

WASTE STREAM	2C311	Graphite ILW
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SITE Chapelcross

SITE OWNER Nuclear Decommissioning Authority

WASTE CUSTODIAN Nuclear Restoration Services Ltd (NRS)

WASTE TYPE ILW

WASTE VOLUMES

	Reported (m ³)	OR	Conditioned (m ³)	Packaged (m ³)
Stocks:	At 1.4.2025	= 0		
Future arisings:	1.4.2060 - 31.3.2079	3647.0		
Total future arisings:		3647.0		
Total waste volume:		3647.0		

Number of waste packages in stock: At 1.4.2025..... - packages

Comment on arising rates: For inventory purposes the arisings are assumed to arise at a uniform rate over 20 years.

Additional information on quantities: Reactor Dismantling & Site Clearance is assumed to commence in 2060 and last for 20 years.

Uncertainty factors on volumes: Stock (upper): x - Arisings (upper): x 1.20
Stock (lower): x - Arisings (lower): x 0.80

WASTE SOURCE Moderator and reflector graphite from reactor dismantling.

PHYSICAL CHARACTERISTICS

General description: Graphite blocks and other graphite components.

Changes since waste generated: -

Bulk density (t/m³): = 1.3

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

Sheet metal proportion / thickness: There are no metallic items present.

Metals and alloys (%wt):

	(%wt)	Type(s) / Grades(s) with proportions	% of total C14 activity
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	-	
Nickel.....	-	-	
Titanium.....	-	-	
Uranium.....	-	-	
Zinc.....	= 0	-	
Zircaloy/Zirconium.....	= 0	-	
Other metals.....	= 0	There are no "other" metals present.	

Organics (%wt):

	(%wt)	Type(s) and comment	% of total C14 activity
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.....	= 0	-	

Other materials (%wt):

	(%wt)	Type(s) and comment	% of total C14 activity
Inorganic ion exchange materials.....	= 0	-	100.0
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	-	

COMPONENTS OF MATERIALS, WASTE PROPERTIES, MATERIALS NOT CONTRIBUTING TO MASS

Inorganic anions (%wt):

	(%wt)	Type(s) and comment
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:

	(%wt)	Type(s) and comment
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.....	0	-
Putrescible wastes.....	= 0	-
Non-putrescible wastes.....		-
Corrosive materials.....	= 0	-
Pyrophoric materials.....	= 0	-
Generating toxic gases.....	= 0	-
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.....	TR	Detected at trace levels in inactive graphite material.
Barium.....	-	-
Boron.....	0	-
Boron (in Boral).....	-	-
Boron (non-Boral).....	-	-
Cadmium.....	-	-
Caesium.....	-	-
Selenium.....	-	-
Chromium.....	-	-
Molybdenum.....	-	-
Thallium.....	TR	Detected at trace levels in inactive graphite material.
Tin.....	-	-
Vanadium.....	-	-
Mercury compounds.....	-	-
Others.....	TR	Gallium, germanium and rubidium detected at trace levels in inactive graphite material.

Complexing agents (%wt):

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

Physical components:

	Number	Type(s) and comment
Sources.....	-	-
Electronic & Electrical Equipment (EEE)	-	-
EEE Type 1.....	-	-
EEE Type 2.....	-	-
EEE Type 3.....	-	-
EEE Type 4.....	-	-
EEE Type 5.....	-	-

TREATMENT, PACKAGING AND DISPOSAL

Planned on-site / off-site treatment(s):

Treatment	On-site / Off-site	Stream volume %
Size reduction	On-site	100.0
Decay storage		
Low force compaction		
Supercompaction (HFC)		
Incineration		
Drying/dewatering/liquid separation		
Tie down/fixatives/strippable coating/painting application		
Decontamination		
Metal treatment		
Recycling / reuse		
Thermal treatment, including vitrification		
Encapsulation		
Polymer encapsulation		
Other physical treatment		
Other chemical treatment		
Containerisation		
Treatment not yet determined		
None		

Comments on planned treatments:

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.

Conditioning plants:

Plant Name	Location
RDC Encap CHX	Chapelcross

Likely conditioning matrix: Unknown

Further information on the conditioning matrix:

It is now assumed that the waste will be encapsulated. The matrix could be BFS/OPC.

Waste Packaging:

Likely container type:	Container	Waste packaged (vol%)	Waste loading (m³)	Payload (m³)	Number of packages	Estimated start date for packaging
	4 m box (0 mm concrete shielding)	100.0	16.2	18.9	226	-

Range in container waste loading: Not yet determined. No significant variability is expected.

Other information on packaging and conditioning:

The container material is expected to be stainless steel. Container choice may be influenced by Transport Regulations at the time. The waste will be in baskets placed in the waste packages. Baskets of different Reactor Dismantling & Site Clearance ILW 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.

Conditioned density (t/m³):

= 1.7

Conditioned density comment:

The conditioned waste density assumes that the waste will be encapsulated.

Management Routes:

Disposal Route	Stream volume %	Raw density t/m³	Start date
Expected to be consigned to a Near Site, Near Surface Disposal Facility (Scotland)	NE		
Expected to be Non-NSD HAW managed under Scottish Government's policy	NE		
Expected to be disposed to LLW Vaults NRS Dounreay			
Expected to be consigned to the Geological Disposal Facility			
Expected to be consigned to a Near Surface Disposal Facility			
Expected to be consigned to the LLW Repository			
Expected to be consigned to a Landfill Facility			
Expected to be disposed On-Site			
Expected to be managed by In-Situ Disposal			
Expected to be consigned to an Incineration Facility			
Expected to be consigned to a Metal Treatment Facility			
Expected to be Out of Scope			
Expected to be recycled / reused			
Disposal route not known			

Classification codes for waste expected to be consigned to a landfill facility:

Opportunities for alternative disposal routing: No

Baseline Management Route	Opportunity Management Route	Stream volume (%)	Opportunity Confidence	Comment
-	-	-	-	-

RADIOACTIVITY

Source:

Activation of the graphite and impurities. There may be some contamination by Cs137. The activities quoted are those at 56 years after reactor shutdown, i.e. in 2060. Fission of trace uranium impurity in the graphite may result in some fission product and actinide activity.

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.

Measurement of radioactivities:

The specific activities have been estimated using a neutron activation calculation.

Chemical form of radionuclides:

H-3: Tritium may be chemically bound with the graphite.
 C-14: The carbon 14 will be present as graphite.
 Cl-36: -
 Se-79: The selenium content is insignificant.
 Tc-99: The technetium content is insignificant.
 I-129: -
 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.

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Nuclide	Mean radioactivity, TBq/m³				Nuclide	Mean radioactivity, TBq/m³			
	Waste at 1.4.2025	Bands and Code	Future Arisings	Bands and Code		Waste at 1.4.2025	Bands and Code	Future Arisings	Bands and Code
H 3			1.41E-02	C C 2	Gd 153				8
Be 10				8	Ho 163				8
C 14			1.28E-01	C C 2	Ho 166m			2.03E-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			4.34E-04	C C 2	Pt 193				8
Mn 53				8	Ti 204				8
Mn 54				8	Pb 205				8
Fe 55			7.23E-08	C C 2	Pb 210				8
Co 60			1.49E-04	C C 2	Bi 208				8
Ni 59			6.25E-05	C C 2	Bi 210m				8
Ni 63			5.82E-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			4.17E-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			2.64E-04	C C 2	Pu 238				8
Sn 123				8	Pu 239				8
Sn 126				8	Pu 240				8
Sb 125				8	Pu 241				8
Sb 126				8	Pu 242				8
Te 125m				8	Am 241				8
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				8	Cm 244				8
Ba 133			4.02E-06	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			2.14E-07	C C 2	Cf 250				8
Pm 147				8	Cf 251				8
Sm 147				8	Cf 252				8
Sm 151			5.00E-07	C C 2	Unsp a				
Eu 152			2.41E-08	C C 2	Unsp b/g				
Eu 154			7.32E-06	C C 2	Total a	0	*	5.99E-16	*
Eu 155			2.06E-07	C C 2	Total b/g	0	*	1.49E-01	*

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 the 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
* Total calculated from the 114 declared radionuclides