WASTE STREAM 6N03 Reflectors

SITE	Rutherford Appleton Laboratory
SITE OWNER	Minor Waste Producers
WASTE CUSTODIAN	Minor Waste Producers
WASTE TYPE	ILW
Is the waste subject to Scottish Policy:	No

WASTE VOLUMES

		Reported
Stocks:	At 1.4.2022.....	2.6 m^3
Future arisings -	1.4.2022 - 31.3.2023.....	0 m^3
	1.4.2023 - 31.3.2024.....	0 m^3
	1.4.2024 - 31.3.2025.....	0 m^3
	1.4.2025 - 31.3.2037.....	~1.0 m^3
Total future arisings:		1.0 m^3
Total waste volume:		3.6 m^3

Comment on volumes: The neutron reflectors are changed infrequently when there is a major design change or change to beam requirements. TS1 reflector was replaced during the 2021 long shutdown, hence increase in stock since 2019. One waste reflector predicted to arise before ISIS decommissioning commencing 2037. Difficult to estimate the volume of the TS1 moderator parts as the beryllium rods are encased in stainless steel cans. We currently have 2 and 1/3rd waste TS1 reflectors. We currently also have one TS2 reflector which is solid beryllium coated with a thin layer of nickel.

Uncertainty factors on volumes:				
	Stock (upper):	x 2.0	Arisings (upper)	x 2.0
	Stock (lower):	x 0.75	Arisings (lower)	x 0.75

WASTE SOURCE Beryllium reflects a neutron beam and this allows the beam from the tungsten target to be directed and focused.

PHYSICAL CHARACTERISTICS

General description:	Approx 0.25 te beryllium metal in each reflector. Former TS1 type of reflector has beryllium rods encased in steel cans with boral surrounding the inner cans (80% of the current holdings are this type) and the other reflector type (in use in TS2 and TS1 from 2021) is almost 100% beryllium metal. Solid dry metals.
Physical components (%wt):	Metallic beryllium rods (27mm) (57%), in steel cans (36%) or solid sections of beryllium metal with thin nickel (<1%) coating. Includes boral (3%), aluminium alloy (5%) and Cd (<1%).
Sealed sources:	The waste does not contain sealed sources.
Bulk density (t/m^3):	~0.98
Comment on density:	Bulk density estimated from current volume and weight

CHEMICAL COMPOSITION

General description and components (%wt):	Be metal and stainless steel.
Chemical state:	Neutral
Chemical form of radionuclides:	H-3: Formed in metal as tritium molecules
Metals and alloys (%wt):	-

	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....	~36.6	304	
Other ferrous metals.....	0		
Iron.....	0		
Aluminium.....	~5.3	Al alloy 5083	

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Beryllium	~57.3
Cobalt	0
Copper	0
Lead	0
Magnox/Magnesium	0
Nickel	~0.89
Titanium	0
Uranium	0
Zinc	0
Zircaloy/Zirconium	0
Other metals	0

Organics (%wt): -

	(%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	0		
Oil or grease	0		
Fuel	0		
Asphalt/Tarmac (cont.coal tar)	0		
Asphalt/Tarmac (no coal tar)	0		
Bitumen	0		
Others	0		
Other organics	0		

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	0		
Sand	0		
Glass/Ceramics	0		

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

Inorganic anions (%wt): -

	(%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: -

	(%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	

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Hazardous substances / non hazardous pollutants: -

	(%wt)	Type(s) and comment
Acrylamide	0	
Benzene	0	
Chlorinated solvents	0	
Formaldehyde	0	
Organometallics	0	
Phenol	0	
Styrene	0	
Tri-butyl phosphate	0	
Other organophosphates	0	
Vinyl chloride	0	
Arsenic	0	
Barium	0	
Boron	~3.0	
Boron (in Boral)	~3.0	
Boron (non-Boral)	0	
Cadmium	~0.80	
Caesium	0	
Selenium	0	
Chromium	0	
Molybdenum	0	
Thallium	0	
Tin	0	
Vanadium	0	
Mercury compounds	0	
Others	0	
Electronic Electrical Equipment (EEE)		
EEE Type 1	0	
EEE Type 2	0	
EEE Type 3	0	
EEE Type 4	0	
EEE Type 5	0	

Complexing agents (%wt): No

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

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Potential for the waste to contain discrete items: Yes. The waste stream is made of large discrete metallic components that will not readily degrade.

PACKAGING AND CONDITIONING

Conditioning method: Not yet known

Plant Name: -

Location: -

Plant startup date: -

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
Not specified	NE	NE	NE	NE

Likely container type comment: -

Range in container waste volume: -

Other information on containers: -

Likely conditioning matrix:

Other information: -

Conditioned density (t/m^3): -

Conditioned density comment: -

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: Neutron activated beryllium metal and activated steel.

Uncertainty: Co-60 activity is determined from measurment, all other activities infered from ratio to Co-60 and uncertainty is dominated by this ratio.

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: Modelling of nuclides backed up with gamma spectroscopy and dose rate measurements of flasks containing reflectors, other nuclides scaled to Co-60 dose measurement.

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Other information:	Other nuclides >1% of fingerprint include Cr-51, Co-56, Co-57, Co-58, V-49, Ce-141, W-185, Be-7.

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Nuclide	Mean radioactivity, TBq/m³				Nuclide	Mean radioactivity, TBq/m³			
	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	~~5.17E-01	D C 2	~~5.17E-01	D C 2	Gd 153		4		4
Be 10		7		7	Ho 163		4		4
C 14		4		4	Ho 166m		4		4
Na 22		5		5	Tm 170		4		4
Al 26		4		4	Tm 171		4		4
Cl 36		4		4	Lu 174		4		4
Ar 39		4		4	Lu 176		4		4
Ar 42		4		4	Hf 178n		4		4
K 40		4		4	Hf 182		4		4
Ca 41		4		4	Pt 193		4		4
Mn 53		4		4	Tl 204		4		4
Mn 54	~~8.03E+00	D C 2	~~8.03E+00	D C 2	Pb 205		4		4
Fe 55	~~1.97E+01	D C 2	~~1.97E+01	D C 2	Pb 210		4		4
Co 60	~~1.89E+00	A A 2	~~1.89E+00	A A 2	Bi 208		4		4
Ni 59		4		4	Bi 210m		4		4
Ni 63	~~2.03E-01	D C 2	~~2.03E-01	D C 2	Po 210		4		4
Zn 65	~~5.14E-01	D C 2	~~5.14E-01	D C 2	Ra 223		4		4
Se 79		4		4	Ra 225		4		4
Kr 81		4		4	Ra 226		4		4
Kr 85		4		4	Ra 228		4		4
Rb 87		4		4	Ac 227		4		4
Sr 90		4		4	Th 227		4		4
Zr 93		4		4	Th 228		4		4
Nb 91		4		4	Th 229		4		4
Nb 92		4		4	Th 230		4		4
Nb 93m		4		4	Th 232		4		4
Nb 94		4		4	Th 234		4		4
Mo 93		4		4	Pa 231		4		4
Tc 97		4		4	Pa 233		4		4
Tc 99		4		4	U 232		4		4
Ru 106		4		4	U 233		4		4
Pd 107		4		4	U 234		4		4
Ag 108m		4		4	U 235		4		4
Ag 110m		4		4	U 236		4		4
Cd 109		4		4	U 238		4		4
Cd 113m		4		4	Np 237		4		4
Sn 119m		4		4	Pu 236		4		4
Sn 121m		4		4	Pu 238		4		4
Sn 123		4		4	Pu 239		4		4
Sn 126		4		4	Pu 240		4		4
Sb 125		4		4	Pu 241		4		4
Sb 126		4		4	Pu 242		4		4
Te 125m		4		4	Am 241		4		4
Te 127m		4		4	Am 242m		4		4
I 129		4		4	Am 243		4		4
Cs 134		4		4	Cm 242		4		4
Cs 135		4		4	Cm 243		4		4
Cs 137		4		4	Cm 244		4		4
Ba 133		4		4	Cm 245		4		4
La 137		4		4	Cm 246		4		4
La 138		4		4	Cm 248		4		4
Ce 144		4		4	Cf 249		4		4
Pm 145		4		4	Cf 250		4		4
Pm 147		4		4	Cf 251		4		4
Sm 147		4		4	Cf 252		4		4
Sm 151		4		4	Other a		4		4
Eu 152		4		4	Other b/g	~~4.42E+00	D C 2	~~4.42E+00	D C 4
Eu 154		4		4	**Total a**	**NE**	**6**	**NE**	**6**
Eu 155		4		4	**Total b/g**	**~~3.53E+01**	**D C 2**	**~~3.53E+01**	**D C 2**

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