

WASTE STREAM**6N02****Moderators****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.....	0.9 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.....	0.7 m ³
Total future arisings:		0.9 m ³
Total waste volume:		1.8 m ³

Comment on volumes: Assumes 6 moderators total per year from both target stations, halved 2022-23 as TS1 replaced the moderators during long shutdown. No envisaged end point to this ongoing operational waste at the moment. The records for the waste arisings are missing some details. When the waste is retrieved from storage the uncertainty on the number of parts will be removed. The volume is of size-reduced for handling but otherwise unprocessed waste with variable but significant voidage. The operation arisings in future will be affected by design changes and hopefully improvements to reduce arisings.

Uncertainty factors on volumes:	Stock (upper):	x 1.5	Arisings (upper)	x 1.5
	Stock (lower):	x 0.8	Arisings (lower)	x 0.8

WASTE SOURCE Moderators alter the neutron spectrum coming from the tungsten target to meet beam-line science requirements.**PHYSICAL CHARACTERISTICS**

General description: Metallic waste. Aluminium moderator head with high surface area aluminium sponge inside. Small amount of neutron-poison in head (Gd foil). Head is connected to a stainless steel umbilical carrying service cables and pipes for coolant and/ or moderating material. Heads are drained of coolant and moderating material and most are cropped from the umbilical.

Physical components (%wt): 87% steel, 13% aluminium alloy, trace% others (copper, Invar, phosphor bronze, ceramic and gadolinium).

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m³): ~2.7

Comment on density: Very approximate as this is difficult to estimate for this unprocessed waste stream.

CHEMICAL COMPOSITION

General description and components (%wt): Potentially <0.01% organic material in the methane-moderator heads as the moderation process causes splitting and joining of the methane molecules to form a mix of carbon, oils and waxes. Methane moderator heads comprise about 75% of the waste stream.

Chemical state: Neutral

Chemical form of radionuclides: H-3: Formed in metal as tritium molecules and as part of the hydrocarbon mix in the methane moderators.
C-14: as carbon, oils and waxes

Metals and alloys (%wt): -

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	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....	~87.0		
Other ferrous metals.....	0		
Iron.....	0		
Aluminium.....	~13.0		
Beryllium.....	0		
Cobalt.....	0		
Copper.....	0		
Lead.....	0		
Magnox/Magnesium.....	0		
Nickel.....	0		
Titanium.....	0		
Uranium.....	0		
Zinc.....	0		
Zircaloy/Zirconium.....	0		
Other metals.....	<0.01	Brass, Gadolinium, Silver. Proportions unknown	

Organics (%wt): 0.0001

	(%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.....	<0.01		

Other materials (%wt): -

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	(%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.....	<0.01		
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	

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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.....	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	

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Complexing agents (%wt): Not yet determined

(%wt) Type(s) and comment

- EDTA.....
- DPTA.....
- NTA.....
- Polycarboxylic acids.....
- Other organic complexants.....
- Total complexing agents.....

Potential for the waste to contain discrete items: Yes. distinct metallic components that will not degrade in the store

PACKAGING AND CONDITIONING

- Conditioning method: None, other than some basic size-reduction on most items.
- 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
	Not specified	100.0	NE	NE	NE

- 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: Yes

Baseline Management Route	Opportunity Management Route	Stream volume (%)	Estimated Date that Opportunity will be realised	Opportunity Confidence	Comment
Disposal at a Geological Disposal	Incineration	NE	-	Low	-

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Facility				
Disposal at a Geological Disposal Facility	Disposal at LLWR	NE	Medium	Disposal to LLWR following decay storage

RADIOACTIVITY

Source:	Activation of components by neutron beam
Uncertainty:	There are 2 target stations one of lowerbeam energy than the other so the moderators arising from each vary in activity for the same irradiation time. Each moderator head has been used for a time unique to that head and there are several moderator types. The specific activity is based on an average activity from measurements and modelling. The total volume of the unprocessed waste is estimated.
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:	Some gamma-spectrometry measurements have been made.
Other information:	Modelling provides data for tritium and other soft-beta emitters.

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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	1.80E+03	CE 2	2.1E+03	CE 2	Gd 153		4		4
Be 10		8		8	Ho 163		4		4
C 14	1.00E-04	CE 2	1E-04	CE 2	Ho 166m		4		4
Na 22	7.91E-01	CD 2	1.6E+00	CD 2	Tm 170		4		4
Al 26	4.2E-04	CD 2	4.2E-04	CD 2	Tm 171		4		4
Cl 36		8		8	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	4.25E-02	CD 2	3E-01	CD 2	Pb 205		4		4
Fe 55		6		6	Pb 210		4		4
Co 60	1.26E+00	CD 2	1.8E+00	CD 2	Bi 208		4		4
Ni 59		4		4	Bi 210m		4		4
Ni 63		6		6	Po 210		4		4
Zn 65	4.13E-03	CD 2	4.4E-02	AD 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	3.32E-04	CD 2	3.4E-03	CD 2	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	8.6E-01	CD 2	8.6E-01	AD 2
Eu 154		4		4	Total a	0	4	0	4
Eu 155		4		4	Total b/g	1.81E+03	CE 2	2.1E+03	AE 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