

|                     |              |   |
|---------------------|--------------|---|
| <b>WASTE STREAM</b> | <b>2C317</b> | <b>Mild Steel (Reactor) Recycle LLW</b> |
|---------------------|--------------|---|

**SITE** Chapelcross  
**SITE OWNER** Nuclear Decommissioning Authority

**WASTE CUSTODIAN** Magnox Limited

**WASTE TYPE** LLW

Is the waste subject to Scottish Policy: No

**WASTE VOLUMES**

|                        |                           | Reported              |
|------------------------|---------------------------|-----------------------|
| Stocks:                | At 1.4.2022.....          | 0 m <sup>3</sup>      |
| Future arisings -      | 1.4.2089 - 31.3.2095..... | 5557.0 m <sup>3</sup> |
| Total future arisings: |                           | 5557.0 m <sup>3</sup> |
| Total waste volume:    |                           | 5557.0 m <sup>3</sup> |

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** Mild steel items from the reactor structure.

**PHYSICAL CHARACTERISTICS**

General description: A variety of mild steel items.  
 Physical components (%vol): Mild steel items (100%).  
 Sealed sources: The waste does not contain sealed sources.  
 Bulk density (t/m<sup>3</sup>): 1.4  
 Comment on density: The density is of the waste as cut for packaging.

**CHEMICAL COMPOSITION**

General description and components (%wt): Mild steel (100%).  
 Chemical state: Neutral  
 Chemical form of radionuclides: H-3: The tritium is incorporated in the steel.  
 C-14: The carbon 14 is incorporated in the steel. There also may be some contamination as graphite.  
 Se-79: The selenium content is insignificant.  
 Tc-99: The chemical form of technetium has not been determined.  
 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): All of the waste will be bulk metal items which will be cut for packaging. Metal thicknesses will probably range from a few mm to about 100 mm.

|                           | (%wt) | Type(s) / Grade(s) with proportions            | % of total C14 activity |
|---------------------------|-------|--|-------------------------|
| Stainless steel.....      | 0     |  |                         |
| Other ferrous metals..... | 100.0 | Mild steel types are MEEHANITE and CONLO (PV). | 100.0                   |
| Iron.....                 |       |  |                         |
| Aluminium.....            | 0     |  |                         |
| Beryllium.....            |       |  |                         |
| Cobalt.....               | <0.02 | Greatest measured value from the               |                         |

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various components.

|                         |       |  |
|-------------------------|-------|--|
| Copper.....             | 0     |  |
| Lead.....               | 0     |  |
| Magnox/Magnesium.....   | 0     |  |
| Nickel.....             | <0.20 | Greatest measured value from the various components. |
| Titanium.....           |       |  |
| Uranium.....            |       |  |
| Zinc.....               | 0     |  |
| Zircaloy/Zirconium..... | 0     |  |
| Other metals.....       | TR    | Silver and niobium.                                  |

Organics (%wt):                      None expected. No halogenated plastics or rubbers will be present.

|                                     | (%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):                      Some graphite dust may be associated with reactor materials.

|                                    | (%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.....                      | TR    |                     |                         |

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|                               |   |
|-------------------------------|---|
| 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):           There may be a trace of chloride present.

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

Materials of interest for waste acceptance criteria:           No materials likely to pose a fire or other non-radiological hazard have been identified.

|  | (%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.....                   |       |                     |
| 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..... |       |                     |

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Hazardous substances / non hazardous pollutants:      None expected

|                                       | (%wt) |  |
|---------------------------------------|-------|--|
| Acrylamide.....                       |       | Type(s) and comment                                  |
| Benzene.....                          |       |  |
| Chlorinated solvents.....             |       |  |
| Formaldehyde.....                     |       |  |
| Organometallics.....                  |       |  |
| Phenol.....                           |       |  |
| Styrene.....                          |       |  |
| Tri-butyl phosphate.....              |       |  |
| Other organophosphates.....           |       |  |
| Vinyl chloride.....                   |       |  |
| Arsenic.....                          |       |  |
| Barium.....                           |       |  |
| Boron.....                            |       |  |
| Boron (in Boral).....                 |       |  |
| Boron (non-Boral).....                |       |  |
| Cadmium.....                          |       |  |
| Caesium.....                          |       |  |
| Selenium.....                         |       |  |
| Chromium.....                         |       |  |
| Molybdenum.....                       | <0.03 | Greatest measured value from the various components. |
| 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

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

**WASTE STREAM 2C317 Mild Steel (Reactor) Recycle LLW**

Potential for the waste to contain discrete items: Yes. Large Metal Items (LMIs)/"substantial" thickness items considered "durable" assumed DIs. NB If recycled then DI Limits n/a

**TREATMENT, PACKAGING AND DISPOSAL**

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

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

Comment on planned treatments:

This waste stream is expected to be sent for Metal Recycle.

**Disposal Routes:**

| Disposal Route  | Stream volume % | Disposal density t/m3 |
|---|-----------------|-----------------------|
| Expected to be consigned to the LLW Repository<br>Expected to be consigned to a Landfill Facility<br>Expected to be consigned to an On-Site Disposal Facility<br>Expected to be consigned to an Incineration Facility<br>Expected to be consigned to a Metal Treatment Facility<br>Expected to be consigned as Out of Scope<br>Expected to be recycled / reused<br>Disposal route not known | 100.0           | 1.4                   |

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

**Upcoming (2022/23-2024/25) Waste Routing (if expected to change from above):**

| Disposal Route  | Stream volume % |         |         |
|---|-----------------|---------|---------|
|   | 2022/23         | 2023/24 | 2024/25 |
| Expected to be consigned to the LLW Repository<br>Expected to be consigned to a Landfill Facility<br>Expected to be consigned to an On-Site Disposal Facility<br>Expected to be consigned to an Incineration Facility<br>Expected to be consigned to a Metal Treatment Facility<br>Expected to be consigned as Out of Scope<br>Expected to be recycled / reused<br>Disposal route not known |                 |         |         |

**Opportunities for alternative disposal routing: -**

| Baseline Management Route | Opportunity Management Route | Stream volume (%) | Estimated Date that Opportunity will be realised | Opportunity Confidence | Comment |
|---------------------------|------------------------------|-------------------|--|------------------------|---------|
| -                         | -                            | -                 | -  | -                      | -       |

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

**WASTE STREAM      2C317      Mild Steel (Reactor) Recycle LLW**

| Container                              | Stream volume % | Waste loading m <sup>3</sup> | 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: -

**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**

Source: Activation of the mild steel and its impurities.

Uncertainty: The values quoted were derived by calculation from available material specifications and are indicative of the activities that are to be 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 2C317 Mild Steel (Reactor) Recycle LLW**

| Nuclide | Mean radioactivity, TBq/m <sup>3</sup> |                |                 |                | Nuclide          | Mean radioactivity, TBq/m <sup>3</sup> |                |                 |                |
|---------|--|----------------|-----------------|----------------|------------------|--|----------------|-----------------|----------------|
|         | 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     |  |                | 1.08E-06        | CC 2           | Gd 153           |  |                |                 | 8              |
| Be 10   |  |                |                 | 8              | Ho 163           |  |                |                 | 8              |
| C 14    |  |                | 6.97E-05        | CC 2           | Ho 166m          |  |                |                 | 8              |
| Na 22   |  |                |                 | 8              | Tm 170           |  |                |                 | 8              |
| Al 26   |  |                |                 | 8              | Tm 171           |  |                |                 | 8              |
| Cl 36   |  |                | 8.52E-09        | CC 2           | Lu 174           |  |                |                 | 8              |
| Ar 39   |  |                |                 | 8              | Lu 176           |  |                |                 | 8              |
| Ar 42   |  |                |                 | 8              | Hf 178n          |  |                |                 | 8              |
| K 40    |  |                |                 | 8              | Hf 182           |  |                |                 | 8              |
| Ca 41   |  |                |                 | 8              | Pt 193           |  |                |                 | 8              |
| Mn 53   |  |                |                 | 8              | Tl 204           |  |                |                 | 8              |
| Mn 54   |  |                |                 | 8              | Pb 205           |  |                |                 | 8              |
| Fe 55   |  |                |                 | 8              | Pb 210           |  |                |                 | 8              |
| Co 60   |  |                | 9.03E-07        | CC 2           | Bi 208           |  |                |                 | 8              |
| Ni 59   |  |                | 1.15E-05        | CC 2           | Bi 210m          |  |                |                 | 8              |
| Ni 63   |  |                | 6.18E-04        | CC 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   |  |                | 3.59E-07        | CC 2           | Th 234           |  |                |                 | 8              |
| Mo 93   |  |                | 3.92E-05        | CC 2           | Pa 231           |  |                |                 | 8              |
| Tc 97   |  |                |                 | 8              | Pa 233           |  |                |                 | 8              |
| Tc 99   |  |                | 3.17E-07        | CC 2           | U 232            |  |                |                 | 8              |
| Ru 106  |  |                |                 | 8              | U 233            |  |                |                 | 8              |
| Pd 107  |  |                |                 | 8              | U 234            |  |                |                 | 8              |
| Ag 108m |  |                | 1.63E-07        | CC 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  |  |                |                 | 8              | Other a          |  |                |                 |                |
| Eu 152  |  |                | 1.14E-08        | CC 2           | Other b/g        |  |                |                 |                |
| Eu 154  |  |                |                 | 8              | <b>Total a</b>   | <b>0</b>                               |                | <b>0</b>        |                |
| Eu 155  |  |                |                 | 8              | <b>Total b/g</b> | <b>0</b>                               |                | <b>7.41E-04</b> | <b>CC 2</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