

| | | |
|---------------------|--------------|---|
| WASTE STREAM | 2C308 | Concrete (Reactor and Non-Reactor) LLW |
|---------------------|--------------|---|

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

WASTE VOLUMES

| | | Reported |
|------------------------|---------------------------|------------------------|
| Stocks: | At 1.4.2019..... | 0 m ³ |
| Future arisings - | 1.4.2089 - 31.3.2095..... | 34903.1 m ³ |
| Total future arisings: | | 34903.1 m ³ |
| Total waste volume: | | 34903.1 m ³ |

Comment on volumes: It has been assumed that the whole of the bioshield will be knocked down and disposed of together. There will be no segregation of waste. 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 Concrete wastes from dismantling of reactors and associated plant.

PHYSICAL CHARACTERISTICS

General description: A wide variety of concrete and reinforced concrete items (reinforcing steel is described in waste stream 2C307).
 Physical components (%vol): Concrete and reinforced concrete (100%), mostly from reactor bioshield.
 Sealed sources: -
 Bulk density (t/m³): 1.4
 Comment on density: The density is of the waste as cut for packaging assuming 20% in blocks and 80% as rubble.

CHEMICAL COMPOSITION

General description and components (%wt): Concrete (100%). Some of the concrete may include iron shot. Reinforcing steel is described in waste stream 2C307.

Chemical state: Alkali

Chemical form of radionuclides:

H-3: The tritium is incorporated in the concrete.
 C-14: The carbon 14 content is insignificant.
 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: The uranium content is insignificant.
 Np: The neptunium content is insignificant.
 Pu: The plutonium content is insignificant.

Metals and alloys (%wt): There are no large or bulk metal items.

| | |
|---------------------------|----|
| Stainless steel..... | 0 |
| Other ferrous metals..... | NE |
| Iron..... | |
| Aluminium..... | 0 |
| Beryllium..... | |
| Cobalt..... | |
| Copper..... | 0 |

Some of the concrete may include iron shot; otherwise only trace quantities of metals are expected.

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Lead..... 0
 Magnox/Magnesium..... 0
 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 are expected to be present.

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):

-
 Inorganic ion exchange materials. 0
 Inorganic sludges and flocs..... 0
 Soil..... 0
 Brick/Stone/Rubble..... 0
 Cementitious material..... ~100.0
 Sand.....
 Glass/Ceramics..... 0
 Graphite..... TR
 Desiccants/Catalysts.....
 Asbestos..... 0
 Non/low friable.....
 Moderately friable.....
 Highly friable.....

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| | | |
|--|--|------|
| | Free aqueous liquids..... | 0 |
| | Free non-aqueous liquids..... | 0 |
| | Powder/Ash..... | 0 |
| Inorganic anions (%wt): | Principal anions will be silicates and aluminates in various anionic forms. Carbonates could be up to 20% if limestone was used as an aggregate. | |
| | Fluoride..... | <1.0 |
| | Chloride..... | <1.0 |
| | Iodide..... | <1.0 |
| | Cyanide..... | 0 |
| | Carbonate..... | <2.0 |
| | Nitrate..... | <1.0 |
| | Nitrite..... | <1.0 |
| | Phosphate..... | <1.0 |
| | Sulphate..... | ~2.0 |
| | Sulphide..... | <1.0 |
| Materials of interest for waste acceptance criteria: | No materials likely to pose a fire or other non-radiological hazard have been identified. | |
| | 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..... | |
| Hazardous substances / non hazardous pollutants: | None expected. | |
| | Acrylamide..... | |
| | Benzene..... | |
| | Chlorinated solvents..... | |
| | Formaldehyde..... | |
| | Organometallics..... | |
| | Phenol..... | |
| | Styrene..... | |
| | Tri-butyl phosphate..... | |
| | Other organophosphates..... | |

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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): No
 EDTA.....
 DPTA.....
 NTA.....
 Polycarboxylic acids.....
 Other organic complexants.....
 Total complexing agents..... 0

TREATMENT, PACKAGING AND DISPOSAL

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

| Treatment | On-site / Off site | Stream volume % |
|-----------------------|--------------------|-----------------|
| Low force compaction | | |
| Supercompaction (HFC) | | |
| Incineration | | |
| Solidification | | |
| Decontamination | | |
| Metal treatment | | |
| Size reduction | | |
| Decay storage | | |
| Recycling / reuse | | |
| Other / various | | |
| None | | 100.0 |

Comment on planned treatments:

-

WASTE STREAM**2C308****Concrete (Reactor and Non-Reactor) LLW****Disposal Routes:**

| Disposal Route | Stream volume % |
|---|-----------------|
| Expected to be consigned to the LLW Repository Expected to be consigned to a Landfill Facility Expected to be consigned to an On-Site Disposal Facility Expected to be consigned to an Incineration Facility Expected to be consigned to a Metal Treatment Facility Expected to be consigned as Out of Scope Expected to be recycled / reused Disposal route not known | 100.0 |

Upcoming (2019/20-2021/22) Waste Routing (if expected to change from above):

| Disposal Route | Stream volume % | | |
|---|-----------------|---------|---------|
| | 2019/20 | 2020/21 | 2021/22 |
| Expected to be consigned to the LLW Repository Expected to be consigned to a Landfill Facility Expected to be consigned to an On-Site Disposal Facility Expected to be consigned to an Incineration Facility Expected to be consigned to a Metal Treatment Facility Expected to be consigned as Out of Scope Expected to be recycled / reused Disposal route not known | | | |

Waste Packaging for Disposal: (Not applicable to this waste stream)

| Container | Stream volume % | Waste loading m ³ | Number of packages |
|--|-----------------|------------------------------|--------------------|
| 1/3 Height IP-1 ISO 2/3 Height IP-2 ISO 1/2 Height WAMAC IP-2 ISO 1/2 Height IP-2 Disposal/Re-usable ISO 2m box (no shielding) 4m box (no shielding) Other | | | |

Other information: -

Waste Planned for Disposal at the LLW Repository: (Not applicable to this waste stream)

Container voidage: -

Waste Characterisation Form (WCH): -

Waste consigned for disposal to LLWR in year of generation: -

Potential for the waste to contain discrete items: -

Non-Containerised Waste for In-Vault Grouting: (Not applicable to this waste stream)

Stream volume (%): -

Waste stream variation: -

Bounding cuboidal volume:

Inaccessible voidage: -

Other information: -

RADIOACTIVITY

WASTE STREAM**2C308****Concrete (Reactor and Non-Reactor) LLW**

| | |
|---|--|
| Source: | Activation of the concrete and impurities. There may be some contamination. |
| Uncertainty: | The values quoted were derived by calculation from available material specifications 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: | 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: | The specific activities have been estimated using a neutron activation calculation. |
| Other information: | The activities quoted are those at 85 years after reactor shutdown, i.e. in 2089. There may be some contamination by Cs137. |

WASTE STREAM

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| Nuclide | Mean radioactivity, TBq/m ³ | | | | Nuclide | Mean radioactivity, TBq/m ³ | | | |
|---------|--|----------------|-----------------|----------------|------------------|--|-----------------|-----------------|----------------|
| | 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 | | | 2.77E-05 | C C 2 | Gd 153 | | | | 8 |
| Be 10 | | | | 8 | Ho 163 | | 1.93E-09 | C C 2 | 8 |
| C 14 | | | 1.33E-06 | C C 2 | Ho 166m | | 3.22E-09 | C C 2 | 8 |
| Na 22 | | | | 8 | Tm 170 | | | | 8 |
| Al 26 | | | | 8 | Tm 171 | | | | 8 |
| Cl 36 | | | 4.83E-07 | 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 | | | 6.21E-06 | 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 | | | | 8 | Bi 208 | | | | 8 |
| Ni 59 | | | 1.13E-08 | C C 2 | Bi 210m | | | | 8 |
| Ni 63 | | | 6.37E-07 | 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 | | | 9.95E-09 | 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 | | | 2.19E-08 | 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 | | | | 8 | 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 | | | | 6 | Cm 244 | | | | 8 |
| Ba 133 | | | | 8 | 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 | | | | 8 | Cf 251 | | | | 8 |
| Sm 147 | | | | 8 | Cf 252 | | | | 8 |
| Sm 151 | | | 3.4E-07 | C C 2 | Other a | | | | |
| Eu 152 | | | 1.91E-06 | C C 2 | Other b/g | | | | |
| Eu 154 | | | 1.03E-08 | C C 2 | Total a | 0 | 0 | | |
| Eu 155 | | | | 8 | Total b/g | 0 | 3.87E-05 | 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