WASTE STREAM 2F04/C Encapsulated LWR Cladding

SITE	Sellafield
SITE OWNER	Nuclear Decommissioning Authority
WASTE CUSTODIAN	Sellafield Limited
WASTE TYPE	ILW
Is the waste subject to Scottish Policy:	No

WASTE VOLUMES

		Conditioned	Packaged
Stocks:	At 1.4.2022.....	1825.8 m^3	2052.2 m^3
Total future arisings:		0 m^3	0 m^3
Total waste volume:		1825.8 m^3	2052.2 m^3
Number of waste packages in stock:	At 1.4.2022.....	3594 package(s)	

Comment on volumes:	The uncertainty on the volumes is expected to be +/- a factor of 1.1.Shearing of Hulls ceased Nov 2018.			
Uncertainty factors on volumes:	Stock (upper):	x 1.1	Arisings (upper)	x
	Stock (lower):	x 0.9	Arisings (lower)	x
WASTE SOURCE	Leached hulls and ends from the reprocessing of PWR and BWR fuel.			

PHYSICAL CHARACTERISTICS

General description:	The waste arises as leached hulls and ends from the reprocessing of PWR and BWR fuel. It includes chopped and leached fuel pins and associated fuel assembly debris (end appendages, spacer grids etc.). This is then encapsulated in concrete. No items require special handling. This waste stream does not undergo any physical or chemical processes prior to conditioning.
Physical components (%wt):	Fuel assembly debris 32%, grout 68% (by weight).
Sealed sources:	The waste does not contain sealed sources.
Bulk density (t/m^3):	~2.5
Comment on density:	Density of conditioned waste. Raw waste density ~0.9 t/m^3.

CHEMICAL COMPOSITION

General description and components (%wt):	Zircaloy (26.9%), Inconel (0.6%), stainless steel (4.5%), concrete (68%), UO2 (TR).
Chemical state:	Alkali
Chemical form of radionuclides:	H-3: Within cladding materials. C-14: Not estimated. Cl-36: Present as trace amounts of clathrate compounds of metallic salts readily lost to aqueous solution. Se-79: Not estimated. Tc-99: Not estimated. I-129: Present as trace amounts of clathrate compounds of metallic salts readily lost to aqueous solution. Ra: Not estimated. Th: Not estimated. U: UO2. Np: Not estimated. Pu: PuO2.
Metals and alloys (%wt):	Mostly Zircaloy hulls - rings ~ 50mm length, 10 mm diameter. Significant proportion is bulky stainless steel end appendages varying in size from 100 x 100 x 100mm to 300 x 300 x 300mm, up to 5mm thick.

WASTE STREAM 2F04/C Encapsulated LWR Cladding

	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel	4.5		100.0
Other ferrous metals	TR		
Iron			
Aluminium	0		
Beryllium	TR		
Cobalt	0		
Copper	0		
Lead	0		
Magnox/Magnesium	0		
Nickel	0.60	Inconel is type X750 or 718.	
Titanium	0		
Uranium	0.04		
Zinc	0		
Zircaloy/Zirconium	26.9		
Other metals	0		

Organics (%wt): There are no organic materials present except for nylon and polyurethane or hydrogenated nitrile rubber (from grout pigs) in very small amounts in drums of encapsulated product. Hydrogenated nitrile rubber and/or polyurethane.

	(%wt)	Type(s) and comment	% of total C14 activity
Total cellulosics	0		
Paper, cotton	0		
Wood	0		
Halogenated plastics	0		
Total non-halogenated plastics	TR		
Condensation polymers	TR		
Others	TR		
Organic ion exchange materials	0		
Total rubber	TR		
Halogenated rubber	0		
Non-halogenated rubber	TR		
Hydrocarbons			
Oil or grease			
Fuel			
Asphalt/Tarmac (cont.coal tar)			
Asphalt/Tarmac (no coal tar)			
Bitumen			
Others			
Other organics	0		

Other materials (%wt): OPC/BFS used as conditioning material.

WASTE STREAM 2F04/C Encapsulated LWR Cladding

	(%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.....	68.0		
Sand.....	0	No sand present in encapsulation grout.	
Glass/Ceramics.....	0		
Graphite.....	0		
Desiccants/Catalysts.....	0		
Asbestos.....	0	No abestos present.	
Non/low friable.....			
Moderately friable.....			
Highly friable.....			
Free aqueous liquids.....	0		
Free non-aqueous liquids.....	0		
Powder/Ash.....	0		

Inorganic anions (%wt): No inorganic anions are present, except for minor traces of nitrate.

	(%wt)	Type(s) and comment
Fluoride.....	0	
Chloride.....	0	
Iodide.....	0	
Cyanide.....	0	
Carbonate.....	0	
Nitrate.....	TR	
Nitrite.....	0	
Phosphate.....	0	
Sulphate.....	0	
Sulphide.....	0	

Materials of interest for waste acceptance criteria: The waste contains Zircaloy.

	(%wt)	Type(s) and comment
Combustible metals.....	P	0.269 (1% allowance for Zirconium fines).
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	

WASTE STREAM 2F04/C Encapsulated LWR Cladding

Corrosive materials.....	0	
Pyrophoric materials.....	0	
Generating toxic gases.....	0	
Reacting with water.....	0	
Higher activity particles.....	P	Small fraction may be present.
Soluble solids as bulk chemical compounds.....	P	Some calcium and sodium compounds.

Hazardous substances / non hazardous pollutants: -

	(%wt)	Type(s) and comment
Acrylamide.....		
Benzene.....	0	
Chlorinated solvents.....		
Formaldehyde.....		
Organometallics.....		
Phenol.....	0	
Styrene.....		
Tri-butyl phosphate.....	0	
Other organophosphates.....		
Vinyl chloride.....	0	
Arsenic.....	0	
Barium.....		
Boron.....	0	
Boron (in Boral).....		
Boron (non-Boral).....		
Cadmium.....	0	
Caesium.....		
Selenium.....	0	
Chromium.....	P	Trace present in OPC in ecapsualtion grout.
Molybdenum.....	0	
Thallium.....		
Tin.....	P	Trace present in OPC in encapsulation grout.
Vanadium.....	0	
Mercury compounds.....		
Others.....	0	
Electronic Electrical Equipment (EEE)		
EEE Type 1.....		
EEE Type 2.....		
EEE Type 3.....		
EEE Type 4.....		
EEE Type 5.....		

WASTE STREAM 2F04/C Encapsulated LWR Cladding

Complexing agents (%wt): No

	(%wt)	Type(s) and comment
EDTA.....		
DPTA.....		
NTA.....		
Polycarboxylic acids…….	0	
Other organic complexants.....	0	
Total complexing agents.....	0	

Potential for the waste to contain discrete items: No.

PACKAGING AND CONDITIONING

Container type:

Container	Waste packaged (%vol)	Waste loading (m^3)	Payload (m^3)	Number of packages
500 l drum	100.0	0.508	0.508	3594

Container type comment: Packaging factor 1.12.

Range in container waste volume: Volume is dependant on cutting length i.e. a better packing fraction can be achieved if hulls lengths are shorter but calculations are based on average cutting length.

Other information on containers: Stainless steel drums fitted with lid that has a filter fitted.

Conditioned density (t/m^3): 2.5

Conditioned density comment: -

Other information on conditioning: Waste is already conditioned.

RADIOACTIVITY

Source: The main sources of activity will be fission product carry-over and activation products.

Uncertainty: -

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: The activities are calculated, based on characteristics of LWR fuel reprocessed to date for stocks.

Other information: -

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Nuclide	Mean radioactivity, TBq/m³ Waste at 1.4.2022	Bands and Code	Future arisings	Bands and Code	Nuclide	Mean radioactivity, TBq/m³ Waste at 1.4.2022	Bands and Code	Future arisings	Bands and Code
H 3	2.38E+00	B B 2			Gd 153	1.93E-13	B B 2		
Be 10	7.65E-09	B B 2			Ho 163	1.59E-12	B B 2		
C 14	1.61E-02	B B 2			Ho 166m	9.10E-08	B B 2		
Na 22					Tm 170		8		
Al 26					Tm 171	1.60E-09	B B 2		
Cl 36	4.57E-05	B B 2			Lu 174		8		
Ar 39	8.74E-07	B B 2			Lu 176	1.22E-12	B B 2		
Ar 42		8			Hf 178n		8		
K 40	6.87E-12	B B 2			Hf 182	6.64E-17	B B 2		
Ca 41	2.15E-05	B B 2			Pt 193		8		
Mn 53	3.84E-15	B B 2			Tl 204		8		
Mn 54	5.54E-04	B B 1			Pb 205		5		
Fe 55	1.41E-01	B B 2			Pb 210	7.01E-11	B B 2		
Co 60	3.34E+00	B B 1			Bi 208		8		
Ni 59	8.04E-02	B B 2			Bi 210m		5		
Ni 63	7.48E+00	B B 2			Po 210	6.73E-11	B B 2		
Zn 65	1.57E-04	B B 1			Ra 223	1.24E-09	B B 2		
Se 79	2.11E-06	B B 2			Ra 225	6.61E-12	B B 2		
Kr 81	3.83E-12	B B 2			Ra 226	2.43E-10	B B 2		
Kr 85	5.03E-02	B B 2			Ra 228	1.30E-14	B B 2		
Rb 87	8.10E-10	B B 2			Ac 227	1.25E-09	B B 2		
Sr 90	1.36E+00	B B 2			Th 227	1.23E-09	B B 2		
Zr 93	8.72E-03	B B 2			Th 228	4.16E-07	B B 2		
Nb 91	6.09E-18	B B 2			Th 229	6.62E-12	B B 2		
Nb 92	1.81E-16	B B 2			Th 230	3.11E-08	B B 2		
Nb 93m	6.66E-03	B B 2			Th 232	1.69E-14	B B 2		
Nb 94	8.56E-03	B B 2			Th 234	2.39E-05	B B 2		
Mo 93	3.92E-04	B B 2			Pa 231	2.66E-09	B B 2		
Tc 97	5.27E-15	B B 2			Pa 233	7.38E-06	B B 2		
Tc 99	5.26E-04	B B 2			U 232	4.02E-07	B B 1		
Ru 106	2.56E-02	B B 1			U 233	1.64E-09	B B 1		
Pd 107	2.95E-06	B B 2			U 234	9.23E-05	B B 1		
Ag 108m	7.22E-01	B B 1			U 235	2.42E-06	B B 1		
Ag 110m	1.45E-05	B B 1			U 236	9.58E-06	B B 1		
Cd 109	4.15E-10	B B 2			U 238	2.39E-05	B B 1		
Cd 113m	5.46E-04	B B 2			Np 237	7.39E-06	B B 2		
Sn 119m	1.43E-07	B B 2			Pu 236	1.54E-08	B B 2		
Sn 121m	3.03E-02	B B 2			Pu 238	8.25E-02	B B 1		
Sn 123		8			Pu 239	4.12E-02	B B 1		
Sn 126	1.03E-05	B B 2			Pu 240	4.22E-02	B B 1		
Sb 125	3.33E-01	B B 1			Pu 241	1.83E+00	B B 1		
Sb 126	1.44E-06	B B 2			Pu 242	8.55E-05	B B 1		
Te 125m	8.34E-02	B B 2			Am 241	1.31E-01	B B 2		
Te 127m		8			Am 242m	1.23E-04	B B 2		
I 129	1.07E-06	B B 2			Am 243	2.50E-04	B B 2		
Cs 134	2.28E-02	B B 1			Cm 242	1.01E-04	B B 2		
Cs 135	2.08E-05	B B 2			Cm 243	1.20E-04	B B 2		
Cs 137	1.37E+01	B B 1			Cm 244	5.54E-02	B B 1		
Ba 133	2.92E-11	B B 2			Cm 245	2.33E-06	B B 2		
La 137	8.95E-11	B B 2			Cm 246	3.57E-07	B B 2		
La 138	8.66E-15	B B 2			Cm 248	2.12E-12	B B 2		
Ce 144	2.87E-04	B B 1			Cf 249	1.93E-11	B B 2		
Pm 145	7.99E-12	B B 2			Cf 250	3.23E-11	B B 2		
Pm 147	4.03E-03	B B 2			Cf 251	7.11E-13	B B 2		
Sm 147	2.90E-10	B B 2			Cf 252	2.47E-13	B B 2		
Sm 151	1.23E-02	B B 2			Other a	4.27E-05	B B 2		
Eu 152	8.85E+00	B B 1			Other b/g	1.81E-02	B B 2		
Eu 154	9.50E-02	B B 1			**Total a**	**3.53E-01**	**B B 2**	**0**	
Eu 155	1.50E-03	B B 2			**Total b/g**	**4.06E+01**	**B B 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