

WASTE STREAM	6N01	Neutron Targets
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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.....	0.1 m ³
Future arisings -	1.4.2022 - 31.3.2023.....	<< 0.1 m ³
	1.4.2023 - 31.3.2024.....	<< 0.1 m ³
	1.4.2024 - 31.3.2025.....	<< 0.1 m ³
	1.4.2025 - 31.3.2037.....	0.1 m ³
Total future arisings:		0.2 m ³
Total waste volume:		0.3 m ³

Comment on volumes: Dates given to 2037 which is the planned date for shutdown of ISIS. From 2022 new TS1 targets used. The future rate of failure of the new TS1 target is conservatively estimated to be one (0.01m3 unprocessed) every 2 years and one ISIS target station 2 target (0.01m3 unprocessed volume) every 2 years. The useable lifetime of the targets and instrument use is a source of uncertainty. Additionally, the assumed volume of the targets is an estimate based on the weight, density, voidage and shape.

Uncertainty factors on volumes: Stock (upper): x 1.0 Arisings (upper) x 10.0
 Stock (lower): x 0.5 Arisings (lower) x 0.1

WASTE SOURCE ISIS is a government-funded, working pulsed neutron spallation source which provides neutron (and muon) beams for research work. The neutrons are produced by bombarding a tantalum-clad tungsten target with protons. This waste stream is the waste neutron spallation targets from both of the ISIS target stations.

PHYSICAL CHARACTERISTICS

General description: Intact tungsten metal neutron spallation sources with tantalum metal cladding, disconnected from their cooling-water circuits and drained of the cooling water. This material is essentially the same as it was pre-irradiation other than the presence of activation products. Solid metallic tungsten with smaller quantities of tantalum metal.

Physical components (%vol): NOT SPECIFIED - Exact proportion of tungsten metal (major component) to tantalum metal depends on the target station and this waste stream is a mixture of both.

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m³): ~12

Comment on density: -

CHEMICAL COMPOSITION

General description and components (%wt): -

Chemical state: -

Chemical form of radionuclides: H-3: Bound into the metal

Metals and alloys (%wt): -

	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....	~68.0	Mainly 304 grade plus 316 grade	
Other ferrous metals.....	0		
Iron.....	0		
Aluminium.....	~0.10	Al alloy 5083	

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Beryllium.....	0
Cobalt.....	0
Copper.....	0
Lead.....	0
Magnox/Magnesium.....	0
Nickel.....	0
Titanium.....	0
Uranium.....	0
Zinc.....	0
Zircaloy/Zirconium.....	0
Other metals.....	~31.9 Tungsten and tantalum

Organics (%wt): -

	(%wt)	Type(s) and comment	% of total C14 activity
Total cellulose.....	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.....	0	
Boron (in Boral).....	0	
Boron (non-Boral).....	0	
Cadmium.....	0	
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.....		
DPTA.....		
NTA.....		
Polycarboxylic acids.....		
Other organic complexants.....		
Total complexing agents.....		

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Potential for the waste to contain discrete items: Yes. Durable metal items

PACKAGING AND CONDITIONING

Conditioning method: This will be undertaken by the MBGWS at Sellafield as this waste is sent, intact, to that location and title for the waste is transferred.

Plant Name: -

Location: -

Plant startup date: -

Total capacity (m³/y incoming waste): -

Target start date for packaging this stream: -

Throughput for this stream (m³/y incoming waste): -

Other information: -

Likely container type:	Container	Waste packaged (%vol)	Waste loading (m ³)	Payload (m ³)	Number of packages

Likely container type comment: -

Range in container waste volume: -

Other information on containers: -

Likely conditioning matrix: -

Other information: -

Conditioned density (t/m³): -

Conditioned density comment: -

Other information on conditioning: -

Opportunities for alternative disposal routing: -

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

RADIOACTIVITY

Source: Proton collision with metals of target.

Uncertainty: All activities are calculated not measured. Volumes of waste are very small but there is a large % uncertainty on the exact volume of each waste target used for these calculations. The targets do not exceed 200 litres as one TS1 current and new design target fits into a 200 litre can for transport and 3 x TS2 targets will fit into another 200 litre can. The minimum volumes may be as low as TS1 target 20 litres and TS2 targets 10 litres.

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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:

Calculations from MCNPX and CINDER90 programs. The specific activities for targets from the 2 target stations are different, but for this submission have been blended into one fingerprint for the current holdings.

Other information:

'Other beta/gamma' is composed mainly of Ta-182 (81% by specific activity), Ta-179 (12%), W-181 (4%), Lu-173 (2%) and Hf-172 (2%). 'Other alpha' is solely composed of Gd-148.

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Nuclide	Mean radioactivity, TBq/m ³				Nuclide	Mean radioactivity, TBq/m ³			
	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	2.98E+02	CC 2	3.49E+02	CC 2	Gd 153	2.67E+01	CC 2	4.65E+01	CC 2
Be 10					Ho 163	1.09E-01	CC 2	1.21E-01	CC 2
C 14					Ho 166m				
Na 22	2.75E-01	CC 2			Tm 170	4.13E-01	CC 2	5.98E-01	CC 2
Al 26					Tm 171	2.93E-01	CC 2	1.83E-01	CC 2
Cl 36					Lu 174	6.41E-01	CC 2	1.99E+01	CC 2
Ar 39	2.54E-02	CC 2	2.32E-02	CC 2	Lu 176				
Ar 42					Hf 178n				
K 40					Hf 182				
Ca 41					Pt 193				
Mn 53					Tl 204				
Mn 54	7.26E+01	CC 2	5.98E+01	CC 2	Pb 205				
Fe 55	1.99E+02	CC 2	4.32E+02	CC 2	Pb 210				
Co 60	3.34E+00	CC 2	2.82E+00	CC 2	Bi 208				
Ni 59			8.80E-02	CC 2	Bi 210m				
Ni 63	1.95E+00	CC 2	1.01E+01	CC 2	Po 210				
Zn 65	1.19E-01	CC 2	3.15E-01	CC 2	Ra 223				
Se 79					Ra 225				
Kr 81					Ra 226				
Kr 85	2.01E-01	CC 2	1.06E-01	CC 2	Ra 228				
Rb 87					Ac 227				
Sr 90	3E-02	CC 2	2.16E-02	CC 2	Th 227				
Zr 93					Th 228				
Nb 91			3.98E-03	CC 2	Th 229				
Nb 92					Th 230				
Nb 93m					Th 232				
Nb 94					Th 234				
Mo 93					Pa 231				
Tc 97					Pa 233				
Tc 99					U 232				
Ru 106	2.93E-02	CC 2	3.49E-02	CC 2	U 233				
Pd 107					U 234				
Ag 108m					U 235				
Ag 110m					U 236				
Cd 109	6.61E-02	CC 2	3.49E-02	CC 2	U 238				
Cd 113m					Np 237				
Sn 119m					Pu 236				
Sn 121m					Pu 238				
Sn 123					Pu 239				
Sn 126					Pu 240				
Sb 125					Pu 241				
Sb 126					Pu 242				
Te 125m					Am 241				
Te 127m					Am 242m				
I 129					Am 243				
Cs 134					Cm 242				
Cs 135					Cm 243				
Cs 137					Cm 244				
Ba 133	1.43E+00	CC 2	1.23E+00	CC 2	Cm 245				
La 137					Cm 246				
La 138					Cm 248				
Ce 144					Cf 249				
Pm 145	1.26E+01	CC 2	9.13E+00	CC 2	Cf 250				
Pm 147			1.31E-03	CC 2	Cf 251				
Sm 147					Cf 252				
Sm 151			9.63E-04	CC 2	Other a	4.31E+00	CC 2	7.64E+00	CC 2
Eu 152	2.37E-01	CC 2	4.32E-01	CC 2	Other b/g	8.28E+03	CC 2	1.28E+04	CC 2
Eu 154	8.45E-02	CC 2	1.20E-01	CC 2	Total a	4.31E+00	CC 2	-7.64E+00	CC 2
Eu 155					Total b/g	8.91E+03	CC 2	-1.38E+04	CC 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