WASTE STREAM 9A61 FED Magnox from Post Irradiation Examination

SITE	Berkeley
SITE OWNER	Nuclear Decommissioning Authority
WASTE CUSTODIAN	Magnox Limited
WASTE TYPE	ILW
Is the waste subject to Scottish Policy:	No

WASTE VOLUMES

		Reported
Stocks:	At 1.4.2022.....	61.9 m^3
Total future arisings:		0 m^3
Total waste volume:		61.9 m^3

Comment on volumes: There will be no further arisings of this waste stream. The volume given is the volume of Magnox fuel element debris as held in drums and other containers. The volume quoted is an upper limit assuming that all the containers are completely full of debris.

Uncertainty factors on volumes:

Stock (upper):	x 1.1	Arisings (upper)	x
Stock (lower):	x 0.9	Arisings (lower)	x

WASTE SOURCE The waste arose from the programme of post irradiation examination of Magnox fuel elements that was undertaken within the research facilities previously on the site.

PHYSICAL CHARACTERISTICS

General description: The waste is predominantly made up of Magnox metal generated from the post irradiation examination work, although it could include other fuel element components. The largest arisings are believed to be splitter cages. There may be a significant quantity of Magnox fuel canning material contaminated by fuel in the debris. There will also be some Sintox discs, along with graphite, stainless steel and zirconium. The waste may be contaminated with Ternary Eutectic Chloride (TEC) (a fire extinguishant). All of the waste is containerised in mild steel black cans and black can liners. There are no large items that may require special handling.

Physical components (%wt): The vast majority of the FED from Berkeley Centre is Magnox (98%wt) together with possible small quantities of zirconium (1.6%wt), Sintox discs (sintered alumina) (0.1%wt), other components (Nimonic springs, graphite, stainless steel) (0.23%wt) and <<0.1%wt thermocouples. There will also be small amounts of mild steel from the containers, and there may be traces of Ternary Eutectic Chloride present.

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m^3): 0.43

Comment on density: Density is calculated from the total mass of the loose waste, and the containerised waste (including the containers), and the volume.

CHEMICAL COMPOSITION

General description and components (%wt): The component breakdown of the FED from Berkeley Centre is 98%wt Magnox, 1.6%wt Zirconium, 0.1%wt Sintox discs (sintered alumina), 0.23%wt. Other components (Nimonic springs, graphite, stainless steel) and <<0.1%wt Thermocouples. There will also be small amounts of mild steel from the containers, and there may be traces of Ternary Eutectic Chloride present.

Chemical state: Alkali

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 or 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 (barium chloride).
Se-79: The selenium content is insignificant.
Tc-99: The technetium content is insignificant.
Ra: Radium isotope content is insignificant.
Th: The thorium isotope content is insignificant.
U: Chemical form of U isotopes has not been determined but may be oxides.
Np: The neptunium content is insignificant.
Pu: Chemical form of plutonium isotopes has not been determined but may be plutonium oxides.

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Metals and alloys (%wt): Bulk items are not expected to be present. Nearly all of the waste is expected to be only 1 or 2 mm thick.

	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel	<0.20	Mild steel will be present as the waste container.	
Other ferrous metals	NE		
Iron			
Aluminium			
Beryllium	TR		
Cobalt			
Copper	0		
Lead	0		
Magnox/Magnesium	98.0	0.8 wt% of this is aluminium.	
Nickel	~0.20	Nimonic.	
Titanium			
Uranium			
Zinc	TR		
Zircaloy/Zirconium	1.6		
Other metals	TR	"Other" metals could include thermocouple wires.	

Organics (%wt): The waste is currently stored in the same vault as the ion exchange material drums, which will have corroded to an extent. Therefore, it is likely to be contaminated with traces of spilt Lewatit DN, the organic ion exchange material.

	(%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	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	TR		

Other materials (%wt): Traces of graphite may be present.

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

Inorganic anions (%wt): Inorganic anions are not expected to be present at greater than trace concentrations.

	(%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: Some of this material may be contaminated with the fire extinguishant powder, Ternary Eutectic Chloride (made up of Sodium chloride (20-35wt%, Potassium chloride (29-40wt%) and barium chloride (25-51wt%)). This may be of potential concern owing to the corrosive effect of sodium chloride on a package.

	(%wt)	Type(s) and comment
Combustible metals.....	98.0	
Low flash point liquids.....	0	
Explosive materials.....	0	
Phosphorus.....	0	
Hydrides.....	0	
Biological etc. materials.....	0	
Biodegradable materials.....	0	
Putrescible wastes.....	0	

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Non-putrescible wastes.....	
Corrosive materials.....	0
Pyrophoric materials.....	0
Generating toxic gases.....	0
Reacting with water.....	98.0
Higher activity particles.....	
Soluble solids as bulk chemical compounds.....	

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.....		

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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. In & of itself not a DI; Will likely contain "rogue" items (HDRIs) that will be (see Nimonic/Others)

PACKAGING AND CONDITIONING

Conditioning method: This stream will be co-packaged together in Concrete boxes (9A62, 9A67, 9A32, 9A40, 9A48, 9A53, 9A73). The remainder of vault 1 waste will be co-packaged together in Type VI DCIC containers (9A25, 9A31, 9A39, 9A47, 9A52, 9A60 and 9A66). Packages for vault 1 are assigned to 9A25, 9A32 & 9A73.

Plant Name: -

Location: Berkeley Site

Plant startup date: -

Total capacity (m^3/y incoming waste): -

Target start date for packaging this stream: -

Throughput for this stream (m^3/y incoming waste): -

Other information: -

Likely container type:

Container	Waste packaged (%vol)	Waste loading (m^3)	Payload (m^3)	Number of packages

Likely container type comment: -

Range in container waste volume: -

Other information on containers: -

Likely conditioning matrix:

Other information: -

Conditioned density (t/m^3): -

Conditioned density comment: -

Other information on conditioning: -

Opportunities for alternative disposal routing: -

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Baseline Management Route	Opportunity Management Route	Stream volume (%)	Estimated Date that Opportunity will be realised	Opportunity Confidence	Comment
-	-	-	-	-	-

RADIOACTIVITY

Source:	Activation when the associated fuel elements were irradiated, of nuclides incorporated in the Magnox and other materials, contamination by fission products and actinides during fuel element examination at Berkeley Technology Centre.
Uncertainty:	The values quoted are indicative of the activities that might be expected.
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:	Values were derived from measurements, calculations of induced activity and estimates of likely contamination.
Other information:	-

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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	4.30E-03	C C 2			Gd 153		8		
Be 10	2E-07	C C 2			Ho 163		8		
C 14	9.99E-05	C C 2			Ho 166m		8		
Na 22		8			Tm 170		8		
Al 26	6E-05	C C 2			Tm 171		8		
Cl 36	2E-04	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	<3E-05	C 3			Pt 193		8		
Mn 53		8			Tl 204		8		
Mn 54		8			Pb 205		8		
Fe 55	4.39E-07	C C 2			Pb 210		8		
Co 60	<1.39E-03	C 3			Bi 208		8		
Ni 59	1E-02	C C 2			Bi 210m		8		
Ni 63	9.00E-01	C C 2			Po 210		8		
Zn 65		8			Ra 223		8		
Se 79	3.45E-08	C C 2			Ra 225		8		
Kr 81		8			Ra 226		8		
Kr 85		8			Ra 228		8		
Rb 87		8			Ac 227		8		
Sr 90	2.10E-02	C C 2			Th 227		8		
Zr 93	2E-06	C C 2			Th 228		8		
Nb 91		8			Th 229		8		
Nb 92		8			Th 230		8		
Nb 93m	9.52E-07	C C 2			Th 232		8		
Nb 94		8			Th 234	3E-06	C C 2		
Mo 93		8			Pa 231		8		
Tc 97		8			Pa 233	1.15E-07	C C 2		
Tc 99	1E-05	C C 2			U 232		8		
Ru 106		8			U 233		8		
Pd 107		8			U 234	2.01E-06	C C 2		
Ag 108m	3.90E-06	C C 2			U 235	6E-08	C C 2		
Ag 110m		8			U 236	3.00E-07	C C 2		
Cd 109		8			U 238	3E-06	C C 2		
Cd 113m	<4.73E-05	C 3			Np 237	1.15E-07	C C 2		
Sn 119m		8			Pu 236		8		
Sn 121m	<3.28E-04	C 3			Pu 238	3.56E-04	C C 2		
Sn 123		8			Pu 239	9.00E-04	C C 2		
Sn 126	3.04E-07	C C 2			Pu 240	9.99E-04	C C 2		
Sb 125	1.81E-08	C C 2			Pu 241	9.74E-03	C C 2		
Sb 126	4.26E-08	C C 2			Pu 242	6E-07	C C 2		
Te 125m	4.54E-09	C C 2			Am 241	3.26E-03	C C 2		
Te 127m		8			Am 242m	3.71E-06	C C 2		
I 129	2E-08	C C 2			Am 243	9.99E-07	C C 2		
Cs 134	1.94E-09	C C 2			Cm 242	3.06E-06	C C 2		
Cs 135	7E-07	C C 2			Cm 243	4.25E-07	C C 2		
Cs 137	2.83E-02	C C 2			Cm 244	5.06E-06	C C 2		
Ba 133	<2.24E-05	C 3			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	3.81E-07	C C 2			Cf 251		8		
Sm 147		8			Cf 252		8		
Sm 151	1.78E-04	C C 2			Other a				
Eu 152	9.19E-07	C C 2			Other b/g				
Eu 154	2.98E-05	C C 2			**Total a**	**5.53E-03**	**C C 2**	**0**	
Eu 155	2.38E-06	C C 2			**Total b/g**	**9.76E-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