## WASTE STREAM 9B25 FED Magnox

**SITE** Bradwell

**SITE OWNER** Nuclear Decommissioning Authority

**WASTE CUSTODIAN** Magnox Limited

**WASTE TYPE** ILW

### WASTE VOLUMES

| | | |
|---|---|---|
| Stocks: | At 1.4.2013..... | 38.5 m³ |
| Total future arisings: | | 0 m³ |
| Total waste volume: | | 38.5 m³ |

Comment on volumes: In calculating the volumes it has been assumed that the vault is full, therefore the waste occupies the nominal volume of each cell that is filled. The waste occupies approximately 6 times the displacement volume of the material.

| Uncertainity factors on volumes: | | |
|---|---|---|
| Stock (upper): | x 1.2 | Arisings (upper) x |
| Stock (lower): | x 0.8 | Arisings (lower) x |

**WASTE SOURCE** The source of the waste is the removal of splitters from fuel elements prior to dispatch of the elements for reprocessing.

### PHYSICAL CHARACTERISTICS

General description: The waste consists of Magnox metal and swarf which may be contaminated by fission products and actinides. Individual components may weigh up to about 100 g and be approx 2 mm x 25 mm x 900 mm. Complete splitter frames weighing about 600 g may have been compressed into a cylinder about 225 mm long by 100 mm diameter. There are no large items in the waste which will require special handling.

Physical components (%vol): The packages will contain discrete waste components, e.g. fuel fragments, fuel element top end fittings which will incorporate Nimonic springs together with some zirconium alloy, fine filter elements and spent ion exchange resin elements.

Bulk density (t/m³): 0.28

Comment on density: The maximum density is 1.7 t/m3, being the density of the Magnox. The average density assumes a packing factor of approximately 6 times the displacement volume of the material.

### CHEMICAL COMPOSITION

General description and components (%wt): Magnox metal (type ZR55) (>99%). Fission product and actinide contamination and a small fraction of Nimonic, a high nickel content alloy, and some zirconium alloy are present. It is assumed that the waste will contain a small amount of fuel fragments.

Chemical state: The waste is neither acid nor alkaline, but it is known to be a reducing agent.

Chemical form of radionuclides:
H-3: Tritium is expected to be present as surface contamination possibly as water but perhaps in the form of other inorganic compounds or as organic compounds.
C-14: Carbon 14 will probably be present as graphite.
Cl-36: Chlorine 36 incorporated in the Magnox may be associated with barium impurity (BaCl2). Other chlorine 36 may be associated with surface contamination.
Tc-99: The chemical form of technetium has not been determined.
U: Chemical form of U isotopes has not been determined but may be oxides.
Np: The chemical form of neptunium has not been determined.
Pu: Chemical form of Pu isotopes has not been determined but may be oxides.

Metals and alloys (%wt): The waste is Magnox ZR55 which includes zirconium as an alloying constituent. Small quantities of Nimonic and zirconium alloys from element top end fittings. The thickness of some of the waste will be of the order of a mm or less.

| | | | |
|---|---|---|---|
| Stainless steel..... | 0 | Bronze..... | 0 |
| Other ferrous metals..... | 0 | Inconel..... | 0 |
| Aluminium..... | 0 | Nimonic..... | TR |
| Copper..... | 0 | Stellite..... | 0 |
| Lead..... | 0 | Boral..... | 0 |
| Zinc..... | 0 | Dural..... | 0 |
| Magnox/Magnesium..... | >99.0 | Monel..... | 0 |
| Zircaloy..... | TR | Uranium..... | NE |
| Brass..... | 0 | Beryllium..... | TR |
| | | Other metals (below)..... | 0 |

Other metals: -

Inorganic anions (%wt): -

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| | | | |
|---|---|---|---|
| Fluoride | TR | Nitrate | TR |
| Chloride | TR | Nitrite | TR |
| Iodide | 0 | Phosphate | TR |
| Cyanide | 0 | Sulphate | TR |
| Carbonate | TR | Sulphide | 0 |

Listed substances: Not present.

Hazardous and problematic materials (%wt): Magnox will ignite under appropriate conditions.

| | | | |
|---|---|---|---|
| Combustible metals | >99.0 | Strong oxidising agents | 0 |
| Low flash point liquids | 0 | Pyrophoric materials | 0 |
| Explosive materials | 0 | Generating toxic gases | 0 |
| Phosphorus | 0 | Reacting with water | >99.0 |
| Hydrides | 0 | Asbestos | 0 |
| Putrescible wastes | 0 | Free aqueous liquids | TR |
| Biological etc. materials | 0 | Free non-aqueous liquids | 0 |
| Powder | TR | | |

Asbestos types and proportions: -

Complexing agents (%wt): Not yet determined.

| | |
|---|---|
| Complexing agents | TR |

Organics (%wt): -

| | |
|---|---|
| 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 |
| Other organics | TR |

Halogenated plastics and rubber (%wt): None present.

Other materials (%wt): Graphite contamination.

| | |
|---|---|
| Inorganic ion exchange materials | 0 |
| Inorganic sludges and flocs | NE |
| Soil | 0 |
| Rubble | 0 |
| Concrete, cement and sand | 0 |
| Glass | 0 |
| Ceramics | 0 |
| Graphite | TR |

### PACKAGING AND CONDITIONING

Conditioning method: The proposed method for conditioning is weak acid dissolution. No packages will be produced.

Plant Name: Bradwell dissolution facility

Location: Bradwell Site

Plant startup date: 2012

Total capacity ($m^3$/y incoming waste): ~350.0

Target start date for packaging this stream: -

Throughput for this stream ($m^3$/y incoming waste): 370.0

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Other information: The secondary waste arisings from dissolution will be placed into DCICs (Ductile Cast Iron Containers). Nominally this will consist of larger non-magnox debris e.g. nimonic springs, end cap fittings and fuel fragments removed pre and post dissolution. In addition it is intended that the fine particulate filtration and Ion exchange elements will be housed within DCICs and grouted in-situ when spent

Likely container type:

| Container | Waste packaged (%vol) | Waste loading ($m^3$) | Payload ($m^3$) | Container displacement volume ($m^3$) |
|---|---|---|---|---|
| | | | | |

Likely container type comment: -

Range in container waste volume: -

Other information on containers: -

Likely conditioning matrix: -

Other information: -

Conditioned density ($t/m^3$): -

Conditioned density comment: -

Other information on conditioning: -

### RADIOACTIVITY

Source: The source of the waste is the removal of splitters from fuel elements prior to dispatch of the elements for reprocessing. Activation of trace impurities in the Magnox and contamination by fission products and actinides will be main sources of activity. In addition activity in waste packages will also be derived from activated fuel element components e.g. nimonic springs and fuel fragments.

Accuracy: The values quoted are indicative of the activities that might be expected.

Definition of total alpha and total beta/gamma: Totals shown on table of radionuclide activities are the sums of the listed alpha or beta/gamma emitting radionuclides plus 'other alpha' or 'other beta/gamma.'

Measurement of specific activities: Values were derived from measurements, calculationed activitation and estimates of likely contamination.

Other information: The activities quoted do not include any allowance for the activity of Nimonic springs or zirconium alloy in top end fittings. However, the resulting average activities in the waste are thought to lie within the uncertainties associated with the average activity of the Magnox. The other beta/gamma in stocks is Al-26 (3.65E-7 TBq/m3).

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| Nuclide | Average specific activity, TBq/m³ | | | | Nuclide | Average specific activity, TBq/m³ | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Waste at 1.4.2013 | Bands and Code | Future arisings | Bands and Code | | Waste at 1.4.2013 | Bands and Code | Future arisings | Bands and Code |
| H 3 | 8.7E-04 | C C 2 | | | Ho 163 | | 8 | | |
| Be 10 | 1.22E-07 | C C 2 | | | Ho 166m | | 8 | | |
| C 14 | 1.1E-04 | C C 2 | | | Tm 170 | | 8 | | |
| Cl 36 | 2.43E-04 | C C 2 | | | Tm 171 | | 8 | | |
| Ar 39 | | 8 | | | Lu 174 | | 8 | | |
| Ar 42 | | 8 | | | Lu 176 | | 8 | | |
| K 40 | | 8 | | | Hf 178n | | 8 | | |
| Ca 41 | <2.43E-05 | C 3 | | | Hf 182 | | 8 | | |
| Mn 53 | | 8 | | | Pt 193 | | 8 | | |
| Mn 54 | | 8 | | | Tl 204 | | 8 | | |
| Fe 55 | 5.23E-04 | C C 2 | | | Pb 205 | | 8 | | |
| Co 60 | 2.76E-03 | C C 2 | | | Pb 210 | | 8 | | |
| Ni 59 | 1.22E-05 | C C 2 | | | Bi 208 | | 8 | | |
| Ni 63 | 2.34E-03 | C C 2 | | | Bi 210m | | 8 | | |
| Zn 65 | | 8 | | | Po 210 | | 8 | | |
| Se 79 | | 8 | | | Ra 223 | | 8 | | |
| Kr 81 | | 8 | | | Ra 225 | | 8 | | |
| Kr 85 | | 8 | | | Ra 226 | | 8 | | |
| Rb 87 | | 8 | | | Ra 228 | | 8 | | |
| Sr 90 | 3.17E-05 | C C 2 | | | Ac 227 | | 8 | | |
| Zr 93 | 1.1E-05 | C C 2 | | | Th 227 | | 8 | | |
| Nb 91 | | 8 | | | Th 228 | | 8 | | |
| Nb 92 | | 8 | | | Th 229 | | 8 | | |
| Nb 93m | 3.4E-06 | C C 2 | | | Th 230 | | 8 | | |
| Nb 94 | | 8 | | | Th 232 | | 8 | | |
| Mo 93 | | 8 | | | Th 234 | 2.43E-08 | C C 2 | | |
| Tc 97 | | 8 | | | Pa 231 | | 8 | | |
| Tc 99 | 8.52E-09 | C C 2 | | | Pa 233 | 2.46E-09 | C C 2 | | |
| Ru 106 | | 8 | | | U 232 | | 8 | | |
| Pd 107 | | 8 | | | U 233 | | 8 | | |
| Ag 108m | 2.41E-06 | C C 2 | | | U 234 | 2.46E-08 | C C 2 | | |
| Ag 110m | | 8 | | | U 235 | | 8 | | |
| Cd 109 | | 8 | | | U 236 | 2.43E-09 | C C 2 | | |
| Cd 113m | <1.82E-04 | C 3 | | | U 238 | 2.43E-08 | C C 2 | | |
| Sn 119m | | 8 | | | Np 237 | 2.46E-09 | C C 2 | | |
| Sn 121m | <2.24E-04 | C 3 | | | Pu 236 | | 8 | | |
| Sn 123 | | 8 | | | Pu 238 | 1.05E-05 | C C 2 | | |
| Sn 126 | | 8 | | | Pu 239 | 9.74E-06 | C C 2 | | |
| Sb 125 | 1.06E-05 | C C 2 | | | Pu 240 | 1.22E-05 | C C 2 | | |
| Sb 126 | | 8 | | | Pu 241 | 3.64E-04 | C C 2 | | |
| Te 125m | 1.13E-05 | C C 2 | | | Pu 242 | 9.74E-09 | C C 2 | | |
| Te 127m | | 8 | | | Am 241 | 1.6E-05 | C C 2 | | |
| I 129 | | 8 | | | Am 242m | 7.08E-08 | C C 2 | | |
| Cs 134 | 1.62E-08 | C C 2 | | | Am 243 | 2.43E-08 | C C 2 | | |
| Cs 135 | | 8 | | | Cm 242 | 5.85E-08 | C C 2 | | |
| Cs 137 | 4.24E-05 | C C 2 | | | Cm 243 | 3.18E-08 | C C 2 | | |
| Ba 133 | <1.64E-04 | C 3 | | | Cm 244 | 3.88E-07 | C C 2 | | |
| La 137 | <3.65E-06 | C 3 | | | Cm 245 | | 8 | | |
| La 138 | | 8 | | | Cm 246 | | 8 | | |
| Ce 144 | | 8 | | | Cm 248 | | 8 | | |
| Pm 145 | | 8 | | | Cf 249 | | 8 | | |
| Pm 147 | <1.24E-03 | C 3 | | | Cf 250 | | 8 | | |
| Sm 147 | | 8 | | | Cf 251 | | 8 | | |
| Sm 151 | 8.14E-08 | C C 2 | | | Cf 252 | | 8 | | |
| Eu 152 | | 8 | | | Other a | | 8 | | |
| Eu 154 | 2.25E-07 | C C 2 | | | Other b/g | 3.65E-07 | C C 2 | | |
| Eu 155 | 5.26E-08 | C C 2 | | | **Total a** | **4.9E-05** | **C C 2** | | |
| Gd 153 | | 8 | | | **Total b/g** | **9.17E-03** | **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 the average specific activity.

**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