

<b>WASTE STREAM</b>	<b>9B318</b>	<b>Miscellaneous Metals and Materials (Reactor and Non-Reactor) LLW</b>
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**SITE** Bradwell

**SITE OWNER** Nuclear Decommissioning Authority

**WASTE CUSTODIAN** Magnox Limited

**WASTE TYPE** LLW

Is the waste subject to Scottish Policy: No

**WASTE VOLUMES**

		Reported
Stocks:	At 1.4.2022.....	0 m <sup>3</sup>
Future arisings -	1.4.2087 - 31.3.2090.....	91.0 m <sup>3</sup>
Total future arisings:		91.0 m <sup>3</sup>
Total waste volume:		91.0 m <sup>3</sup>

Comment on volumes: Final Site Clearance is assumed to commence in 2083 with reactor dismantling commencing in 2087 and lasting for three years. Volumes and radioactivity have been calculated for 85 years after reactor shutdown, i.e. 2087.

Uncertainty factors on volumes: Stock (upper): x Arisings (upper) x 1.2  
 Stock (lower): x Arisings (lower) x 0.8

**WASTE SOURCE** A variety of materials from plant dismantling, including thermocouple.

**PHYSICAL CHARACTERISTICS**

General description: A variety of materials including Nimonic restraint bars, steel alloy Wigner probes and thermocouple metals.

Physical components (%vol): A variety of constituents including metallic items from the reactor (<0.6%), temporary active drains (~46.4%) and vacuum clean and washdown area items (~53%).

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m<sup>3</sup>): ~1

Comment on density: The density is of the waste as prepared for packaging.

**CHEMICAL COMPOSITION**

General description and components (%wt): A variety of materials including metals. Materials will include special steels, zirconium and magnesium oxide.

Chemical state: Neutral

Chemical form of radionuclides: H-3: The chemical form of tritium has not been assessed.  
 C-14: The chemical form of carbon 14 has not been assessed but may be graphite.  
 Cl-36: The chemical form of chlorine 36 has not been assessed.

Metals and alloys (%wt): Items will have been cut for packaging. An assessment of item dimensions has not been made.

	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....			
Other ferrous metals.....			
Iron.....			
Aluminium.....	NE		
Beryllium.....	0		
Cobalt.....			
Copper.....	NE		
Lead.....	NE		
Magnox/Magnesium.....	NE		
Nickel.....			

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Titanium.....  
 Uranium.....  
 Zinc..... NE  
 Zircaloy/Zirconium..... <0.60 Zirconium will be present.  
 Other metals..... NE Non-ferrous metals have not been estimated.

Organics (%wt):                      Plastics may be present. Halogenated rubbers are not expected. Halogenated plastics have not been estimated.

	(%wt)	Type(s) and comment	% of total C14 activity
Total cellulose	0		
Paper, cotton	0		
Wood	0		
Halogenated plastics	NE		
Total non-halogenated plastics	NE		
Condensation polymers	NE		
Others	NE		
Organic ion exchange materials	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):                      There might be traces of graphite.

	(%wt)	Type(s) and comment	% of total C14 activity
Inorganic ion exchange materials	0		
Inorganic sludges and flocs	53.0	vacuum clean and washdown area items	
Soil	0		
Brick/Stone/Rubble	0		
Cementitious material	46.4	temporary active drains	
Sand			
Glass/Ceramics			
Graphite	TR		
Desiccants/Catalysts			
Asbestos			
Non/low friable			
Moderately friable			

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Highly friable.....  
 Free aqueous liquids..... 0  
 Free non-aqueous liquids..... 0  
 Powder/Ash..... 0

Inorganic anions (%wt): -

	(%wt)	Type(s) and comment
Fluoride.....	NE	
Chloride.....	NE	
Iodide.....	NE	
Cyanide.....	0	
Carbonate.....	NE	
Nitrate.....	NE	
Nitrite.....	NE	
Phosphate.....	NE	
Sulphate.....	NE	
Sulphide.....	NE	

Materials of interest for waste acceptance criteria: The presence or absence of asbestos has yet to be confirmed.

	(%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.....		
Putrescible wastes.....	0	
Non-putrescible wastes.....		
Corrosive materials.....	0	
Pyrophoric materials.....	0	
Generating toxic gases.....	0	
Reacting with water.....	0	
Higher activity particles.....		
Soluble solids as bulk chemical compounds.....		

Hazardous substances / non hazardous pollutants: -

	(%wt)	Type(s) and comment
Acrylamide.....		
Benzene.....		
Chlorinated solvents.....		
Formaldehyde.....		

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- Organometallics.....
- Phenol.....
- Styrene.....
- Tri-butyl phosphate.....
- Other organophosphates.....
- Vinyl chloride.....
- Arsenic.....
- Barium.....
- Boron.....
  - Boron (in Boral).....
  - Boron (non-Boral).....
- 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.....

Complexing agents (%wt):      Yes

(%wt)      Type(s) and comment

- EDTA.....
- DPTA.....
- NTA.....
- Polycarboxylic acids.....
- Other organic complexants.....
- Total complexing agents.....      TR

Potential for the waste to contain discrete items:      Yes. Large Concrete Items (LCIs) may be DIs; drummed (ungrouted)/"rubbleised" wastes assumed NOT DIs

**TREATMENT, PACKAGING AND DISPOSAL**

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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		100.0

Comment on planned treatments:

-

**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	1.0

Classification codes for waste expected to be consigned to a landfill facility: 17 01 01, 16 10 01\*/16 10 02

**Upcoming (2022/23-2024/25) Waste Routing (if expected to change from above):**

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:** (Not applicable to this waste stream)

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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:** (Not applicable to this waste stream)

Container voidage: -

Waste Characterisation Form (WCH): -

Waste consigned for disposal to LLWR in year of generation: -

**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: Activation of the materials and impurities. There may be some contamination.

Uncertainty: Only very approximate estimates have been made of the total specific activities. The activities quoted are those at the time of Final Dismantling &amp; Site Clearance.

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: The specific activities of the reactor material were estimated from neutron activation calculations of the reactor material and its impurities.

Other information: The activities quoted are those at 85 years after reactor shutdown, i.e. in 2087. There may be some contamination by Cs137.

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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			3.78E-05	CC 2	Gd 153				8
Be 10				8	Ho 163				8
C 14			7.3E-05	CC 2	Ho 166m				8
Na 22				8	Tm 170				8
Al 26				8	Tm 171				8
Cl 36			1.27E-06	CC 2	Lu 174				8
Ar 39				8	Lu 176				8
Ar 42				8	Hf 178n				8
K 40				8	Hf 182				8
Ca 41			1.54E-05	CC 2	Pt 193				8
Mn 53				8	Tl 204				8
Mn 54				8	Pb 205				8
Fe 55				8	Pb 210				8
Co 60			6.21E-08	CC 2	Bi 208				8
Ni 59			1.16E-09	CC 2	Bi 210m				8
Ni 63			2.79E-05	CC 2	Po 210				8
Zn 65				8	Ra 223				8
Se 79				8	Ra 225				8
Kr 81				8	Ra 226				8
Kr 85				8	Ra 228				8
Rb 87				8	Ac 227				8
Sr 90				8	Th 227				8
Zr 93				8	Th 228				8
Nb 91				8	Th 229				8
Nb 92				8	Th 230				8
Nb 93m				6	Th 232				8
Nb 94			1.57E-09	CC 2	Th 234				8
Mo 93			1.28E-08	CC 2	Pa 231				8
Tc 97				8	Pa 233				8
Tc 99				6	U 232				8
Ru 106				8	U 233				8
Pd 107				8	U 234				8
Ag 108m				6	U 235				8
Ag 110m				8	U 236				8
Cd 109				8	U 238				8
Cd 113m				8	Np 237				8
Sn 119m				8	Pu 236				8
Sn 121m			5.82E-08	CC 2	Pu 238				8
Sn 123				8	Pu 239				8
Sn 126				8	Pu 240				8
Sb 125				8	Pu 241				8
Sb 126				8	Pu 242				8
Te 125m				8	Am 241				8
Te 127m				8	Am 242m				8
I 129				8	Am 243				8
Cs 134				8	Cm 242				8
Cs 135				8	Cm 243				8
Cs 137				6	Cm 244				8
Ba 133			2.74E-08	CC 2	Cm 245				8
La 137				8	Cm 246				8
La 138				8	Cm 248				8
Ce 144				8	Cf 249				8
Pm 145				8	Cf 250				8
Pm 147				8	Cf 251				8
Sm 147				8	Cf 252				8
Sm 151			1.93E-06	CC 2	Other a				
Eu 152			1.15E-05	CC 2	Other b/g				
Eu 154			1.92E-07	CC 2	<b>Total a</b>	<b>0</b>	<b>0</b>		
Eu 155				8	<b>Total b/g</b>	<b>0</b>	<b>1.69E-04</b>	<b>CC 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