

<b>WASTE STREAM</b>	<b>9A32</b>	<b>FED Graphite</b>
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**SITE** Berkeley

**SITE OWNER** Nuclear Decommissioning Authority

**WASTE CUSTODIAN** Magnox Limited

**WASTE TYPE** ILW

**WASTE VOLUMES**

Stocks:	At 1.4.2019.....	Reported 225.2 m <sup>3</sup>
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Total future arisings: 0 m<sup>3</sup>

Total waste volume: 225.2 m<sup>3</sup>

Comment on volumes: Station operation ceased in March 1989. This waste stream was accumulated between April 1967 and October 1972. The volume quoted is the estimated bulk volume of the waste if separated from other wastes with which it is mixed.

Uncertainty factors on volumes: Stock (upper): x 1.1 Arisings (upper) x  
Stock (lower): x 0.9 Arisings (lower) x

**WASTE SOURCE**

The source of the waste is the removal of graphite struts from fuel elements prior to dispatch of the elements to Sellafield. There may be a few stabilising wedges and support frames.

**PHYSICAL CHARACTERISTICS**

General description: This waste comprises graphite struts, two per fuel element. It was generated during the destrutting operations performed on the cooled fuel elements. The struts (two per element) were each originally 575mm x 25mm x 27mm and weighed 556g. The two graphite support struts are often fractured in more than one place, resulting in a number of different lengths of graphite debris. A pair of struts often remain connected by stainless steel or zirconium bridge pieces. The graphite strut was broken during the destrutting operation. It is therefore unlikely that there will be any large items which will require special handling. The waste is loose in the vaults.

Physical components (%vol): Graphite struts (100 vol%).

Sealed sources: -

Bulk density (t/m<sup>3</sup>): 0.57

Comment on density: The bulk density of 0.57 t/m<sup>3</sup> assumes a packing factor to give an overall volume of about three times the displacement volume of the waste. The packing factor will be variable and the bulk density can be up to 1.7 t/m<sup>3</sup>.

**CHEMICAL COMPOSITION**

General description and components (%wt): Graphite will account for all of the waste. The graphite will be contaminated with fission products and actinides and there may be activation of impurities within the graphite.

Chemical state: Neutral

Chemical form of radionuclides: H-3: Some tritium may be chemically bound with the graphite. Other tritium may be present as water.  
C-14: Carbon 14 will probably be present as graphite.  
Cl-36: Chlorine 36 will probably be chemically bound to the graphite. Some may be linked chemically with impurities within the graphite.  
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 uranium isotopes has not been determined but may be uranium oxides.  
Np: The neptunium content is insignificant.  
Pu: Chemical form of plutonium isotopes has not been determined but may be plutonium oxides.

Metals and alloys (%wt): There are no metallic items present. Only trace quantities of metals as impurities incorporated into the graphite are expected.

**WASTE STREAM****9A32****FED Graphite**

Stainless steel..... 0  
 Other ferrous metals..... 0  
 Iron.....  
 Aluminium..... 0  
 Beryllium..... TR  
 Cobalt.....  
 Copper..... 0  
 Lead..... 0  
 Magnox/Magnesium..... 0  
 Nickel.....  
 Titanium.....  
 Uranium.....  
 Zinc..... 0  
 Zircaloy/Zirconium..... 0  
 Other metals..... 0

There are no "other" metals.

## Organics (%wt):

This loose graphite is currently stored in the same vault as the drums of ion exchange material, although in different sub-sections. It may be possible that the graphite has been contaminated with the ion exchange material that has leaked from the drums.

Total cellulose..... 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):

Principally graphite.  
 Inorganic ion exchange materials. 0  
 Inorganic sludges and flocs..... 0  
 Soil..... 0  
 Brick/Stone/Rubble..... 0  
 Cementitious material..... 0

**WASTE STREAM****9A32****FED Graphite**

	Sand.....	
	Glass/Ceramics.....	0
	Graphite.....	>99.0
	Desiccants/Catalysts.....	
	Asbestos.....	0
	Non/low friable.....	
	Moderately friable.....	
	Highly friable.....	
	Free aqueous liquids.....	TR
	Free non-aqueous liquids.....	0
	Powder/Ash.....	P
Inorganic anions (%wt):	None of the inorganic anions listed in the table is expected to be present at greater than trace concentration.	
	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:	The risk of a graphite dust explosion is very low as the dust is mixed with other materials which will inhibit an explosion. Graphite blocks, although very difficult to ignite, will burn in air.	
	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.....	

**WASTE STREAM****9A32****FED Graphite**Hazardous substances /  
non hazardous pollutants:

-

Acrylamide.....

Benzene.....

Chlorinated solvents.....

Formaldehyde.....

Organometallics.....

Phenol.....

Styrene.....

Tri-butyl phosphate.....

Other organophosphates.....

Vinyl chloride.....

Arsenic.....

Barium.....

Boron.....

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

    EDTA.....

    DPTA.....

    NTA.....

    Polycarboxylic acids.....

    Other organic complexants.....

    Total complexing agents..... TR

**PACKAGING AND CONDITIONING**

Conditioning method:

This stream will be co-packaged together in Concrete boxes (9A61, 9A62, 9A67, 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:

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<b>WASTE STREAM</b>	<b>9A32</b>	<b>FED Graphite</b>
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Location: Berkeley Site  
 Plant startup date: -  
 Total capacity (m<sup>3</sup>/y incoming waste): -  
 Target start date for packaging this stream: -  
 Throughput for this stream (m<sup>3</sup>/y incoming waste): -  
 Other information: -

Likely container type:	Container	Waste packaged (%vol)	Waste loading (m <sup>3</sup> )	Payload (m <sup>3</sup> )	Number of packages
	6m <sup>3</sup> concrete box (SD)	100.0	~2.619	5.8	86

Likely container type comment: -  
 Range in container waste volume: -  
 Other information on containers: -  
 Likely conditioning matrix:  
 Other information: -  
 Conditioned density (t/m<sup>3</sup>): -  
 Conditioned density comment: -  
 Other information on conditioning: -  
 Opportunities for alternative disposal routing: No

Treatment	Stream volume (%)	Comment
-	-	-

**RADIOACTIVITY**

Source: Activation, when the associated fuel elements were irradiated, of nuclides incorporated into the graphite. Contamination by fission products and actinides when the fuel elements were in the fuel pond.  
 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: Specific activity is a function of Station operating history. Estimates were derived from theoretical assessments of activation product activity and from experimental measurements of the contamination of Magnox.  
 Other information: -

**WASTE STREAM 9A32 FED Graphite**

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	1.53E-02	CC 2			Gd 153				
Be 10		8			Ho 163				
C 14	2.00E-03	CC 2			Ho 166m	7.96E-06	CC 2		
Na 22		8			Tm 170				
Al 26		8			Tm 171				
Cl 36	2E-05	CC 2			Lu 174				
Ar 39		8			Lu 176				
Ar 42		8			Hf 178n				
K 40		8			Hf 182				
Ca 41	2E-05	CC 2			Pt 193				
Mn 53		8			Tl 204				
Mn 54		8			Pb 205				
Fe 55	1.87E-08	CC 2			Pb 210				
Co 60	6.18E-05	CC 2			Bi 208				
Ni 59	2E-07	CC 2			Bi 210m				
Ni 63	1.84E-05	CC 2			Po 210				
Zn 65		8			Ra 223				
Se 79	5E-09	CC 2			Ra 225				
Kr 81		8			Ra 226				
Kr 85		8			Ra 228				
Rb 87		8			Ac 227				
Sr 90	3.76E-04	CC 2			Th 227				
Zr 93		8			Th 228				
Nb 91		8			Th 229				
Nb 92		8			Th 230				
Nb 93m	8.06E-09	CC 2			Th 232				
Nb 94	8.00E-07	CC 2			Th 234	7E-07	CC 2		
Mo 93	2.00E-08	CC 2			Pa 231				
Tc 97		8			Pa 233	4.12E-08	CC 2		
Tc 99	4E-09	CC 2			U 232				
Ru 106		8			U 233				
Pd 107		8			U 234	6.04E-07	CC 2		
Ag 108m	2.96E-06	CC 2			U 235	2E-08	CC 2		
Ag 110m		8			U 236	5.00E-08	CC 2		
Cd 109		8			U 238	7E-07	CC 2		
Cd 113m	3.85E-07	CC 2			Np 237	4.12E-08	CC 2		
Sn 119m		8			Pu 236				
Sn 121m	2.56E-07	CC 2			Pu 238	7.28E-05	CC 2		
Sn 123		8			Pu 239	2E-04	CC 2		
Sn 126	7E-09	CC 2			Pu 240	2.00E-04	CC 2		
Sb 125		8			Pu 241	1.69E-03	CC 2		
Sb 126		8			Pu 242	6E-08	CC 2		
Te 125m		8			Am 241	3.38E-04	CC 2		
Te 127m		8			Am 242m	3.76E-07	CC 2		
I 129		8			Am 243	8.00E-08	CC 2		
Cs 134		8			Cm 242	3.11E-07	CC 2		
Cs 135	6E-09	CC 2			Cm 243	4.55E-08	CC 2		
Cs 137	5.30E-04	CC 2			Cm 244	2.52E-07	CC 2		
Ba 133	1.82E-07	CC 2			Cm 245				
La 137		8			Cm 246				
La 138		8			Cm 248				
Ce 144		8			Cf 249				
Pm 145	3.74E-07	CC 2			Cf 250				
Pm 147	8.42E-09	CC 2			Cf 251				
Sm 147		8			Cf 252				
Sm 151	9.11E-06	CC 2			Other a				
Eu 152	1.62E-04	CC 2			Other b/g				
Eu 154	7.58E-05	CC 2			<b>Total a</b>	<b>8.13E-04</b>	<b>CC 2</b>	<b>0</b>	
Eu 155	5.51E-07	CC 2			<b>Total b/g</b>	<b>2.03E-02</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