

WASTE STREAM	5B33	PFR Mixer Breeder Sections
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SITE Dounreay

SITE OWNER Nuclear Decommissioning Authority

WASTE CUSTODIAN Nuclear Restoration Services Ltd (NRS)

WASTE TYPE ILW

WASTE VOLUMES

	Reported (m ³)	OR	Conditioned (m ³)	Packaged (m ³)
Stocks:	At 1.4.2025			
Future arisings:	1.4.2030 - 31.3.2031			
Total future arisings:		< 0.1		
Total waste volume:		5.4		

Number of waste packages in stock: At 1.4.2025..... - packages

Comment on arising rates: Arisings data is based on best estimate.

Additional information on quantities: -

Uncertainty factors on volumes:

Stock (upper):	x 1.02	Arisings (upper):	x 1.02
Stock (lower):	x 0.98	Arisings (lower):	x 0.98

WASTE SOURCE Mixer breeder elements irradiated in PFR.

PHYSICAL CHARACTERISTICS

General description: The PFR mixer breeders are the top sections of fuel sub-assemblies that were irradiated in the PFR core. The mixer breeder sections contained mixer breeder pins that were held in place above the fuel pins by hexagonal grids and were surrounded by a stainless steel wrapper. Above the upper grid are stainless steel pipes that helped mix the circulating sodium.

Changes since waste generated: -

Bulk density (t/m³): = 2.0

Comment on density: -

CHEMICAL COMPOSITION

General description and components (%wt): Stainless steel (68%), uranium dioxide (32%)

Chemical state: Neutral

Sheet metal proportion / thickness: Pin cladding is M316, wrappers and other structures were made from various steels including En58B, Fv548, HL548, 12R72HV, P316, PE16, FV607 and FV448.

Metals and alloys (%wt):

	(%wt)	Type(s) / Grades(s) with proportions	% of total C14 activity
Stainless steel.....	= 68.0	-	
Other ferrous metals.....	= 0	-	
Iron.....	= 0	-	
Aluminium.....	= 0	-	
Beryllium.....	P	-	
Cobalt.....	= 0	-	
Copper.....	= 0	-	
Lead.....	= 0	-	
Magnox/Magnesium.....	= 0	-	
Nickel.....	= 0	-	
Titanium.....	= 0	-	
Uranium.....	= 32.0	Uranium Dioxide	
Zinc.....	= 0	-	
Zircaloy/Zirconium.....	= 0	-	
Other metals.....	= 0	-	

Organics (%wt):

	(%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	-	
Halogenated rubber.....	= 0	-	
Non-halogenated rubber.....	= 0	-	
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.....	= 0	-	
Graphite.....	= 0	-	
Desiccants/Catalysts.....	= 0	-	
Asbestos.....	= 0	-	
Non/low friable.....	= 0	-	
Moderately friable.....	= 0	-	
Highly friable.....	= 0	-	
Free aqueous liquids.....	= 0	-	
Free non-aqueous liquids.....	= 0	-	
Powder/Ash.....	= 0	-	

COMPONENTS OF MATERIALS, WASTE PROPERTIES, MATERIALS NOT CONTRIBUTING TO MASS

Inorganic anions (%wt):

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

Materials of interest for waste acceptance criteria:

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

Hazardous substances / non hazardous pollutants:

	(%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.....	NE	-
Boron (in Boral).....	NE	-
Boron (non-Boral).....	NE	-
Cadmium.....	NE	-
Caesium.....	NE	-
Selenium.....	NE	-
Chromium.....	NE	-
Molybdenum.....	NE	-
Thallium.....	NE	-
Tin.....	NE	-
Vanadium.....	NE	-
Mercury compounds.....	NE	-
Others.....	NE	-

Complexing agents (%wt):

Not yet determined		
	(%wt)	Type(s) and comment
EDTA.....	NE	-
DPTA.....	NE	-
NTA.....	NE	-
Polycarboxylic acids.....	NE	-
Other organic complexants.....	NE	-
Total complexing agents.....	NE	-

Physical components:

	Number	Type(s) and comment
Sources.....	= 0	-
Electronic & Electrical Equipment (EEE)		
EEE Type 1.....	= 0	-
EEE Type 2.....	= 0	-
EEE Type 3.....	= 0	-
EEE Type 4.....	= 0	-
EEE Type 5.....	= 0	-

TREATMENT, PACKAGING AND DISPOSAL

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

Treatment	On-site / Off-site	Stream volume %
Size reduction Decay storage Low force compaction Supercompaction (HFC) Incineration Drying/dewatering/liquid separation Tie down/fixatives/strippable coating/painting application Decontamination Metal treatment Recycling / reuse Thermal treatment, including vitrification Encapsulation Polymer encapsulation Other physical treatment Other chemical treatment Containerisation Treatment not yet determined None	On-site	= 100.0

Comments on planned treatments:

The waste will be conditioned into 500 L drums for long term storage

Conditioning method:

The waste will initially be stored in 160 litre crates within 200 litre drums. It will be conditioned using a grout matrix into 500 L drums for long term storage. This will be done through a dedicated ILW repackaging facility, which will handle both RHILW and CHILW 200 L drums. This facility will produce conditioned 500 L drums.

Conditioning plants:

Plant Name	Location
Combined ILW Repackaging Facility	Dounreay

Likely conditioning matrix:

Non-standard

Further information on the conditioning matrix:

PFA/OPC mixture 3:1, ~42% water

Waste Packaging:

Likely container type:	Container	Waste packaged (vol%)	Waste loading (m³)	Payload (m³)	Number of packages	Estimated start date for packaging
	500 l drum (basket for waste)	100.0	1.4	0.40	4	-

Range in container waste loading: Assumption is that there will be 1 x 160L waste crate inside 1 x 500L drum

Other information on packaging and conditioning: -

Conditioned density (t/m³): = 2.3
Conditioned density comment: -

Management Routes:

Disposal Route	Stream volume %	Raw density t/m³	Start date
Expected to be consigned to a Near Site, Near Surface Disposal Facility (Scotland)	= 100.0		
Expected to be Non-NSD HAW managed under Scottish Government's policy			
Expected to be disposed to LLW Vaults NRS Dounreay			
Expected to be consigned to the Geological Disposal Facility			
Expected to be consigned to a Near Surface Disposal Facility			
Expected to be consigned to the LLW Repository			
Expected to be consigned to a Landfill Facility			
Expected to be disposed On-Site			
Expected to be managed by In-Situ Disposal			
Expected to be consigned to an Incineration Facility			
Expected to be consigned to a Metal Treatment Facility			
Expected to be Out of Scope			
Expected to be recycled / reused			
Disposal route not known			

Classification codes for waste expected to be consigned to a landfill facility:

Opportunities for alternative disposal routing: Yes

Baseline Management Route	Opportunity Management Route	Stream volume (%)	Opportunity Confidence	Comment
Non-NSDF HAW	Dounreay LLWDV	NE	RED	There is potential for LLW to be diverted out of this stream during repackaging of ILW into 500L drums. However, details of this will be confirmed through the design process of the repackaging facility

RADIOACTIVITY

Source: Irradiation of mixer breeder sections in PFR

Uncertainty: -

Measurement of radioactivities: The plutonium inventory of the mixer breeders was calculated using the COSMOS program POWHIST. The POWHIST code was run at the end of each PFR run and additionally a sister program, POSTART was also run at the beginning of each reactor run. Aligns to Dounreay nuclear accountancy data.

Chemical form of radionuclides:

- H-3: -
- C-14: -
- Cl-36: -
- Se-79: -
- Tc-99: -
- I-129: -
- Ra: -
- Th: -
- U: Present as nat/dep UO₂.
- Np: -
- Pu: -

WASTE STREAM			5B33		PFR Mixer Breeder Sections				
Nuclide	Mean radioactivity, TBq/m³				Nuclide	Mean radioactivity, TBq/m³			
	Waste at 1.4.2025	Bands and Code	Future Arisings	Bands and Code		Waste at 1.4.2025	Bands and Code	Future Arisings	Bands and Code
H 3	= 1.13E-03	A A 2	= 1.13E-03	A A 2	Gd 153	= 4.27E-15	A A 2	= 4.27E-15	A A 2
Be 10	= 1.40E-09	A A 2	= 1.40E-09	A A 2	Ho 163	= 9.08E-09	A A 2	= 9.08E-09	A A 2
C 14	= 7.05E-05	A A 2	= 7.05E-05	A A 2	Ho 166m	= 1.24E-06	A A 2	= 1.24E-06	A A 2
Na 22					Tm 170	= 5.84E-20	A A 2	= 5.84E-20	A A 2
Al 26					Tm 171	= 8.82E-08	A A 2	= 8.82E-08	A A 2
Cl 36	= 6.06E-09	A A 2	= 6.06E-09	A A 2	Lu 174	= 4.62E-10	A A 2	= 4.62E-10	A A 2
Ar 39	= 5.45E-05	A A 2	= 5.45E-05	A A 2	Lu 176	= 6.32E-13	A A 2	= 6.32E-13	A A 2
Ar 42	= 6.27E-12	A A 2	= 6.27E-12	A A 2	Hf 178n	= 1.47E-08	A A 2	= 1.47E-08	A A 2
K 40	= 7.90E-11	A A 2	= 7.90E-11	A A 2	Hf 182	= 6.32E-13	A A 2	= 6.32E-13	A A 2
Ca 41	= 1.00E-06	A A 2	= 1.00E-06	A A 2	Pt 193	= 8.11E-06	A A 2	= 8.11E-06	A A 2
Mn 53	= 2.37E-12	A A 2	= 2.37E-12	A A 2	Tl 204				
Mn 54	= 2.84E-09	A A 2	= 2.84E-09	A A 2	Pb 205	= 2.45E-10	A A 2	= 2.45E-10	A A 2
Fe 55	= 5.18E-03	A A 2	= 5.18E-03	A A 2	Pb 210	= 6.12E-14	A A 2	= 6.12E-14	A A 2
Co 60	= 3.59E-01	A A 2	= 3.59E-01	A A 2	Bi 208	= 1.58E-11	A A 2	= 1.58E-11	A A 2
Ni 59	= 7.90E-04	A A 2	= 7.90E-04	A A 2	Bi 210m	= 1.19E-10	A A 2	= 1.19E-10	A A 2
Ni 63	= 6.06E-02	A A 2	= 6.06E-02	A A 2	Po 210	= 6.19E-14	A A 2	= 6.19E-14	A A 2
Zn 65	= 1.35E-11	A A 2	= 1.35E-11	A A 2	Ra 223	= 5.10E-10	A A 2	= 5.10E-10	A A 2
Se 79	= 6.14E-08	A A 2	= 6.14E-08	A A 2	Ra 225	= 6.91E-10	A A 2	= 6.91E-10	A A 2
Kr 81	= 3.81E-08	A A 2	= 3.81E-08	A A 2	Ra 226	= 2.18E-14	A A 2	= 2.18E-14	A A 2
Kr 85	= 3.76E-03	A A 2	= 3.76E-03	A A 2	Ra 228	= 1.86E-10	A A 2	= 1.86E-10	A A 2
Rb 87	= 2.74E-09	A A 2	= 2.74E-09	A A 2	Ac 227	= 5.12E-10	A A 2	= 5.12E-10	A A 2
Sr 90	= 6.84E-02	A A 2	= 6.84E-02	A A 2	Th 227	= 5.04E-10	A A 2	= 5.04E-10	A A 2
Zr 93	= 3.82E-06	A A 2	= 3.82E-06	A A 2	Th 228	= 7.57E-09	A A 2	= 7.57E-09	A A 2
Nb 91	= 1.60E-07	A A 2	= 1.60E-07	A A 2	Th 229	= 6.92E-10	A A 2	= 6.92E-10	A A 2
Nb 92	= 3.16E-11	A A 2	= 3.16E-11	A A 2	Th 230	= 7.68E-12	A A 2	= 7.68E-12	A A 2
Nb 93m	= 2.76E-03	A A 2	= 2.76E-03	A A 2	Th 232	= 1.90E-10	A A 2	= 1.90E-10	A A 2
Nb 94	= 1.56E-04	A A 2	= 1.56E-04	A A 2	Th 234	= 5.11E-05	A A 2	= 5.11E-05	A A 2
Mo 93	= 1.58E-03	A A 2	= 1.58E-03	A A 2	Pa 231	= 1.14E-09	A A 2	= 1.14E-09	A A 2
Tc 97	= 7.90E-12	A A 2	= 7.90E-12	A A 2	Pa 233	= 4.39E-07	A A 2	= 4.39E-07	A A 2
Tc 99	= 9.44E-05	A A 2	= 9.44E-05	A A 2	U 232	= 7.23E-09	A A 2	= 7.23E-09	A A 2
Ru 106	= 5.15E-07	A A 2	= 5.15E-07	A A 2	U 233	= 2.46E-07	A A 2	= 2.46E-07	A A 2
Pd 107	= 2.80E-07	A A 2	= 2.80E-07	A A 2	U 234	= 4.18E-08	A A 2	= 4.18E-08	A A 2
Ag 108m	= 1.32E-05	A A 2	= 1.32E-05	A A 2	U 235	= 1.14E-06	A A 2	= 1.14E-06	A A 2
Ag 110m	= 1.35E-12	A A 2	= 1.35E-12	A A 2	U 236	= 6.74E-07	A A 2	= 6.74E-07	A A 2
Cd 109	= 7.53E-09	A A 2	= 7.53E-09	A A 2	U 238	= 5.11E-05	A A 2	= 5.11E-05	A A 2
Cd 113m	= 5.52E-05	A A 2	= 5.52E-05	A A 2	Np 237	= 4.39E-07	A A 2	= 4.39E-07	A A 2
Sn 119m	= 2.79E-11	A A 2	= 2.79E-11	A A 2	Pu 236	= 1.07E-10	A A 2	= 1.07E-10	A A 2
Sn 121m	= 4.84E-05	A A 2	= 4.84E-05	A A 2	Pu 238	= 2.77E-04	A A 2	= 2.77E-04	A A 2
Sn 123	= 1.63E-12	A A 2	= 1.63E-12	A A 2	Pu 239	= 6.32E-02	A A 2	= 6.32E-02	A A 2
Sn 126	= 7.23E-07	A A 2	= 7.23E-07	A A 2	Pu 240	= 3.16E-03	A A 2	= 3.16E-03	A A 2
Sb 125	= 6.80E-05	A A 2	= 6.80E-05	A A 2	Pu 241	= 5.91E-03	A A 2	= 5.91E-03	A A 2
Sb 126	= 7.23E-07	A A 2	= 7.23E-07	A A 2	Pu 242	= 9.60E-09	A A 2	= 9.60E-09	A A 2
Te 125m	= 1.61E-05	A A 2	= 1.61E-05	A A 2	Am 241	= 5.97E-04	A A 2	= 5.97E-04	A A 2
Te 127m	= 1.45E-12	A A 2	= 1.45E-12	A A 2	Am 242m				
I 129	= 6.83E-08	A A 2	= 6.83E-08	A A 2	Am 243	= 3.82E-09	A A 2	= 3.82E-09	A A 2
Cs 134	= 3.16E-04	A A 2	= 3.16E-04	A A 2	Cm 242	= 6.52E-11	A A 2	= 6.52E-11	A A 2
Cs 135	= 3.20E-06	A A 2	= 3.20E-06	A A 2	Cm 243	= 3.51E-08	A A 2	= 3.51E-08	A A 2
Cs 137	= 1.38E-01	A A 2	= 1.38E-01	A A 2	Cm 244	= 1.44E-08	A A 2	= 1.44E-08	A A 2
Ba 133	= 1.52E-04	A A 2	= 1.52E-04	A A 2	Cm 245	= 4.74E-13	A A 2	= 4.74E-13	A A 2
La 137	= 2.65E-07	A A 2	= 2.65E-07	A A 2	Cm 246				
La 138	= 1.58E-12	A A 2	= 1.58E-12	A A 2	Cm 248				
Ce 144	= 4.57E-07	A A 2	= 4.57E-07	A A 2	Cf 249				
Pm 145	= 1.40E-07	A A 2	= 1.40E-07	A A 2	Cf 250				
Pm 147	= 9.71E-04	A A 2	= 9.71E-04	A A 2	Cf 251				
Sm 147	= 2.38E-11	A A 2	= 2.38E-11	A A 2	Cf 252				
Sm 151	= 6.03E-03	A A 2	= 6.03E-03	A A 2	Unsp a				
Eu 152	= 8.80E-05	A A 2	= 8.80E-05	A A 2	Unsp b/g				
Eu 154	= 3.09E-04	A A 2	= 3.09E-04	A A 2	Total a	6.73E-02	*	6.73E-02	*
Eu 155	= 6.59E-04	A A 2	= 6.59E-04	A A 2	Total b/g	6.56E-01	*	6.56E-01	*

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 the 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
* Total calculated from the 114 declared radionuclides