11 with 3 spikes and one can with 4 spikes). These will then be sent to Harwell in flasks for intermediate storage. Final conditioning will be undertaken at Harwell into 500l drums, as 5C52

Likely container type:	Container	Waste packaged (%vol)	Waste loading (m ³)	Payload (m ³)	Number of packages

Likely container type comment: -

Range in container waste volume: -

Other information on containers: -

Likely conditioning matrix: Pulverised Fly Ash / Ordinary Portland Cement

Other information: 3:1 PFA/OPC at a 0.42 w/s ratio

Conditioned density (t/m³): ~2.0

Conditioned density comment: The density will vary according to the nature of individual drum contents

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: Contamination and activation from location in core and purpose of waste

Uncertainty: Activity based on Dragon activation model [RET0458 Issue B]

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'.

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Measurement of
radioactivities:

A 3D model of the reactor was used to calculate the neutron fluxes utilising the Monte Carlo code MCNP4C2. The flux calculations of the Monte-Carlo model were then input into a series of FISPACT calculations

Other information:

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DRAGON High Active Components

Nuclide	Mean radioactivity, TBq/m ³				Nuclide	Mean radioactivity, TBq/m ³			
	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	6.79E-01	CC 2			Gd 153		8		
Be 10	4.08E-08	CC 2			Ho 163	2.16E-06	CC 2		
C 14	3.48E-01	CC 2			Ho 166m	2.76E-05	CC 2		
Na 22		8			Tm 170		8		
Al 26		8			Tm 171	2.97E-08	CC 2		
Cl 36	5.16E-05	CC 2			Lu 174		8		
Ar 39	9.29E-04	CC 2			Lu 176		8		
Ar 42	5.30E-07	CC 2			Hf 178n	1.46E-03	CC 2		
K 40	2.16E-08	CC 2			Hf 182	1.12E-09	CC 2		
Ca 41	3.12E-04	CC 2			Pt 193	5.41E-03	CC 2		
Mn 53		8			Tl 204	1.11E-03	CC 2		
Mn 54		8			Pb 205	1.12E-08	CC 2		
Fe 55	7.29E-02	CC 2			Pb 210		8		
Co 60	3.16E+00	CC 2			Bi 208		8		
Ni 59	2.16E+00	CC 2			Bi 210m	4.44E-09	CC 2		
Ni 63	2.12E+02	CC 2			Po 210		8		
Zn 65		8			Ra 223		8		
Se 79	3.48E-07	CC 2			Ra 225	8.85E-08	CC 2		
Kr 81	3.36E-06	CC 2			Ra 226		8		
Kr 85	2.87E-04	CC 2			Ra 228	1.13E-08	CC 2		
Rb 87	4.32E-09	CC 2			Ac 227		8		
Sr 90	1.79E-03	CC 2			Th 227		8		
Zr 93	1.56E-07	CC 2			Th 228	3.72E-07	CC 2		
Nb 91	6.34E-07	CC 2			Th 229	8.86E-08	CC 2		
Nb 92		8			Th 230	2.06E-09	CC 2		
Nb 93m	2.61E-03	CC 2			Th 232	1.13E-08	CC 2		
Nb 94	4.44E-03	CC 2			Th 234	1.92E-08	CC 2		
Mo 93	1.80E-03	CC 2			Pa 231		8		
Tc 97	3.84E-09	CC 2			Pa 233	2.83E-09	CC 2		
Tc 99	3.48E-04	CC 2			U 232	3.49E-07	CC 2		
Ru 106		8			U 233	1.19E-05	CC 2		
Pd 107	3.36E-09	CC 2			U 234	6.37E-07	CC 2		
Ag 108m	2.03E-04	CC 2			U 235		8		
Ag 110m		8			U 236	3.24E-09	CC 2		
Cd 109		8			U 238	1.92E-08	CC 2		
Cd 113m	2.47E-06	CC 2			Np 237	2.84E-09	CC 2		
Sn 119m		8			Pu 236		8		
Sn 121m	1.62E-04	CC 2			Pu 238	7.50E-05	CC 2		
Sn 123		8			Pu 239	1.03E-05	CC 2		
Sn 126	7.8E-09	CC 2			Pu 240	4.92E-05	CC 2		
Sb 125	1.07E-06	CC 2			Pu 241	7.48E-04	CC 2		
Sb 126	1.09E-09	CC 2			Pu 242	2.04E-07	CC 2		
Te 125m	2.69E-07	CC 2			Am 241	2.07E-04	CC 2		
Te 127m		8			Am 242m	4.97E-07	CC 2		
I 129	1.2E-09	CC 2			Am 243	4.32E-07	CC 2		
Cs 134	1.10E-07	CC 2			Cm 242	4.10E-07	CC 2		
Cs 135	1.44E-07	CC 2			Cm 243	2.13E-07	CC 2		
Cs 137	1.79E-03	CC 2			Cm 244	2.67E-06	CC 2		
Ba 133	3.84E-05	CC 2			Cm 245		8		
La 137	1.92E-06	CC 2			Cm 246		8		
La 138		8			Cm 248		8		
Ce 144		8			Cf 249		8		
Pm 145	1.17E-05	CC 2			Cf 250		8		
Pm 147	7.60E-08	CC 2			Cf 251		8		
Sm 147		8			Cf 252		8		
Sm 151	3.05E-04	CC 2			Other a				
Eu 152	7.82E-07	CC 2			Other b/g	1.12E-09			
Eu 154	1.88E-03	CC 2			Total a	3.59E-04	CC 2	0	
Eu 155	1.17E-05	CC 2			Total b/g	2.18E+02	CC 2	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