Nuclear Decommissioning Authority

Department of Energy & Climate Change

2013 UK Radioactive Waste Inventory:

Radioactive Waste Composition

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The 2013 UK Radioactive Waste Inventory

Radioactive Waste Composition

Report prepared for the Department of
Energy & Climate Change (DECC) and the
Nuclear Decommissioning Authority (NDA)
by Pöyry Energy Limited and Amec plc.

PREFACE

The 2013 United Kingdom Radioactive Waste & Materials Inventory (hereafter referred to as the 2013 Inventory) will provide comprehensive and up-to-date information on radioactive waste and materials as at 1 April 2013. It is part of an ongoing programme of research jointly conducted by the Department of Energy and Climate Change (DECC) and the Nuclear Decommissioning Authority (NDA).

DECC and NDA have commissioned the 2013 Inventory to provide information on the status of radioactive waste stocks (at 1 April 2013) and forecasts of future arisings in the United Kingdom. Additional information on radioactive materials which may become wastes is collated. Its aim is to provide data in an open and transparent manner for those interested in radioactive waste and material issues.

Information collected for the 2013 Inventory is presented in a series of reports, as listed below:

- High Level Summary
- Summary of Data for International Reporting
- Scope and Conventions
- Scenario for Future Radioactive Waste & Material Arisings
- Waste Quantities from All Sources
- Radioactive Waste Composition
- Radioactivity Content of Wastes
- Radioactive Wastes & Materials Not Reported in the 2013 UK Radioactive Waste Inventory.

All documents have been prepared on the basis of information supplied to the 2013 Inventory contractors, Pöyry Energy and Amec. This information was verified in accordance with arrangements established by Pöyry Energy and Amec.

This radioactive waste composition reporting output provides summary information on the material content of radioactive wastes in the 2013 Inventory.

Conditions of Publication

Feedback

You are invited to provide feedback to the NDA on the content, clarity and presentation of this report and the UK Radioactive Waste Inventory (i.e. the Inventory). Please do not hesitate to contact the NDA if you have any queries on the Inventory and radioactive waste issues. Such feedback and queries should be addressed to:

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Contents

1 INTRODUCTION

This reporting output presents summary information on the composition of radioactive wastes in the 2013 Inventory. The values for material content are derived from data on the materials composition of each individual waste stream. For each waste stream, the total mass of each constituent material is calculated from its reported mass fraction in the stream, the stream volume and the stream bulk density. The resulting masses for individual waste streams are then summed for all relevant streams. Where a complete quantified breakdown of a waste stream is unavailable, the mass fraction of the stream for which there is no numerical data is designated "unspecified"[1].

For waste that has been conditioned, the material content includes the encapsulating matrix, but excludes the container and any capping material. Similarly for the small quantity of waste that has been packaged but has not been encapsulated, the material content is that of the waste, and excludes the container.

Summed waste stream masses are rounded to two significant figures. This can result in rounding errors affecting the last significant figure within tables of data if totals are compared with the sums of individual values. This is purely an arithmetical effect and has no practical significance.

[1] For a very small proportion of waste streams the material constituents are reported as volume rather than mass fractions. In calculating material masses it has been assumed that the volume fractions are equivalent to mass fractions. Also, where a waste stream density is not quantified a default value of 1t/m^3 is used in deriving material component masses.

2 WASTE CONDITIONING

The composition of waste changes when it is conditioned. It is therefore necessary to distinguish between those wastes that are being conditioned (i.e. waste streams with a /C in the identifier) and all other wastes.

Conditioning of liquid High Level Waste (HLW) at Sellafield commenced in 1990 with the start-up of the Waste Vitrification Plant (WVP). The liquid waste undergoes an evaporation process before vitrification into borosilicate glass blocks within stainless steel canisters. The vitrified glass blocks are made up of about 25% calcined waste oxide and 75% glass by mass, and are roughly one-third of the volume of the original liquid waste.

Increasing quantities of Intermediate Level Waste (ILW) at Sellafield and at other sites are being conditioned for safe longer-term storage by immobilising the wastes in cement-based or polymer matrices within steel or concrete containers. On 1 April 2013 there were accumulations of conditioned ILW at:

- Sellafield – Magnox fuel cladding, Enhanced Actinide Removal Plant (EARP) floc, Advanced Gas-cooled Reactor (AGR) and Light Water Reactor (LWR) fuel cladding, Plutonium Contaminated Material (PCM), centrifuge cake, barium carbonate slurry and Multi-Element Bottle (MEB) crud, pond sludge, fuel stringer debris and decommissioning wastes from Windscale Advanced Gas-cooled Reactor (WAGR), miscellaneous beta/gamma waste and maintenance scrap, all in cement-based matrices;
- Dounreay – Materials Testing Reactor (MTR) liquors in a cement-based matrix;
- Harwell – sludges and liquors in cement-based matrices;
- Winfrith – sludges in a cement-based matrix;
- Trawsfynydd – ion exchange material in an organic polymer, and Magnox fuel element debris, miscellaneous activated components and pond debris in cement-based matrices.

The composition of conditioned ILW is governed by the nature of the waste, but typically varies between about 50% and 80% encapsulating material by mass.

Conditioned ILW packages are stored in engineered facilities.

Waste producers are also adopting alternatives to the cementation of ILW in thin-walled steel containers of the type currently adopted for most UK ILW. Thick-walled Ductile Cast Iron Containers (DCICs) can provide storage and disposal functions that do not involve immobilising the waste in cement or polymer. On 1 April 2013 there were small accumulations of desiccant and miscellaneous contaminated items in DCICs at Bradwell.

At the Low Level Waste Repository (LLWR) all containers of solid Low Level Waste (LLW) are first grouted using low viscosity cement before being placed in vaults. In addition to the conditioned waste at the LLWR, at 1 April 2013 there were small volumes of LLW that had been immobilised in cement-based matrices at:

- Hinkley Point A – filters;
- Sellafield – decommissioning waste from WAGR;
- Devonport – sludge, ion exchange material and filters;

The proportion of cement that makes up these conditioned products typically varies between about 40% and 80% by mass depending on the particular waste.

3 WASTE COMPOSITION

Table 1 gives the total mass of materials in HLW, ILW, LLW and Very Low Level Waste (VLLW). This includes wastes at 1 April 2013 that had been conditioned as well as future arisings that are reported as conditioned waste.

Table 1: Material components of wastes from all sources

Material	Mass (tonnes) [1]			
	HLW [2]	ILW	LLW	VLLW
METALS:				
Stainless steel	0.7	32,000	110,000	71
Other steel	1.2	54,000	350,000	620
Magnox	0	7,200	98	0.1
Aluminium	0	2,800	16,000	5.4
Zircaloy	0	1,400	22	0.1
Other & unspecified [3]	21	4,700	110,000	140,000
ORGANICS:				
Cellulosics	0	2,800	40,000	44,000
Plastics	0	7,700	46,000	1,400
Rubbers	0	2,000	17,000	530
Other & unspecified [3]	0	1,200	22,000	18,000
INORGANICS:				
Asbestos	0	300	22,000	28,000
Concrete, cement, and sand	0	59,000	780,000	2,100,000
Graphite	0	82,000	14,000	0.5
Glass & Ceramics	2,800 [5]	720	12,000	3,100
Sludges, flocs & liquids	0	33,000	10,000	0.5
Other & unspecified [3]	0	2,500	33	0
SOIL & RUBBLE [4]	0	2,600	140,000	530,000
UNSPECIFIED MATERIALS	0	15,000	57,000	34,000
TOTAL	2,900	310,000	1,700,000	2,900,000

(1) HLW material components masses are those of conditioned waste. ILW and LLW material component masses are those for untreated or partly treated waste, apart from conditioned waste streams where the components masses are those of conditioned waste.

(2) HLW metals are scrap plant items and not waste containers.

(3) Includes materials that are identified as metals, organics and inorganics but are not specified. Unspecified metals, organics and inorganics are likely to comprise the materials listed in the table, but have not been apportioned to specific materials by waste producers.

(4) There is potentially contaminated ground that has yet to be sufficiently well characterised, and consequently where there is considerable uncertainty in the waste quantities that might arise. Waste producers have chosen not to include these in the inventory of radioactive wastes until there is more certainty on the waste quantities that might be produced. This potentially contaminated ground is included in the reporting output '*Radioactive Materials*'.

(5) Mass of vitrified product. Includes about 640 tonnes of waste oxides.

The materials are categorised in the table as metals, organics, inorganics, soil, and unspecified. Where waste is reported to be metal, but the type of metal is not given, its mass is included with “other metals”. The same approach is adopted for organics and inorganics where the type of material is not given. Where the composition of waste is not reported, its mass is designated as “unspecified materials”.

3.1 High Level Waste

HLW is initially produced as a concentrated nitric acid solution containing fission products from the primary stage of reprocessing spent nuclear fuel. The Inventory includes liquids that are awaiting conditioning, the glass product of conditioning, and small quantities of contaminated scrap items from the WVP, which consist mostly of metal and ceramic and which are treated as HLW because they are contaminated with small quantities of vitrified HLW glass. Insoluble Fission Products (IFPs) are also recovered during Post Operational Clean Out (POCO).

The mass of conditioned HLW at 1 April 2013 was 2,200 tonnes. A further 1,200 tonnes of liquid waste remained to be conditioned. Once all waste at 1 April 2013 and projected future arisings of liquid waste and contaminated scrap items are conditioned the total mass will be about 2,900 tonnes. This does not include HLW that will be exported.

3.2 Intermediate Level Waste

The major components are steels, graphite, concrete, cement and sand, sludges, ion exchange resins and flocs. There is a wide range of steel items, including plant items and equipment, fuel cladding and reactor components. Most graphite is in the form of moderator blocks from final stage reactor dismantling at Magnox and AGR power stations.

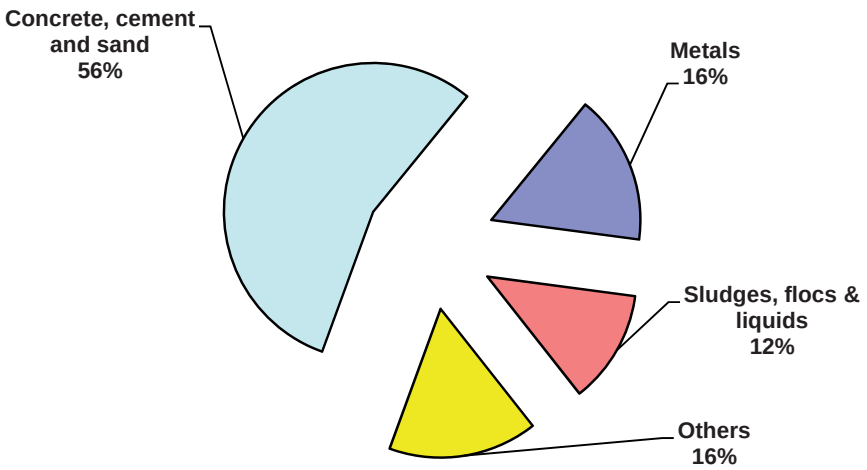
The majority of waste reported as “concrete, cement and sand” is cement associated with conditioned waste. The remainder is mostly higher activity concrete from building decommissioning. Most sludge and floc waste is from the treatment of liquid effluents and from the corrosion of stored Magnox fuel cladding waste.

Figure 1 illustrates the materials content of ILW. The material content of ILW streams reported in the inventory as conditioned (i.e. with a /C in the identifier) and those that are unconditioned are shown separately.

The principal material components of unconditioned ILW are metals (mainly steels) and graphite, with smaller proportions of sludges and flocs and of concrete, cement and sand.

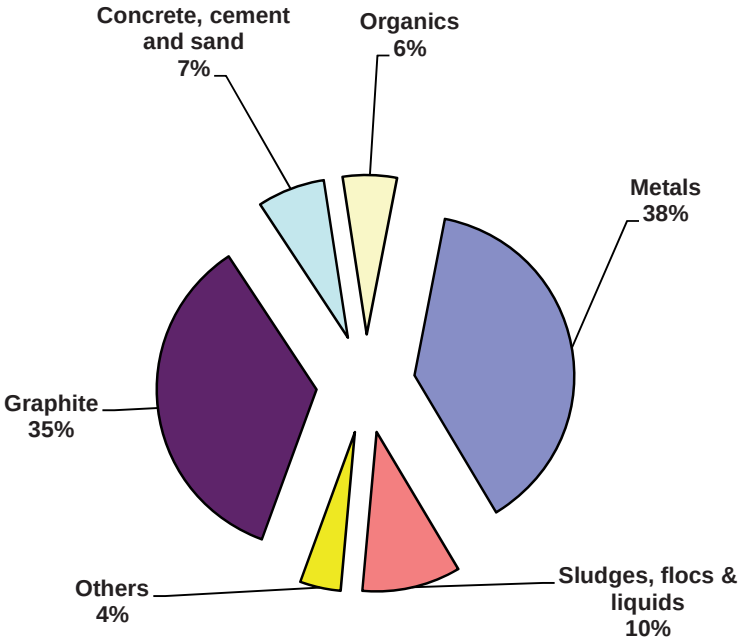
The material composition of conditioned ILW reflects the nature of the encapsulating medium and of the wastes that are being conditioned. Sellafield waste streams that are encapsulated in cement-based matrices account for about 83% of the conditioned waste mass. These streams mainly include fuel cladding (Magnox, AGR and LWR), PCM and EARP floc.

Figure 1: Material composition of ILW from all sources



(total mass 78,000 tonnes)

Composition of conditioned waste



(total mass 230,000 tonnes)

Composition of unconditioned waste

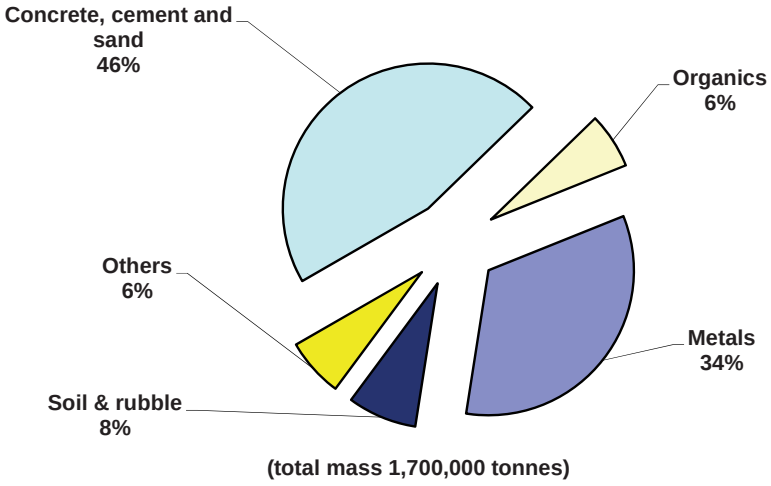
3.3 Low Level Waste

The major components of LLW are building rubble, soil and steel items such as framework, pipework and reinforcement from the dismantling and demolition of nuclear reactors and other nuclear facilities and the clean up of nuclear sites.

Figure 2 illustrates the materials content of unconditioned LLW reported in the Inventory.

The materials content of conditioned LLW streams is not shown because it is only a very minor component of LLW at about 50,000 tonnes (~3% by mass). Most of this conditioned waste is currently held in Vaults 8 and 9 at the LLWR.

Figure 2: Material composition of LLW from all sources



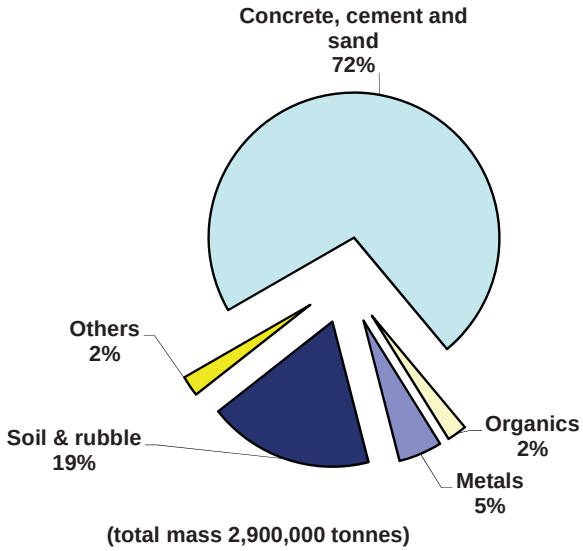
Composition of unconditioned waste

3.4 Very Low Level Waste

The major components of VLLW are building structural materials (principally concrete, with brick, metal and other materials) from the dismantling and demolition of nuclear facilities. There are also smaller quantities of excavated soil from construction and demolition activities.

Figure 3 illustrates the materials content of unconditioned VLLW. There is no conditioned VLLW.

Figure 3: Material composition of VLLW from all sources



4 UNCERTAINTY IN MATERIAL QUANTITIES

For most existing wastes there is a high level of confidence in the volume, mass and composition, based on measurement. The greatest uncertainty rests with future arisings of waste, particularly from facilities decommissioning and site clean-up.

The 2013 Inventory includes information on the confidence levels in waste stream stock and future arising volumes. These data have been used to project lower and upper waste volume estimates (see reporting output *'Waste Quantities from All Sources'*). While the 2013 Inventory does not include specific information on the uncertainties in material masses, these uncertainties are expected to be similar to those reported for waste volumes.

5 COMPARISON WITH THE 2010 INVENTORY

The principal reasons for changes in total waste masses compared with those reported in the 2010 Inventory are the same as those for changes in waste volumes (see reporting output *'Waste Quantities from All Sources'* for an explanation of the differences in the volumes of HLW, ILW, LLW and VLLW).

The material mass of HLW is similar, as is the material composition, which reflects the make-up of the vitrified product.

The material mass of ILW has increased by about 5,000 tonnes (about 1.6%). There have been a number of minor changes in material masses, including an increase in the reported quantities of cellulosics and plastics. However the overall compositions of conditioned and unconditioned wastes are little changed.

In the 2010 Inventory the mass of waste for the VLLW sub-category was included within LLW. The total material mass of LLW and VLLW has decreased by about 125,000 tonnes (about 2.7%). The principal changes are decreases in masses of metals, organics and soil and rubble, and an increase in the mass of concrete.

6 GLOSSARY

The glossary contains a list of specialised terms and abbreviations used in this reporting output.

AGR	Advanced Gas-cooled Reactor.
DCIC	Ductile Cast Iron Container.
DECC	Department of Energy and Climate Change. The UK Government department responsible for all aspects of UK energy policy and for tackling global climate change on behalf of the UK.
EARP	Enhanced Actinide Removal Plant (at Sellafield).
HLW	High Level Waste
IFP	Insoluble Fission Products
ILW	Intermediate Level Waste.
LLW	Low Level Waste.
LLWR	The Low Level Waste Repository south of Sellafield in Cumbria has operated as a national disposal facility for LLW since 1959.
LWR	Light Water Reactor.
MEB	Multi-Element Bottle. Container used to hold irradiated LWR fuel in cooling ponds prior to reprocessing.
MTR	Materials Testing Reactor.
NDA	Nuclear Decommissioning Authority. A non-departmental public body set up by the Government in April 2005 with responsibility for the UK's public sector civil nuclear liabilities, and their subsequent management. In October 2006, the Government also gave the NDA the responsibility for developing and ensuring delivery and implementation of the programmes for interim storage and geological disposal of the UK's higher activity wastes. From March 2007, the NDA was also given responsibility for developing a UK wide strategy for managing the UK nuclear industry's LLW and for securing disposal capacity for LLW generated by non-nuclear industry users.
PCM	Plutonium Contaminated Material.
POCO	Post Operational Clean Out. Activity after final shutdown that prepares a plant for decommissioning.
VLLW	Very Low Level Waste.
WAGR	Windscale Advanced Gas-cooled Reactor (shut down in 1981).
WVP	Waste Vitrification Plant (at Sellafield).

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Electronic copies of this and other 2013 Inventory documents can be obtained from the NDA (see contact details below) or via the UK Radioactive Waste Inventory website
www.nda.gov.uk/ukinventory

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Front cover images: left - waste packages at Dounreay, top - LLW vaults, bottom left - deplanting and demolition at Sizewell A, bottom right - demolition, making room for new facilities