WASTE STREAM 2C311 Graphite ILW

SITE	Chapelcross
SITE OWNER	Nuclear Decommissioning Authority
WASTE CUSTODIAN	Magnox Limited
WASTE TYPE	ILW

WASTE VOLUMES

		Reported
Stocks:	At 1.4.2019.....	0 m³
Future arisings -	1.4.2089 - 31.3.2095.....	3647.0 m³
Total future arisings:		3647.0 m³
Total waste volume:		3647.0 m³

Comment on volumes: For inventory purposes the arisings are assumed to arise at a uniform rate over 6 years. Final Dismantling & Site Clearance is assumed to commence in 2085 with reactor dismantling commencing in 2089 and lasting for 6 years. The volumes and radioactivity have been calculated for 85 years after reactor shutdown, i.e. 2089.

Uncertainty factors on volumes:

Stock (upper):	x	Arisings (upper)	x 1.2
Stock (lower):	x	Arisings (lower)	x 0.8

WASTE SOURCE Moderator and reflector graphite from reactor dismantling.

PHYSICAL CHARACTERISTICS

General description: Graphite blocks and other graphite components.

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

Sealed sources: -

Bulk density (t/m³): 1.25

Comment on density: Density estimate based upon the assumed packing efficiency of the waste. The density is the effective density for packaging assuming 90% of the graphite is in blocks and 10% is rubble.

CHEMICAL COMPOSITION

General description and components (%wt): Graphite and possibly traces of ferrous metals.

Chemical state: Neutral

Chemical form of radionuclides:
H-3: Tritium may be chemically bound with the graphite.
C-14: The carbon 14 will be present as graphite.
Se-79: The selenium content is insignificant.
Tc-99: The technetium content is insignificant.
Ra: The radium content is insignificant.
Th: The thorium content is insignificant.
U: There may be traces of uranium as metal or oxide.
Np: The neptunium content is insignificant.
Pu: There may be traces of plutonium as metal or oxide.

Metals and alloys (%wt): There are no metallic items present.

Stainless steel.....	0	
Other ferrous metals.....	TR	There may be trace contamination by ferrous metals.
Iron.....		
Aluminium.....	0	
Beryllium.....		
Cobalt.....		
Copper.....	0	
Lead.....	0	
Magnox/Magnesium.....	0	

WASTE STREAM 2C311 Graphite ILW

	Nickel		
	Titanium		
	Uranium		
	Zinc	0	
	Zircaloy/Zirconium	0	
	Other metals	0	There are no "other" metals present.
Organics (%wt):	None expected. No halogenated plastics or rubbers will be present.		
	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	0	
Other materials (%wt):	-		
	Inorganic ion exchange materials.	0	
	Inorganic sludges and flocs	0	
	Soil	0	
	Brick/Stone/Rubble	0	
	Cementitious material	0	
	Sand		
	Glass/Ceramics	0	
	Graphite	100.0	
	Desiccants/Catalysts		
	Asbestos	0	
	Non/low friable		
	Moderately friable		
	Highly friable		
	Free aqueous liquids	0	
	Free non-aqueous liquids	0	

	Powder/Ash.....	0	
Inorganic anions (%wt):	None of the inorganic anions listed in the table is expected to be present at greater than trace concentrations.		
	Fluoride.....	TR	Detected at trace levels in inactive graphite material.
	Chloride.....	TR	
	Iodide.....	0	
	Cyanide.....	0	
	Carbonate.....	TR	
	Nitrate.....	TR	
	Nitrite.....	TR	
	Phosphate.....	TR	Detected at trace levels in inactive graphite material.
	Sulphate.....	TR	Detected at trace levels in inactive graphite material.
	Sulphide.....	0	
Materials of interest for waste acceptance criteria:	No materials likely to pose a fire or other non-radiological hazard have been identified. Graphite presents a low fire risk; it is difficult but not impossible to ignite.		
	Combustible metals.....	0	
	Low flash point liquids.....	0	
	Explosive materials.....	0	
	Phosphorus.....	TR	Detected at trace levels in inactive graphite material.
	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:	None expected.		
	Acrylamide.....		
	Benzene.....		
	Chlorinated solvents.....		
	Formaldehyde.....		
	Organometallics.....		
	Phenol.....		
	Styrene.....		
	Tri-butyl phosphate.....		
	Other organophosphates.....		

WASTE STREAM 2C311 Graphite ILW

Vinyl chloride.....		
Arsenic.....	TR	Detected at trace levels in inactive graphite material.
Barium.....		
Boron.....		
Cadmium.....		
Caesium.....		
Selenium.....		
Chromium.....		
Molybdenum.....		
Thallium.....	TR	Detected at trace levels in inactive graphite material.
Tin.....		
Vanadium.....		
Mercury compounds.....		
Others.....	TR	
Electronic Electrical Equipment (EEE)		
EEE Type 1.....		
EEE Type 2.....		
EEE Type 3.....		
EEE Type 4.....		
EEE Type 5.....		

Complexing agents (%wt):

EDTA.....	
DPTA.....	
NTA.....	
Polycarboxylic acids……	
Other organic complexants.....	
Total complexing agents.....	TR

PACKAGING AND CONDITIONING

Conditioning method:	The waste is not expected to be supercompacted. It will be placed in baskets in the waste packages, and is now assumed to be encapsulated.
Plant Name:	-
Location:	Chapelcross Power Station
Plant startup date:	2089
Total capacity (m^3/y incoming waste):	-
Target start date for packaging this stream:	2089
Throughput for this stream (m^3/y incoming waste):	~521.0
Other information:	-

WASTE STREAM 2C311 Graphite ILW

Likely container type:

Container	Waste packaged (%vol)	Waste loading (m^3)	Payload (m^3)	Number of packages
4m box (no shielding)	100.0	~16.2	18.9	226

Likely container type comment:	The waste is assumed to be in baskets in the waste package so the occupied volume in the package is greater than the original waste volume.
Range in container waste volume:	Not yet determined. No significant variability is expected.
Other information on containers:	The container material is expected to be stainless steel. Container choice may be influenced by Transport Regulations at the time of final site clearance.
Likely conditioning matrix:	Blast Furnace Slag / Ordinary Portland Cement
Other information:	It is now assumed that the waste will be encapsulated. The matrix could be BFS/OPC.
Conditioned density (t/m^3):	1.7
Conditioned density comment:	The conditioned waste density assumes that the waste will be encapsulated.
Other information on conditioning:	The waste will be in baskets placed in the waste packages. Baskets of different Final Dismantling & Site Clearance ILW wastes may be in the same waste package. Should encapsulation not be required the density of the conditioned waste product would be about 1.1 t/m3. Data have been presented as if the waste will be placed in a container with other ILW.
Opportunities for alternative disposal routing:	No

Treatment	Stream volume (%)	Comment
-	-	-

RADIOACTIVITY

Source:	Activation of the graphite and impurities.
Uncertainty:	The values quoted were derived by calculation from available material specification and are indicative of the activities that are expected. The major source of uncertainty is the impurity levels.
Definition of total alpha and total beta/gamma:	Total beta/gamma is defined as the sum of the listed activities of all nuclides other than alpha emitters. Activity estimates for individual alpha emitting nuclides have not been provided.
Measurement of radioactivities:	The specific activities have been estimated using a neutron activation calculation.
Other information:	There may be some contamination by Cs137. The activities quoted are those at 85 years after reactor shutdown, i.e. in 2089. Fission of trace uranium impurity in the graphite may result in some fission product and actinide activity.

WASTE STREAM 2C311 Graphite ILW

Nuclide	Mean radioactivity, TBq/m³				Nuclide	Mean radioactivity, TBq/m³			
	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			2.76E-03	C C 2	Gd 153				8
Be 10				8	Ho 163				8
C 14			1.28E-01	C C 2	Ho 166m			1.99E-05	C C 2
Na 22				8	Tm 170				8
Al 26				8	Tm 171				8
Cl 36			2.94E-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			3.44E-04	C C 2	Pt 193				8
Mn 53				8	Tl 204				8
Mn 54				8	Pb 205				8
Fe 55				8	Pb 210				8
Co 60			3.3E-06	C C 2	Bi 208				8
Ni 59			6.25E-05	C C 2	Bi 210m				8
Ni 63			4.76E-03	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			1.82E-05	C C 2	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			8.72E-07	C C 2	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			1.83E-04	C C 2	Pu 238				6
Sn 123				8	Pu 239				6
Sn 126				8	Pu 240				6
Sb 125				8	Pu 241				8
Sb 126				8	Pu 242				8
Te 125m				8	Am 241				6
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				6	Cm 244				8
Ba 133			5.94E-07	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			6.88E-08	C C 2	Cf 250				8
Pm 147				8	Cf 251				8
Sm 147				8	Cf 252				8
Sm 151			4.03E-07	C C 2	Other a				
Eu 152				8	Other b/g				
Eu 154			6.92E-07	C C 2	**Total a**	**0**		**0**	
Eu 155			3.58E-09	C C 2	**Total b/g**	**0**		**1.36E-01**	**C C 2**

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