

WASTE STREAM	6N03	Reflectors
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SITE Rutherford Appleton Laboratory

SITE OWNER UK Research and Innovation

WASTE CUSTODIAN UK Research and Innovation

WASTE TYPE ILW

WASTE VOLUMES

	Reported (m ³)	OR	Conditioned (m ³)	Packaged (m ³)
Stocks:	At 1.4.2025	2.6		
Future arisings:	1.4.2025 - 31.3.2026	0		
	1.4.2026 - 31.3.2027	0		
	1.4.2027 - 31.3.2028	0		
	1.4.2028 - 31.3.2045	1.0		
Total future arisings:		1.0		
Total waste volume:		3.6		

Number of waste packages in stock: At 1.4.2025..... - packages

Comment on arising rates: 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.

Additional information on quantities: 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 2.00 Arisings (upper): x 2.00
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.

Changes since waste generated: Solid dry metals.

Bulk density (t/m³): ~ 0.98

Comment on density: Bulk density estimated from current volume and weight

CHEMICAL COMPOSITION

General description and components (%wt): Beryllium metal and stainless steel (57.25% and 36.6%)

Chemical state: Neutral

Sheet metal proportion / thickness: -

Metals and alloys (%wt):

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

COMPONENTS OF MATERIALS, WASTE PROPERTIES, MATERIALS NOT CONTRIBUTING TO MASS

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	-

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	-

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	-

Physical components:

	Number	Type(s) and comment
Sources.....		-
Electronic & Electrical Equipment (EEE)		-
EEE Type 1.....		-
EEE Type 2.....		-
EEE Type 3.....		-
EEE Type 4.....		-
EEE Type 5.....		-

TREATMENT, PACKAGING AND DISPOSAL

Planned on-site / off-site treatment(s):

Treatment	On-site / Off-site	Stream volume %
Size reduction Decay storage Low force compaction Supercompaction (HFC) Incineration Drying/dewatering/liquid separation Tie down/fixatives/strippable coating/painting application Decontamination Metal treatment Recycling / reuse Thermal treatment, including vitrification Encapsulation Polymer encapsulation Other physical treatment Other chemical treatment Containerisation Treatment not yet determined None	On-site	~ 100.0

Comments on planned treatments:

-

Conditioning method:

-

Conditioning plants:

Plant Name	Location

Likely conditioning matrix:

-

Further information on the conditioning matrix:

-

Waste Packaging:

Likely container type:

Container	Waste packaged (vol%)	Waste loading (m³)	Payload (m³)	Number of packages	Estimated start date for packaging
Not yet determined	100.0	-	-	-	-

Range in container waste loading:

Other information on packaging and conditioning:

-

Conditioned density (t/m³):

-

Conditioned density comment:

-

Management Routes:

Disposal Route	Stream volume %	Raw density t/m³	Start date
Expected to be consigned to a Near Site, Near Surface Disposal Facility (Scotland)	100.0		
Expected to be Non-NSD HAW managed under Scottish Government's policy			
Expected to be disposed to LLW Vaults NRS Dounreay			
Expected to be consigned to the Geological Disposal Facility			
Expected to be consigned to a Near Surface Disposal Facility			
Expected to be consigned to the LLW Repository			
Expected to be consigned to a Landfill Facility			
Expected to be disposed On-Site			
Expected to be managed by In-Situ Disposal			
Expected to be consigned to an Incineration Facility			
Expected to be consigned to a Metal Treatment Facility			
Expected to be Out of Scope			
Expected to be recycled / reused			
Disposal route not known			

Classification codes for waste expected to be consigned to a landfill facility:

Opportunities for alternative disposal routing: Yes

Baseline Management Route	Opportunity Management Route	Stream volume (%)	Opportunity Confidence	Comment
GDF	NSDF	100.0	RED	-

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.

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.

Chemical form of radionuclides:

- H-3: Formed in metal as tritium molecules
- C-14: -
- Cl-36: -
- Se-79: -
- Tc-99: -
- I-129: -
- Ra: -
- Th: -
- U: -
- Np: -
- Pu: -

WASTE STREAM				6N03				Reflectors			
Nuclide	Mean radioactivity, TBq/m³				Nuclide	Mean radioactivity, TBq/m³					
	Waste at 1.4.2025	Bands and Code	Future Arisings	Bands and Code		Waste at 1.4.2025	Bands and Code	Future Arisings	Bands and Code		
H 3	~~ 8.74E-01	D C 2	~~ 8.74E-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	~~ 5.60E+00	D C 2	~~ 5.60E+00	D C 2	Pb 205		4		4		
Fe 55	~~ 1.30E+01	D C 2	~~ 1.30E+01	D C 2	Pb 210		4		4		
Co 60	~~ 1.15E+00	A A 2	~~ 1.15E+00	A A 2	Bi 208		4		4		
Ni 59		4		4	Bi 210m		4		4		
Ni 63	~~ 8.00E-02	D C 2	~~ 8.00E-02	D C 2	Po 210		4		4		
Zn 65	~~ 8.40E-01	D C 2	~~ 8.40E-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	Unsp a		4		4		
Eu 152		4		4	Unsp b/g	~~ 1.68E+01	D C 2	~~ 1.68E+01	D C 4		
Eu 154		4		4	Total a	0	*	0	*		
Eu 155		4		4	Total b/g	3.84E+01	*	3.84E+01	*		

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 the 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
* Total calculated from the 114 declared radionuclides