

WASTE STREAM	5B01	PFR Raffinate
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SITE Dounreay
SITE OWNER Nuclear Decommissioning Authority
WASTE CUSTODIAN Dounreay Site Restoration Limited
WASTE TYPE ILW

WASTE VOLUMES

		Reported
Stocks:	At 1.4.2019.....	166.2 m ³
Total future arisings:		0 m ³
Total waste volume:		166.2 m ³

Comment on volumes: There will be no further arisings of this waste stream. Stocks will reduce in the coming submissions as the waste is conditioned. This will produce stocks within 5B01/C. Stocks uncertainty related only to tank level monitoring equipment error margin. There will be no future arisings. Tank washouts will be undertaken but have not been quantified as yet.

Uncertainty factors on volumes:	Stock (upper):	x 1.05	Arisings (upper)	x
	Stock (lower):	x 0.95	Arisings (lower)	x

WASTE SOURCE The source of this waste is from the reprocessing of Prototype Fast Reactor (PFR) fuel.

PHYSICAL CHARACTERISTICS

General description: The waste is a raffinate from fuel reprocessing. There are no large items in the waste. Some of the raffinate has been evaporated to reduce its volume.

Physical components (%wt): Aqueous liquor (100%).

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m³): 1.27

Comment on density: The density of the raffinate has historically been measured at about 1.27 t/m³.

CHEMICAL COMPOSITION

General description and components (%wt): The raffinate is a nitric acid solution containing fission products and trace quantities of uranium and plutonium. Nitric acid (96.6%) and metals in solution (copper, sodium, iron, cadmium, nickel and zinc) (3.4%).

Chemical state: Acid

Chemical form of radionuclides:

- H-3: Likely to be present as water.
- C-14: Unknown - possibly present as traces of dissolved solvent.
- 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 as nitrate.
- Th: Present as nitrate.
- U: Present as nitrate.
- Np: Likely to be present, form unknown.
- Pu: Present as nitrate.

Metals and alloys (%wt):

-
- Stainless steel..... 0
- Other ferrous metals..... P
- Iron.....
- Aluminium.....
- Beryllium..... 0
- Cobalt..... 0
- Copper..... P
- Lead..... 0
- Magnox/Magnesium..... 0

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Nickel.....	
Titanium.....	0
Uranium.....	0
Zinc.....	P
Zircaloy/Zirconium.....	0
Other metals.....	3.4

Covers a range of metallic species which are in solution including sodium, cadmium and nickel.

Organics (%wt):

The only organic materials present in the waste are trace quantities of complexing agents.

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):

-	
Inorganic ion exchange materials.	0
Inorganic sludges and flocs.....	0
Soil.....	0
Brick/Stone/Rubble.....	0
Cementitious material.....	0
Sand.....	0
Glass/Ceramics.....	0
Graphite.....	0
Desiccants/Catalysts.....	
Asbestos.....	0
Non/low friable.....	
Moderately friable.....	
Highly friable.....	
Free aqueous liquids.....	96.6

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	Free non-aqueous liquids.....	0
	Powder/Ash.....	0
Inorganic anions (%wt):	The waste contains nitrate and traces of sulphates, phosphates and chlorides.	
	Fluoride.....	0
	Chloride.....	TR
	Iodide.....	0
	Cyanide.....	0
	Carbonate.....	0
	Nitrate.....	30.0
	Nitrite.....	0
	Phosphate.....	TR
	Sulphate.....	TR
	Sulphide.....	0

Materials of interest for waste acceptance criteria:

	The waste contains nitric acid.	
	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.....	P =96.6%
	Pyrophoric materials.....	0
	Generating toxic gases.....	P =96.6%
	Reacting with water.....	0
	Active particles.....	0
	Soluble solids as bulk chemical compounds.....	0

Hazardous substances / non hazardous pollutants:

	Cadmium is present in solution in small quantities. Nitric acid (96.6%).	
	Acrylamide.....	
	Benzene.....	
	Chlorinated solvents.....	
	Formaldehyde.....	
	Organometallics.....	
	Phenol.....	
	Styrene.....	
	Tri-butyl phosphate.....	
	Other organophosphates.....	
	Vinyl chloride.....	

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Arsenic.....
 Barium.....
 Boron.....
 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):

Yes
 EDTA.....
 DPTA.....
 NTA.....
 Polycarboxylic acids.....
 Other organic complexants..... TR

 Total complexing agents..... TR

Traces of organic complexing agents (MDP, DBP, TBP) may be present.

PACKAGING AND CONDITIONING

Conditioning method: The current strategy is neutralisation of the PFR raffinate followed by immobilisation with cement into 500 litre drums in a modified Dounreay Cementation Plant.
 Plant Name: Dounreay Cementation Plant
 Location: Dounreay
 Plant startup date: 01/09/1996
 Total capacity (m³/y incoming waste): ~200.0
 Target start date for packaging this stream: 2017
 Throughput for this stream (m³/y incoming waste): ~177.0
 Other information: -

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Likely container type:	Container	Waste packaged (%vol)	Waste loading (m ³)	Payload (m ³)	Number of packages
	500 l drum	100.0	0.227	0.5	733

Likely container type comment: The loading will vary slightly , depending upon the chemical composition of the raffinate in that tank.

Range in container waste volume: The target loading is 0.28 m3 of raw raffinate per drum, but is dependent on composition of the raffinate in the tank. A final volume of 328 l of neutralised liquor will be dispensed to each drum.

Other information on containers: Stainless Steel. The container will be manufactured from 316 stainless steel.

Likely conditioning matrix: PFA/OPC

Other information: The raffinate will probably be incorporated into a cement based lattice using a 1:2 PFA/OPC formulation, with an average of 227 litres of raffinate being incorporated into each drum. The waste will undergo a neutralisation process using sodium hydroxide.

Conditioned density (t/m³): ~1.77

Conditioned density comment: The density of the conditioned waste will probably be about 1.8 t/m³.

Other information on conditioning: -

Opportunities for alternative disposal routing: No

Treatment	Stream volume (%)	Comment
-	-	-

RADIOACTIVITY

Source: Activity arises mainly from the fission products separated from the irradiated Prototype Fast Reactor fuel at reprocessing

Uncertainty: The activity accuracy is within a factor of 3 for stocks.

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: Samples were taken from the tanks and subsequently analysed. These results gave specific activities for the principle radionuclides. Other specific activities were estimated from earlier results and Fispin calculations.

Other information: Activities are based on a combination of analysis and FISPIN data. The total activities of stocks are for partially evaporated liquor; there will be no further arisings. The range in activity levels are based on samples of the PFR raffinate tanks in November 2003. Alpha 11 - 99 TBq/m³, beta/gamma 150 - 1,300 TBq/m³. The intention is to blend liquors from each of the four tanks to provide a consistent feedstock for processing.

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Nuclide	Mean radioactivity, TBq/m ³				Nuclide	Mean radioactivity, TBq/m ³			
	Waste at 1.4.2019	Bands and Code	Future arisings	Bands and Code		Waste at 1.4.2019	Bands and Code	Future arisings	Bands and Code
H 3	8.14E-03	BB 1			Gd 153	2.69E-16	BB 2		
Be 10	2.32E-09	BB 2			Ho 163	6.89E-10	BB 2		
C 14	9.52E-05	BB 2			Ho 166m	7.33E-08	BB 2		
Na 22					Tm 170	1.86E-24	BB 2		
Al 26					Tm 171	2.7E-08	BB 2		
Cl 36	4.73E-09	BB 2			Lu 174	5.83E-09	BB 2		
Ar 39					Lu 176	3.19E-14	BB 2		
Ar 42					Hf 178n	1.22E-07	BB 2		
K 40	3.49E-10	BB 2			Hf 182	5.94E-13	BB 2		
Ca 41	3.92E-07	BB 2			Pt 193	4.67E-06	BB 2		
Mn 53	2.99E-09	BB 2			Tl 204	2.4E-05	BB 2		
Mn 54	2.12E-09	BB 2			Pb 205	1.72E-10	BB 2		
Fe 55	3.1E-03	BB 2			Pb 210	1.67E-10	BB 2		
Co 60	2.51E-02	BB 1			Bi 208	1.29E-10	BB 2		
Ni 59	7.06E-04	BB 2			Bi 210m	4.35E-11	BB 2		
Ni 63	3.09E-02	BB 2			Po 210	1.6E-10	BB 2		
Zn 65	8E-13	BB 2			Ra 223	2.95E-09	BB 2		
Se 79	2.16E-04	BB 2			Ra 225	1.27E-10	BB 2		
Kr 81					Ra 226	5.79E-10	BB 2		
Kr 85					Ra 228	5.66E-12	BB 2		
Rb 87	4.39E-08	BB 2			Ac 227	2.96E-09	BB 2		
Sr 90	7.15E+01	BB 1			Th 227	2.91E-09	BB 2		
Zr 93	4.72E-03	BB 2			Th 228	2.16E-07	BB 2		
Nb 91	5.35E-06	BB 2			Th 229	1.27E-10	BB 2		
Nb 92	1.73E-10	BB 2			Th 230	7.21E-08	BB 2		
Nb 93m	5.49E-03	BB 2			Th 232	5.91E-12	BB 2		
Nb 94	5.57E-05	BB 2			Th 234	4.41E-06	BB 2		
Mo 93	4.11E-04	BB 2			Pa 231	5.55E-09	BB 2		
Tc 97	3.37E-12	BB 2			Pa 233	4.05E-04	BB 2		
Tc 99	4.96E-02	BB 2			U 232	1.92E-07	BB 2		
Ru 106	1.05E-04	BB 2			U 233	5.89E-08	BB 2		
Pd 107	1.08E-03	BB 2			U 234	8.9E-05	BB 1		
Ag 108m	3.52E-06	BB 2			U 235	1.71E-07	BB 1		
Ag 110m	3.54E-11	BB 2			U 236	4.42E-07	BB 1		
Cd 109	4.59E-09	BB 2			U 238	4.41E-06	BB 1		
Cd 113m	6.84E-03	BB 2			Np 237	4.06E-04	BB 2		
Sn 119m	3.12E-11	BB 2			Pu 236	1.22E-09	BB 2		
Sn 121m	1.66E-01	BB 2			Pu 238	1.31E+00	BB 1		
Sn 123	4.19E-21	BB 2			Pu 239	1.49E-01	BB 1		
Sn 126	1.89E-03	BB 2			Pu 240	1.63E-01	BB 1		
Sb 125	8.99E-02	BB 2			Pu 241	2.08E+00	BB 1		
Sb 126	2.65E-04	BB 2			Pu 242	1.24E-04	BB 1		
Te 125m	2.25E-02	BB 2			Am 241	2.76E+01	BB 1		
Te 127m	7.36E-27	BB 2			Am 242m	7.82E-01	BB 2		
I 129	1.25E-04	BB 2			Am 243	5.06E-02	BB 2		
Cs 134	1.11E-02	BB 1			Cm 242	6.45E-01	BB 2		
Cs 135	6.1E-03	BB 2			Cm 243	1.49E-01	BB 2		
Cs 137	2.07E+02	BB 1			Cm 244	1.3E+00	BB 2		
Ba 133	2.69E-05	BB 2			Cm 245	1.36E-04	BB 2		
La 137	4.38E-08	BB 2			Cm 246	5.39E-06	BB 2		
La 138	2.1E-13	BB 2			Cm 248	1.91E-11	BB 2		
Ce 144	5.48E-07	BB 2			Cf 249	1.46E-10	BB 2		
Pm 145	3.81E-07	BB 2			Cf 250	5.37E-11	BB 2		
Pm 147	1.1E+00	BB 2			Cf 251	2.69E-14	BB 2		
Sm 147	3.25E-08	BB 2			Cf 252	1.1E-16	BB 2		
Sm 151	1.09E+01	BB 2			Other a				
Eu 152	7.28E-05	BB 2			Other b/g				
Eu 154	1.16E+00	BB 1			Total a	3.14E+01	BB 2	0	
Eu 155	7.51E-01	BB 1			Total b/g	2.96E+02	BB 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