WASTE STREAM 2D74 Pile Fuel Storage Pond Ion Exchange Material

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

WASTE VOLUMES

		Reported
Stocks:	At 1.4.2022......................	0.5 m³
Future arisings -	1.4.2022 - 31.3.2023.........	0 m³
	1.4.2023 - 31.3.2024.........	0.5 m³
Total future arisings:		0.5 m³
Total waste volume:		1.0 m³

Comment on volumes: Local Effluent Treatment Plant commenced operation in July 2007 and from this date began to remove beta activity from the pond water on to Ionsiv cartridges. Dewatering date yet to be confirmed, therefore further arisings may occur. During the 20 years of expected operations the plant will be operated to minimise the generation of this secondary waste but ensure discharges and plant conditions are acceptable and meet all regulatory and safety parameters. Note the Ionsiv cartridge was designed to fit into a 250 litre liner for export in the plant 12te flask.

Uncertainty factors on volumes:				
	Stock (upper):	x 1.0	Arisings (upper)	x 1.3
	Stock (lower):	x 1.0	Arisings (lower)	x 0.7

WASTE SOURCE

The waste is a cartridge 580mm diameter 993mm in height containing the ion exchange medium Ionsiv IE-911 (165kg). This becomes radioactive by removing predominately Cs and Sr from the pond water. The cartridge was designed to fit into a 250 litre liner for waste export from the plant in the 12te flask.

PHYSICAL CHARACTERISTICS

General description: The cartridge container has been designed so that it can be handled by the plant and its flasking equipment and is suitable for a number of disposal options. The secondary waste package is not yet confirmed but a couple of options are being progressed with the regulators. Once created the waste will be stable and when the cartridge is fully loaded (used up) it will be stored in the pond. There will be some generation of hydrogen from the radiolysis of water and this is allowed for in the design of the cartridge.

Physical components (%wt): Stainless steel cartridge container (67%), Ion exchange material Ionsiv 911 (33%).

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m³): ~2

Comment on density: The envelope volume of the cartridge is approximately 0.250m3 and its overall mass is approximately 500kg giving a bulk density of 500/0.250kg/m3 = 2,000kg/m3.

CHEMICAL COMPOSITION

General description and components (%wt): Cartridge (67%) is iron with small amounts of carbon, Cr.The Ionsiv (33% of weight) is made up as follows: TiO2 28.6 to 34.8% wt; SiO2 14.8 to 18.2% wt; Nb2O5 18.5 to 22.7% wt; Na2O 3.6% to 4.4% wt; ZrO2 14.1 to 18.8% wt; Cl 0.12 to 0.33% wt.

Chemical state: The waste is neutral and is not strongly oxidising or reducing.

Chemical form of radionuclides: -

Metals and alloys (%wt): -

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

Organics (%wt): -

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

Other materials (%wt): -

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	(%wt)	Type(s) and comment	% of total C14 activity
Inorganic ion exchange materials..	~33.0	Ionsiv IE- 911.	
Inorganic sludges and flocs...........			
Soil...			
Brick/Stone/Rubble.......................			
Cementitious material...................			
Sand...	0		
Glass/Ceramics............................			
Graphite..			
Desiccants/Catalysts....................	0		
Asbestos......................................	0		
Non/low friable........................			
Moderately friable...................			
Highly friable...........................			
Free aqueous liquids....................			
Free non-aqueous liquids.............			
Powder/Ash.................................			

Inorganic anions (%wt): -

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

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	0
Soluble solids as bulk chemical compounds	0

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)	0	
Boron (non-Boral)	0	
Cadmium	0	
Caesium		
Selenium	0	
Chromium	0	
Molybdenum	0	
Thallium		
Tin	0	
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		

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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

Conditioning method: The designated route for the used IonSiv cartridges is to be conditioned in WEP for grouting to immobilise the ion exchange material inside the cartridge, and then 4 cartridges within product drums would be placed in a stillage and sent to EPS3 for storage until a repository is available. Transfers to WEP commenced in Q4 2018/19.

Plant Name: Waste Encapsulation Plant

Location: Sellafield

Plant startup date: Available

Total capacity (m^3/y incoming waste): -

Target start date for packaging this stream: -

Throughput for this stream (m^3/y incoming waste): -

Other information: -

Likely container type:

Container	Waste packaged (%vol)	Waste loading (m^3)	Payload (m^3)	Number of packages
500 l drum	100.0	0.472	0.472	3

Likely container type comment: The existing route is that the used Ionsiv cartridges loaded with predominately Cs and Sr are to initially be stored in the pond. The cartridges will be exported in a 250 litre liner to WEP. The envelope volume of 0.25m³ containing the ion exchange material loaded with beta activity will be immobilised in situ using a cement grout formulation.

Range in container waste volume: -

Other information on containers: -

Likely conditioning matrix: Cement

Other information: -

Conditioned density (t/m^3): -

Conditioned density comment: -

Other information on conditioning: -

Opportunities for alternative disposal routing: Not yet determined

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Baseline Management Route	Opportunity Management Route	Stream volume (%)	Estimated Date that Opportunity will be realised	Opportunity Confidence	Comment
-	-	-	-	-	-

RADIOACTIVITY

Source: The activity originates from the corrosion of fuel and is predominately the soluble fission products Cs and Sr, which are transferred to the pond water. The pond water is then treated by passing through the Local Effluent Treatment Plant (LETP) which removes the Cs and Sr on to the Ionsiv contained in a purpose built cartridge.

Uncertainty: Having been operational for over 10 years, the IonSiv's are proving highly effective in absorbing beta activity from the pond water. The radionuclides removed are predominately Cs and Sr. Each cartridge will changed once the overall activity of each pair is analysed to be around 7-8TBq. under certain operational circumstances this may be higher with the possibility of activity levels of 20TBq however it is more likely to be 11-12TBq as the Ionsivs will be "blinded" prior to reaching this activity level. Early removal of fuel from the pond has led to a revised downward estimation of lifetime cartridge requirements from previous submissions. As caesium 137 is prefentially removed over strontium 90 and the cartridges will always be changed on total activity, there will be a change in the Cs to Sr ratio over time. For stocks the ratio is 60:40, for arisings this has been changed to 50:50.

Definition of total alpha and total beta/gamma: The nature and radiological fingerprint of the sludge differs with the pond areas, for instance, within the bays there is a higher fuel content within the sludge than there is within the pond, as activities in the bays is disturbed we may note different ratios of radionuclides on the cartridges. Sampling of these areas is an ongoing actitivity and this data will be utilised to ascertain the radiological fingerprint on the cartridges for disposal.

Measurement of radioactivities: The loading of activity onto the Ionsiv cartridge will be calculated by sampling and flow measurements. The samples will be analysed for total beta and alpha and other radionuclides and by spreadsheet calculations. The quantities of radioactivity absorbed on to the Ionsiv cartridges will be calculated and monitored to ensure it remains below 7TBq beta per pair of cartridges.

Other information: The activity loaded on to the Ionsiv cartridges will be estimated from sampling and volume calculation (from flow meters). The calculated radionuclide inventory will be from analysis data comprising of total alpha, total beta and the individual isotopes Cs and Sr (the main nuclides involved).

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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					Gd 153				
Be 10					Ho 163				
C 14					Ho 166m				
Na 22					Tm 170				
Al 26					Tm 171				
Cl 36					Lu 174				
Ar 39					Lu 176				
Ar 42					Hf 178n				
K 40					Hf 182				
Ca 41					Pt 193				
Mn 53					Tl 204				
Mn 54					Pb 205				
Fe 55					Pb 210				
Co 60					Bi 208				
Ni 59					Bi 210m				
Ni 63					Po 210				
Zn 65					Ra 223				
Se 79					Ra 225				
Kr 81					Ra 226				
Kr 85					Ra 228				
Rb 87					Ac 227				
Sr 90	4.76E+00	AA 1	5.40E+00	AA 2	Th 227				
Zr 93					Th 228				
Nb 91					Th 229				
Nb 92					Th 230				
Nb 93m					Th 232				
Nb 94					Th 234				
Mo 93					Pa 231				
Tc 97					Pa 233				
Tc 99					U 232				
Ru 106					U 233				
Pd 107					U 234				
Ag 108m					U 235				
Ag 110m					U 236				
Cd 109					U 238				
Cd 113m					Np 237				
Sn 119m					Pu 236				
Sn 121m					Pu 238				
Sn 123					Pu 239				
Sn 126					Pu 240				
Sb 125					Pu 241				
Sb 126					Pu 242				
Te 125m					Am 241				
Te 127m					Am 242m				
I 129					Am 243				
Cs 134					Cm 242				
Cs 135					Cm 243				
Cs 137	5.10E+00	AA 1	5.40E+00	AA 2	Cm 244				
Ba 133					Cm 245				
La 137					Cm 246				
La 138					Cm 248				
Ce 144					Cf 249				
Pm 145					Cf 250				
Pm 147					Cf 251				
Sm 147					Cf 252				
Sm 151					Other a				
Eu 152					Other b/g				
Eu 154					**Total a**	**NE**		**NE**	
Eu 155					**Total b/g**	**NE**		**NE**	

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