

WASTE STREAM	7D34	Ion Exchange Resin from Primary Circuit Decontamination
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SITE HMNB Devonport

SITE OWNER Ministry of Defence (MOD)

WASTE CUSTODIAN Babcock International Group

WASTE TYPE LLW

WASTE VOLUMES

	Reported (m ³)	OR	Conditioned (m ³)	Packaged (m ³)
Stocks:	At 1.4.2025	= 9.9		
Future arisings:	1.4.2025 - 31.3.2028	~ -3.5		
	1.4.2028 - 31.3.2031	~ -2.8		
	1.4.2031 - 31.3.2034	~ -3.6		
Total future arisings:		-9.9		
Total waste volume:		0.0		

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

Comment on arising rates: 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 decay from LLW wastestream and expectation of future conditioning of current stock. 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 remove chelates and significantly reduce C14. 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.

Additional information on quantities: The future arising rate is expected to be influenced by Resin Disposal Program (RDP) treatment /conditioning to 7D26/C. With regard to volume estimation; a 2.0 m long stainless steel probe with 2 mounted detectors is used to record the height of the water level and the resin/water interface level within an Resin Storage Vessel (RSV). A conductivity detector indicates the depth of over-standing water by generating a signal when immersed in water. An Infra-Red Interface Detector (IRID) indicates the height of the resin/water interface by passing a beam of IR light between two detectors 3 mm apart; when the probe is in contact with resin at the resin/water interface the IR beam is broken and a signal generated. The length of probe that has been inserted when these signals are generated is used in conjunction with the RSV dimensions to determine the water and water/resin heights.

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 processing 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 until treated/processed. There are no large items present.

Changes since waste generated: Resin waste is insoluble and is stored within a purpose designed resin storage vessel (RSV) until treatment/disposal. The waste resin will have been conditioned at an external treatment facility and diverted to 7D26/C prior to disposal at NWS.

Bulk density (t/m³): = 1.1

Comment on density: The waste contains organic based ion exchange resin. There are equal numbers of active anion and cation sites. The resin is a polystyrene based bead consisting of uniform spheroids of approximately 1mm diameter. Pre-conditioned resin is always held in a wet state and is 'headed' by a quantity of demineralised water. Due to the chemical decontamination process being used the resin will contain appreciable quantities of chelating agents (>>1 % by weight). There are no large items present. The density will be in the region of 1-1.1 t/m³. Once conditioned for disposal the density will increase as the waste will be encapsulated into an appropriate concrete matrix.

CHEMICAL COMPOSITION

General description and components (%wt):

Raw waste ion exchange resin (75%), water (25%).

Chemical state:

Acid

Sheet metal proportion / thickness: Whilst stored pending treatment no metal waste products are in the waste.

Metals and alloys (%wt):

	(%wt)	Type(s) / Grades(s) with proportions	% of total C14 activity
Stainless steel.....	= 0	Primary containment is stainless steel. Containers are re-used, so not included.	
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	-	

Organics (%wt):

	(%wt)	Type(s) and comment	% of total C14 activity
Total cellulotics.....	= 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	
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):

	(%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.....		-	
Glass/Ceramics.....	= 0	-	
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.	
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.....	< 0.03	Present in the some resin packages. Average concentration over full 7D34 inventory: ~ 10.75 mg/l. Average over boronated packages only: 68.1 mg/l. Maximum conc in any single RSV: 160 mg/l
Boron (in Boral).....	= 0	-
Boron (non-Boral).....	< 0.03	-
Cadmium.....	-	-
Caesium.....	-	-
Selenium.....	-	-
Chromium.....	-	-
Molybdenum.....	-	-
Thallium.....	-	-
Tin.....	-	-
Vanadium.....	-	-
Mercury compounds.....	-	-
Others.....	-	-

Complexing agents (%wt):

Yes		
	(%wt)	Type(s) and comment
EDTA.....	-	-
DPTA.....	-	-
NTA.....	-	-
Polycarboxylic acids.....	-	-
Other organic complexants.....	< 1.7	Averaged over entire inventory: Picolinate (~1.4 %mass) and Averaged Formate (~0.1 %mass). Average over chelated inventory: Picolinate: 1.56 %wt, Formate: 0.12 %wt. Max chelate in any RSV: Picolinate: 4.7 %wt, Formate: 0.4 %wt
Total complexing agents.....	< 1.7	-

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		
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	Off-site	= 100.0
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 when the waste is diverted into 7D26/C waste stream.

Waste Packaging:

Likely container type:

Container	Waste packaged (vol%)	Waste loading (m³)	Payload (m³)	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/m³):
Conditioned density comment:

~ 1.9
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)	= 100.0	~ 1.9	
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			
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 significantly 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: HTO predominantly.
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: Possibility of Pu-241, form not known. Present in extremely low concentration.

WASTE STREAM		7D34		Ion Exchange Resin from Primary Circuit Decontamination					
Nuclide	Mean radioactivity, TBq/m³				Nuclide	Mean radioactivity, TBq/m³			
	Waste at 1.4.2025	Bands and Code	Future Arisings	Bands and Code		Waste at 1.4.2025	Bands and Code	Future Arisings	Bands and Code
H 3	=	1.24E-04	A A 1	~	1.24E-04	B B 2	Gd 153		
Be 10							Ho 163		
C 14	=	3.94E-05	A A 1	~	3.94E-05	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	=	1.72E-07	A A 1	~	1.72E-07	B B 2	Hf 182		
Ca 41							Pt 193		
Mn 53							Tl 204		
Mn 54	=	2.36E-08	A A 1	~	2.36E-08	B B 2	Pb 205		
Fe 55	=	4.84E-04	A A 1	~	4.84E-04	B B 2	Pb 210		
Co 60	=	2.90E-03	A A 1	~	2.90E-03	B B 2	Bi 208		
Ni 59							Bi 210m		
Ni 63	=	5.88E-04	A A 1	~	5.88E-04	B B 2	Po 210		
Zn 65	=	4.24E-11	A A 1	~	4.24E-11	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	=	1.51E-11	A A 1	~	1.51E-11	B B 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	=	7.83E-07	A A 1	~	7.83E-07	B B 2	Pu 241		
Sb 126							Pu 242		
Te 125m							Am 241	=	4.15E-07 A A 2 ~ 4.15E-07 B B 2
Te 127m							Am 242m		
I 129							Am 243		
Cs 134							Cm 242		
Cs 135							Cm 243		
Cs 137	=	7.79E-08	A A 1	~	7.79E-08	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	=	5.10E-12 A A 1 ~ 5.10E-12 B B 2
Eu 154							Total a	4.15E-07	4.15E-07
Eu 155	=	5.80E-08	A A 1	~	5.80E-08	B B 2	Total b/g	4.14E-03	4.14E-03

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