

<b>WASTE STREAM</b>	<b>5C305</b>	<b>DIDO Reactor Decommissioning LLW</b>
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**SITE** Harwell  
**SITE OWNER** Nuclear Decommissioning Authority  
**WASTE CUSTODIAN** Magnox Limited  
**WASTE TYPE** LLW

**WASTE VOLUMES**

		Reported
Stocks:	At 1.4.2019.....	0 m <sup>3</sup>
Future arisings -	1.4.2021 - 31.3.2025.....	262.0 m <sup>3</sup>
Total future arisings:		262.0 m <sup>3</sup>
Total waste volume:		262.0 m <sup>3</sup>
Comment on volumes:	Volumes updated for 2016 RWI to reflect SMART Inventory review	
Uncertainty factors on volumes:	Stock (upper): x	Arisings (upper) x 1.3
	Stock (lower): x	Arisings (lower) x 0.7

**WASTE SOURCE** Decommissioning of a 26MW(T) reactor in steel containment building with heavy water moderator.

**PHYSICAL CHARACTERISTICS**

General description: Steels and concrete from reactor and reactor storage blocks, lead fill and secondary waste.  
 Physical components (%vol): Biological shield (79%), steel tanks, top shield plug and annular shield (2%) and care and maintenance waste (19%).  
 Sealed sources: -  
 Bulk density (t/m<sup>3</sup>): ~3  
 Comment on density: Average density of barytes concrete (3.4 t/m<sup>3</sup>), lead (11.3 t/m<sup>3</sup>), steel (7.8 t/m<sup>3</sup>), boral (2.7 t/m<sup>3</sup>) and care and maintenance waste (0.81 t/m<sup>3</sup>).

**CHEMICAL COMPOSITION**

General description and components (%wt): The biological shield and the waste from the care and maintenance will dominate the chemical composition of the waste. Barytes concrete 86%, lead ~7%, Steel+ Boral ~1%; C&M waste (soft organics) ~6%.  
 Chemical state: Neutral  
 Chemical form of radionuclides: H-3: Tritium is present in the concrete and there are some tritium contaminated components.  
 C-14: Activation product  
 Cl-36: Activation product  
 Metals and alloys (%wt): Metal is present in a large range of thicknesses.

Stainless steel.....	~1.0	Steel+ Boral
Other ferrous metals.....	P	
Iron.....		
Aluminium.....	P	
Beryllium.....	0	
Cobalt.....		
Copper.....	NE	
Lead.....	~7.0	
Magnox/Magnesium.....	TR	
Nickel.....		
Titanium.....		
Uranium.....	TR	
Zinc.....	NE	
Zircaloy/Zirconium.....	TR	

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	Other metals.....	NE	
Organics (%wt):	The waste contains polythene resulting from secondary waste items (tents, protective clothing etc.). Halogenated plastics which are present in the waste are PVC and PTFE; the rubbers are neoprene and hypalon.		
	Total cellulosics.....	~~1.0	
	Paper, cotton.....	~~1.0	
	Wood.....	P	
	Halogenated plastics .....	~~1.0	PVC and PTFE
	Total non-halogenated plastics.....	~~2.0	
	Condensation polymers.....	TR	
	Others.....	~~2.0	
	Organic ion exchange materials....	0	
	Total rubber.....	0.90	
	Halogenated rubber .....	~~0.90	neoprene and hypalon.
	Non-halogenated rubber.....	NE	
	Hydrocarbons.....		
	Oil or grease .....		
	Fuel.....		
	Asphalt/Tarmac (cont.coal tar)...		
	Asphalt/Tarmac (no coal tar)....		
	Bitumen.....		
	Others.....		
	Other organics.....	TR	
Other materials (%wt):	-		
	Inorganic ion exchange materials.	0	
	Inorganic sludges and flocs.....	0	
	Soil.....	TR	
	Brick/Stone/Rubble.....	TR	
	Cementitious material.....	86.0	Barytes concrete
	Sand.....		
	Glass/Ceramics.....	0	
	Graphite.....	0	
	Desiccants/Catalysts.....		
	Asbestos.....	<1.0	Probably chrysotile
	Non/low friable.....		
	Moderately friable.....		
	Highly friable.....		
	Free aqueous liquids.....	0	
	Free non-aqueous liquids.....	0	
	Powder/Ash.....	0	
Inorganic anions (%wt):	-		

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Fluoride.....	0
Chloride.....	0
Iodide.....	0
Cyanide.....	0
Carbonate.....	P
Nitrate.....	0
Nitrite.....	0
Phosphate.....	0
Sulphate.....	0
Sulphide.....	0

Materials of interest for  
waste acceptance criteria:

-	
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
Active particles.....	
Soluble solids as bulk chemical compounds.....	

Hazardous substances /  
non hazardous pollutants:

Asbestos (<1%) and Bulk Lead Metal (<6.5%).	
Acrylamide.....	
Benzene.....	
Chlorinated solvents.....	
Formaldehyde.....	
Organometallics.....	
Phenol.....	
Styrene.....	
Tri-butyl phosphate.....	
Other organophosphates.....	
Vinyl chloride.....	
Arsenic.....	
Barium.....	
Boron.....	

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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):

No  
 EDTA.....  
 DPTA.....  
 NTA.....  
 Polycarboxylic acids.....  
 Other organic complexants.....  
 Total complexing agents..... 0

**TREATMENT, PACKAGING AND DISPOSAL**

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

Treatment	On-site / Off site	Stream volume %
Low force compaction	Off-site	19.0
Supercompaction (HFC)		
Incineration		
Solidification		
Decontamination		
Metal treatment		
Size reduction		
Decay storage		
Recycling / reuse		
Other / various		
None	81.0	

Comment on planned treatments:

-

**WASTE STREAM****5C305****DIDO Reactor Decommissioning LLW****Disposal Routes:**

Disposal Route	Stream volume %
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

**Upcoming (2019/20-2021/22) Waste Routing (if expected to change from above):**

Disposal Route	Stream volume %		
	2019/20	2020/21	2021/22
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			

**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	~19.0 ~81.0	~21.6 10	3 22

## Other information:

21.6m<sup>3</sup> loading volume is calculated based on the fact that you can fit 36 off (200 litre/0.2m<sup>3</sup>) drums (7.2m<sup>3</sup>) into a ½ height ISO, each drum can be super-compacted to a 1/3 of its original volume so therefore we can get 3 x the amount of un-compacted drums into the final disposal container (21.6m<sup>3</sup>).

**Waste Planned for Disposal at the LLW Repository:**

Container voidage: -

Waste Characterisation Form (WCH):

The waste meets the LLWR's Waste Acceptance Criteria (WAC).  
The waste does not have a current WCH.

Waste consigned for disposal to LLWR in year of generation:

Yes.

Potential for the waste to contain discrete items:

-

**Non-Containerised Waste for In-Vault Grouting:** (Not applicable to this waste stream)

Stream volume (%): -

Waste stream variation: -

Bounding cuboidal volume:

Inaccessible voidage: -

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Other information:

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**RADIOACTIVITY**

Source:

The main sources of activity are activated steel components and concrete with small traces of contamination.

Uncertainty:

Expected that waste will comprise primarily of beta/gamma emitting radionuclides. Alpha emitting radionuclides may be present but they are expected to be in small quantities.

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:

Specific activity calculated based on the original radioactive inventory for the structural components of Dido and on the known operational history and the flux rates of the reactors. This inventory has been improved and corrected to include the structural materials.

Other information:

-

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Nuclide	Mean radioactivity, TBq/m <sup>3</sup>				Nuclide	Mean radioactivity, TBq/m <sup>3</sup>			
	Waste at 1.4.2019	Bands and Code	Future arisings	Bands and Code		Waste at 1.4.2019	Bands and Code	Future arisings	Bands and Code
H 3			6.94E-03	C C 2	Gd 153				8
Be 10				8	Ho 163				8
C 14				8	Ho 166m				8
Na 22				8	Tm 170				8
Al 26				8	Tm 171				8
Cl 36			2.11E-07	C C 2	Lu 174				8
Ar 39				8	Lu 176				8
Ar 42				8	Hf 178n				8
K 40				8	Hf 182				8
Ca 41				8	Pt 193				8
Mn 53				8	Tl 204				8
Mn 54				8	Pb 205				8
Fe 55			9.83E-03	C C 2	Pb 210				8
Co 60			1.03E-02	C C 2	Bi 208				8
Ni 59				8	Bi 210m				8
Ni 63			2.8E-02	C C 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				8	Th 232				8
Nb 94				8	Th 234				8
Mo 93				8	Pa 231				8
Tc 97				8	Pa 233				8
Tc 99				8	U 232				8
Ru 106				8	U 233				8
Pd 107				8	U 234				8
Ag 108m				8	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				8	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				8	Cm 244				8
Ba 133			4.14E-04	C C 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			1.54E-08	C C 2	Other a				
Eu 152			3.18E-04	C C 2	Other b/g				
Eu 154			2.44E-05	C C 2	<b>Total a</b>	<b>0</b>		<b>0</b>	
Eu 155				8	<b>Total b/g</b>	<b>0</b>		<b>5.58E-02</b>	<b>C C 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