WASTE STREAM 9B59/C FED Magnox

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.....	5.2 m^3	13.2 m^3
Total future arisings:		0 m^3	0 m^3
Total waste volume:		5.2 m^3	13.2 m^3
Number of waste packages in stock:	At 1.4.2022.....	10 package(s)	

Comment on volumes:	Volume from WD/CALC/4107 Issue 3			
Uncertainty factors on volumes:	Stock (upper):	x 1.2	Arisings (upper)	x
	Stock (lower):	x 0.8	Arisings (lower)	x

WASTE SOURCE The source of the waste is the removal of splitters from fuel elements prior to dispatch of the elements for reprocessing. This waste was processed through the FED dissolution plant.

PHYSICAL CHARACTERISTICS

General description:	The waste consists of Magnox metal and swarf which may be contaminated by fission products and actinides. Some waste from pond clean-up operations (relatively rich in uranium corrosion products) was tipped into Vault 8B, making the interface wastes too contaminated to allow separation. The wastes comprise various mixtures of the following: Magnox FED, FED oxidation product, waste from pond clean-up operations (principally pond sludge).
Physical components (%vol):	The packages will contain discrete waste components from Magnox splitters.
Sealed sources:	The waste does not contain sealed sources.
Bulk density (t/m^3):	0.24
Comment on density:	The density was calculated using the known waste mass and volume of the total waste stream.

CHEMICAL COMPOSITION

General description and components (%wt):	Magnox metal (type ZR55) (>96%). Fission product and actinide contamination. The waste volume will includes a small fraction of Nimonic and zirconium alloys. Also contains IEX Resin from 56V (3%) and ADAP Sludge (2%).
Chemical state:	Neutral
Chemical form of radionuclides:	H-3: Tritium is expected to be present as surface contamination possibly as water but perhaps in the form of other inorganic compounds or as organic compounds. C-14: Carbon 14 will probably be present as graphite. Cl-36: Chlorine 36 incorporated in the Magnox may be associated with barium impurity ($BaCl_2$). Other chlorine 36 may be associated with surface contamination. U: Chemical form of U isotopes has not been determined but are present as oxides. Pu: Chemical form of Pu isotopes has not been determined but may be oxides.
Metals and alloys (%wt):	The thickness of some of the waste will be of the order of a mm or less.

	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....	0		
Other ferrous metals.....	0		
Iron.....	0		
Aluminium.....	0		

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Beryllium		
Cobalt		
Copper	0	
Lead	0	
Magnox/Magnesium	96.0	The waste is Magnox ZR55 which contains 0.55 wt% zirconium as an alloying constituent.
Nickel	TR	Small quantities of Nimonic, a high nickel content alloy.
Titanium		
Uranium		
Zinc		
Zircaloy/Zirconium		
Other metals	TR	Manganese

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	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	TR		

Other materials (%wt): Graphite contamination on the surface of the Magnox metal. IEX resin and ADAP sludge present.

	(%wt)	Type(s) and comment	% of total C14 activity
Inorganic ion exchange materials	3.0	IEX resin from 56V	
Inorganic sludges and flocs	2.0	ADAP sludge	
Soil	0		
Brick/Stone/Rubble	0		
Cementitious material	0		

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Sand	
Glass/Ceramics	0
Graphite	TR
Desiccants/Catalysts	
Asbestos	0
Non/low friable	
Moderately friable	
Highly friable	
Free aqueous liquids	TR
Free non-aqueous liquids	0
Powder/Ash	TR

Inorganic anions (%wt): -

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

Materials of interest for waste acceptance criteria: Magnox will ignite under appropriate conditions.

	(%wt)	Type(s) and comment
Combustible metals	>96.0	
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		
Corrosive materials	0	
Pyrophoric materials	0	
Generating toxic gases	0	
Reacting with water	>96.0	
Higher activity particles		
Soluble solids as bulk chemical compounds		

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Hazardous substances / non hazardous pollutants: None expected

	(%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.....		

Complexing agents (%wt): Yes

	(%wt)	Type(s) and comment
EDTA.....		
DPTA.....		
NTA.....		
Polycarboxylic acids…….		
Other organic complexants.....		
Total complexing agents.....	TR	

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Potential for the waste to contain discrete items: Yes. In & of itself not a DI; Will likely contain "rogue" items (HDRIs) that will be (see Nimonic/Others)

PACKAGING AND CONDITIONING

Container type:

Container	Waste packaged (%vol)	Waste loading (m^3)	Payload (m^3)	Number of packages
500 l RS drum (0mm Pb)	100.0	0.516	0.516	10

Container type comment: Waste has been packaged in 10 MOSAIK T ISAR IP-2 containers.

Range in container waste volume: -

Other information on containers: -

Conditioned density (t/m^3): 0.24

Conditioned density comment: Calculated using known wastestream volume and mass.

Other information on conditioning: -

RADIOACTIVITY

Source: The source of the waste is the removal of splitters from fuel elements prior to dispatch of the elements to Sellafield. Activation of trace nuclides in the Magnox and contamination by fission products and actinides will be main sources of activity. In addition activity in waste packages will also be derived from activated fuel element components e.g. nimonic springs and fuel fragments.

Uncertainty: Specific activities of all 10 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 all 10 waste packages were measured and derived using gamma spectroscopy and the application of fingerprints. The total activity for all packages was summed and divided by the waste stream volume to obtain specific activity. Decayed to 01/04/2022.

Other information: The activities quoted do not include any allowance for the activity of Nimonic springs or zirconium alloy in top end fittings. However, the resulting average activities in the waste are thought to lie within the uncertainties associated with the average activity of the Magnox.

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Nuclide	Mean radioactivity, TBq/m³ Waste at 1.4.2022	Bands and Code	Future arisings	Bands and Code	Nuclide	Mean radioactivity, TBq/m³ Waste at 1.4.2022	Bands and Code	Future arisings	Bands and Code
H 3	3.19E-02	C C 2			Gd 153		8		
Be 10		8			Ho 163		8		
C 14	5.71E-04	C C 2			Ho 166m	7.95E-07	C C 2		
Na 22		8			Tm 170		8		
Al 26		8			Tm 171		8		
Cl 36	5.62E-06	C C 2			Lu 174		8		
Ar 39	1.04E-04	C C 2			Lu 176		8		
Ar 42	3.12E-09	C C 2			Hf 178n	1.82E-06	C C 2		
K 40	1.2E-09	C C 2			Hf 182		8		
Ca 41	3.76E-05	C C 2			Pt 193	6.92E-05	C C 2		
Mn 53		8			Tl 204	2.21E-06	C C 2		
Mn 54		8			Pb 205		8		
Fe 55	1.52E-03	C C 2			Pb 210		8		
Co 60	2.24E-03	C C 2			Bi 208	3.76E-03	C C 2		
Ni 59	2.7E-05	C C 2			Bi 210m		8		
Ni 63	3.86E-03	C C 2			Po 210	1.05E-05	C C 2		
Zn 65		8			Ra 223		8		
Se 79	2.67E-09	C C 2			Ra 225		8		
Kr 81		8			Ra 226		8		
Kr 85	1.81E-04	C C 2			Ra 228		8		
Rb 87		8			Ac 227	3.27E-03	C C 2		
Sr 90	4.41E-02	C C 2			Th 227		8		
Zr 93	1.78E-06	C C 2			Th 228	1.06E-07	C C 2		
Nb 91		8			Th 229		8		
Nb 92		8			Th 230	3.91E-07	C C 2		
Nb 93m	2.88E-06	C C 2			Th 232	9.81E-08	C C 2		
Nb 94	1.79E-07	C C 2			Th 234		8		
Mo 93	5.15E-09	C C 2			Pa 231		8		
Tc 97		8			Pa 233		8		
Tc 99	4.86E-06	C C 2			U 232	3.57E-08	C C 2		
Ru 106	7.31E-09	C C 2			U 233	6.4E-08	C C 2		
Pd 107	6.51E-09	C C 2			U 234	3.4E-06	C C 2		
Ag 108m	1.12E-05	C C 2			U 235	1.06E-07	C C 2		
Ag 110m		8			U 236	3.91E-07	C C 2		
Cd 109	3.9E-09	C C 2			U 238	1.51E-06	C C 2		
Cd 113m	5.25E-07	C C 2			Np 237	2.1E-04	C C 2		
Sn 119m		8			Pu 236	3.22E-09	C C 2		
Sn 121m	8.33E-08	C C 2			Pu 238	1.95E-03	C C 2		
Sn 123		8			Pu 239	1.84E-03	C C 2		
Sn 126	2.42E-08	C C 2			Pu 240	2.21E-03	C C 2		
Sb 125	1.83E-06	C C 2			Pu 241	3.26E-02	C C 2		
Sb 126	3.39E-09	C C 2			Pu 242	1.57E-05	C C 2		
Te 125m	4.57E-07	C C 2			Am 241	9.56E-03	C C 2		
Te 127m		8			Am 242m	1.13E-05	C C 2		
I 129	2.26E-09	C C 2			Am 243	5.2E-06	C C 2		
Cs 134	7.46E-07	C C 2			Cm 242	7.87E-03	C C 2		
Cs 135	6.09E-08	C C 2			Cm 243	1.52E-06	C C 2		
Cs 137	5.28E-03	C C 2			Cm 244	2.46E-05	C C 2		
Ba 133	5.97E-06	C C 2			Cm 245	2.21E-09	C C 2		
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	4.18E-05	C C 2			Cf 251		8		
Sm 147		8			Cf 252		8		
Sm 151	6.41E-04	C C 2			Other a				
Eu 152	1.96E-06	C C 2			Other b/g				
Eu 154	1.63E-04	C C 2			**Total a**	**2.37E-02**	**C C 2**	**0**	
Eu 155	2.33E-05	C C 2			**Total b/g**	**1.30E-01**	**C C 2**	**0**	

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