

**WASTE STREAM****9B79/C****FED Magnox - Solid Secondary Waste**

**SITE** Bradwell  
**SITE OWNER** Nuclear Decommissioning Authority

**WASTE CUSTODIAN** Magnox Limited

**WASTE TYPE** ILW

Is the waste subject to Scottish Policy: No

**WASTE VOLUMES**

		Conditioned	Packaged
Stocks:	At 1.4.2022.....	0.4 m <sup>3</sup>	2.6 m <sup>3</sup>
Total future arisings:		0 m <sup>3</sup>	0 m <sup>3</sup>
Total waste volume:		0.4 m <sup>3</sup>	2.6 m <sup>3</sup>
Number of waste packages in stock:	At 1.4.2022.....	2 package(s)	
Comment on volumes:	-		
Uncertainty factors on volumes:	Stock (upper): x 1.1	Arisings (upper)	x
	Stock (lower): x 0.9	Arisings (lower)	x

**WASTE SOURCE** Consists of segregated items, isolated prior to processing of FED through the FED dissolution plant, and insoluble items obtained after processing through the FED dissolution plant.

**PHYSICAL CHARACTERISTICS**

**General description:** Secondary solid waste consists primarily of nimonic springs, thermocouple wires and fuel fragments. Additionally, the volume will include a small fraction of top end fittings (spiders) containing zirconium alloy. Springs weigh approx 5g each and are estimated to be 33mm long and 10mm diameter. Thermocouples components are comprised of stainless steel and other metals. Top end fittings comprised of zirconium alloy and weigh approx 88g each. Also consists of sludge-entrained organics, assumed to be oils and adhesive tape used to manage particulates.

**Physical components (%wt):** The waste stream consists primarily of MAC (miscellaneous activated components) including segregated Nimonic springs, thermocouple wires and small fractions of fuel fragments and top end fittings.

**Sealed sources:** The waste does not contain sealed sources.

**Bulk density (t/m<sup>3</sup>):** 0.7

**Comment on density:** The density is calculated using known wastestream mass and volume.

**CHEMICAL COMPOSITION**

**General description and components (%wt):** The waste is comprised of solid waste removed from FED prior to it undergoing dissolution and residues from the chemical dissolution of Magnox. The waste will primarily consist of MAC (miscellaneous activated components) including segregated Nimonic springs, thermocouple wires and small fractions of fuel fragments and top end fittings.

**Chemical state:** -

**Chemical form of radionuclides:** C-14: Carbon 14 may be present as graphite.  
 Cl-36: The chemical form of chlorine 36 may be inorganic chloride.  
 U: Uranium is present as pieces of segregated fuel and miscellaneous particulates.  
 Pu: The chemical form of plutonium isotopes has not been determined but will probably be plutonium oxides.

**Metals and alloys (%wt):** Magnox MN80 is the primary component, accounting for 80.2wt%. Stainless steel from thermocouples is 10.5wt%, zirconium alloy from the spider is 2.7wt%, Nimonic 80A from top end fitting springs is 3.5wt%, uranium as pieces of segregated fuel is 3wt%.

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	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....	10.5	Thermocouples, nose cones, miscellaneous (e.g. head, lifter and metal)	
Other ferrous metals.....	0		
Iron.....			
Aluminium.....	NE		
Beryllium.....	TR		
Cobalt.....			
Copper.....	TR		
Lead.....	TR		
Magnox/Magnesium.....	80.2	Spider, nose cones, miscellaneous (e.g. end-cap, FED piece and fin)	
Nickel.....	3.5	Present as Nimonic 80A, Top End Fitting springs, miscellaneous (e.g. part of head and lifter).	
Titanium.....			
Uranium.....	3.0	Pieces of segregated fuel and miscellaneous particulates	
Zinc.....	NE		
Zircaloy/Zirconium.....	2.7	Spider, miscellaneous (e.g. pin)	
Other metals.....	0		
Organics (%wt):		Sludge-entrained organics, assumed to be oils and adhesive tape used to manage particulate.	
	(%wt)	Type(s) and comment	% of total C14 activity
Total cellulosics.....	NE		
Paper, cotton.....	NE		
Wood.....	NE		
Halogenated plastics .....	0		
Total non-halogenated plastics.....	0		
Condensation polymers.....	0		
Others.....	0		
Organic ion exchange materials....	TR		
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.....	0.10	Sludge-entrained organics, assumed to be oils and adhesive tape used to manage particulate.	

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Other materials (%wt):

-

	(%wt)	Type(s) and comment	% of total C14 activity
Inorganic ion exchange materials..	NE		
Inorganic sludges and flocs.....	0		
Soil.....	0		
Brick/Stone/Rubble.....	0		
Cementitious material.....	0		
Sand.....			
Glass/Ceramics.....	0		
Graphite.....	NE		
Desiccants/Catalysts.....			
Asbestos.....	0		
Non/low friable.....			
Moderately friable.....			
Highly friable.....			
Free aqueous liquids.....	P		
Free non-aqueous liquids.....	TR		
Powder/Ash.....	0		

Inorganic anions (%wt): Not fully assessed.

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

Materials of interest for waste acceptance criteria: Biological components are not present in the waste stream.

	(%wt)	Type(s) and comment
Combustible metals.....	0	
Low flash point liquids.....	0	
Explosive materials.....	0	
Phosphorus.....	0	
Hydrides.....	0	
Biological etc. materials.....	TR	
Biodegradable materials.....	0	
Putrescible wastes.....	0	

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Non-putrescible wastes.....  
 Corrosive materials..... 0  
 Pyrophoric materials..... 0  
 Generating toxic gases..... NE  
 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.....  
 Organometallics.....  
 Phenol.....  
 Styrene.....  
 Tri-butyl phosphate.....  
 Other organophosphates.....  
 Vinyl chloride.....  
 Arsenic.....  
 Barium.....  
 Boron..... 0  
   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.....

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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. Springs are DIs by definition.

**PACKAGING AND CONDITIONING**

Container type:	Container	Waste packaged (%vol)	Waste loading (m <sup>3</sup> )	Payload (m <sup>3</sup> )	Number of packages
	500 l RS drum (50mm Pb)	100.0	0.175	0.175	2

Container type comment: -

Range in container waste volume: Not yet determined.

Other information on containers: The container material is cast iron.

Conditioned density (t/m<sup>3</sup>): ~0.7

Conditioned density comment: The conditioned density is calculated using the known mass and volume of the wastestream.

Other information on conditioning: -

**RADIOACTIVITY**

Source: Activation of metal components that were in close proximity to fuel during generating operation. In addition to activation, a significant amount of contamination is expected.

Uncertainty: Specific activities of both waste packages were determined using gamma spectroscopy and fingerprints.

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 activities of both waste packages were measured and derived using gamma spectroscopy and the application of fingerprints. Specific activities of each waste package along with wastestream volume was used to calculate specific activity.

Other information: -

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Nuclide	Mean radioactivity, TBq/m <sup>3</sup>				Nuclide	Mean radioactivity, TBq/m <sup>3</sup>			
	Waste at 1.4.2022	Bands and Code	Future arisings	Bands and Code		Waste at 1.4.2022	Bands and Code	Future arisings	Bands and Code
H 3	2.58E-01	CC 2			Gd 153		8		
Be 10	4.9E-07	CC 2			Ho 163	5.36E-09	CC 2		
C 14	8.46E-03	CC 2			Ho 166m	9.02E-04	CC 2		
Na 22		8			Tm 170		8		
Al 26		8			Tm 171		8		
Cl 36	1.06E-05	CC 2			Lu 174	1.19E-07	CC 2		
Ar 39	5.26E-04	CC 2			Lu 176		8		
Ar 42	1.03E-08	CC 2			Hf 178n	1.89E-03	CC 2		
K 40	2.96E-09	CC 2			Hf 182		8		
Ca 41	1.84E-05	CC 2			Pt 193	3.02E-04	CC 2		
Mn 53	7.92E-09	CC 2			Tl 204	3.44E-03	CC 2		
Mn 54	1.72E-08	CC 2			Pb 205		8		
Fe 55	1.08E-01	CC 2			Pb 210		8		
Co 60	1.49E+00	CC 2			Bi 208	3.9E-05	CC 2		
Ni 59	5.7E-02	CC 2			Bi 210m	1.26E-09	CC 2		
Ni 63	5.87E+00	CC 2			Po 210	4.64E-06	CC 2		
Zn 65		8			Ra 223		8		
Se 79	3.18E-06	CC 2			Ra 225	5.95E-09	CC 2		
Kr 81	2.62E-06	CC 2			Ra 226	6.38E-09	CC 2		
Kr 85	7.01E-02	CC 2			Ra 228	1.58E-09	CC 2		
Rb 87	5.08E-09	CC 2			Ac 227	3.57E-05	CC 2		
Sr 90	2.50E+00	CC 2			Th 227	6.25E-09	CC 2		
Zr 93	1.7E-04	CC 2			Th 228	5.7E-06	CC 2		
Nb 91	1.66E-06	CC 2			Th 229	6.21E-09	CC 2		
Nb 92		8			Th 230	2.1E-05	CC 2		
Nb 93m	1.09E-03	CC 2			Th 232	6.72E-06	CC 2		
Nb 94	1.44E-04	CC 2			Th 234	1.27E-09	CC 2		
Mo 93	1.17E-04	CC 2			Pa 231	1.23E-08	CC 2		
Tc 97		8			Pa 233		8		
Tc 99	1.23E-03	CC 2			U 232	7.94E-07	CC 2		
Ru 106	8.37E-08	CC 2			U 233	1.98E-06	CC 2		
Pd 107	7.41E-06	CC 2			U 234	1.95E-04	CC 2		
Ag 108m	3.08E-05	CC 2			U 235	5.7E-06	CC 2		
Ag 110m		8			U 236	2.1E-05	CC 2		
Cd 109	4.31E-09	CC 2			U 238	5.25E-05	CC 2		
Cd 113m	2.56E-04	CC 2			Np 237	6.55E-03	CC 2		
Sn 119m		8			Pu 236	1.9E-08	CC 2		
Sn 121m	1.22E-03	CC 2			Pu 238	2.38E-02	CC 2		
Sn 123		8			Pu 239	6.01E-02	CC 2		
Sn 126	2.76E-05	CC 2			Pu 240	7.95E-02	CC 2		
Sb 125	1.08E-04	CC 2			Pu 241	2.32E-04	CC 2		
Sb 126	3.86E-06	CC 2			Pu 242	7.04E-04	CC 2		
Te 125m	2.71E-05	CC 2			Am 241	1.88E-01	CC 2		
Te 127m		8			Am 242m	3.6E-09	CC 2		
I 129	2.57E-06	CC 2			Am 243	7.13E-05	CC 2		
Cs 134	1.54E-03	CC 2			Cm 242	1.55E-01	CC 2		
Cs 135	5.58E-05	CC 2			Cm 243	2.86E-05	CC 2		
Cs 137	3.44E+00	CC 2			Cm 244	3.59E-04	CC 2		
Ba 133	3.94E-04	CC 2			Cm 245	3.03E-08	CC 2		
La 137	9.49E-07	CC 2			Cm 246	1.82E-09	CC 2		
La 138		8			Cm 248		8		
Ce 144	2.99E-09	CC 2			Cf 249		8		
Pm 145	2.71E-06	CC 2			Cf 250		8		
Pm 147	1.36E-03	CC 2			Cf 251		8		
Sm 147	1.29E-09	CC 2			Cf 252		8		
Sm 151	3.15E-02	CC 2			Other a				
Eu 152	4.84E-05	CC 2			Other b/g				
Eu 154	1.15E-02	CC 2			<b>Total a</b>	<b>5.14E-01</b>	<b>CC 2</b>	<b>0</b>	
Eu 155	1.19E-03	CC 2			<b>Total b/g</b>	<b>1.39E+01</b>	<b>CC 2</b>	<b>0</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