WASTE STREAM 7D41 ILW Submarine Ion Exchange Resin

SITE	HMNB Devonport
SITE OWNER	Ministry of Defence
WASTE CUSTODIAN	Babcock International Group
WASTE TYPE	ILW
Is the waste subject to Scottish Policy:	No

WASTE VOLUMES

		Reported
Stocks:	At 1.4.2022.....	1.4 m³
Future arisings -	1.4.2023 - 31.3.2025.....	~0.6 m³
	1.4.2025 - 31.3.2028.....	<< 0.1 m³
	1.4.2028 - 31.3.2031.....	~0.6 m³
	1.4.2031 - 31.3.2034.....	~0.5 m³
Total future arisings:		1.7 m³
Total waste volume:		3.1 m³

Comment on volumes: Generation rate is dependent upon the submarine refit/maintenance plan, which is variable. 'Current Stocks' declared are for waste stored in raw form awaiting treatment. Waste disposal due to commence c. 2024 which will follow a conditioning/treatment campaign as part of a MoD driven Resin Disposal Project (RDP) to remove C14 & chelates which is expected to reduce waste to LLW. Reported volumes in 'future arisings' represent a balance of newly generated waste versus a program of work in which this wastestream will be reduced and converted into conditioned wastestream: 7D26/C. The volume quoted above is the total volume of the ion exchange resin and water within the Resin Storage Vessel (RSV)

Uncertainty factors on volumes:				
	Stock (upper):	x 1.1	Arisings (upper)	x 1.5
	Stock (lower):	x 0.9	Arisings (lower)	x 0.5

WASTE SOURCE During operation of the submarine reactor system primary coolant is passed through an onboard ion exchange resin which removes soluble activation products and also acts as a very coarse filter.

PHYSICAL CHARACTERISTICS

General description: Resin is held within a Resin Storage Vessel (RSV). Resin is held in a raw state. The resin is nuclear grade polystyrene bead based (H-OH resin), consisting of uniform spheroids of approximately 0.6 - 1 mm diameter. There are no large items present. The waste will be mixed with a standard cement mixture (see below) before an inactive capping grout is applied to the drum to seal the active surface. The waste will be stored in the raw state until it has decayed to LLW levels and/or has been treated/conditioned to remove chelates and remove/reduce C-14 and is able to be managed in accordance with 7D26/C.

Physical components (%wt): Resin (75%), water (25%).

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m³): ~1.1

Comment on density: Density is for raw resin i.e unconditioned. Raw waste is organic ion exchange resin headed by an amount of water.

CHEMICAL COMPOSITION

General description and components (%wt): Organic ion exchange resin and water.

Chemical state: Alkali

Chemical form of radionuclides: H-3: HTO. Possible minor contribution is as OBT.
C-14: C-14 is present on resin in a number of different chemical forms, mainly carbonate, organic acids and carbide in magnetite.

Metals and alloys (%wt): -

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	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel	0		
Other ferrous metals	0		
Iron	0		
Aluminium	0		
Beryllium	0		
Cobalt	0		
Copper	0		
Lead	0		
Magnox/Magnesium	0		
Nickel	0		
Titanium			
Uranium	0		
Zinc	0		
Zircaloy/Zirconium	0		
Other metals	0	Not applicable.	

Organics (%wt): The resin is a commercial high nuclear grade anion/cation mixed resin.

	(%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	75.0		100.0
Total rubber	0		
Halogenated rubber	0		
Non-halogenated rubber	0		
Hydrocarbons	0		
Oil or grease			
Fuel			
Asphalt/Tarmac (cont.coal tar)			
Asphalt/Tarmac (no coal tar)			
Bitumen			
Others			
Other organics	0		

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.....	25.0		
Free non-aqueous liquids.....	0		
Powder/Ash.....	0		

Inorganic anions (%wt): There should not be a significant amount of inorganic anions within the resin/water mixture.

	(%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: Raw waste is headed by an amount of water. There should be no other hazardous materials within the waste.

	(%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.....		
Benzene.....	0	
Chlorinated solvents.....		
Formaldehyde.....		
Organometallics.....		
Phenol.....	0	
Styrene.....		
Tri-butyl phosphate.....	0	
Other organophosphates.....		
Vinyl chloride.....	0	
Arsenic.....	0	
Barium.....		
Boron.....	P	Not present in current inventory but may contain Boron in future holdings dependant on submarine processes i.e potential for on-board boronation of primary effluent. This would equate to an average boron concentration comparable to 7D26/C waste stream (~ 22 mg/l)
Boron (in Boral).....	0	
Boron (non-Boral).....	0	
Cadmium.....	0	
Caesium.....		
Selenium.....	0	
Chromium.....	0	
Molybdenum.....	0	
Thallium.....		
Tin.....	0	
Vanadium.....	0	
Mercury compounds.....		
Others.....	0	
Electronic Electrical Equipment (EEE)		
EEE Type 1.....		
EEE Type 2.....		
EEE Type 3.....		
EEE Type 4.....		

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EEE Type 5.....

Complexing agents (%wt): No

	(%wt)	Type(s) and comment
EDTA.....		
DPTA.....		
NTA.....		
Polycarboxylic acids…….		
Other organic complexants.....	<<0.01	Sampling includes analysis for complexing agents. Only resins with results below detection thresholds will be disposed under this wastestream. However, although not expected, it is possible there may be very small trace quantities of undetected organic complexing agents present (i.e. << 0.01 %wt).
Total complexing agents.....	<<0.01	

Potential for the waste to contain discrete items: . No

TREATMENT, PACKAGING AND DISPOSAL

Waste that is currently ILW: The waste will decay to/be conditioned to LLW limits. Major nuclide is Co-60. C-14 is also a major contributor to the total waste stream total. Batched treatment/conditioning (Tradebe-Inutec: Modulox) as part of the RDP will remove/reduce the C-14 along with the chelate content. This is dependent upon the specific activity of the waste at the time of generation. Treatment/conditioning is also expected to significantly reduce C-14 activity.

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

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

Comment on planned treatments: It is planned that waste will be treated/conditioned to reduce the C-14 before the resulting product will be encapsulated for disposal.

Disposal Routes:

Disposal Route	Stream volume %	Disposal density t/m3
Expected to be consigned to the LLW Repository	100.0	~1.9
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		

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):

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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: -

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

Waste Packaging for Disposal:

Container	Stream volume %	Waste loading m³	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	100.0	3.25	< 1

Other information: Encapsulated resin direct into HHISO. If not, within standard 200 litre drums loaded into HHISO containers for disposal to LLWR. Alternative may be considered depending on the conditioning/treatment option used.

Waste Planned for Disposal at the LLW Repository:

Container voidage: <10%.

The waste does not meet the LLWR's Waste Acceptance Criteria (WAC).

ILW

Waste consigned for disposal to LLWR in year of generation: No. The waste is an ILW stream. Held in store to allow for decay storage. There are also significant C-14 concentrations, which inhibits the resin conditioning for disposal. Resins can be stored for periods of up to 30 years before being acceptable for preconditioning to remove the C-14 content. Treatment/conditioning of waste form is planned to take place within the next 2-5 yrs i.e. pre 2027.

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

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Source:	The main source of activity held on the ion exchange resin are activation products from operation of PWR reactor. The main contaminants are cobalt-60, iron-55, carbon-14, nickel-63 and tritium. The waste is generated by the processing of radioactive liquid by submarine coolant treatment systems.
Uncertainty:	The raw resin within each container is representatively sampled using a full core sampling technique. The resin is then analysed for a range of beta/gamma nuclides e.g. Co-60, Fe-55, Ni-63, C-14, Cl-36 and H-3 & gamma spectroscopy. There are triggers in the sampling and analysis routine that carries out additional analysis for other nuclides should certain key nuclides be detected. Other nuclides detected below limit of detection may have generic resin fingerprint values applied. Errors associated with the measurements are within the tolerances of a UKAS accredited laboratory.
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:	Core samples are taken from each resin container. The sample is prepared and analysed to determine the major nuclides by gamma spectroscopy and other selective chemical techniques for other beta/gamma nuclides. Gross alpha and gross beta measurements are also taken. If certain trigger nuclides (e.g. Cs-137) are detected then additional analysis will be undertaken for other nuclides (e.g. I-129).Specific Activity figures have been derived from current stock data and represent a reasonably consistent waste origin, therefore future arisings, which are expected to remain consistent, can only be estimated based on the same SA estimated figure i.e. the values are specific activity not total activity (which would vary depending on expected volume).
Other information:	-

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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	8.15E-03	A A 1	~8.15E-03	C C 2	Gd 153				
Be 10					Ho 163				
C 14	4.87E-02	A A 1	~4.87E-02	C C 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	4.55E-08	A A 1	~4.55E-08	C C 2	Pb 205				
Fe 55	1.11E-03	A A 1	~1.11E-03	C C 2	Pb 210				
Co 60	1.41E-03	A A 1	~1.41E-03	C C 2	Bi 208				
Ni 59					Bi 210m				
Ni 63	2.06E-03	A A 1	~2.06E-03	C C 2	Po 210				
Zn 65					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					U 233				
Pd 107					U 234				
Ag 108m					U 235				
Ag 110m	6.81E-11	A A 1	6.81E-11	C C 2	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	2.36E-06	A A 1	~2.36E-06	C C 2	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	3.02E-05	A A 1	~3.02E-05	C C 2	Cm 244				
Ba 133					Cm 245				
La 137					Cm 246				
La 138					Cm 248				
Ce 144					Cf 249				
Pm 145					Cf 250				
Pm 147					Cf 251				
Sm 147					Cf 252				
Sm 151					Other a	4.39E-06	A A 1	~4.39E-06	C C 2
Eu 152					Other b/g				
Eu 154					**Total a**	**4.39E-06**	**A A 1**	**~4.39E-06**	**C C 2**
Eu 155					**Total b/g**	**6.15E-02**	**A A 1**	**~6.15E-02**	**C 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