WASTE STREAM	7D40	ILW PCD Ion Exchange Resin

SITE HMNB Devonport

SITE OWNER Ministry of Defence (MOD)

WASTE CUSTODIAN Babcock International Group

WASTE TYPE ILW

WASTE VOLUMES

	Reported (m^3)
Stocks: At 1.4.2025	= 6.0
Future arisings: 1.4.2025 - 31.3.2028	~ -1.6
1.4.2028 - 31.3.2031	~ -1.6
1.4.2031 - 31.3.2034	~ -2.9
Total future arisings:	**-6.0**
Total waste volume:	**0.0**

OR

Conditioned (m^3)	Packaged (m^3)

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

Comment on arising rates: The PCD process is no longer being undertaken. Therefore, there are no future arisings expected for the 7D40 (ILW resin) waste stream. It should noted that this wastestream will be processed/treated to remove chelates and remove/reduce C-14 and/or decay to LLW which will subsequently be disposed under 7D26/C. In the next 10 years the reported 2025 volume will reduce by ~ 6.015 m^3. Reported negative volumes in 'future arisings' represent the program of work in which this wastestream will be reduced and converted into conditioned wastestream: 7D26/C.

Additional information on quantities: Waste generated from the primary circuit decontamination (PCD) of submarines during major maintenance periods. PCD operations have now ceased at Devonport therefore future arisings generation rate is based on expectation of future conditioning. Current Stocks declared are for waste stored in raw form awaiting treatment. Waste disposal due to commence c. 2025/26 which will follow a conditioning/treatment campaign as part of a MoD driven Resin Disposal Project (RDP) to significantly reduce C14 & remove chelates. Campaign expected to include all other DRDL resin waste streams which include C-14 as well as chelate content. Reported negative volumes in 'future arisings' represent the program of work in which this wastestream will be reduced and converted into conditioned wastestream: 7D26/C.

Uncertainty factors on volumes:

Stock (upper):	x 1.10	Arisings (upper):	x 1.50
Stock (lower):	x 0.90	Arisings (lower):	x 0.50

WASTE SOURCE Submarine primary plant (reactor & associated systems) is chemically decontaminated to remove magnetite layer and hence radioactive activation products. Resin is used to remove soluble metal activation products that are generated when the magnetite layer is removed from the primary plant. Soluble activity is removed from process liquid using ion exchange resin. Primary plant dose rates are significantly reduced as a result of the process.

PHYSICAL CHARACTERISTICS

General description: The waste consists of resin beads which are uniform spheroids of approximately 1.0 mm size. The ion exchange resin is organic mixed cation and anion hydrogen-hydroxide (H-OH) type where the active groups are quaternary amines and sulphonic groups. These are manufactured from polystyrene divinylbenzene copolymer. The ion exchange resin is mixed to ensure an even number of anion / cation active sites. When resin is shown to be exhausted it is discharged into a Resin Storage Vessel (RSV). Resin is headed by an amount of water and remains wet during its storage period. Due to the chemical process used the resin will also contain an amount of organic chelating agents. Due to the chemical decontamination process being used the resin will contain appreciable quantities of chelating agents. There are no large items present. It is anticipated that this waste stream will be treated/conditioned to remove chealtes and significant quantities of C-14 and divert the waste to compliant 7D26/C waste-stream.

Changes since waste generated: Resin waste is insoluble and is stored in a raw state within a purpose designed resin storage vessel (RSV) until treatment/disposal. The waste resin will have been conditioned at an external treatment facility prior to disposal at NWS.

Bulk density (t/m^3): = 1.1

Comment on density: The density will be in the region of 1-1.1 t/m^3. Once conditioned for disposal the density will increase as the waste will be encapsulated into an appropriate concrete matrix (~ 1.9 t/m^3).

CHEMICAL COMPOSITION

General description and components (%wt): The waste consists of polystyrene bead mixed cation/anion resin. The main elements removed are metallic activation products. Other anions are also held by the resin. Chelating agents will be present due to nature of the decontamination plant chemistry. Ion exchange resin (75%), water (25%)

Chemical state: Acid

Sheet metal proportion / thickness: -

Metals and alloys (%wt):

	(%wt)	Type(s) / Grades(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	= 0	-	
Uranium	= 0	-	
Zinc	= 0	-	
Zircaloy/Zirconium	= 0	-	
Other metals	= 0	Not applicable apart from the metal activation products that may have adhered to the resin. This would be in very small concentrations.	

Organics (%wt):

	(%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	ion exchange resin of organic mixed cation and anion hydrogen-hydroxide (H-OH) type. These are manufactured from polystyrene divinylbenzene copolymer	4.2
Total rubber	= 0	-	
Halogenated rubber	= 0	-	
Non-halogenated rubber	= 0	-	
Hydrocarbons		-	
Oil or grease		-	
Fuel		-	
Asphalt/Tarmac (cont.coal tar)		-	
Asphalt/Tarmac (no coal tar)		-	
Bitumen		-	
Others		-	
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		-	
Graphite	= 0	-	
Desiccants/Catalysts	= 0	-	
Asbestos	= 0	-	
Non/low friable		-	
Moderately friable		-	
Highly friable		-	
Free aqueous liquids	25.0	Resin remains wet when stored with overstanding head of water.	< 0.1
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		-
Benzene		-
Chlorinated solvents		-
Formaldehyde		-
Organometallics		-
Phenol		-
Styrene		-
Tri-butyl phosphate		-
Other organophosphates		-
Vinyl chloride		-
Arsenic		-
Barium		-
Boron	< 0.01	Value quoted based on weighted average across boronated volume. Weighted Average over the entire waste stream inventory is 21.33 mg/l. Average Boron concentration over only boronated packages: 51.2 mg/l. Maximum conc in any single RSV: 187 mg/l
Boron (in Boral)	= 0	-
Boron (non-Boral)	< 0.01	Value quoted based on weighted average across boronated volume. Weighted Average over the entire waste stream inventory is 21.33 mg/l. Average Boron concentration over only boronated packages: 51.2 mg/l. Maximum conc in any single RSV: 187 mg/l
Cadmium		-
Caesium		-
Selenium		-
Chromium		-
Molybdenum		-
Thallium		-
Tin		-
Vanadium		-
Mercury compounds		-
Others		-

Complexing agents (%wt): Yes

	(%wt)	Type(s) and comment
EDTA	P 0.84	Detected in one sample (1 of 12) but possibly due to derivation and measurement error caused by prescence of picolinate.
DPTA		-
NTA		-
Polycarboxylic acids		-
Other organic complexants	< 2.9	Averaged across entire inventory: Picolinate Acid ~ 2.5 %wt , Formate Acid ~ 0.1 %wt. Average across chelated inventory: Picolinate Acid ~ 2.77 %wt , Formate Acid ~ 0.12 %wt. maximum chelate in any single RSV: Picolinate Acid ~ 10.7 %wt , Formate Acid ~ 0.20 %wt
Total complexing agents	< 3.7	-

Physical components:

	Number	Type(s) and comment
Sources	= 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	-

TREATMENT, PACKAGING AND DISPOSAL

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

Treatment	On-site / Off-site	Stream volume %
Size reduction		
Decay storage	On-site	= 100.0
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		

Comments on planned treatments: Due to the chelate and C-14 concentrations, it is intended that the resin will be treated/conditioned prior to disposal to destroy the organic chelates and also remove significant proportions of C-14 from the waste stream. Once treated/processed, It is assumed the resulting compliant product is likely to be encapsulated under wastestream 7D26/C for final disposal at NWS/LLW Repository. Treatment/processing is due to commence 2025/26

Conditioning method: Following decay/treatment/processing the resin will be assessed for suitability to move into the 7D26/C resin waste-stream. In this case the resin will be immobilised in a cement matrix using an in-drum mixing technique in order for NWS/LLW Repository wasteform requirements to be met. The wastestream will be conditioned in the Tradebe Inutec LLW Cementation Plant at Winfrith and the final product consists of an uncompactable waste matrix. The encapsulation process will be carefully controlled to ensure that each container and its contents meet all aspects of the NWS WAC, including Discrete Item limits where applicable. The wastestream is conditioned by mixing the wet resin with a blend of cement powders so that the resultant grout sets to a dry, solid monolith. An IX/cement resin formulation has been developed which is based on 120 litres of fully water-saturated and flooded resin mixed with 170kg blended cement powder. The blended cement powder consists of a standard mixture of ground-granulated blast furnace slag (ggBFS) and ordinary Portland cement (OPC) in the mass ratio 9:1 respectively for non-borated resin and 100 % OPC for borated resin. The waste loading of the final cement wasteform for 7D26/C is typically 25% by mass

Conditioning plants:

Plant Name	Location

Likely conditioning matrix: Non-standard

Further information on the conditioning matrix: When stored, the waste is held in its raw state. If treated/processed into the 7D26/c waste stream, a IX/cement resin formulation has been developed which is based on 120 litres of fully water-saturated and flooded resin mixed with 170kg blended cement powder. The blended cement powder consists of a standard mixture of ground-granulated blast furnace slag (ggBFS) and ordinary Portland cement (OPC) in the mass ratio 9:1 respectively for non-borated resin and 100 % OPC for borated resin. However, this will only occur following treatment wher the waste is diverted into 7D26/C waste stream.

Waste Packaging:

Likely container type:

Container	Waste packaged (vol%)	Waste loading (m^3)	Payload (m^3)	Number of packages	Estimated start date for packaging
1/2 Height IP-2 Disposal/Re-usable ISO (TC01/TC02)	100.0	-	-	-	-

Range in container waste loading: If conditioned/treated, this waste will be disposed under 7D26/C waste stream. The following comments are based on the assumption that waste is diverted into 7D26/C

Other information on packaging and conditioning: The method of preparation, using a in-drum mixing technique, ensures a homogeneous product. The fully-filled 200 litre drums will then be placed in a half height 2910 ISO freight container of the approved design for transport to the LLW Repository. As an alternative packaging process, the conditioned waste may be used to fill interstitial space between 200 litre drums of waste within a disposal container (e.g. 1/2 height ISO) to increase the packing efficiency of the final disposal container although this option has not yet been used.

Conditioned density (t/m^3): ~ 1.9

Conditioned density comment: Unconditioned 'Raw' wet ion exchange resin waste has an average density of around 1100 kgm-3 as stored. The cement conditioned product in mild steel drums has an average density of around 1900 kgm-3. The wastestream (if diverted to 7D26/C) is conditioned by mixing the wet resin with a blend of cement powders so that the resultant grout sets to a dry, solid monolith. The waste loading of the final cement wasteform is typically 25% by mass

Management Routes:

Disposal Route	Stream volume %	Raw density t/m^3	Start date
Expected to be consigned to a Near Site, Near Surface Disposal Facility (Scotland)			
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	= 100.0	~ 1.9	
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: Not yet determined

Baseline Management Route	Opportunity Management Route	Stream volume (%)	Opportunity Confidence	Comment
-	-	-	-	-

RADIOACTIVITY

Source: Activation products that have been removed from the primary plant during the decontamination process. The decontamination process used strips the magnetite layer from the internals of the primary circuit bringing the activation products into solution. Ion exchange resin is used to remove soluble anion/cations. Resin also contains organic chelating agents.

Uncertainty: Activity for the major nuclides is determined by sampling and an exhaustive radiochemical analysis. Future treatment of the waste may signifcantly reduce C-14 content.

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).

Chemical form of radionuclides:	H-3:	Present as HTO in the overstanding water. Not expected as organically bound tritium on resin. Total activity of tritium not significant
	C-14:	On resin in various chemical forms, mainly adhered to the resin.
	Cl-36:	-
	Se-79:	-
	Tc-99:	-
	I-129:	-
	Ra:	-
	Th:	-
	U:	-
	Np:	-
	Pu:	-

WASTE STREAM **7D40** **ILW PCD Ion Exchange Resin**

Nuclide	Mean radioactivity, TBq/m³ Waste at 1.4.2025	Bands and Code	Mean radioactivity, TBq/m³ Future Arisings	Bands and Code	Nuclide	Mean radioactivity, TBq/m³ Waste at 1.4.2025	Bands and Code	Mean radioactivity, TBq/m³ Future Arisings	Bands and Code
H 3	= 4.20E-04	A A 1	= 4.20E-04	B B 2	Gd 153				
Be 10					Ho 163				
C 14	= 2.87E-03	A A 1	= 2.87E-03	B B 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	= 7.57E-07	A A 1	= 7.57E-07	B B 2	Pb 205				
Fe 55	= 3.22E-02	A A 1	= 3.22E-02	B B 2	Pb 210				
Co 60	= 2.78E-02	A A 1	= 2.78E-02	B B 2	Bi 208				
Ni 59					Bi 210m				
Ni 63	= 4.91E-03	A A 1	= 4.91E-03	B B 2	Po 210				
Zn 65	= 1.22E-10	A A 1	= 1.22E-10	B B 2	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					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	= 1.59E-07	A A 1	= 1.59E-07	B B 2	Pu 241				
Sb 126					Pu 242				
Te 125m					Am 241	= 9.98E-08	A A 1	~ 9.98E-08	B B 2
Te 127m					Am 242m				
I 129					Am 243				
Cs 134					Cm 242				
Cs 135					Cm 243				
Cs 137	= 9.24E-06	A A 1	= 9.24E-06	B B 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					Unsp a				
Eu 152					Unsp b/g	= 8.80E-11	B B 1	= 8.80E-11	B B 2
Eu 154					**Total a**	**9.98E-08**	*	**9.98E-08**	*
Eu 155					**Total b/g**	**6.82E-02**	*	**6.82E-02**	*

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