

<b>WASTE STREAM</b>	<b>7D29 Intermediate 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** ILW

Is the waste subject to Scottish Policy: No

**WASTE VOLUMES**

		Reported
Stocks:	At 1.4.2022.....	6.9 m <sup>3</sup>
Future arisings -	1.4.2023 - 31.3.2025.....	~-2.2 m <sup>3</sup>
	1.4.2025 - 31.3.2028.....	~-3.1 m <sup>3</sup>
	1.4.2028 - 31.3.2031.....	~-1.1 m <sup>3</sup>
	1.4.2031 - 31.3.2034.....	~-0.5 m <sup>3</sup>
Total future arisings:		-6.9 m <sup>3</sup>
Total waste volume:		0 m <sup>3</sup>

Comment on volumes: The MODIX process is no longer being undertaken. Therefore, there are no future arisings expected for the 7D29 (ILW resin) waste stream. It should be noted that this wastestream will decay into 7D28 and/or be treated/processed into 7D26/C. In the next 10 years the reported 2022 volume will reduce by 6.923 m<sup>3</sup> via treatment/conditioning to 7D26/C wastestream. TSSBN refitting introduced a different decontamination process. Resins in this category will undergo program of treatment/conditioning at Tradebe-Inutec which will remove complexants/chelates and reduce C-14 to LLW levels which will fall into 7D26/C wastestream.

Uncertainty factors on volumes: Stock (upper): x 1.1 Arisings (upper) x 1.3  
 Stock (lower): x 0.9 Arisings (lower) x 0.7

**WASTE SOURCE** Submarine primary plant (reactor & associated systems) plant decontamination. Resin is used to remove soluble metal activation products that are generated when the magnetite layer is removed from the primary plant.

**PHYSICAL CHARACTERISTICS**

General description: The waste contains organic based ion exchange resin where the active groups are quaternary amines and sulphonic groups. 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. 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 sodium EDTA and citric acid (>>0.1% by weight). There are no large items present.

Physical components (%vol): Ion exchange resin (75%), water (25%).

Sealed sources: The waste does not contain sealed sources.

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

Comment on density: The mean density of resin/water mixture is 1.1t/m<sup>3</sup>, i.e. resin is slightly heavier than the overstanding water. This value is for the raw waste only and does not take into consideration the conditioning matrix.

**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.

Chemical state: Acid

Chemical form of radionuclides: H-3: Tritium is present as HTO in overstanding water. Not expected as organically bound tritium on resin. Total activity of tritium not significant.  
 C-14: Will be present on the resin primarily in a carbonate form.  
 I-129: Present in trace amounts and adsorbed on the ion exchange resin.  
 Pu: Pu-241 present in trace amounts and adsorbed on the ion exchange resin.

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.....	0		
Uranium.....	0		
Zinc.....	0		
Zircaloy/Zirconium.....	0		
Other metals.....	0	Not applicable.	

Organics (%wt):                      The waste is a polystyrene based mixed anion and cation resin. Different resins are mixed such that there are same number of active sites on the 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		
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.....			
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):      Organic ion exchange resin used in conjunction with mainly organic main process chemicals in the decontamination process. Minimal free inorganic anions will be present in the waste as stored.

	(%wt)	Type(s) and comment
Fluoride.....	0	
Chloride.....	0	
Iodide.....	0	
Cyanide.....	0	
Carbonate.....	<<0.01	
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).

	(%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	

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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 /            There are no heavy metals in the waste.  
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.....	P	< 1.08 mg/l Average boron concentration (1 RSV has 14 mg/l)
Boron (in Boral).....		
Boron (non-Boral).....	<0.01	
Cadmium.....		
Caesium.....		
Selenium.....		
Chromium.....		
Molybdenum.....		
Thallium.....		
Tin.....		
Vanadium.....		
Mercury compounds.....		
Others.....		
Electronic Electrical Equipment (EEE)		
EEE Type 1.....		
EEE Type 2.....		
EEE Type 3.....		
EEE Type 4.....		
EEE Type 5.....		

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Complexing agents (%wt): Yes

	(%wt)	Type(s) and comment
EDTA.....	~0.90	Weighted average of inventory
DPTA.....		
NTA.....		
Polycarboxylic acids.....	~0.90	Weighted average of inventory
Other organic complexants.....		Maximum values : Sodium EDTA (<5.98%), citric acid (<4.3%). Content variable dependent upon when resin was used in the decontamination process.
Total complexing agents.....	<2.0	

Potential for the waste to contain discrete items: No.

**TREATMENT, PACKAGING AND DISPOSAL**

**Waste that is currently ILW:** The waste will become LLW as a result of radioactive decay into 7D28 and/or treatment/conditioning. Waste may be treated to reduce C-14 and remove chelate content. Treatment & conditioning option is currently- due to be undertaken for all resins containing chelates (and/or high C-14). This is likely to be in the next 3 to 5 years. This is dependent upon initial specific activity and potential treatment/conditioning option that is chosen.

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

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

Comment on planned treatments:

Treatment/conditioning process yet to be confirmed. The product will then be encapsulated and disposed of to LLWR.

**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 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: Encapsulated resin into steel drums or potentially direct into HHISO for disposal to NWS. 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).

Treatment/conditioning project currently underway which has determined the most appropriate way to manage the waste, e.g. C-14 removal and chelate destruction.

Waste consigned for disposal to LLWR in year of generation:

No. Waste will have to be sampled prior to being sentenced for disposal. The waste is ILW and could be held in storage for up to 30 years to allow for decay to LLW levels. Treatment /conditioning of this waste form , together with other relevant waste forms is expected to enable disposal within the next 3 to 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: -

**WASTE STREAM****7D29****Intermediate Level Waste Resin from Plant  
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Source:	The main nuclides are activation products (beta/gamma) that arise from the operation of the submarine pressurised water reactor. 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. The main nuclides in terms of activity are Co-60, Fe-55, C-14, Ni-63, Ag-110m, Mn-54 and Sb-125.. Resin also contains organic chelating agents.
Uncertainty:	Activity for the major nuclides is determined by sampling and an exhaustive radiochemical analysis. The total specific activity should therefore be within $\pm 50\%$ .
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).
Other information:	A core sample of the resin is taken from the RSV. This sample is subject to full radiochemical analysis for alpha and beta/gamma activities. The chelate concentration is also determined. The H-3 within the overstanding water is also assessed along with pH, conductivity and chloride analysis.

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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	1.29E-03	AA 1	1.29E-03	AA 1	Gd 153				
Be 10					Ho 163				
C 14	9.53E-03	AA 1	9.53E-03	AA 1	Ho 166m				
Na 22					Tm 170				
Al 26					Tm 171				
Cl 36	3.27E-05	AA 1	3.27E-05	AA 1	Lu 174				
Ar 39					Lu 176				
Ar 42					Hf 178n				
K 40					Hf 182				
Ca 41					Pt 193				
Mn 53					Tl 204				
Mn 54	2.85E-09	AA 1	2.85E-09	AA 1	Pb 205				
Fe 55	9.19E-04	AA 1	9.19E-04	AA 1	Pb 210				
Co 60	1.54E-02	AA 1	1.54E-02	AA 1	Bi 208				
Ni 59					Bi 210m				
Ni 63	3.08E-03	AA 1	3.08E-03	AA 1	Po 210				
Zn 65	2.16E-13	AA 1	2.16E-13	AA 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					U 233				
Pd 107					U 234				
Ag 108m	4.27E-07	AA	4.27E-07	AA	U 235				
Ag 110m	2.13E-13	AA 1	2.13E-13	AA 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	2.26E-06	AA 1	2.26E-06	AA 1	Pu 241	6.30E-05	AA 1	6.30E-05	AA 1
Sb 126					Pu 242				
Te 125m					Am 241	2.28E-04	AA 1	2.28E-04	AA 1
Te 127m					Am 242m				
I 129	1.07E-06	AA 1	1.07E-06	AA 1	Am 243				
Cs 134					Cm 242				
Cs 135					Cm 243				
Cs 137	8.58E-05	AA 1	8.58E-05	AA 1	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	~1.25E-05	AA 1	~1.25E-05	AA 1
Eu 152					Other b/g	3.09E-10	AA 1	3.09E-10	AA 1
Eu 154					<b>Total a</b>	<b>~2.28E-04</b>	<b>AA 1</b>	<b>~2.28E-04</b>	<b>AA 1</b>
Eu 155					<b>Total b/g</b>	<b>3.04E-02</b>	<b>AA 1</b>	<b>3.04E-02</b>	<b>AA 1</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