WASTE STREAM 5B05/C Cemented DFR Raffinate

SITE	Dounreay
SITE OWNER	Nuclear Decommissioning Authority
WASTE CUSTODIAN	Dounreay Site Restoration Limited
WASTE TYPE	ILW
Is the waste subject to Scottish Policy:	Yes

WASTE VOLUMES

		Conditioned	Packaged
Stocks:	At 1.4.2022.....	439.0 m³	501.3 m³
Total future arisings:		0 m³	0 m³
Total waste volume:		439.0 m³	501.3 m³
Number of waste packages in stock:	At 1.4.2022.....	878 package(s)	

Comment on volumes: There will be no further arisings of raw waste.

Uncertainty factors on volumes:

Stock (upper):	x 1.0	Arisings (upper)	x
Stock (lower):	x 1.0	Arisings (lower)	x

WASTE SOURCE Dounreay Fast Reactor (DFR) fuel reprocessing.

PHYSICAL CHARACTERISTICS

General description: The waste consists of a cemented ferric/aluminium nitrate solution containing fission products and some actinides from reprocessing spent DFR fuel and some plutonium fuel. There are no large items in the waste. The waste has been cemented into 500 litre drums.

Physical components (%vol): Cemented aqueous liquors (100%).

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m³): ~1.67

Comment on density: The density is about 1.67 te/m3. The raw waste density has been measured around 1.18 te/m3.

CHEMICAL COMPOSITION

General description and components (%wt): The waste is a cement product containing neutralised DFR raffinate. Cementitious grout - 100 %

Chemical state: Alkali

Chemical form of radionuclides:
H-3: Likely to be present, form unknown.
C-14: Likely to be present, form unknown.
Cl-36: Likely to be present, form unknown.
Se-79: Likely to be present, form unknown.
Tc-99: Likely to be present, form unknown.
I-129: Likely to be present, form unknown.
Ra: Likely to be present, form unknown.
Th: Likely to be present, form unknown.
U: Likely to be present, form unknown.
Np: Likely to be present, form unknown.
Pu: Likely to be present, form unknown.

Metals and alloys (%wt): -

	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....	0		
Other ferrous metals.....	0		
Iron.....	~0.49		
Aluminium.....	P		
Beryllium.....	0		

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Cobalt	0	
Copper	0	
Lead	P	
Magnox/Magnesium	0	
Nickel	0	
Titanium		
Uranium	P	
Zinc	0	
Zircaloy/Zirconium	0	
Other metals	0.31	A range of metallic species are present (aluminium, cadmium, chromium, mercury, molybdenum, lead, sodium, phosphorus and uranium) at trace levels in the cemented wasteform.

Organics (%wt): The raw waste may have contained trace quantities of odourless kerosene, MBP, DBP and TBP. No halogenated plastics or rubbers are present.

	(%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	TR		

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	99.2		

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

Inorganic anions (%wt): In addition to nitrate, sulphate and chloride, the waste contains trace quantities of fluoride (<0.008%). Phosphates may be present.

	(%wt)	Type(s) and comment
Fluoride	TR	
Chloride	<0.01	
Iodide	0	
Cyanide	0	
Carbonate	0	
Nitrate	5.0	
Nitrite	NE	
Phosphate	NE	
Sulphate	<0.03	
Sulphide	0	

Materials of interest for waste acceptance criteria: The waste also contains aluminium, cadmium, chromium, mercury, molybdenum, lead, sodium, phosphorus and uranium at trace quantities.

	(%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	

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Soluble solids as bulk chemical compounds.....	0

Hazardous substances / non hazardous pollutants: The waste contains a small amount of cadmium (0.002%).

	(%wt)	Type(s) and comment
Acrylamide.....		
Benzene.....	NE	
Chlorinated solvents.....		
Formaldehyde.....		
Organometallics.....		
Phenol.....	NE	
Styrene.....		
Tri-butyl phosphate.....	NE	
Other organophosphates.....		
Vinyl chloride.....	NE	
Arsenic.....	NE	
Barium.....		
Boron.....	NE	
Boron (in Boral).....		
Boron (non-Boral).....		
Cadmium.....	P	0.002 wt%
Caesium.....		
Selenium.....	NE	
Chromium.....	P	
Molybdenum.....	P	
Thallium.....		
Tin.....	NE	
Vanadium.....	NE	
Mercury compounds.....		
Others.....	P	
Electronic Electrical Equipment (EEE)		
EEE Type 1.....		
EEE Type 2.....		
EEE Type 3.....		
EEE Type 4.....		
EEE Type 5.....		

Complexing agents (%wt):

	(%wt)	Type(s) and comment
EDTA.....		
DPTA.....		
NTA.....		
Polycarboxylic acids……		
Other organic complexants.....	TR	The raw waste may have contained trace

quantities of odourless kerosene, MBP, DBP and TBP (butyl phosphates).

Total complexing agents..... TR

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	0.5	0.5	878

Container type comment: The waste is already conditioned.

Range in container waste volume: -

Other information on containers: Stainless Steel. The container is 316 stainless steel .

Conditioned density (t/m^3): ~1.67

Conditioned density comment: The density is about 1.67t/m^3.

Other information on conditioning: -

RADIOACTIVITY

Source: Activity arises mainly from fission products from the reactor fuel.

Uncertainty: Analysis figures are accurate to within a factor of three.

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: All tanks have been samples and analysed during the transfer process in preparation for cementation. Inventory presented is derived from analysis results, FISPIN data and assumption regarding mixing of raffinates.

Other information: Some uncertainties remain outstanding on the inventory assumptions. Specific activity uses UKRWI 2019 data decayed to 2022

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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	6.25E-04	B B 2			Gd 153	8.43E-28	B B 2		
Be 10	1.99E-07	B B 2			Ho 163	7.93E-14	B B 2		
C 14	7.31E-05	B B 2			Ho 166m	5.27E-10	B B 2		
Na 22					Tm 170	2.34E-45	B B 2		
Al 26					Tm 171	1.74E-12	B B 2		
Cl 36	2.88E-05	B B 2			Lu 174	5.16E-15	B B 2		
Ar 39					Lu 176	2.22E-18	B B 2		
Ar 42					Hf 178n	7.98E-19	B B 2		
K 40					Hf 182	9.02E-17	B B 2		
Ca 41	2.48E-04	B B 2			Pt 193				
Mn 53					Tl 204	1.17E-28	B B 2		
Mn 54	1.10E-15	B B 2			Pb 205	4.3E-27	B B 2		
Fe 55	5.14E-04	B B 2			Pb 210	2.32E-09	B B 2		
Co 60	2.66E-04	B B 2			Bi 208	1.75E-23	B B 2		
Ni 59	3.95E-04	B B 2			Bi 210m	6.78E-24	B B 2		
Ni 63	7.00E-02	B B 2			Po 210	2.28E-09	B B 2		
Zn 65	1.87E-20	B B 2			Ra 223	2.86E-08	B B 2		
Se 79	8.35E-05	B B 2			Ra 225	6.38E-11	B B 2		
Kr 81					Ra 226	5.03E-09	B B 2		
Kr 85					Ra 228	3.43E-14	B B 2		
Rb 87	1.07E-08	B B 2			Ac 227	2.86E-08	B B 2		
Sr 90	1.26E+01	B B 2			Th 227	2.82E-08	B B 2		
Zr 93	8.72E-04	B B 2			Th 228	1.76E-07	B B 2		
Nb 91	3.35E-18	B B 2			Th 229	6.38E-11	B B 2		
Nb 92	2.25E-17	B B 2			Th 230	2.68E-07	B B 2		
Nb 93m	1.18E-03	B B 2			Th 232	3.47E-14	B B 2		
Nb 94	9.10E-05	B B 2			Th 234	2.38E-07	B B 2		
Mo 93	5.58E-04	B B 2			Pa 231	3.8E-08	B B 2		
Tc 97	4.21E-16	B B 2			Pa 233	1.38E-05	B B 2		
Tc 99	6.41E-03	B B 2			U 232	1.71E-07	B B 2		
Ru 106	7.07E-12	B B 2			U 233	3.15E-09	B B 2		
Pd 107	1.25E-05	B B 2			U 234	6.52E-05	B B 2		
Ag 108m	1.26E-11	B B 2			U 235	1.65E-06	B B 2		
Ag 110m	1.47E-23	B B 2			U 236	9.91E-07	B B 2		
Cd 109	1.00E-20	B B 2			U 238	2.38E-07	B B 2		
Cd 113m	7.41E-04	B B 2			Np 237	1.39E-05	B B 2		
Sn 119m	2.51E-19	B B 2			Pu 236	1.15E-10	B B 2		
Sn 121m	7.61E-03	B B 2			Pu 238	5.19E-02	B B 2		
Sn 123	4.54E-40	B B 2			Pu 239	8.85E-02	B B 2		
Sn 126	9.52E-05	B B 2			Pu 240	9.34E-02	B B 2		
Sb 125	4.65E-05	B B 2			Pu 241	3.12E-01	B B 2		
Sb 126	1.33E-05	B B 2			Pu 242	6.38E-05	B B 2		
Te 125m	1.16E-05	B B 2			Am 241	1.83E-01	B B 2		
Te 127m	9.58E-46	B B 2			Am 242m	2.14E-03	B B 2		
I 129	8.25E-07	B B 2			Am 243	1.70E-04	B B 2		
Cs 134	6.49E-07	B B 2			Cm 242	1.76E-03	B B 2		
Cs 135	5.49E-04	B B 2			Cm 243	2.05E-04	B B 2		
Cs 137	1.45E+01	B B 2			Cm 244	1.03E-03	B B 2		
Ba 133	4.49E-10	B B 2			Cm 245	5.12E-07	B B 2		
La 137	8.46E-11	B B 2			Cm 246	2.19E-08	B B 2		
La 138	3.57E-15	B B 2			Cm 248	8.89E-14	B B 2		
Ce 144	2.82E-15	B B 2			Cf 249	7.18E-13	B B 2		
Pm 145	3.26E-12	B B 2			Cf 250	4.66E-14	B B 2		
Pm 147	8.30E-04	B B 2			Cf 251	1.34E-16	B B 2		
Sm 147	4.1E-09	B B 2			Cf 252	1.29E-22	B B 2		
Sm 151	7.14E-01	B B 2			Other a				
Eu 152	3.95E-06	B B 2			Other b/g				
Eu 154	1.20E-03	B B 2			**Total a**	**4.20E-01**	**B B 2**	**0**	
Eu 155	2.12E-03	B B 2			**Total b/g**	**2.81E+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