

<b>WASTE STREAM</b>	<b>7D28</b>	<b>Low Level Waste Resin from Plant Decontamination (MODIX)</b>
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**SITE** HMNB Devonport  
**SITE OWNER** Ministry of Defence  
**WASTE CUSTODIAN** Babcock International Group

**WASTE TYPE** LLW

Is the waste subject to Scottish Policy: No

**WASTE VOLUMES**

		Reported
Stocks:	At 1.4.2022.....	20.5 m <sup>3</sup>
Future arisings -	1.4.2023 - 31.3.2025.....	~-5.1 m <sup>3</sup>
	1.4.2025 - 31.3.2028.....	~-9.9 m <sup>3</sup>
	1.4.2028 - 31.3.2031.....	~-5.5 m <sup>3</sup>
Total future arisings:		-20.5 m <sup>3</sup>
Total waste volume:		0 m <sup>3</sup>

Comment on volumes: The MODIX process is no longer being undertaken so there will be no future generation due to this process. Future arisings rate is based on 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. 2024 which will follow a conditioning/treatment campaign as part of a MoD driven Resin Disposal Project (RDP) to remove C14 & 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. The future arising rate is expected to be influenced by Resin Disposal Program (RDP) treatment /conditioning to 7D26/C.

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** Submarine primary circuit is chemically decontaminated to remove magnetite layer and hence radioactive activation products. 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 uniform spheroids of approximately 1.0 mm size. The ion exchange resin is a mixture of anion and cation resin 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. There are no large items present.

Physical components (%vol): Resin (70%), water (30%).

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m<sup>3</sup>): 1.1

Comment on density: Raw waste has a density of 1.1 t/m<sup>3</sup> (resin /water mixture).

**CHEMICAL COMPOSITION**

General description and components (%wt): Resin (75%), water (25%)

Chemical state: Acid

Chemical form of radionuclides: H-3: tritium present as HTO and could also be fixed to the resin surface as OBT.  
 C-14: C-14 is present in the waste in varying concentrations dependent on decontamination stage.  
 I-129: Trace amounts adsorbed to the resin.  
 Pu: Trace amounts adsorbed to the resin.

Metals and alloys (%wt): Not present in waste.

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	(%wt)	Type(s) / Grade(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):                      Nuclear Grade Organic H-OH resins. Active groups are quaternary - tertiary amines and sulphonic acids.

	(%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.....			
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 are no free inorganic anions in the waste.

	(%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:           There are no hazardous materials present in the waste apart from those already identified (e.g. citric acid and sodium EDTA). Chelating agents will be present within the raw waste (adhered to the resin surface) and are declared for current stocks in raw state. Chelates will be removed, and C-14 removed/reduced following successful conditioning/treatment as part of the MoD driven Resin Disposal Project (RDP) in which this waste will move to the 7D26/C 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	

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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:      There are no heavy metals in the waste.

	(%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.....	<0.05	Present in the resin. Average concentration over full 7D28 inventory: ~ 16 mg/l. Average over boronated packages only: 168 mg/l. Max in any single RSV 400 mg/l
Boron (in Boral).....	0	
Boron (non-Boral).....	<0.05	
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.....		

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EEE Type 4.....

EEE Type 5.....

Complexing agents (%wt):      Yes

	(%wt)	Type(s) and comment
EDTA.....	<0.70	Weighted average over chelated assets
DPTA.....		
NTA.....		
Polycarboxylic acids.....	<0.53	Citric acid present at ~0.53% wt (weighted average over chelated assets). Maximum Citric Acid in single RSV: 4.21 %wt
Other organic complexants.....		
Total complexing agents.....	<1.3	

Potential for the waste to contain discrete items:      No.

**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:

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. It is assumed the resulting compliant product is likely to be encapsulated for final disposal at NWS

**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	~1.9

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 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:**

Container voidage: &lt;10%.

Waste Characterisation Form (WCH): The waste does not meet the LLWR's Waste Acceptance Criteria (WAC).  
The waste does not have a current WCH.

Not currently compliant with NWS WAC so stored awaiting treatment/conditioning prior to disposal.

Waste consigned for disposal to LLWR in year of generation: No. It is presently envisaged that this waste will be treated/conditioned prior to disposal to NWS (to remove C-14 and chelate content) waste will be batched with other resins with the aim that disposal will take place within the next 3-5 yrs i.e. before 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**

Source: The main sources of activity are activation products, mainly Co-60, Fe-55, C-14, Ni-63 etc.

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	that arise when the magnetite layer is removed from the primary circuit during decontamination operations.
Uncertainty:	The figures are based on average specific activity levels for the whole waste-stream. Possibility that individual nuclide activities for an individual Resin container could be higher than quoted. The activity of the major nuclides within the Resin Storage Vessel is determined from representative sampling and radiochemical analysis. The laboratory that is used is UKAS accredited.
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:	Radiochemical analysis of the main nuclides and gross beta and alpha measurements. Average waste stream values have been presented. 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:	A core sample of the resin from the RSV is taken and subjected to full radiochemical analysis for beta/gamma and alpha activities. No other nuclides are considered to be present in significant quantities. Assessment work has identified potential nuclides that could be present. Measurement, where practicable, is undertaken to prove absence/presence. The sampling and analysis methodology is periodically reviewed against each set of analysis results.

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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	1.80E-04	AA 1	~1.80E-04	BB 2	Gd 153				
Be 10					Ho 163				
C 14	1.04E-03	AA 1	~1.04E-03	BB 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	4.93E-11	AA 1	~4.93E-11	BB 2	Pb 205				
Fe 55	1.47E-04	AA 1	~1.47E-04	BB 2	Pb 210				
Co 60	3.71E-03	AA 1	~3.71E-03	BB 2	Bi 208				
Ni 59					Bi 210m				
Ni 63	1.27E-03	AA 1	~1.27E-03	BB 2	Po 210				
Zn 65	2.20E-12	AA 1	~2.20E-12	BB 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	4.82E-07	AA 1	~4.82E-07	BB 2	U 235				
Ag 110m	1.86E-14	AA 1	~1.86E-14	BB 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	2.68E-07	AA 1	~2.68E-07	BB 2	Pu 241	7.09E-07	AA 1	~7.09E-07	BB 2
Sb 126					Pu 242				
Te 125m					Am 241	2.09E-05	AA 1	~2.09E-05	BB 2
Te 127m					Am 242m				
I 129	1.93E-06	AA 1	~1.93E-06	BB 2	Am 243				
Cs 134					Cm 242				
Cs 135					Cm 243				
Cs 137	1.49E-05	AA 1	~1.49E-05	BB 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	8.00E-07	AA 1	~8.00E-07	BB 2
Eu 152	2.21E-07	AA 1	~2.21E-07	BB 2	Other b/g	3.30E-11	AA 1	~3.30E-11	BB 2
Eu 154					<b>Total a</b>	<b>~2.09E-05</b>	<b>AA 1</b>	<b>~2.09E-05</b>	<b>BB 2</b>
Eu 155	1.41E-07	AA 1	~1.41E-07	BB 2	<b>Total b/g</b>	<b>~6.36E-03</b>	<b>AA 1</b>	<b>~6.36E-03</b>	<b>BB 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