WASTE STREAM	7D28	Low Level Waste Resin from Plant Decontamination (MODIX)

SITE HMNB Devonport

SITE OWNER Ministry of Defence (MOD)

WASTE CUSTODIAN Babcock International Group

WASTE TYPE LLW

WASTE VOLUMES

		Reported (m^3)
Stocks:	At 1.4.2025	= 19.4
Future arisings:	1.4.2025 - 31.3.2028	~ -7.1
	1.4.2028 - 31.3.2031	~ -7.2
	1.4.2031 - 31.3.2034	~ -5.1
Total future arisings:		**-19.4**
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 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. 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 C-14. 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) treament /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: No physical/chemical processes or changes to the waste since 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/m^3): = 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/m^3. 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 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	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):

	(%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	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	= 0	-
Chlorinated solvents		-
Formaldehyde		-
Organometallics		-
Phenol	= 0	-
Styrene		-
Tri-butyl phosphate	= 0	-
Other organophosphates		-
Vinyl chloride	= 0	-
Arsenic	= 0	-
Barium		-
Boron	< 0.07	Based on entire % boron in entire resin stock. Average concentration over full 7D28 inventory: ~ 16.88 mg/l. Average over boronated packages only: 169 mg/l. Max in any single RSV 400 mg/l
Boron (in Boral)	= 0	-
Boron (non-Boral)	< 0.07	-
Cadmium	= 0	-
Caesium		-
Selenium	= 0	-
Chromium	= 0	-
Molybdenum	= 0	-
Thallium		-
Tin	= 0	-
Vanadium	= 0	-
Mercury compounds		-
Others	= 0	-

Complexing agents (%wt): Yes

	(%wt)	Type(s) and comment
EDTA	< 0.70	Weighted average across chelated assets
DPTA		-
NTA		-
Polycarboxylic acids	< 0.55	Citric acid present at ~0.55% wt (weighted average over chelated assets). Maximum Citric Acid in single RSV: 1.97 %wt
Other organic complexants		-
Total complexing agents	< 1.3	-

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 Polymer encapsulation Other physical treatment Other chemical treatment Containerisation Treatment not yet determined None	Off-site	= 100.0

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.

Conditioning method: Once treated the resin will be assessed for suitability to move into the 7D26/C resin waste-stream. In this case the resin is immobilised in a cement matrix using an in-drum mixing technique in order for NWS/LLW Repository wasteform requirements to be met. The wastestream is 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:

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 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	= 100.0	~ 1.9	

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

Measurement of radioactivities: Representative core samples taken, then the sample subjected to a range of chemical analysis and radiochemical techniques. Average waste stream values have been presented. The resin is 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. Specific Activity figures have been derived from current stock data and represent a reasonably consistant waste origin, therefore future arisings, which are expected to remain consistant, 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). An assessment has identified the major nuclides and also Difficult to Measure (DTM) nuclides that could be present within the waste.

Chemical form of radionuclides:

H-3: Tritium present as HTO and could also be fixed to the resin surface as OBT.
C-14: On resin in various chemical forms, mainly adhered to the resin in varying concentrations dependent on MODIX decontamination stage.
Cl-36: -
Se-79: -
Tc-99: -
I-129: Trace amounts adsorbed to the resin.
Ra: -
Th: -
U: -
Np: -
Pu: Trace amounts may be adsorbed to the resin.

WASTE STREAM **7D28** **Low Level Waste Resin from Plant Decontamination (MODIX)**

Nuclide	Mean radioactivity, TBq/m³ Waste at 1.4.2025	Bands and Code	Future Arisings	Bands and Code	Nuclide	Mean radioactivity, TBq/m³ Waste at 1.4.2025	Bands and Code	Future Arisings	Bands and Code
H 3	= 1.12E-04	A A 1	~ 1.12E-04	B B 2	Gd 153				
Be 10					Ho 163				
C 14	= 1.04E-03	A A 1	~ 1.04E-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	= 1.43E-11	A A 1	~ 1.43E-11	B B 2	Pb 205				
Fe 55	= 9.36E-05	A A 1	~ 9.36E-05	B B 2	Pb 210				
Co 60	= 3.13E-03	A A 1	~ 3.13E-03	B B 2	Bi 208				
Ni 59					Bi 210m				
Ni 63	= 1.35E-03	A A 1	~ 1.35E-03	B B 2	Po 210				
Zn 65	= 1.05E-13	A A 1	~ 1.05E-13	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	= 5.07E-07	A A 1	~ 5.07E-07	B B 2	U 235				
Ag 110m	= 1.57E-15	A A 1	~ 1.57E-15	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	= 2.20E-07	A A 1	~ 2.20E-07	B B 2	Pu 241	= 6.47E-07	A A 1	~ 6.47E-07	B B 2
Sb 126					Pu 242				
Te 125m					Am 241	= 3.58E-05	A A 1	~ 3.58E-05	B B 2
Te 127m					Am 242m				
I 129	= 2.05E-06	A A 1	~ 2.05E-06	B B 2	Am 243				
Cs 134					Cm 242				
Cs 135					Cm 243				
Cs 137	= 1.91E-05	A A 1	~ 1.91E-05	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	= 2.02E-07	A A 1	~ 2.02E-07	B B 2	Unsp b/g	= 3.54E-12	A A 1	~ 3.54E-12	B B 2
Eu 154					**Total a**	**3.58E-05**	*	**3.58E-05**	*
Eu 155	= 7.90E-08	A A 1	~ 7.90E-08	B B 2	**Total b/g**	**5.76E-03**	*	**5.76E-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