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| WASTE STREAM | 1A10 | ILW Containing Radium |
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SITE Amersham
SITE OWNER GE Healthcare Limited
WASTE CUSTODIAN GE Healthcare Limited
WASTE TYPE ILW

Is the waste subject to Scottish Policy: No

WASTE VOLUMES

| | | Reported |
|------------------------|---------------------------|---------------------|
| Stocks: | At 1.4.2022..... | ~2.0 m ³ |
| Future arisings - | 1.4.2022 - 31.3.2030..... | 9.0 m ³ |
| Total future arisings: | | 9.0 m ³ |
| Total waste volume: | | 11.0 m ³ |

Comment on volumes: This waste stream represents legacy waste. A full detailed analysis of all packaged radium was carried out for the 2013 inventory with no changes for 2022. A radium strategy and project is anticipated to commence in 2023 which will improve the understanding of this waste stream

Uncertainty factors on volumes: Stock (upper): x 1.5 Arisings (upper) x 1.5
 Stock (lower): x 0.5 Arisings (lower) x 0.5

WASTE SOURCE Sealed and closed source production.

PHYSICAL CHARACTERISTICS

General description: The waste consists of solid and absorbed liquid wastes within steel cans or fibreboard drums as primary containment, all contained in sealed PVC bags. (Wastes arising from 1990 are dry). Solids include glassware, rubber gloves, paper tissue, and small items of redundant laboratory equipment such as hotplates, retort stands, etc. Liquids comprise aqueous solutions.

Physical components (%vol): The waste consists mainly of glass (10.5%) metals (17%) plastics (33%) cellulose (31%) others (8.5%).

Sealed sources: The waste contains sealed sources. Present as closed sources (not leak tested and defined as a sealed source). Number not yet estimated.

Bulk density (t/m³): NE

Comment on density: NE

CHEMICAL COMPOSITION

General description and components (%wt): The waste is believed to consist mainly of glass, plastics, cellulose and some metal.

Chemical state: Neutral

Chemical form of radionuclides: Ra: Radium sulphate, radium bromide, radium carbonate.

Metals and alloys (%wt): Not estimated

| | (%wt) | Type(s) / Grade(s) with proportions | % of total C14 activity |
|---------------------------|-------|-------------------------------------|-------------------------|
| Stainless steel..... | ~5.0 | 316L used for sealed sources. | |
| Other ferrous metals..... | ~7.0 | Mild steel tins. | |
| Iron..... | 0 | | |
| Aluminium..... | <1.0 | | |
| Beryllium..... | 0.10 | | |
| Cobalt..... | 0 | | |
| Copper..... | <1.0 | | |
| Lead..... | <2.0 | | |

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| Magnox/Magnesium..... | 0 | |
| Nickel..... | 0 | |
| Titanium..... | 0 | |
| Uranium..... | 0 | |
| Zinc..... | <1.0 | |
| Zircaloy/Zirconium..... | 0 | |
| Other metals..... | NE | The waste may contain platinum, rhodium, iridium and gold. |

Organics (%wt):

| | (%wt) | Type(s) and comment | % of total C14 activity |
|-------------------------------------|-------|--------------------------|-------------------------|
| Total cellulosics..... | ~31.0 | | |
| Paper, cotton..... | ~30.0 | | |
| Wood..... | ~1.0 | | |
| Halogenated plastics | ~17.0 | PVC bags / sheeting. | |
| Total non-halogenated plastics..... | ~16.0 | | |
| Condensation polymers..... | ~9.5 | | |
| Others..... | ~6.5 | | |
| Organic ion exchange materials.... | TR | | |
| Total rubber..... | ~4.0 | | |
| Halogenated rubber | ~2.0 | Hypalon/neoprene gloves. | |
| Non-halogenated rubber..... | <2.0 | Latex gloves. | |
| Hydrocarbons..... | 0 | | |
| Oil or grease | 0 | | |
| Fuel..... | 0 | | |
| Asphalt/Tarmac (cont.coal tar)... | 0 | | |
| Asphalt/Tarmac (no coal tar).... | 0 | | |
| Bitumen..... | 0 | | |
| Others..... | 0 | | |
| Other organics..... | 0 | | |

Other materials (%wt):

| | (%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..... | 0 | | |
| Glass/Ceramics..... | ~~14.8 | | |
| Graphite..... | 0 | | |
| Desiccants/Catalysts..... | 0 | | |
| Asbestos..... | <0.10 | | |
| Non/low friable..... | <0.05 | | |

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| Moderately friable..... | <0.05 |
| Highly friable..... | 0 |
| Free aqueous liquids..... | 0 |
| Free non-aqueous liquids..... | 0 |
| Powder/Ash..... | NE |

Inorganic anions (%wt): No details available at present.

| | (%wt) | Type(s) and comment |
|----------------|-------|---------------------------|
| Fluoride..... | NE | Not thought to be present |
| Chloride..... | NE | Not thought to be present |
| Iodide..... | NE | Not thought to be present |
| Cyanide..... | NE | Not thought to be present |
| Carbonate..... | NE | Not thought to be present |
| Nitrate..... | NE | Not thought to be present |
| Nitrite..... | NE | Not thought to be present |
| Phosphate..... | NE | Not thought to be present |
| Sulphate..... | NE | Not thought to be present |
| Sulphide..... | NE | Not thought to be present |

Materials of interest for waste acceptance criteria: A very small fraction of the inventory is in a mixture of hydrochloric acid and nitric acid, but this will be neutralised prior to final storage or disposal arrangements.

| | (%wt) | Type(s) and comment |
|--|-------|--|
| Combustible metals..... | | |
| Low flash point liquids..... | | |
| Explosive materials..... | | |
| Phosphorus..... | | |
| Hydrides..... | | |
| Biological etc. materials..... | | |
| Biodegradable materials..... | | |
| Putrescible wastes..... | | |
| Non-putrescible wastes..... | | |
| Corrosive materials..... | <1.0 | Aqua Regia (mixture of hydrochloric acid and nitric acid). |
| Pyrophoric materials..... | | |
| Generating toxic gases..... | | |
| Reacting with water..... | | |
| Higher activity particles..... | | |
| Soluble solids as bulk chemical compounds..... | | |

Hazardous substances / non hazardous pollutants: Not yet fully determined. Boron (non-Boral) estimated using figures of 10% of all glass is borosilicate, and the boron concentration in borosilicate glass is 8%

| | (%wt) | Type(s) and comment |
|---------------------------|-------|---------------------|
| Acrylamide..... | 0 | |
| Benzene..... | 0 | |
| Chlorinated solvents..... | 0 | |

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| Formaldehyde..... | 0 | |
| Organometallics..... | 0 | |
| Phenol..... | 0 | |
| Styrene..... | 0 | |
| Tri-butyl phosphate..... | 0 | |
| Other organophosphates..... | 0 | |
| Vinyl chloride..... | ~17.0 | 17% PVC bags. |
| Arsenic..... | 0 | |
| Barium..... | 0 | |
| Boron..... | ~-0.08 | |
| Boron (in Boral)..... | | |
| Boron (non-Boral)..... | ~-0.08 | Borosilicate Glass |
| Cadmium..... | 0 | |
| Caesium..... | 0 | |
| Selenium..... | 0 | |
| Chromium..... | 0 | |
| Molybdenum..... | 0 | |
| Thallium..... | 0 | |
| Tin..... | 0 | |
| Vanadium..... | 0 | |
| Mercury compounds..... | 0 | |
| Others..... | NE | |
| Electronic Electrical Equipment (EEE) | | |
| EEE Type 1..... | 0 | |
| EEE Type 2..... | 0 | |
| EEE Type 3..... | 0 | |
| EEE Type 4..... | 0 | |
| EEE Type 5..... | 0 | |

Complexing agents (%wt): Not yet determined

| | (%wt) | Type(s) and comment |
|--------------------------------|-------|----------------------------------|
| EDTA..... | NE | No details available at present. |
| DPTA..... | NE | No details available at present. |
| NTA..... | NE | No details available at present. |
| Polycarboxylic acids..... | NE | No details available at present. |
| Other organic complexants..... | NE | No details available at present. |
| Total complexing agents..... | NE | |

Potential for the waste to contain discrete items: Yes. Some of the laboratory equipment might constitute discrete items.

PACKAGING AND CONDITIONING

Conditioning method: GE Healthcare IWS is not to condition at this time. Radium project currently defining proof of principle for long term storage on site prior to third party transfer (as yet unidentified), subject to BAT. Principle likely to be multibarrier containment of raw waste (no conditioning).

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Plant Name: -
 Location: -
 Plant startup date: -
 Total capacity (m³/y incoming waste): -
 Target start date for packaging this stream: -
 Throughput for this stream (m³/y incoming waste): -
 Other information: -

| | | | | | |
|------------------------|---------------|-----------------------|---------------------------------|---------------------------|--------------------|
| Likely container type: | Container | Waste packaged (%vol) | Waste loading (m ³) | Payload (m ³) | Number of packages |
| | Not specified | 100.0 | NE | NE | NE |

Likely container type comment: Container likely to be 500l DEVA drum (may or may not be lead lined - dose rate depending), this has yet to be determined.
 Range in container waste volume: Not specified
 Other information on containers: Not Specified
 Likely conditioning matrix: Not specified
 Other information: -
 Conditioned density (t/m³): NE
 Conditioned density comment: NE
 Other information on conditioning: -
 Opportunities for alternative disposal routing: Yes

| Baseline Management Route | Opportunity Management Route | Stream volume (%) | Estimated Date that Opportunity will be realised | Opportunity Confidence | Comment |
|--|------------------------------|-------------------|--|------------------------|--|
| Disposal at a Geological Disposal Facility | Recycling | <1.0 | - | Medium | Closed sources being investigated for transfer for recycling, low % by vol (<1) but significant % by activity of the waste stream (~90). |

RADIOACTIVITY

Source: This waste was generated from sealed source production.
 Uncertainty: Details of waste holdings are estimated using pessimistic assumptions.
 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 data has been calculated from records of waste holdings.
 Other information: No account has been made for radium decay daughters.

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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 | | | | | Gd 153 | | | | |
| Be 10 | | | | | Ho 163 | | | | |
| C 14 | | | | | 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 | | | | | Pb 210 | | | | |
| Co 60 | | | | | Bi 208 | | | | |
| Ni 59 | | | | | Bi 210m | | | | |
| Ni 63 | | | | | Po 210 | | | | |
| Zn 65 | | | | | Ra 223 | | | | |
| Se 79 | | | | | Ra 225 | | | | |
| Kr 81 | | | | | Ra 226 | ~3.97E+00 | AA 2 | ~3.23E-02 | AA 2 |
| Kr 85 | | | | | Ra 228 | | | | |
| Rb 87 | | | | | Ac 227 | | | | |
| Sr 90 | | | | | Th 227 | | | | |
| Zr 93 | | | | | Th 228 | | | | |
| Nb 91 | | | | | Th 229 | | | | |
| Nb 92 | | | | | Th 230 | | | | |
| Nb 93m | | | | | Th 232 | | | | |
| Nb 94 | | | | | Th 234 | | | | |
| Mo 93 | | | | | Pa 231 | | | | |
| Tc 97 | | | | | Pa 233 | | | | |
| Tc 99 | | | | | 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 | | | | |
| Sn 123 | | | | | Pu 239 | | | | |
| Sn 126 | | | | | Pu 240 | | | | |
| Sb 125 | | | | | Pu 241 | | | | |
| Sb 126 | | | | | Pu 242 | | | | |
| Te 125m | | | | | Am 241 | | | | |
| Te 127m | | | | | Am 242m | | | | |
| I 129 | | | | | Am 243 | | | | |
| Cs 134 | | | | | Cm 242 | | | | |
| Cs 135 | | | | | Cm 243 | | | | |
| Cs 137 | | | | | Cm 244 | | | | |
| Ba 133 | | | | | Cm 245 | | | | |
| La 137 | | | | | Cm 246 | | | | |
| La 138 | | | | | Cm 248 | | | | |
| Ce 144 | | | | | Cf 249 | | | | |
| Pm 145 | | | | | Cf 250 | | | | |
| Pm 147 | | | | | Cf 251 | | | | |
| Sm 147 | | | | | Cf 252 | | | | |
| Sm 151 | | | | | Other a | | | | |
| Eu 152 | | | | | Other b/g | | | | |
| Eu 154 | | | | | Total a | ~3.97E+00 | AA 2 | ~3.23E-02 | AA 2 |
| Eu 155 | | | | | Total b/g | | | | |

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