

**WASTE STREAM****7F23****Submarine Reactor Wastes (Metallic LLW)****SITE** Clyde Submarine Base**SITE OWNER** Ministry of Defence**WASTE CUSTODIAN** Ministry of Defence**WASTE TYPE** LLW

Is the waste subject to Scottish Policy: No

**WASTE VOLUMES**

		Reported
Stocks:	At 1.4.2022.....	17.0 m <sup>3</sup>
Future arisings -	1.4.2022 - 31.3.2030.....	55.0 m <sup>3</sup>
	1.4.2030 - 31.3.2040.....	50.0 m <sup>3</sup>
	1.4.2040 - 31.3.2050.....	50.0 m <sup>3</sup>
	1.4.2050 - 31.3.2060.....	50.0 m <sup>3</sup>
	1.4.2060 - 31.3.2070.....	50.0 m <sup>3</sup>
	1.4.2070 - 31.3.2080.....	50.0 m <sup>3</sup>
	1.4.2080 - 31.3.2090.....	50.0 m <sup>3</sup>
	1.4.2090 - 31.3.2100.....	50.0 m <sup>3</sup>
	1.4.2100 - 31.3.2110.....	50.0 m <sup>3</sup>
		1.4.2110 - 31.3.2111.....
Total future arisings:		470.0 m <sup>3</sup>
Total waste volume:		487.0 m <sup>3</sup>

Comment on volumes: The rate of future arisings depends on the number of submarines berthed at Clyde and site decommissioning work. Future arisings largely depend on submarine maintenance programme. Maintenance programmes for nuclear submarines are very well developed and predictable; however, there have been historical examples of unexpected repairs which could generate significant quantities of waste. REDF decommissioning wastes have been included in predicted arisings for 2023 and NSH decommissioning wastes have been included in 2110.

Uncertainty factors on volumes: Stock (upper): x 1.2 Arisings (upper) x 2.0  
Stock (lower): x 0.8 Arisings (lower) x 0.5

**WASTE SOURCE** Metallic LLW is generated primarily from NRP maintenance; secondary wastes are generated in the nuclear facilities that provide submarine support services e.g. radioactive component processing, radiochemistry laboratory, etc.

**PHYSICAL CHARACTERISTICS**

General description: The waste consists of metallic materials such as pipework, valves etc. It is not anticipated that any items will be generated that will require special handling.

Physical components (%vol): Waste stream comprises 100% metal: pipes, valves, tools, etc.

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m<sup>3</sup>): 0.203

Comment on density: Total mass of waste in stock is 3458.49 kg.

**CHEMICAL COMPOSITION**

General description and components (%wt): Metals (100%).

Chemical state: Neutral

Chemical form of radionuclides: H-3: Tritium in corrosion resistant alloys (e.g. Zircaloy, stainless steel, inconel)  
C-14: Carbon-14 in compounds likely to degrade and produce gases or species mobile in water

Metals and alloys (%wt): All metal items present as bulk items. Dimensions range from a few centimetres up to that of a 200 l drum. Larger items would be size reduced prior to transfer offsite for metal treatment.

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	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....	75.0		
Other ferrous metals.....	5.0		
Iron.....	NE		
Aluminium.....	0		
Beryllium.....	0		
Cobalt.....	0		
Copper.....	15.0	Copper (5%wt), Bronze (5%wt) and Brass (5%wt)	
Lead.....	0		
Magnox/Magnesium.....	0		
Nickel.....	3.0	Monel (5%wt)	
Titanium.....	0		
Uranium.....	0		
Zinc.....	2.0		
Zircaloy/Zirconium.....	0		
Other metals.....	0		

Organics (%wt): Polythene - no further details are available. No halogenated plastics or rubbers are known to be present.

	(%wt)	Type(s) and comment	% of total C14 activity
Total cellulosics.....	0		
Paper, cotton.....			
Wood.....			
Halogenated plastics .....	0		
Total non-halogenated plastics.....	0		
Condensation polymers.....	0		
Others.....	<0.01	Polythene	
Organic ion exchange materials....	0		
Total rubber.....	0		
Halogenated rubber .....	0		
Non-halogenated rubber.....	0		
Hydrocarbons.....	TR		
Oil or grease .....	TR		
Fuel.....			
Asphalt/Tarmac (cont.coal tar)...			
Asphalt/Tarmac (no coal tar)....			
Bitumen.....			
Others.....			
Other organics.....	NE		

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

Inorganic anions (%wt): -

	(%wt)	Type(s) and comment
Fluoride.....	NE	
Chloride.....	NE	
Iodide.....	NE	
Cyanide.....	NE	
Carbonate.....	NE	
Nitrate.....	NE	
Nitrite.....	NE	
Phosphate.....	NE	
Sulphate.....	NE	
Sulphide.....	NE	

Materials of interest for waste acceptance criteria: There are no hazardous materials associated with this stream.

	(%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).....		
Boron (non-Boral).....		
Cadmium.....	0	
Caesium.....	NE	
Selenium.....	0	
Chromium.....	13.0	13% part of steel composition
Molybdenum.....	0	
Thallium.....	NE	
Tin.....	0.40	0.4% part of steel composition
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): 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: Yes. 7F23 metallic waste stream contains items of interest.

**TREATMENT, PACKAGING AND DISPOSAL**

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

Treatment	On-site / Off site	Stream volume %
Low force compaction Supercompaction (HFC) Incineration Solidification Decontamination Metal treatment Size reduction Decay storage Recycling / reuse Other / various None	Off-site	~100.0

Comment on planned treatments:

Clyde intends to use the LLWR framework to identify suitable metal treatment solutions.

**Disposal Routes:**

Disposal Route	Stream volume %	Disposal density t/m3
Expected to be consigned to the LLW Repository Expected to be consigned to a Landfill Facility Expected to be consigned to an On-Site Disposal Facility Expected to be consigned to an Incineration Facility Expected to be consigned to a Metal Treatment Facility Expected to be consigned as Out of Scope Expected to be recycled / reused Disposal route not known	100.0	0.75

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

**Upcoming (2022/23-2024/25) Waste Routing (if expected to change from above):**

Disposal Route	Stream volume %		
	2022/23	2023/24	2024/25
Expected to be consigned to the LLW Repository Expected to be consigned to a Landfill Facility Expected to be consigned to an On-Site Disposal Facility Expected to be consigned to an Incineration Facility Expected to be consigned to a Metal Treatment Facility Expected to be consigned as Out of Scope Expected to be recycled / reused Disposal route not known			

**Opportunities for alternative disposal routing:** Not yet determined

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

**Waste Packaging for Disposal:** (Not applicable to this waste stream)

Container	Stream volume %	Waste loading m <sup>3</sup>	Number of packages
1/3 Height IP-1 ISO			
2/3 Height IP-2 ISO			
1/2 Height WAMAC IP-2 ISO			
1/2 Height IP-2 Disposal/Re-usable ISO			
2m box (no shielding)			
4m box (no shielding)			
Other			

Other information: -

**Waste Planned for Disposal at the LLW Repository:** (Not applicable to this waste stream)

Container voidage: -

Waste Characterisation Form (WCH): -

Waste consigned for disposal to LLWR in year of generation: -

**Non-Containerised Waste for In-Vault Grouting:** (Not applicable to this waste stream)

Stream volume (%): -

Waste stream variation: -

Bounding cuboidal volume:

Inaccessible voidage: -

Other information: -

**RADIOACTIVITY**

Source: Submarine reactor plant maintenance; coolant contaminated items and activated components. Additional waste from submarine support services.

Uncertainty: Systematic sampling and analysis is periodically undertaken to provide a generic fingerprint for heterogeneous metallic waste; difficult to measure radionuclides are inferred from assessment of total gamma activity.

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: Active waste monitors are used to assess waste for medium to high energy gamma activity. The 7F23 waste stream characterisation fingerprint is used to infer the activity of difficult to measure radionuclides. Future arisings will be subject to further radiochemical analysis to substantiate or augment the derived fingerprint.

Other information: Radionuclide specific activities have been re-calculated using measured activity and mass, WCH fingerprint, and estimated volumes.

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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	1.08E-08	AC 2	1.08E-08	AC 2	Gd 153				
Be 10					Ho 163				
C 14	2.65E-06	AC 2	2.65E-06	AC 2	Ho 166m				
Na 22					Tm 170				
Al 26					Tm 171				
Cl 36					Lu 174				
Ar 39					Lu 176				
Ar 42					Hf 178n				
K 40					Hf 182				
Ca 41					Pt 193				
Mn 53					Tl 204				
Mn 54	3.77E-08	AC 1	3.77E-08	AC 1	Pb 205				
Fe 55	3.67E-06	AC 2	3.67E-06	AC 2	Pb 210				
Co 60	1.16E-06	AC 1	1.16E-06	AC 1	Bi 208				
Ni 59					Bi 210m				
Ni 63	4.82E-07	AC 2	4.82E-07	AC 2	Po 210				
Zn 65	1.75E-07	AC 1	1.75E-07	AC 1	Ra 223				
Se 79					Ra 225				
Kr 81					Ra 226				
Kr 85					Ra 228				
Rb 87					Ac 227				
Sr 90					Th 227				
Zr 93					Th 228				
Nb 91					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	3.7E-07	AC 1	3.7E-07	AC 1	U 233				
Pd 107					U 234				
Ag 108m					U 235				
Ag 110m	4.76E-08	AC 1	4.76E-08	AC 1	U 236				
Cd 109					U 238				
Cd 113m					Np 237				
Sn 119m					Pu 236				
Sn 121m					Pu 238				
Sn 123					Pu 239				
Sn 126					Pu 240				
Sb 125	9.88E-08	AC 1	9.88E-08	AC 1	Pu 241				
Sb 126					Pu 242				
Te 125m					Am 241				
Te 127m					Am 242m				
I 129					Am 243				
Cs 134	3.5E-08	AC 1	3.5E-08	AC 1	Cm 242				
Cs 135					Cm 243				
Cs 137	4.58E-08	AC 1	4.58E-08	AC 1	Cm 244				
Ba 133					Cm 245				
La 137					Cm 246				
La 138					Cm 248				
Ce 144	1.24E-07	AC 1	1.24E-07	AC 1	Cf 249				
Pm 145					Cf 250				
Pm 147					Cf 251				
Sm 147					Cf 252				
Sm 151					Other a				
Eu 152					Other b/g				
Eu 154					<b>Total a</b>	<b>0</b>		<b>0</b>	
Eu 155					<b>Total b/g</b>	<b>8.91E-06</b>	<b>AC 2</b>	<b>8.91E-06</b>	<b>AC 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