## WASTE STREAM 9A53 FED Zirconium

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|---|---|
| **SITE** | Berkeley |
| **SITE OWNER** | Nuclear Decommissioning Authority |
| **WASTE CUSTODIAN** | Magnox Limited |
| **WASTE TYPE** | ILW |

**WASTE VOLUMES**

| | | Reported |
|---|---|---|
| Stocks: | At 1.4.2019..... | 3.3 m³ |
| Total future arisings: | | 0 m³ |
| Total waste volume: | | 3.3 m³ |

Comment on volumes: Station operation ceased in March 1989. The volume quoted is the estimated bulk volume of the waste if separated from other wastes with which it is mixed. The range in the volume of zirconium debris is estimated to be between 3.16m³ and 3.44m³.

| Uncertainty factors on volumes: | | | | |
|---|---|---|---|---|
| | Stock (upper): | x 1.1 | Arisings (upper) | x |
| | Stock (lower): | x 0.9 | Arisings (lower) | x |

**WASTE SOURCE** The source of the waste is the removal of graphite struts and associated zirconium and stainless steel bridge pieces from fuel elements prior to the dispatch of the elements to Sellafield.

### PHYSICAL CHARACTERISTICS

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|---|---|
| General description: | The waste comprises zirconium support bridges of about 127mm in length. The bridge pieces may still be connected to the graphite struts. Approximately 62% of fuel elements used zirconium top support bridges. All of the fuel elements had bottom support bridges made from zirconium. A zirconium top support bridge weighs approximately 30g and a bottom support bridge weighs approxiamtely 41g. It is unlikely that there will be any large items which will require special handling. The waste is loose in the vaults. |
| Physical components (%vol): | Zirconium bridge pieces (>99 vol%). No other constituents identified. |
| Sealed sources: | - |
| Bulk density (t/m³): | 2.2 |
| Comment on density: | The average bulk density of 2.2 t/m³ assumes a packing factor to give an overall volume of about three times the displacement volume of the waste. The density can be up to 6.5 t/m³. |

### CHEMICAL COMPOSITION

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|---|---|
| General description and components (%wt): | Zirconium (>98.3%) and impurities (<1.7%). There may be fission product, actinide and graphite contamination. |
| Chemical state: | Neutral |
| Chemical form of radionuclides: | H-3: Tritium may be incorporated in the zirconium or be present as surface contamination in the form of water, other inorganic or organic compounds.<br>C-14: Carbon 14 will probably be present as graphite and also to a minor degree, as impurity within the zirconium.<br>Cl-36: The chemical form of chlorine 36 has not been determined.<br>Se-79: The selenium content is insignificant.<br>Tc-99: The technetium content is insignificant.<br>Ra: Radium isotope content is insignificant.<br>Th: The thorium isotope content is insignificant.<br>U: Chemical form of U isotopes has not been determined but may be oxides.<br>Np: The neptunium content is insignificant.<br>Pu: Chemical form of plutonium isotopes has not been determined but may be plutonium oxides. |
| Metals and alloys (%wt): | Items are approximately 127 mm x 25 mm x 17 mm. |

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|---|---|---|
| Stainless steel | 0 | |
| Other ferrous metals | 0 | |
| Iron | | |
| Aluminium | 0 | |
| Beryllium | 0 | |
| Cobalt | | |
| Copper | 0 | |
| Lead | 0 | |
| Magnox/Magnesium | TR | |
| Nickel | | |
| Titanium | | |
| Uranium | | |
| Zinc | 0 | |
| Zircaloy/Zirconium | ~100.0 | |
| Other metals | 0 | The waste will be zirconium with impurities incorporated in the zirconium. |

Organics (%wt): This loose Zirconium is currently stored in the same vault as the drums of ion exchange material, although in different sub-sections. It may be possible that the Zirconium has been contaminated with the ion exchange material that has leaked from the drums.

| | |
|---|---|
| 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 | TR |
| 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 | TR |

Other materials (%wt): Graphite contamination.

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|---|---|
| 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..... | TR |
| Free non-aqueous liquids..... | 0 |
| Powder/Ash..... | P |

Inorganic anions (%wt): Inorganic anions are not expected to be present at greater than trace concentrations.

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

Materials of interest for waste acceptance criteria: There are no identified materials likely to represent a fire or other non-radiological hazard.

| | |
|---|---|
| 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..... | |

**WASTE STREAM 9A53 FED Zirconium**

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.....

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): Yes

EDTA.....

DPTA.....

NTA.....

Polycarboxylic acids……

Other organic complexants.....

Total complexing agents..... TR

**PACKAGING AND CONDITIONING**

Conditioning method: This stream will be co-packaged together in Concrete boxes (9A61, 9A62, 9A67, 9A32, 9A40, 9A48, 9A73). The remainder of vault 1 waste will be co-packaged together in Type VI DCIC containers (9A25, 9A31, 9A39, 9A47, 9A52, 9A60 and

9A66). Packages for vault 1 are assigned to 9A25, 9A32 & 9A73.

Plant Name: -

Location: Berkeley Site

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: -

Likely container type:

| Container | Waste packaged (%vol) | Waste loading ($m^3$) | Payload ($m^3$) | Number of packages |
|---|---|---|---|---|
| | | | | |

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: -

Opportunities for alternative disposal routing:

| Treatment | Stream volume (%) | Comment |
|---|---|---|
| - | - | - |

## RADIOACTIVITY

Source: Activation when the associated fuel elements were irradiated, of nuclides incorporated in the zirconium. Contamination by fission products and actinides when the fuel elements were in the fuel pond.

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

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: Specific activity is a function of Station operating history. Values were derived from calculations of induced activity and estimates of likely contamination.

Other information: -

## WASTE STREAM 9A53 FED Zirconium

| Nuclide | Mean radioactivity, TBq/m³ Waste at 1.4.2019 | Bands and Code | Future arisings | Bands and Code | Nuclide | Mean radioactivity, TBq/m³ Waste at 1.4.2019 | Bands and Code | Future arisings | Bands and Code |
|---|---|---|---|---|---|---|---|---|---|
| H 3 | <1.02E+00 | D 3 | | | Gd 153 | | 8 | | |
| Be 10 | | 8 | | | Ho 163 | | 8 | | |
| C 14 | 3.00E-02 | C C 2 | | | Ho 166m | | 8 | | |
| Na 22 | | 8 | | | Tm 170 | | 8 | | |
| Al 26 | <8E-07 | D 3 | | | Tm 171 | | 8 | | |
| Cl 36 | <2E-03 | C 3 | | | Lu 174 | | 8 | | |
| Ar 39 | | 8 | | | Lu 176 | | 8 | | |
| Ar 42 | | 8 | | | Hf 178n | | 8 | | |
| K 40 | | 8 | | | Hf 182 | | 8 | | |
| Ca 41 | <4E-05 | D 3 | | | Pt 193 | | 8 | | |
| Mn 53 | | 8 | | | Tl 204 | | 8 | | |
| Mn 54 | | 8 | | | Pb 205 | | 8 | | |
| Fe 55 | <2.34E-05 | D 3 | | | Pb 210 | | 8 | | |
| Co 60 | <6.18E-02 | D 3 | | | Bi 208 | | 8 | | |
| Ni 59 | <7E-04 | D 3 | | | Bi 210m | | 8 | | |
| Ni 63 | 1.84E-01 | D D 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 | 3.76E-04 | C C 2 | | | Th 227 | | 8 | | |
| Zr 93 | 5E-03 | C C 2 | | | Th 228 | | 8 | | |
| Nb 91 | | 8 | | | Th 229 | | 8 | | |
| Nb 92 | 1E-07 | C C 2 | | | Th 230 | | 8 | | |
| Nb 93m | 3.74E-03 | C C 2 | | | Th 232 | | 8 | | |
| Nb 94 | | 8 | | | Th 234 | 7E-07 | C C 2 | | |
| Mo 93 | <6.00E-03 | D 3 | | | Pa 231 | | 8 | | |
| Tc 97 | | 8 | | | Pa 233 | 4.12E-08 | C C 2 | | |
| Tc 99 | <1E-03 | D 3 | | | U 232 | | 8 | | |
| Ru 106 | | 8 | | | U 233 | | 8 | | |
| Pd 107 | | 8 | | | U 234 | 6.04E-07 | C C 2 | | |
| Ag 108m | | 8 | | | U 235 | 2E-08 | C C 2 | | |
| Ag 110m | | 8 | | | U 236 | 5.00E-08 | C C 2 | | |
| Cd 109 | | 8 | | | U 238 | 7E-07 | C C 2 | | |
| Cd 113m | <1.65E-04 | D 3 | | | Np 237 | 4.12E-08 | C C 2 | | |
| Sn 119m | | 8 | | | Pu 236 | | 8 | | |
| Sn 121m | <1.70E-02 | D 3 | | | Pu 238 | 7.28E-05 | C C 2 | | |
| Sn 123 | | 8 | | | Pu 239 | 2E-04 | C C 2 | | |
| Sn 126 | 3.04E-09 | C C 2 | | | Pu 240 | 2.00E-04 | C C 2 | | |
| Sb 125 | 1.93E-06 | C C 2 | | | Pu 241 | 1.69E-03 | C C 2 | | |
| Sb 126 | | 8 | | | Pu 242 | 6E-08 | C C 2 | | |
| Te 125m | 4.84E-07 | C C 2 | | | Am 241 | 3.38E-04 | C C 2 | | |
| Te 127m | | 8 | | | Am 242m | 3.76E-07 | C C 2 | | |
| I 129 | | 8 | | | Am 243 | 8.00E-08 | C C 2 | | |
| Cs 134 | | 8 | | | Cm 242 | 3.11E-07 | C C 2 | | |
| Cs 135 | 6E-09 | C C 2 | | | Cm 243 | 4.55E-08 | C C 2 | | |
| Cs 137 | 5.30E-04 | C C 2 | | | Cm 244 | 2.52E-07 | C C 2 | | |
| 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 | 4.38E-04 | C C 2 | | | Cf 250 | | 8 | | |
| Pm 147 | 8.42E-09 | C C 2 | | | Cf 251 | | 8 | | |
| Sm 147 | | 8 | | | Cf 252 | | 8 | | |
| Sm 151 | <1.82E-02 | D 3 | | | Other a | | | | |
| Eu 152 | <1.62E+00 | D 3 | | | Other b/g | | | | |
| Eu 154 | <7.58E-01 | D 3 | | | **Total a** | **8.13E-04** | **C C 2** | **0** | |
| Eu 155 | 3.65E-03 | C C 2 | | | **Total b/g** | **3.74E+00** | **C C 2** | **0** | |

**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