

WASTE STREAM**2F41****LWR Pond Furniture (MEBs) in Interim Storage**

SITE Sellafield
SITE OWNER Nuclear Decommissioning Authority

WASTE CUSTODIAN Sellafield Limited

WASTE TYPE LLW

Is the waste subject to Scottish Policy: No

WASTE VOLUMES

| | | |
|------------------------|------------------|----------------------|
| | | Reported |
| Stocks: | At 1.4.2022..... | 742.6 m ³ |
| Total future arisings: | | 0 m ³ |
| Total waste volume: | | 742.6 m ³ |

Comment on volumes: MEB arisings are a function of keeping the ponds operational and removal as part of POCO. Since 2011, MEBs have been sent directly off-site without being placed in the interim store (MEBIS). MEBs reside in MEBIS are expected to be transferred and removed in line with pond furniture. Stock volume is based on an average envelope volume of 2.79 m³ per MEB for 266 MEBs. MEB size is variable (2.2m³ to 3.4m³). The arising volume can vary by +/- 25% but the overall volumetric uncertainty is low.

Uncertainty factors on volumes:

| | | | |
|----------------|--------|------------------|---|
| Stock (upper): | x 1.05 | Arisings (upper) | x |
| Stock (lower): | x 0.95 | Arisings (lower) | x |

WASTE SOURCE Transport and pond storage containers for LWR fuel prior to reprocessing.

PHYSICAL CHARACTERISTICS

General description: Multi Element Bottles (MEBs). MEBs vary in size, but are generally cylindrical in shape. All MEBs are large (2.2m³ to 3.4m³) and heavy (1.3 to 4.34t). The waste has not undergone any changes since it was generated.

Physical components (%vol): MEBs (100%).

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m³): ~1.01

Comment on density: The bulk density is based on the summed mass and the summed envelope volumes of the MEBs.

CHEMICAL COMPOSITION

General description and components (%wt): Boronated stainless steel, stainless steel, boral, lead, aluminium. Minor components include copper/bronze, nickel and traces of rubber. The following composition is for a representative MEB design: stainless steel (80%), aluminium bronze (0.3%), boral (<6%, of which 1% is elemental boron), lead (<14%), rubber (TR). The proportions of materials will vary between different designs and may be between the following ranges: stainless steel 80-99% (some of which may be boronated), boral 0.2-10%, lead 0-14%, concrete 0-15%, aluminium bronze 0.1-0.5%. Other materials are present in small or trace quantities.

Chemical state: Neutral

Chemical form of radionuclides: C-14: Oxides.
Tc-99: Oxides.
U: Oxides.
Pu: Oxides.

Metals and alloys (%wt): 62% sheet metal (thickness approx 1/4 inch), 24% bulk metal (thickness from 1-3 inches), 14% lead ballast (1 7/8 inches diam.)

| | (%wt) | Type(s) / Grade(s) with proportions | % of total C14 activity |
|---------------------------|-------|-------------------------------------|-------------------------|
| Stainless steel..... | 80.0 | 304L. | |
| Other ferrous metals..... | 0 | | |
| Iron..... | | | |
| Aluminium..... | 6.0 | Boral | |
| Beryllium..... | | | |

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| Cobalt..... | 0 |
| Copper..... | TR |
| Lead..... | <12.0 |
| Magnox/Magnesium..... | 0 |
| Nickel..... | 0 |
| Titanium..... | NE |
| Uranium..... | NE |
| Zinc..... | 0 |
| Zircaloy/Zirconium..... | 0 |
| Other metals..... | 0 |

Organics (%wt): Rubber is present as 'O' rings/gaskets. Neoprene 'O' rings, 0.065%.

| | (%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..... | ~0.07 | | |
| Halogenated rubber | ~0.07 | | |
| Non-halogenated rubber..... | NE | | |
| Hydrocarbons..... | NE | | |
| Oil or grease | | | |
| Fuel..... | | | |
| Asphalt/Tarmac (cont.coal tar)... | | | |
| Asphalt/Tarmac (no coal tar).... | | | |
| Bitumen..... | | | |
| Others..... | | | |
| Other organics..... | 0 | | |

Other materials (%wt): The waste contains crud consisting of metal oxide corrosion products (either haematite or nickel substituted spinels) dislodged from the fuel previously held in the containers which constitute the waste. The principal constituents are Co-60 and Fe-55.

| | (%wt) | Type(s) and comment | % of total C14 activity |
|------------------------------------|-------|---------------------|-------------------------|
| Inorganic ion exchange materials.. | 0 | | |
| Inorganic sludges and flocs..... | <1.9 | | 100.0 |
| Soil..... | 0 | | |
| Brick/Stone/Rubble..... | 0 | | |
| Cementitious material..... | 0 | | |
| Sand..... | | | |
| Glass/Ceramics..... | | | |

| | | |
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|-------------------------------|-------|
| Graphite..... | 0 |
| Desiccants/Catalysts..... | |
| Asbestos..... | 0 |
| Non/low friable..... | |
| Moderately friable..... | |
| Highly friable..... | |
| Free aqueous liquids..... | <0.02 |
| Free non-aqueous liquids..... | 0 |
| Powder/Ash..... | 0 |

Inorganic anions (%wt): The listed anions are unlikely to be present.

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

Materials of interest for waste acceptance criteria: MEBs are dewatered before disposal both by primary dewatering to remove bulk of water from MEB body and by secondary dewatering to remove the heel of liquor from the MEB base cavity. Some MEBs have catalytic recombiners present but the recombiner material is a very small proportion of the waste stream.

| | (%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..... | 0 | |
| Putrescible wastes..... | 0 | |
| Non-putrescible wastes..... | 0 | |
| Corrosive materials..... | 0 | |
| Pyrophoric materials..... | 0 | |
| Generating toxic gases..... | 0 | |
| Reacting with water..... | 0 | |
| Higher activity particles..... | P | Activity is present in the crud particles (<2wt%). |
| Soluble solids as bulk chemical compounds..... | 0 | |

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Hazardous substances /
non hazardous pollutants:

The waste contains lead as ballast in MEB types 1175, 1176, 1190, 1192 & 3321 only. Catalytic recombiners made from platinum/palladium are present in a very small proportion of the MEBs (1% of wastestream). The weight of this material is negligible compared with the MEB weight.

| | (%wt) | Type(s) and comment |
|---------------------------------------|-------|--|
| Acrylamide..... | NE | |
| Benzene..... | NE | |
| Chlorinated solvents..... | NE | |
| Formaldehyde..... | NE | |
| Organometallics..... | NE | |
| Phenol..... | NE | |
| Styrene..... | NE | |
| Tri-butyl phosphate..... | NE | |
| Other organophosphates..... | NE | |
| Vinyl chloride..... | NE | |
| Arsenic..... | NE | |
| Barium..... | NE | |
| Boron..... | 1.0 | 1%wt Boron is the value per MEB (for 2F36, 2F15 & 2F41) but the total Boron for all MEBs (1,673) comes to 44.5te noted here to reserve the capacity at LLWR. |
| Boron (in Boral)..... | 1.0 | |
| Boron (non-Boral)..... | 0 | |
| Cadmium..... | NE | |
| Caesium..... | NE | |
| Selenium..... | NE | |
| Chromium..... | NE | |
| Molybdenum..... | NE | |
| Thallium..... | NE | |
| Tin..... | NE | |
| Vanadium..... | NE | |
| Mercury compounds..... | NE | |
| Others..... | NE | |
| Electronic Electrical Equipment (EEE) | | |
| EEE Type 1..... | NE | |
| EEE Type 2..... | NE | |
| EEE Type 3..... | NE | |
| EEE Type 4..... | NE | |
| EEE Type 5..... | NE | |

Complexing agents (%wt): No

| | (%wt) | Type(s) and comment |
|-----------|-------|---------------------|
| EDTA..... | NE | |
| DPTA..... | NE | |
| NTA..... | NE | |

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Polycarboxylic acids..... NE
 Other organic complexants..... NE
 Total complexing agents..... NE

Potential for the waste to contain discrete items: Yes. Size-reduced boron plates have been judged to be Discrete Items.

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 | Off-site | 100.0 |

Comment on planned treatments:

The MEBs will be transferred off-site to a metal recycling facility. Current experience suggests that ~40% of the waste may comprise unrecyclable material, and for the purpose of the 2022 UK Inventory this assumption has been used. Unrecyclable material is assumed to be consigned to the LLWR from the MRF, but is reported here to ensure it is captured in the 2022 UK Inventory.

Disposal Routes:

| Disposal Route | Stream volume % | Disposal density t/m3 |
|--|-----------------|-----------------------|
| Expected to be consigned to the LLW Repository | ~40.0 | |
| 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 | ~60.0 | |
| Expected to be consigned as Out of Scope | | |
| Expected to be recycled / reused | | |
| Disposal route not known | | |

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 | | | |
| 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 | | | |

Opportunities for alternative disposal routing: No

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

Waste Packaging for Disposal:

| 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 | ~40.0 | ~10 | 30 |

Other information: The waste loading is the typical value for uncompacted wastes grouted at LLWR.

Waste Planned for Disposal at the LLW Repository:

Container voidage: Voidage expected to be minimised to acceptable levels as waste is size-reduced metal and treatment technique should be tailored to minimise voidage.

Waste Characterisation Form (WCH): It is not yet determined if the waste meets LLWR's Waste Acceptance Criteria (WAC).

Waste consigned for disposal to LLWR in year of generation: Yes.

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: The activity arises from a) corrosion products in the reactor cooling circuit adhering to the fuel and being dislodged in the MEB and b) contamination from pond water.

Uncertainty: The specific activity is based on the average activity measured for a large number of MEBs already exported divided by the average mass per MEB and is the best estimate.

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 assessment unchanged from 2019 UKRWI assessment. The specific activity is based on the average measured internal Co-60 activity of a large number of MEBs already measured and disposed of divided by the average MEB volume of 2.88m³ (averaged over 2F15, 2F36, 2F41). Activity values for the other isotopes present are derived from the measured Co-60 activity using the fingerprint developed in 2014 after analysis of fuel crud from several MEBs in combination with external HP&S swab data. The external contamination is very much lower than the internal and the external fingerprint is equivalent to that of pond water which contributes only a very small fraction to the overall fingerprint.

Other information: Beta/gamma activity is dominant.

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| Nuclide | Mean radioactivity, TBq/m ³ | | | | Nuclide | Mean radioactivity, TBq/m ³ | | | |
|---------|--|----------------|-----------------|----------------|------------------|--|----------------|-----------------|----------------|
| | 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 | 2.92E-07 | BC 2 | | | Gd 153 | | | | |
| Be 10 | | | | | Ho 163 | | | | |
| C 14 | 5.53E-06 | BC 2 | | | Ho 166m | | | | |
| Na 22 | | | | | Tm 170 | | | | |
| Al 26 | | | | | Tm 171 | | | | |
| Cl 36 | | | | | Lu 174 | | | | |
| Ar 39 | | | | | Lu 176 | | | | |
| Ar 42 | | | | | Hf 178n | | | | |
| K 40 | | | | | Hf 182 | | | | |
| Ca 41 | | | | | Pt 193 | | | | |
| Mn 53 | | | | | Tl 204 | | | | |
| Mn 54 | | | | | Pb 205 | | | | |
| Fe 55 | 1.33E-05 | BC 2 | | | Pb 210 | | | | |
| Co 60 | 7.89E-05 | AA 1 | | | Bi 208 | | | | |
| Ni 59 | | | | | Bi 210m | | | | |
| Ni 63 | 2.08E-04 | BC 2 | | | Po 210 | | | | |
| Zn 65 | | | | | Ra 223 | | | | |
| Se 79 | | | | | Ra 225 | | | | |
| Kr 81 | | | | | Ra 226 | | | | |
| Kr 85 | | | | | Ra 228 | | | | |
| Rb 87 | | | | | Ac 227 | | | | |
| Sr 90 | 8.87E-07 | BB 2 | | | Th 227 | | | | |
| Zr 93 | | | | | Th 228 | | | | |
| Nb 91 | | | | | Th 229 | | | | |
| Nb 92 | | | | | Th 230 | | | | |
| Nb 93m | | | | | Th 232 | | | | |
| Nb 94 | 5.63E-07 | BB 2 | | | Th 234 | | | | |
| Mo 93 | | | | | Pa 231 | | | | |
| Tc 97 | | | | | Pa 233 | | | | |
| Tc 99 | 5.12E-08 | BB 2 | | | U 232 | | | | |
| Ru 106 | | | | | U 233 | | | | |
| Pd 107 | | | | | U 234 | | | | |
| Ag 108m | | | | | U 235 | | | | |
| Ag 110m | | | | | U 236 | | | | |
| Cd 109 | | | | | U 238 | | | | |
| Cd 113m | | | | | Np 237 | | | | |
| Sn 119m | | | | | Pu 236 | | | | |
| Sn 121m | | | | | Pu 238 | 1.47E-07 | BC 2 | | |
| Sn 123 | | | | | Pu 239 | 1.02E-07 | BC 2 | | |
| Sn 126 | | | | | Pu 240 | 1.02E-07 | BC 2 | | |
| Sb 125 | 1.24E-06 | BB 2 | | | Pu 241 | 6.50E-06 | BC 2 | | |
| Sb 126 | | | | | Pu 242 | | | | |
| Te 125m | | | | | Am 241 | 4.39E-07 | BC 2 | | |
| Te 127m | | | | | Am 242m | | | | |
| I 129 | | | | | Am 243 | | | | |
| Cs 134 | 3.64E-08 | BB 2 | | | Cm 242 | | | | |
| Cs 135 | | | | | Cm 243 | | | | |
| Cs 137 | 2.01E-05 | BC 2 | | | Cm 244 | 4.07E-08 | BC 2 | | |
| Ba 133 | | | | | Cm 245 | | | | |
| La 137 | | | | | Cm 246 | | | | |
| La 138 | | | | | Cm 248 | | | | |
| Ce 144 | | | | | Cf 249 | | | | |
| Pm 145 | | | | | Cf 250 | | | | |
| Pm 147 | 1.11E-06 | BC 2 | | | Cf 251 | | | | |
| Sm 147 | | | | | Cf 252 | | | | |
| Sm 151 | 9.10E-06 | BC 2 | | | Other a | | | | |
| Eu 152 | | | | | Other b/g | | | | |
| Eu 154 | | | | | Total a | 8.32E-07 | BC 2 | 0 | |
| Eu 155 | | | | | Total b/g | 3.46E-04 | BC 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