

|                     |              |                                 |
|---------------------|--------------|---------------------------------|
| <b>WASTE STREAM</b> | <b>9J311</b> | <b>Mild Steel (Reactor) LLW</b> |
|---------------------|--------------|---------------------------------|

**SITE** Hunterston A  
**SITE OWNER** Nuclear Decommissioning Authority  
**WASTE CUSTODIAN** Magnox Limited  
**WASTE TYPE** LLW

**WASTE VOLUMES**

|                        |                           | Reported             |
|------------------------|---------------------------|----------------------|
| Stocks:                | At 1.4.2019.....          | 0 m <sup>3</sup>     |
| Future arisings -      | 1.4.2072 - 31.3.2080..... | 818.0 m <sup>3</sup> |
| Total future arisings: |                           | 818.0 m <sup>3</sup> |
| Total waste volume:    |                           | 818.0 m <sup>3</sup> |

Comment on volumes: Waste arisings are assumed to occur at a uniform rate over 8 years. Final Dismantling & Site Clearance is assumed to commence in 2071 and lasting for 9 years. Volumes and radioactivity have been calculated for 85 years after reactor shutdown.

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 (%wt): Mild steel items (100%).  
 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.  
 Cl-36: The chlorine-36 is incorporated in the steel.  
 Se-79: The selenium content is insignificant.  
 Tc-99: Technetium will be incorporated in the steel. It is an activation product of Mo-98.  
 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.

|                           |       |
|---------------------------|-------|
| Stainless steel.....      | 0     |
| Other ferrous metals..... | 100.0 |
| Iron.....                 |       |
| Aluminium.....            | 0     |
| Beryllium.....            | 0     |
| Cobalt.....               |       |
| Copper.....               | 0     |
| Lead.....                 | 0     |
| Magnox/Magnesium.....     | 0     |

All of the waste included in this waste stream is mild steel.

**WASTE STREAM****9J311****Mild Steel (Reactor) LLW**

|                        |  |                              |
|------------------------|--|------------------------------|
|                        | Nickel.....  |                              |
|                        | Titanium.....  |                              |
|                        | Uranium.....   |                              |
|                        | Zinc.....  | 0                            |
|                        | Zircaloy/Zirconium.....  | 0                            |
|                        | Other metals.....  | 0                            |
|                        |  | There are no "other" metals. |
| Organics (%wt):        | None expected. There are no halogenated plastics or rubbers 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): | Expect only graphite.  |                              |
|                        | 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                           |
|                        | Desiccants/Catalysts.....  |                              |
|                        | Asbestos.....  | 0                            |
|                        | Non/low friable.....   |                              |
|                        | Moderately friable.....  |                              |
|                        | Highly friable.....  |                              |
|                        | Free aqueous liquids.....  | 0                            |
|                        | Free non-aqueous liquids.....  | 0                            |
|                        | Powder/Ash.....  | 0                            |

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Inorganic anions (%wt):

There may be a trace of chloride present.

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.

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.....

Vinyl chloride.....

Arsenic.....

Barium.....

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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):

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

**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 |                    | 100.0           |

Comment on planned treatments:

-

**WASTE STREAM****9J311****Mild Steel (Reactor) LLW****Disposal Routes:**

| Disposal Route  | Stream volume % |
|---|-----------------|
| 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           |

**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<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 |                 |         |         |

**Waste Packaging for Disposal:**

| Container  | Stream volume % | Waste loading m <sup>3</sup> | Number of packages |
|--|-----------------|------------------------------|--------------------|
| 1/3 Height IP-1 ISO<br>2/3 Height IP-2 ISO<br>1/2 Height WAMAC IP-2 ISO<br>1/2 Height IP-2 Disposal/Re-usable ISO<br>2m box (no shielding)<br>4m box (no shielding)<br>Other | 100.0           | 10                           | 82                 |

Other information: -

**Waste Planned for Disposal at the LLW Repository:**

Container voidage: In-accessible voidage is not expected.

Waste Characterisation Form (WCH): -

Waste consigned for disposal to LLWR in year of generation: Yes. The waste will be packaged when the reactors are dismantled and it is be disposed of immediately.

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: -

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**9J311**

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**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: | Total beta/gamma is defined as the sum of the listed activities of all nuclides other than alpha emitters. All alpha emitter activities are insignificant.   |
| Measurement of radioactivities:                 | The specific activities were estimated from neutron activation calculations of the material and its impurities.  |
| Other information:                              | There may be some contamination by Cs137. The activities quoted are those at 85 years after reactor shutdown, i.e. in 2072.  |

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| Nuclide | Mean radioactivity, TBq/m <sup>3</sup> |                |                 |                | Nuclide          | Mean radioactivity, TBq/m <sup>3</sup> |                 |                 |                |
|---------|--|----------------|-----------------|----------------|------------------|--|-----------------|-----------------|----------------|
|         | 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     |  |                |                 | 8              | Gd 153           |  |                 |                 | 8              |
| Be 10   |  |                |                 | 8              | Ho 163           |  |                 |                 | 8              |
| C 14    |  |                | 1.3E-03         | C C 2          | Ho 166m          |  |                 |                 | 8              |
| Na 22   |  |                |                 | 8              | Tm 170           |  |                 |                 | 8              |
| Al 26   |  |                |                 | 8              | Tm 171           |  |                 |                 | 8              |
| Cl 36   |  |                | 2.07E-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   |  |                |                 | 8              | Pt 193           |  |                 |                 | 8              |
| Mn 53   |  |                |                 | 8              | Tl 204           |  | 5.04E-09        | C C 2           | 8              |
| Mn 54   |  |                |                 | 8              | Pb 205           |  |                 |                 | 8              |
| Fe 55   |  |                | 9.61E-09        | C C 2          | Pb 210           |  |                 |                 | 8              |
| Co 60   |  |                | 1.28E-05        | C C 2          | Bi 208           |  |                 |                 | 8              |
| Ni 59   |  |                | 5.71E-05        | C C 2          | Bi 210m          |  |                 |                 | 8              |
| Ni 63   |  |                | 3.42E-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  |  |                |                 | 6              | Th 232           |  |                 |                 | 8              |
| Nb 94   |  |                | 7.91E-08        | C C 2          | Th 234           |  |                 |                 | 8              |
| Mo 93   |  |                | 1.6E-05         | C C 2          | Pa 231           |  |                 |                 | 8              |
| Tc 97   |  |                |                 | 8              | Pa 233           |  |                 |                 | 8              |
| Tc 99   |  |                | 3.66E-06        | C C 2          | U 232            |  |                 |                 | 8              |
| Ru 106  |  |                |                 | 8              | U 233            |  |                 |                 | 8              |
| Pd 107  |  |                |                 | 8              | U 234            |  |                 |                 | 8              |
| Ag 108m |  |                | 9.1E-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 |  |                |                 | 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  |  |                |                 | 8              | 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>4.81E-03</b> | <b>C C 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