

<b>WASTE STREAM</b>	<b>5B325</b>	<b>DFR Ion Exchange Columns</b>
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**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**

		Reported
Stocks:	At 1.4.2022.....	1.6 m <sup>3</sup>
Future arisings -	1.4.2031 - 31.3.2032.....	<< 0.1 m <sup>3</sup>
	1.4.2032 - 31.3.2033.....	0.2 m <sup>3</sup>
	1.4.2033 - 31.3.2034.....	0.2 m <sup>3</sup>
Total future arisings:		0.4 m <sup>3</sup>
Total waste volume:		2.0 m <sup>3</sup>

Comment on volumes: It should be noted that the DSRL site programme is provisional and that arisings dates are subject to change.

Uncertainty factors on volumes: Stock (upper): x 1.02 Arisings (upper) x 1.1  
 Stock (lower): x 0.98 Arisings (lower) x 0.9

**WASTE SOURCE** The ion-exchange columns were used in a treatment plant to remove radioactivity, mainly Cs-137, from DFR sodium/potassium alloy, which was used as a reactor coolant and primary heat exchanger.

**PHYSICAL CHARACTERISTICS**

General description: Cs treatment ion exchange columns will be fabricated from 40 mm thick polypropylene to prevent any adverse interaction between the chloride ions in the process liquor and steel components. The column will be completely enclosed in a 3 mm 304L stainless steel container that will provide protection during handling and provide the long-term containment once chloride ions have been flushed from the columns after use.

Physical components (%wt): Stainless steel (55%), polypropylene (21%), Cs Treat resin (24%).

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m<sup>3</sup>): 0.8

Comment on density: -

**CHEMICAL COMPOSITION**

General description and components (%wt): Stainless steel (55%), polypropylene (21%), Cs Treat resin (24%).

Chemical state: Neutral

Chemical form of radionuclides: -

Metals and alloys (%wt): Stainless steel is present as the 3 mm thick column skin.

	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....	55.0	304L	
Other ferrous metals.....	0		
Iron.....			
Aluminium.....			
Beryllium.....	0		
Cobalt.....	0		
Copper.....			
Lead.....	0		

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Magnox/Magnesium.....	0
Nickel.....	
Titanium.....	
Uranium.....	0
Zinc.....	0
Zircaloy/Zirconium.....	0
Other metals.....	0

Organics (%wt): Cs treatment ion exchange columns will be fabricated from 40 mm thick polypropylene to prevent any adverse interaction between the chloride ions in the process liquor and steel components.

	(%wt)	Type(s) and comment	% of total C14 activity
Total cellulose.....	0		
Paper, cotton.....	0		
Wood.....	0		
Halogenated plastics .....	0		
Total non-halogenated plastics.....	21.0		
Condensation polymers.....	0		
Others.....	21.0		
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): Cs Treat resin [Potassium Hexacyano Cobalt(II) - Ferrate(II)] is odourless, non-toxic, non-flammable, and has a brown/black granular appearance. Hydrogen cyanide may evolve if heated with strong mineral acids.

	(%wt)	Type(s) and comment	% of total C14 activity
Inorganic ion exchange materials..	24.0		
Inorganic sludges and flocs.....	0		
Soil.....	0		
Brick/Stone/Rubble.....	0		
Cementitious material.....	0		
Sand.....	0		
Glass/Ceramics.....			
Graphite.....	0		
Desiccants/Catalysts.....			

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

Inorganic anions (%wt):           There are no inorganic anions present.

	(%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:           There are no hazardous materials present.

	(%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.....	NE	
Soluble solids as bulk chemical compounds.....	0	

Hazardous substances / non hazardous pollutants:           -

	(%wt)	Type(s) and comment
Acrylamide.....		

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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.....	NE
Caesium.....	
Selenium.....	NE
Chromium.....	NE
Molybdenum.....	NE
Thallium.....	
Tin.....	NE
Vanadium.....	NE
Mercury compounds.....	
Others.....	NE
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	

Potential for the waste to contain discrete items:      No.

**PACKAGING AND CONDITIONING**

Conditioning method:      The columns will be immobilised by first filling with polymer to immobilise the ion exchange material, then by cementing into a 500 litre drum.

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Plant Name: RHILW Repackaging facility  
 Location: Dounreay  
 Plant startup date: 2028  
 Total capacity (m<sup>3</sup>/y incoming waste): -  
 Target start date for packaging this stream: 2031  
 Throughput for this stream (m<sup>3</sup>/y incoming waste): -  
 Other information: RHILW Repackaging facility is currently in design phase

Likely container type:	Container	Waste packaged (%vol)	Waste loading (m <sup>3</sup> )	Payload (m <sup>3</sup> )	Number of packages
	500 l drum	100.0	~0.3	0.5	7

Likely container type comment: The conditioning factor will be 1.67 if a single column is immobilised in each 500 litre drum.  
 Range in container waste volume: Waste loading will be variable and dependant on nuclear material content of the wastes. Assume 3:2 Z6033 to 500L drum ratio. Assume Z6033 loading @ 0.2m<sup>3</sup> =0.6m<sup>3</sup> in 2 500L drums (1m<sup>3</sup>) = 0.3m<sup>3</sup> per 500L drum.  
 Other information on containers: -  
 Likely conditioning matrix: Cement  
 Other information: -  
 Conditioned density (t/m<sup>3</sup>): ~2.5  
 Conditioned density comment: Density is if waste is grouted directly into 500 litre drums. Assume density similar to CHILW repack  
 Other information on conditioning: -  
 Opportunities for alternative disposal routing: No

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

### RADIOACTIVITY

Source: The activity arises from the decontamination of DFR NaK coolant by ion-exchange. The activity is predominantly caesium.  
 Uncertainty: Specific Activity data was taken from the DFR IXC LoC (both stocks and arisings). Data are best estimates.  
 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: Ion exchange columns will be a maximum of 200 TBq Cs137.  
 Other information: Specific Activity uses UKRWI 2019 data decayed to 2022

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Nuclide	Mean radioactivity, TBq/m <sup>3</sup>				Nuclide	Mean radioactivity, TBq/m <sup>3</sup>			
	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					Gd 153				
Be 10					Ho 163				
C 14					Ho 166m				
Na 22	4.98E-06	CC 2	9.22E-06	CC 2	Tm 170				
Al 26					Tm 171				
Cl 36					Lu 174				
Ar 39					Lu 176				
Ar 42					Hf 178n				
K 40	1.48E-02	CC 2	1.48E-02	CC 2	Hf 182				
Ca 41					Pt 193				
Mn 53					Tl 204				
Mn 54					Pb 205				
Fe 55					Pb 210		2.74E-10	CC 2	
Co 60					Bi 208				
Ni 59					Bi 210m				
Ni 63					Po 210		2.29E-10	CC 2	
Zn 65					Ra 223		1.1E-16	CC 2	
Se 79					Ra 225		1.35E-18	CC 2	
Kr 81					Ra 226		3.07E-09	CC 2	
Kr 85					Ra 228		2.64E-20	CC 2	
Rb 87					Ac 227		1.24E-16	CC 2	
Sr 90	4.64E-03	CC 2	4.98E-03	CC 2	Th 227		1.14E-16	CC 2	
Zr 93					Th 228		5.94E-21	CC 2	
Nb 91					Th 229		1.43E-18	CC 2	
Nb 92					Th 230		1.83E-12	CC 2	
Nb 93m					Th 232		2.39E-19	CC 2	
Nb 94					Th 234		8.79E-15	CC 2	
Mo 93					Pa 231		3.99E-15	CC 2	
Tc 97					Pa 233		2.33E-09	CC 2	
Tc 99					U 232				
Ru 106					U 233		1.53E-14	CC 2	
Pd 107					U 234		1.32E-07	CC 2	
Ag 108m					U 235	8E-08	CC 2	1.26E-10	CC 2
Ag 110m					U 236			3.23E-09	CC 2
Cd 109					U 238	1.44E-07	CC 2	9.08E-15	CC 2
Cd 113m					Np 237			2.42E-09	CC 2
Sn 119m					Pu 236				
Sn 121m					Pu 238	2.91E-05	CC 2	1.54E-02	CC 2
Sn 123					Pu 239	1.32E-03	CC 2	4.26E-02	CC 2
Sn 126					Pu 240			3.68E-02	CC 2
Sb 125					Pu 241			7.41E-02	CC 2
Sb 126					Pu 242			1.95E-05	CC 2
Te 125m					Am 241			2.55E-03	CC 2
Te 127m					Am 242m				
I 129					Am 243			4.39E-10	CC 2
Cs 134	4.08E-06	CC 2	8.25E-06	CC 2	Cm 242			1.03E-08	CC 2
Cs 135	3.2E-03	CC 2	3.2E-03	CC 2	Cm 243			6.82E-10	CC 2
Cs 137	1.38E+02	CC 2	1.47E+02	CC 2	Cm 244			4.79E-05	CC 2
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			9.20E-09	CC 2
Eu 152					Other b/g			1.39E+02	CC 2
Eu 154					<b>Total a</b>	<b>1.35E-03</b>	<b>CC 2</b>	<b>9.74E-02</b>	<b>CC 2</b>
Eu 155					<b>Total b/g</b>	<b>1.38E+02</b>	<b>CC 2</b>	<b>2.87E+02</b>	<b>CC 2</b>

**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