## WASTE STREAM 7D24 ILW Reactor Components

**SITE** HMNB Devonport

**SITE OWNER** Ministry of Defence

**WASTE CUSTODIAN** Babcock International Group

**WASTE TYPE** ILW

**WASTE VOLUMES**

| | | Reported |
|---|---|---|
| Stocks: | At 1.4.2019..... | 3.3 m³ |
| Future arisings - | 1.4.2019 - 31.3.2030..... | <5.0 m³ |
| Total future arisings: | | 5.0 m³ |
| Total waste volume: | | 8.3 m³ |

Comment on volumes: Not constant. Dependent upon reactor components that must be removed during the course of the maintenance operations. Future Submarine Disposal Program waste arisings not yet quantified (not included). The rate of arising is dependent on the submarine refit/disposal programme.

Uncertainty factors on volumes:

| | | | |
|---|---|---|---|
| Stock (upper): | x 1.5 | Arisings (upper) | x 2.0 |
| Stock (lower): | x 0.5 | Arisings (lower) | x 0.5 |

**WASTE SOURCE** Activated reactor components.

### PHYSICAL CHARACTERISTICS

General description: The waste consists of reactor components which are neutron activated: reactor assemblies, thermal shields and other irradiated core components. Waste hierarchy will be applied

Physical components (%wt): 100% metallic components comprising irradiated core components, thermal shields and miscellaneous assemblies.

Sealed sources: -

Bulk density (t/m³): ~8

Comment on density: The waste contains mostly steel items with little interstitial space.

### CHEMICAL COMPOSITION

General description and components (%wt): Stainless steel (99.9%), copper (0.1%).

Chemical state: Neutral

Chemical form of radionuclides: H-3: Highly unlikely to be present in any appreciable quantity.
C-14: Present in activated stainless steel in small concentration.

Metals and alloys (%wt): The items are a variety of different sizes and thicknesses. The items will be volume reduced to either be disposed of as non-compactable waste or to fit inside 200 litre drums.

| | | |
|---|---|---|
| Stainless steel..... | 99.9 | 316 Stainless Steel. |
| Other ferrous metals..... | 0 | |
| Iron..... | P | In the stainless steel. |
| Aluminium..... | | |
| Beryllium..... | 0 | |
| Cobalt..... | 0 | |
| Copper..... | 0.10 | |
| Lead..... | 0 | |
| Magnox/Magnesium..... | 0 | |
| Nickel..... | P | In the stainless steel. |
| Titanium..... | | |
| Uranium..... | 0 | |
| Zinc..... | 0 | |

| WASTE STREAM | 7D24 ILW Reactor Components | |
|---|---|---|
| | Zircaloy/Zirconium | 0 |
| | Other metals | 0 |
| 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 |
| | Hydrocarbons | |
| | Oil or grease | |
| | Fuel | |
| | Asphalt/Tarmac (cont.coal tar) | |
| | Asphalt/Tarmac (no coal tar) | |
| | Bitumen | |
| | Others | |
| | Other organics | 0 |
| Other materials (%wt): | - | |
| | Inorganic ion exchange materials. | 0 |
| | Inorganic sludges and flocs | 0 |
| | Soil | 0 |
| | Brick/Stone/Rubble | 0 |
| | Cementitious material | 0 |
| | Sand | 0 |
| | Glass/Ceramics | 0 |
| | Graphite | 0 |
| | Desiccants/Catalysts | 0 |
| | Asbestos | 0 |
| | Non/low friable | |
| | Moderately friable | |
| | Highly friable | |
| | Free aqueous liquids | 0 |
| | Free non-aqueous liquids | 0 |
| | Powder/Ash | 0 |
| Inorganic anions (%wt): | There are no inorganic anions present in the waste. | |

| WASTE STREAM | 7D24 ILW Reactor Components |
|---|---|

| | |
|---|---|
| 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: There are no hazardous materials present in the waste.

| | |
|---|---|
| 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 |
| Active particles | 0 |
| Soluble solids as bulk chemical compounds | 0 |

Hazardous substances / non hazardous pollutants: There are no heavy metals present in the waste.

| | |
|---|---|
| Acrylamide | |
| Benzene | 0 |
| Chlorinated solvents | |
| Formaldehyde | |
| Organometallics | |
| Phenol | 0 |
| Styrene | |
| Tri-butyl phosphate | 0 |
| Other organophosphates | |
| Vinyl chloride | 0 |
| Arsenic | 0 |
| Barium | |
| Boron | 0 |

| | | |
|---|---|---|
| Cadmium | 0 | |
| Caesium | | |
| Selenium | 0 | |
| Chromium | P | Present in the stainless steel |
| Molybdenum | P | Present in the stainless steel |
| Thallium | | |
| Tin | 0 | |
| Vanadium | 0 | |
| Mercury compounds | | |
| Others | 0 | |

Electronic Electrical Equipment (EEE)

- EEE Type 1
- EEE Type 2
- EEE Type 3
- EEE Type 4
- EEE Type 5

Complexing agents (%wt): No

| | | |
|---|---|---|
| EDTA | | |
| DPTA | | |
| NTA | | |
| Polycarboxylic acids | | |
| Other organic complexants | | No organic or inorganic complexing agents are present. |
| Total complexing agents | 0 | |

**LAW TREATMENT, PACKAGING AND DISPOSAL**

**Waste that is currently ILW:** The main nuclide of interest is Co-60 which has a 5.27yr half-life. The Co-60 activity of the waste has been assessed from radiological survey information or by the drum monitor. This is dependent upon the item.

Planned on-site / off-site treatments(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>Recyling / reuse<br>Other / various<br>None | On-site | 100.0 |

Comment on planned treatments: -

## WASTE STREAM 7D24 ILW Reactor Components

**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 m³ | 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 | 8.3 | < 1 |

Other information: Large plant items that fulfil the LLWR Ltd criteria for disposal as non-compactable waste. Consigned as non-compactable waste.

**Waste Consigned to the LLW Repository:**

Container voidage: <10%.

Waste Characterisation Form (WCH): The waste does not meet the LLWR's Waste Acceptance Criteria (WAC).

There is no WCH for 7D24. However after a suitable period of decay storage the material will have decayed to LLW and will be disposed of under 7D23 waste stream.

Waste consigned for disposal to LLWR in year of generation: No. The waste stream is presently in the ILW category. However the main nuclide is Co-60 which has a short half-life. Assessments have estimated the decay storage periods to LLW levels (approx. a further 7 years). The waste will then be suitable for disposal as 7D23.

Potential for the waste to contain discrete items: Yes

**Non-Containerised Waste for In-Vault Grouting:**

Stream volume (%): -

Waste stream variation: There is no existing waste stream variation for this waste

## WASTE STREAM 7D24 ILW Reactor Components

Bounding cuboidal volume:

Inaccessible voidage: -

Other information: -

### RADIOACTIVITY

| | |
|---|---|
| Source: | Activation products, mainly Co-60 with other beta nuclides Fe-55, Ni-63 and also C-14. The activity arises from neutron activation of the predominant material stainless steel. |
| Uncertainty: | The total activity assessment is based on radiation survey measurement and then the use of appropriate shielding models and geometries to determine the total Co-60 activity. The activity of other nuclides will for the purpose of this assessment be based on the use of the generic LLW fingerprint. Actual calculations are based on available data from a small number of items currently stored at Devonport that have yet to be accurately characterised. This work is intended to take place within the next 36 months therefore the detail in this RWI is likely to change, possibly significantly. Final characterisation may determine that the items move out of the 7D24 ILW wastream to a LLW stream. Future arising is based on the possibility of similar un-characterised items being received on site. |
| 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: | The Co-60 activity of the waste material is assessed from survey information and then the use of shielding calculations. The other nuclides have been assessed by applying the generic radionuclide fingerprint of waste stream 7D23.Specific Activity figures have been derived from current stock data and represent a reasonably consistant waste origin, therefore future arisings, which are expected to remain consistant, can only be estimated based on the same SA estimated figure i.e. the values are specific activity not total activity (which would vary depending on expected volume). |
| Other information: | - |

## WASTE STREAM 7D24 ILW Reactor Components

| Nuclide | Mean radioactivity, TBq/m³ | | | | Nuclide | Mean radioactivity, TBq/m³ | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 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 | ~~8.65E-07 | D D 2 | ~~3E-05 | D D 2 | Gd 153 | | | | |
| Be 10 | | | | | Ho 163 | | | | |
| C 14 | ~~8.08E-04 | D D 2 | ~~8.1E-04 | D D 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 | | | ~~2.1E-04 | D D 2 | Pb 205 | | | | |
| Fe 55 | ~~3.59E-05 | D D 2 | ~~6.35E-03 | D D 2 | Pb 210 | | | | |
| Co 60 | ~~4.33E-04 | C D 2 | ~~6E-03 | D D 2 | Bi 208 | | | | |
| Ni 59 | ~~5.62E-06 | D D 2 | ~~6E-06 | D D 2 | Bi 210m | | | | |
| Ni 63 | ~~1.69E-04 | D D 2 | ~~1.92E-04 | D D 2 | Po 210 | | | | |
| Zn 65 | | | ~~5.4E-05 | D D 2 | Ra 223 | | | | |
| Se 79 | | | | | Ra 225 | | | | |
| Kr 81 | | | | | Ra 226 | | | | |
| 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 | ~~4.33E-07 | D D 2 | ~~4.8E-05 | D D 2 | Pu 241 | | | | |
| Sb 126 | | | | | Pu 242 | | | | |
| Te 125m | | | | | Am 241 | | | | |
| Te 127m | | | | | Am 242m | | | | |
| I 129 | | | | | Am 243 | | | | |
| Cs 134 | | | ~~1.2E-06 | D D 2 | Cm 242 | | | | |
| Cs 135 | | | | | Cm 243 | | | | |
| Cs 137 | ~~2.60E-06 | D D 2 | ~~4.2E-06 | D D 2 | 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 | ~~1.30E-06 | D D 2 | ~~4.2E-06 | D D 2 | Other b/g | | | | |
| Eu 154 | | | | | **Total a** | **0** | | **0** | |
| Eu 155 | | | | | **Total b/g** | **~~1.46E-03** | **D D 2** | **~~1.37E-02** | **D D 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 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