WASTE STREAM 5G304 DRAGON Reactor Decommissioning ILW

SITE	Winfrith
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.....	0 m³
Future arisings -	1.4.2023 - 31.3.2028.....	22.0 m³
Total future arisings:		22.0 m³
Total waste volume:		22.0 m³

Comment on volumes: Arisings volume of 22 m3 is taken from 2012 intermediate LoC submission. Volumes based on assessment (ILW/LLW) of individual items. The volume was reassessed separately in the 2013 SMART review and for 2012 intermediate LOC, giving 34 and 22 m3 respectively. The difference in these values has been taken into account in the estimation of the uncertainty.

Uncertainty factors on volumes:

Stock (upper):	x	Arisings (upper)	x 1.5
Stock (lower):	x	Arisings (lower)	x 0.8

WASTE SOURCE Winfrith Dragon reactor core decommissioning operations.

PHYSICAL CHARACTERISTICS

General description: Pressure vessel (excluding neck) 11'6" dia x ~32', up to 2" thick. Plenum chamber 6'2" dia x 11'4", 0.5" thick. Upper neutron shield 10'5" dia x5'7", 0.75" plate. Other items of similar dimensions that will require size reduction

Physical components (%wt): Pressure vessel 15.21%, Main Shield Plug 13.36%, Metalwork Associated with Main Shield Plug 1.72%, Plenum chamber 13.53%, Core chamber 22.33%, Core Chamber Graphite 33.40%, Items external to Pressure Vessel 0.45%.

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m³): ~3.5

Comment on density: The mean bulk density is based on the total mass and total volume of raw waste given in the 2012 iLoC.

CHEMICAL COMPOSITION

General description and components (%wt): Mild steel 44.6%, Marwe-426 14.5%, Stainless steel 2.7%, Graphite 36.6%, Nimonic-75 1.5%, Monel-400 0.1%, Boron carbide <0.1%

Chemical state: Neutral

Chemical form of radionuclides:
H-3: Radionuclide are present as trace elements in the activated waste materials. Also present from contamination.
C-14: Radionuclide are present as trace elements in the activated waste materials. Also present from contamination.
Cl-36: Radionuclide are present as trace elements in the activated waste materials.
Se-79: Radionuclide are present as trace elements in the activated waste materials.
Tc-99: Radionuclide are present as trace elements in the activated waste materials.
I-129: Radionuclide are present as trace elements in the activated waste materials.
Ra: Radionuclide are present as trace elements in the activated waste materials. Possible presence from contamination.
Th: Radionuclide are present as trace elements in the activated waste materials. Also present from contamination.
U: Radionuclide are present as trace elements in the activated waste materials. Also present from contamination.
Np: Radionuclide are present as trace elements in the activated waste materials. Also present from contamination.
Pu: Radionuclide are present as trace elements in the activated waste materials. Also present from contamination.

Metals and alloys (%wt): Plate thicknesses are ~2" for the pressure vessel, ½" for the nimonic plenum. The other waste items are mainly smaller plant items and fittings. It should be noted that the material

will be sized reduced to allow it to be packed into the WAGR boxes.

	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....	2.7	A typical AISI 321 stainless steel composition is an appropriate assumption for stainless steel within the Dragon RPV with the exception of the inner live reflector block top fittings which had Niobium stabilised stainless steel in their top fittings.	
Other ferrous metals.....	59.1	Mild steel 44.6%, Marwe-426 14.5%,	
Iron.....			
Aluminium.....	0		
Beryllium.....	0		
Cobalt.....			
Copper.....	0		
Lead.....	0		
Magnox/Magnesium.....	0		
Nickel.....	1.6	The monel material used was reported to be monel-400. The nimonic material used was nimonic-75. (Nimonic-75 1.5%, Monel-400 0.1%,)	
Titanium.....			
Uranium.....	TR		
Zinc.....			
Zircaloy/Zirconium.....	0		
Other metals.....		None	

Organics (%wt): N/A

	(%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.....			

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Others	
Other organics	0

Other materials (%wt): Static reflector block graphite- ~600 blocks, each approx 6½" x 6½" x 24". Outer reflector block graphite- 30 blocks, each approx 8" x 8" x 96". Inner reflector block graphite- 30 blocks, each approx 6" x 6" x 96". Main shield plug graphite-Approx 2m3 net volume, sections approx. 7" thick.

	(%wt)	Type(s) and comment	% of total C14 activity
Inorganic ion exchange materials	0		
Inorganic sludges and flocs	0		
Soil	0		
Brick/Stone/Rubble	0		
Cementitious material	0		
Sand			
Glass/Ceramics	0		
Graphite	36.6		
Desiccants/Catalysts			
Asbestos	TR		
Non/low friable			
Moderately friable			
Highly friable			
Free aqueous liquids	0		
Free non-aqueous liquids	0		
Powder/Ash	0		

Inorganic anions (%wt): Boron carbide 0.1%

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

Materials of interest for waste acceptance criteria: Asbestos will be disposed separately to this wastestream.

	(%wt)	Type(s) and comment
Combustible metals	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	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.....

Complexing agents (%wt): No

	(%wt)	Type(s) and comment
EDTA.....		
DPTA.....		
NTA.....		
Polycarboxylic acids…….		
Other organic complexants.....		
Total complexing agents.....	0	

Potential for the waste to contain discrete items: Yes. Large Metal Items (LMIs)/"substantial" thickness items considered "durable" assumed DIs; Stainless items assumed DIsGraphite Bricks/Tiles assumed to be DIs

PACKAGING AND CONDITIONING

Conditioning method: The waste will be packaged into 6m3 boxes and encapsulated with cement prior to transfer to the Harwell ILW Store

Plant Name: Dragon ILW Processing Plant

Location: Winfrith

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: A dedicated plant will be constructed at the reactor site

Likely container type:

Container	Waste packaged (%vol)	Waste loading (m^3)	Payload (m^3)	Number of packages
6m^3 concrete box (HD)	100.0	0.89	5.8	25

Likely container type comment: -

Range in container waste volume: -

Other information on containers: -

Likely conditioning matrix: Pulverised Fly Ash / Ordinary Portland Cement

Other information: 3:1 PFA/OPC with w/s of 0.42

Conditioned density (t/m^3): ~2.3

Conditioned density comment: This is the value given in 2012 iLoC for an average package.

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:	Neutron activation of primary vessel and components within.
Uncertainty:	The main source of uncertainty is the elemental uncertainties in the material compositions. The uncertainties relate to the trace elements present within the material used to manufacture the Dragon reactor core components. Wherever possible specific compositions and trace element data was used for each component in the activation modelling. The uncertainty presented by the flux modelling is regarded to be much less than that presented by the elemental uncertainties. Further, the modelling approach used upper bound precursor data which will mean that the inventory derived for Dragon core component materials will also be upper bounding values.
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:	A reactor activation study was carried out as part of the Conceptual Stage Letter of Compliance submission. The activation model was based on a 3-D Monte Carlo neutron transport code to determine energy dependent neutron flux spectra, and on the EASY/FISPACT neutron activation code.
Other information:	Fuel and fission product contamination has not been calculated for inclusion. Although present, activity associated with contamination is believed to be negligible in comparison to activity associated with activation.

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Nuclide	Mean radioactivity, TBq/m³				Nuclide	Mean radioactivity, TBq/m³			
	Waste at 1.4.2022	Bands and Code	Future arisings	Bands and Code		Waste at 1.4.2022	Bands and Code	Future arisings	Bands and Code
H 3			<1.90E-01	B 3	Gd 153				8
Be 10			<1.58E-06	B 3	Ho 163			<2.8E-07	B 3
C 14			<3.51E-02	B 3	Ho 166m			<2.15E-05	B 3
Na 22				8	Tm 170				8
Al 26				8	Tm 171			<8.26E-09	B 3
Cl 36			<2.44E-04	B 3	Lu 174				8
Ar 39			<1.87E-04	B 3	Lu 176				8
Ar 42			<8.97E-08	B 3	Hf 178n			<1.32E-04	B 3
K 40			<9.07E-09	B 3	Hf 182				8
Ca 41			<1.55E-04	B 3	Pt 193			<8.16E-04	B 3
Mn 53				8	Tl 204			<3.56E-03	B 3
Mn 54				8	Pb 205			<2.66E-09	B 3
Fe 55			<1.64E-02	B 3	Pb 210				8
Co 60			<4.10E-01	B 3	Bi 208				8
Ni 59			<9.14E-02	B 3	Bi 210m				8
Ni 63			<8.74E+00	B 3	Po 210				8
Zn 65				8	Ra 223			<1.49E-09	B 3
Se 79			<1.26E-07	B 3	Ra 225			<1.16E-07	B 3
Kr 81			<3.8E-05	B 3	Ra 226				8
Kr 85			<5.39E-04	B 3	Ra 228			<2.36E-08	B 3
Rb 87			<2.65E-07	B 3	Ac 227			<1.49E-09	B 3
Sr 90			<2.13E-03	B 3	Th 227			<1.47E-09	B 3
Zr 93			<1.4E-07	B 3	Th 228			<6.1E-07	B 3
Nb 91			<2.18E-07	B 3	Th 229			<1.16E-07	B 3
Nb 92				8	Th 230			<1.68E-09	B 3
Nb 93m			<9.16E-04	B 3	Th 232			<2.52E-08	B 3
Nb 94			<4.35E-04	B 3	Th 234			<4.92E-08	B 3
Mo 93			<2.74E-04	B 3	Pa 231			<2.08E-09	B 3
Tc 97			<4.86E-09	B 3	Pa 233				8
Tc 99			<4.22E-05	B 3	U 232			<6.02E-07	B 3
Ru 106				8	U 233			<1.51E-05	B 3
Pd 107			<1.78E-09	B 3	U 234			<9.4E-07	B 3
Ag 108m			<1.45E-05	B 3	U 235			<2.04E-09	B 3
Ag 110m				8	U 236			<1.35E-09	B 3
Cd 109				8	U 238			<4.92E-08	B 3
Cd 113m			<2.83E-05	B 3	Np 237				8
Sn 119m				8	Pu 236				8
Sn 121m			<7.61E-06	B 3	Pu 238			<1.92E-05	B 3
Sn 123				8	Pu 239			<1.17E-05	B 3
Sn 126			<6.13E-09	B 3	Pu 240			<1.52E-05	B 3
Sb 125			<1.97E-07	B 3	Pu 241			<2.49E-04	B 3
Sb 126				8	Pu 242			<6.8E-08	B 3
Te 125m			<4.93E-08	B 3	Am 241			<5.06E-05	B 3
Te 127m				8	Am 242m			<9.01E-08	B 3
I 129			<1.19E-09	B 3	Am 243			<3.47E-07	B 3
Cs 134			<6.85E-06	B 3	Cm 242			<7.43E-08	B 3
Cs 135			<1.46E-07	B 3	Cm 243			<9.74E-08	B 3
Cs 137			<1.88E-03	B 3	Cm 244			<6.38E-06	B 3
Ba 133			<3.36E-04	B 3	Cm 245			<1.49E-09	B 3
La 137			<9.71E-07	B 3	Cm 246				8
La 138				8	Cm 248				8
Ce 144				8	Cf 249				8
Pm 145			<6.49E-06	B 3	Cf 250				8
Pm 147			<2.94E-07	B 3	Cf 251				8
Sm 147				8	Cf 252				8
Sm 151			<2.75E-04	B 3	Other a				
Eu 152			<8.9E-03	B 3	Other b/g				
Eu 154			<1.62E-03	B 3	**Total a**	**0**		**<1.21E-04**	**B 3**
Eu 155			<1.77E-05	B 3	**Total b/g**	**0**		**<9.50E+00**	**B 3**

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