

| | | |
|---------------------|-------------|---|
| WASTE STREAM | 7D23 | Devonport RA Hard Trash (for Disposal to LLWR) |
|---------------------|-------------|---|

SITE HMNB Devonport

SITE OWNER Ministry of Defence

WASTE CUSTODIAN Babcock International Group

WASTE TYPE LLW

WASTE VOLUMES

| | | Reported |
|------------------------|---------------------------|-----------------------|
| Stocks: | At 1.4.2019..... | 7.4 m ³ |
| Future arisings - | 1.4.2019 - 31.3.2030..... | ~161.7 m ³ |
| Total future arisings: | | 161.7 m ³ |
| Total waste volume: | | 169.1 m ³ |

Comment on volumes: Arisings are dependent upon the level of submarine refit and maintenance activity that is carried out. Arisings have been calculated on average generation rate of 14.7 m³ per year.

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 The waste is produced as a consequence of the general support of Naval nuclear propulsion programme e.g. reactor plant maintenance and refuelling operations.

PHYSICAL CHARACTERISTICS

General description: Solid low level waste for disposal to the LLWR, comprising metal items of varying size from contaminated tools to large plant items. Other items include metal pipes, valves, swarf, glass and thermal lagging materials and mild steel waste drums. All items derive from the submarines or from shore based facilities. Large items do occasionally originate from the nuclear submarine reactor plant or from support services. In these instances the item will be classified as non-compactable waste and will be packed into half height ISO containers, or other container, as agreed by LLWR Ltd, for disposal as non-compactable waste. Material may have been size reduced to fit within 200l drum. Certain large items of hard waste could be consigned as being non-compactable waste should they satisfy the LLWR CFA.

Physical components (%wt): Metal (94%), soil/rubble (1%), biodegradable-non putrescibles (1%), plastic/rubber (3%), others (1%).

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m³): 0.41

Comment on density: The average density of hard trash within 200 litre drums is 410 kg/m³.

CHEMICAL COMPOSITION

General description and components (%wt): The waste consists of mainly metallic components primarily stainless steel. There are lesser amounts of mild steel, iron and also aluminium. Drums are mild steel. Other constituents of the stream are calcium silicate lagging, glass. There will be small amounts of polythene within drums along with other soft organics, e.g. paper.

Chemical state: Neutral

Chemical form of radionuclides: H-3: Potential to be present as tritiated water adhered to internal surface of pipes (0.02% of total activity).
 C-14: Present in waste in various chemical forms, predominately carbonate, (5.9% of total activity iaw extant WCH).

Metals and alloys (%wt): Large primary circuit components will be classed as non-compactable waste and will be disposed of in half height ISO containers, or other, as agreed with LLWR Ltd. Difficult to provide dimensional information. Total percentage of waste <<10% of current arisings.

| | | |
|---------------------------|-------|--|
| Stainless steel..... | P | 316L stainless steel |
| Other ferrous metals..... | ~83.8 | Mild Steel Drum |
| Iron..... | | |
| Aluminium..... | | |
| Beryllium..... | | |
| Cobalt..... | P | In the form of mild/stainless steel for example stellite |

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| | | | |
|------------------------|--|-------|--|
| | Copper..... | | |
| | Lead..... | | |
| | Magnox/Magnesium..... | | |
| | Nickel..... | | |
| | Titanium..... | | |
| | Uranium..... | | |
| | Zinc..... | ~0.11 | As a metal in solid form. |
| | Zircaloy/Zirconium..... | | |
| | Other metals..... | ~10.1 | Stellite is present in certain valve seats. Other metals include Chromium and Molybdenum |
| Organics (%wt): | There will be small quantities of organic material in the waste, namely polythene, paper and possibly cotton. The percentage composition is very small when compared to the total mass of metal present in the waste stream. | | |
| | Total cellulosics..... | ~1.0 | Paper/cotton. |
| | Paper, cotton..... | ~1.0 | Paper/cotton. |
| | Wood..... | 0 | |
| | Halogenated plastics | 0 | |
| | Total non-halogenated plastics..... | 2.0 | e.g. Polythene |
| | Condensation polymers..... | 0 | |
| | Others..... | 2.0 | Polythene |
| | Organic ion exchange materials.... | 0 | |
| | Total rubber..... | 1.0 | |
| | Halogenated rubber | 0 | |
| | Non-halogenated rubber..... | 1.0 | |
| | Hydrocarbons..... | 0 | |
| | 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..... | ~0.50 | |
| | Cementitious material..... | ~0.50 | |
| | Sand..... | | |
| | Glass/Ceramics..... | ~1.0 | Glass |
| | Graphite..... | 0 | |
| | Desiccants/Catalysts..... | | |
| | Asbestos..... | 0 | |

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| | | |
|--|---|--|
| | Non/low friable..... | |
| | Moderately friable..... | |
| | Highly friable..... | |
| | Free aqueous liquids..... | 0 |
| | Free non-aqueous liquids..... | 0 |
| | Powder/Ash..... | 0 |
| Inorganic anions (%wt): | Silicate from lagging is the only inorganic anion in the waste. However this will reduce in forthcoming years because new re-usable metallic lagging is being installed onto the submarine reactor plant. | |
| | 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: | - | |
| | Combustible metals..... | 0 |
| | Low flash point liquids..... | 0 |
| | Explosive materials..... | 0 |
| | Phosphorus..... | 0 |
| | Hydrides..... | 0 |
| | Biological etc. materials..... | 0 |
| | Biodegradable materials..... | 1.0 |
| | Putrescible wastes..... | 0 |
| | Non-putrescible wastes..... | ~1.0 |
| | Corrosive materials..... | 0 |
| | Pyrophoric materials..... | 0 |
| | Generating toxic gases..... | 0 |
| | Reacting with water..... | TR |
| | Active particles..... | P |
| | | 0.025 m3 (every 3 years) of materials which react significantly on contact with water or cement grout contact with water or cement grout |
| | Soluble solids as bulk chemical compounds..... | 0 |
| Hazardous substances / non hazardous pollutants: | There are no heavy metals in the waste. Certain identified items may contain boron-10 (<<0.1%) in nucleonic instrumentation and also titanium (<1%). Prior to consignment offsite, approval from LLWR to accept waste will be obtained by D5 route. All documentation to comply with special waste regulations is also generated. | |
| | Acrylamide..... | |
| | Benzene..... | 0 |

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| | |
|---------------------------------------|------|
| Chlorinated solvents..... | |
| Formaldehyde..... | |
| Organometallics..... | |
| Phenol..... | 0 |
| Styrene..... | |
| Tri-butyl phosphate..... | 0 |
| Other organophosphates..... | |
| Vinyl chloride..... | 0 |
| Arsenic..... | 0 |
| Barium..... | |
| Boron..... | NE |
| Cadmium..... | 0 |
| Caesium..... | |
| Selenium..... | 0 |
| Chromium..... | ~8.8 |
| Molybdenum..... | ~1.4 |
| Thallium..... | |
| Tin..... | 0 |
| Vanadium..... | 0 |
| Mercury compounds..... | |
| Others..... | NE |
| 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..... | |
| Total complexing agents..... | NE |

It is estimated 1582.97 kg of Chromium, in metal as an alloy will be generated over the 3 years.

It is estimated 243.3 kg of Molybdenum, in alloy or as a metal will be generated over the next 3 years in this waste stream.

There are no organic complexing agents in the waste.

TREATMENT, PACKAGING AND DISPOSAL

Planned on-site / off-site treatment(s):

| Treatment | On-site / Off site | Stream volume % |
|-----------------------|--------------------|-----------------|
| Low force compaction | | |
| Supercompaction (HFC) | Off-Site | ~7.5 |
| Incineration | Off-site | ~17.5 |
| Solidification | | |
| Decontamination | | |
| Metal treatment | | |
| Size reduction | | |
| Decay storage | | |
| Recycling / reuse | Off-site | ~~32.5 |
| Other / various | | |
| None | Off-site | ~42.5 |

Comment on planned treatments:

Approximate stream volumes derived from current holdings.

Disposal Routes:

| Disposal Route | Stream volume % |
|--|-----------------|
| Expected to be consigned to the LLW Repository | ~22.5 |
| Expected to be consigned to a Landfill Facility | ~27.5 |
| Expected to be consigned to an On-Site Disposal Facility | |
| Expected to be consigned to an Incineration Facility | ~17.5 |
| Expected to be consigned to a Metal Treatment Facility | |
| Expected to be consigned as Out of Scope | |
| Expected to be recycled / reused | ~~32.5 |
| Disposal route not known | |

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 | | | |
| 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 | | | |

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 | 22.5 | ~35 | 2 |
| 2m box (no shielding) | | | |
| 4m box (no shielding) | | | |
| Other | | | |

Other information:

When conditioned the total volume of waste will decrease approximately by a factor of 2.7. It is assumed each 1/2 Height IP-2 Disposal/Re-usable ISO (TC01/TC02) will approximately have a 13m³ waste loading which equates to approximately 35 m³ of raw waste.

Waste Planned for Disposal at the LLW Repository:

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Container voidage: <10%. Openings into plant items are covered with soluble polythene and vent holes are drilled into large items. When grouting occurs the grout should be able to permeate fully into the item.

Waste Characterisation Form (WCH): The waste meets the LLWR's Waste Acceptance Criteria (WAC). The waste has a current WCH. Differences exist between Inventory information and current WCH. Updated waste routings from recent sentencing experiences.

Waste consigned for disposal to LLWR in year of generation: No. Not always consigned in the year of generation. Waste is consigned for conditioning on a batch basis. It is therefore possible that waste will be retained until sufficient drums (70) for a 'full' load is available for consignment to Inutec Winfrith for supercompaction prior to consignment to LLWR.

Potential for the waste to contain discrete items: Yes

Non-Containerised Waste for In-Vault Grouting:

Stream volume (%): -

Waste stream variation: -

Bounding cuboidal volume:

Inaccessible voidage: -

Other information: -

RADIOACTIVITY

Source: Contamination of plant items through contact with the submarine primary plant. Minor neutron activation of components can also occur. Major nuclides at time of generation are Fe-55 (46%), Co-60 (44%), C-14 (5.9%), Mn-54 (1.5%), Ni-63 (1.4%) and others.

Uncertainty: The drum monitor assesses the gamma activity of the waste using a segmented gamma spectroscopy system. The system accuracy is assessed to be $\pm 20\%$ of gamma activity. Activity of other beta/gamma nuclides associated with the waste is assessed using a generic fingerprint relative to the measured Co-60 activity. Accuracy of the total activity measurement and assessment is considered to be within 50%.

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: Co-60 is measured directly by the drum monitor system using segmented gamma spectroscopy. Other gamma emitters will also be detected if present within the waste. The fingerprint has been derived by the use of best available sampling information and accepted international practice to determine correlations and relationships. All other nuclides are determined relative to Co-60 activity. Specific activity figures have been derived from current stock data and represent a reasonably consistent waste origin, therefore future arisings, which are expected to remain consistent, 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: Drummed waste is subjected to gamma spectrometry. Beta nuclides are apportioned to Co-60 activity in normalised ratios.

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| Nuclide | Mean radioactivity, TBq/m ³ | | | | Nuclide | Mean radioactivity, TBq/m ³ | | | |
|---------|--|----------------|-----------------|----------------|------------------|--|----------------|------------------|----------------|
| | 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 | -6.36E-09 | BB 2 | -6.36E-09 | CC 2 | Gd 153 | | | | |
| Be 10 | | | | | Ho 163 | | | | |
| C 14 | -2.96E-06 | BB 2 | -2.96E-06 | CC 2 | Ho 166m | | | | |
| Na 22 | -1.90E-11 | BB 2 | -1.90E-11 | CC 2 | Tm 170 | | | | |
| Al 26 | | | | | Tm 171 | | | | |
| Cl 36 | -1.10E-11 | BB 2 | -1.10E-11 | CC 2 | Lu 174 | | | | |
| Ar 39 | | | | | Lu 176 | | | | |
| Ar 42 | | | | | Hf 178n | | | | |
| K 40 | | | | | Hf 182 | | | | |
| Ca 41 | | | | | Pt 193 | | | | |
| Mn 53 | | | | | Tl 204 | | | | |
| Mn 54 | -1.56E-08 | BB 2 | -1.56E-08 | CC 2 | Pb 205 | | | | |
| Fe 55 | -2.3E-06 | BB 2 | -2.3E-06 | CC 2 | Pb 210 | | | | |
| Co 60 | -6.52E-06 | BB 2 | -6.52E-06 | CC 2 | Bi 208 | | | | |
| Ni 59 | -2.20E-08 | BB 2 | -2.20E-08 | CC 2 | Bi 210m | | | | |
| Ni 63 | -6.57E-07 | BB 2 | -6.57E-07 | CC 2 | Po 210 | | | | |
| Zn 65 | -2.91E-09 | BB 2 | -2.91E-09 | CC 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 | -2.19E-10 | BB 2 | -2.19E-10 | CC 2 | Pa 231 | | | | |
| Tc 97 | | | | | Pa 233 | | | | |
| Tc 99 | | | | | U 232 | | | | |
| Ru 106 | | | | | U 233 | | | | |
| Pd 107 | | | | | U 234 | | | | |
| Ag 108m | | | | | U 235 | | | | |
| Ag 110m | -2.63E-10 | BB 2 | -2.63E-10 | CC 2 | 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 | -2.10E-08 | BB 2 | -2.10E-08 | CC 2 | Pu 241 | | | | |
| Sb 126 | | | | | Pu 242 | | | | |
| Te 125m | | | | | Am 241 | | | | |
| Te 127m | | | | | Am 242m | | | | |
| I 129 | | | | | Am 243 | | | | |
| Cs 134 | -4.34E-10 | BB 2 | -4.34E-10 | CC 2 | Cm 242 | | | | |
| Cs 135 | | | | | Cm 243 | | | | |
| Cs 137 | -1.16E-08 | BB 2 | -1.16E-08 | CC 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 | -9.18E-09 | BB 2 | -9.18E-09 | CC 2 | Other b/g | -4.27E-10 | BB 2 | -4.27E-10 | CC 2 |
| Eu 154 | | | | | Total a | 0 | | 0 | |
| Eu 155 | | | | | Total b/g | -1.25E-05 | BB 2 | -1.25E-05 | CC 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