National Waste Programme

UK Management of Radioactive Waste:
A Good Practice Guide for the Application of the Waste Hierarchy

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**Document history**

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1. Introduction

1.1. What is the purpose of this document?
This guidance aims to promote the understanding and application of the Waste Hierarchy (WH). The application of the WH is central to the implementation of the UK Strategy for the Management of Solid Low Level Radioactive Waste [Ref. 1], is best practice, will assist LLW generators in determining the best waste management option, save money and reduce resource usage. This document provides an overview of the WH and how it fits with waste management, providing ideas and examples of how the WH can be applied in the nuclear industry.

1.2. What does this guidance cover?
This guidance:
- Describes and emphasises the importance of the WH in waste management programmes at all nuclear licensed sites.
- Describes how the WH fits with other waste management principles.
- Describes how the WH can be effectively implemented.
- Provides direction to appropriate supporting guidance.

This guidance focuses on waste classified as VLLW (Very Low Level Waste) or LLW as defined in Figure 1. It is recognised that the WH is also applicable to other levels of waste classifications.

1.3. Who is this guidance for?
The guidance has been written for all sites that generate or have the potential to generate VLLW or LLW. In particular the guidance is aimed at waste managers, facilities managers, and waste practitioners. The guidance has also been produced for those organisations that support the nuclear industry in, for example, a design or decommissioning capacity, outlining the how they can use the WH.

![Figure 1 - UK LLW Classification Definitions](image-url)
2. What is the Waste Hierarchy?

The WH (illustrated by Figure 2) is a waste management principle which defines a ranked list of waste management options according to their environmental impact. The basis of the WH principle is that waste producers should have a preference for waste management options that have the lowest possible environmental impact (i.e. those that are at the top of the hierarchy).

By moving up the hierarchy waste producers will save money, minimise raw material consumption, and reduce overall environmental impact.

The WH is embodied in the 2007 UK LLW Policy [Ref. 3], UK legal requirements, European Directives and the UK Solid LLW Strategy.

In practical terms, the WH must be applied with due consideration of other factors such as worker / public dose, cost and technical viability over the full lifecycle of the waste. Those applying the hierarchy must do so with the cognisance of other waste management principles such as As Low As Reasonably Achievable (ALARA) and Best Available Technique / Best Practicable Means (BAT / BPM) (as described in section 4).

The Waste Hierarchy principle should be considered and applied across the waste lifecycle. There are some steps of the waste lifecycle which are enabling steps – these provide
information or prepare waste to enable different elements of the WH to be applied. The other steps of the waste lifecycle are delivery steps – these are where the WH can be applied to wastes. This is summarised in Figure 3.

3. What are the benefits of applying the Waste Hierarchy?

- Meets regulatory expectations
- Meets national LLW Policy and Strategy expectations
- Enables early solutions to be identified and delivered
- Saves money
- Minimises raw material consumption
- Reduces environmental impacts
- Saves waste disposal capacity for those wastes that require it

Figure 3 - Waste Hierarchy and the waste lifecycle
4. **The Waste Hierarchy and other waste management principles**

The Waste Hierarchy is only one of a number of waste management principles that should be considered when making waste management decisions.

The main waste management principles are:

- The Waste Hierarchy
- Best Available Technique / Best Practicable Means (BAT / BPM)
- As Low As Reasonably Achievable (ALARA)
- The presumption to early solutions
- The proximity principle

4.1. **Waste management principles**

Definitions of the other waste management principles beyond the Waste Hierarchy which should be considered in decision making are summarised in Figure 4.

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**Figure 4 - Waste Management Principles besides the Waste Hierarchy**

- **BAT / BPM**
  
  Waste producers should ensure that the best option is achieved for the management of waste. BAT / BPM involves the consideration of a wide range of factors—such as cost, safety, environmental detriment, technical feasibility and proportionality—to identify and implement optimum waste management decisions.

- **ALARA**
  
  This is a radiation safety principle which involves the minimisation of ionising radiation dose and release of radioactive materials through the use of all reasonable methods. Application of ALARA is a regulatory expectation.

- **Presumption to early solutions**

  There should be a preference towards solutions that can be implemented earlier rather than later. This applies to both waste management decision making and to decisions for decommissioning or clean-up of sites.

- **Proximity Principle**

  There should be a preference that waste should be managed or disposed of in the nearest geographical facility, to minimise the transport of waste.

  For LLW management, there may be only a small number of waste management facilities and so application of the proximity principle may be difficult, and so may not be considered as a significant waste management principle. The proximity principle and the desire to reduce unnecessary transports should, however, be considered along with other relevant factors and principles when making waste management decisions.
4.2. How do these waste management principles interact with the Waste Hierarchy?

All of the waste management principles described in Figure 4 should be considered when making waste management decisions. The relative importance of the different principles will probably change depending on the wastes and organisations.

The Waste Hierarchy interacts with the other waste management principles:

- BAT / BPM embodies the principles underpinning the WH and so formal consideration of the hierarchy should be included when a BAT is carried out, although the BAT case may deviate from the strict application of the hierarchy, because of other considerations and factors.

- Application of the Waste Hierarchy supports achieving ALARA as:
  - Avoiding the generation of radioactive waste will avoid the public being exposed to ionising radiation
  - Reducing the amount and activity of radioactive waste generated, and containerising wastes, will reduce the amount of ionising radiation the public is exposed to
  - Where waste cannot be avoided or reduced, careful choice of the waste management route can be used to limit release of radioactivity to the environment and thus to people

ALARA also involves consideration and minimisation of radiation dose exposure to workers; and there can be a tension between this and minimising impact on the public. There should be consideration of radiation dose exposure to workers and to the public in waste management decision making.

- The presumption to early solutions drives a preference for the use of solutions that can be implemented earlier rather than later; but this should not drive a preference for disposal, if that is the only early solution available.

- The proximity principle drives the use of local waste management facilities, where appropriate and available. The proximity principle and the desire to reduce unnecessary transports should be considered in waste management decision making but must be balanced by other relevant factors on a case by case basis.

There can be tension and conflict between the different waste management principles and care is required during decision making to ensure that all the relevant factors are considered.
5. Waste Hierarchy Enabling Steps

A number of steps in the waste lifecycle – planning and characterisation, pre-treatment and transport – are enabling steps for the application of the Waste Hierarchy. Decisions made during these parts of the waste lifecycle can help or hinder application of the Waste Hierarchy later on in the waste management process.

5.1 Planning and Characterisation

The planning and characterisation step involves making decisions about what should be included in the waste management lifecycle for a particular population of waste. This requires the gathering information about the wastes provenance (origin and history) and properties (through characterisation) to decide how the waste should be retrieved, stored, pre-treated or conditioned, packaged, transported and treated. This is a critical step for application of the waste hierarchy because the amount and quality of information gathered, and the decisions made on the basis of it, will determine how the waste hierarchy is applied. Characterisation is used to gather information to assist in planning and waste management decision making.

What is characterisation?

Characterisation of radioactive waste is the process of determining its radiological, chemical and physical properties. It is can be achieved using a range of different methods such as by studying the material's provenance, by using non-destructive measurement (such as drum scanners), intrusive sampling and analysis, or computer modelling.

Knowing the properties of the waste will enable correct WH choices to be made, and so characterisation should be undertaken at as early a point as possible in the waste lifecycle to support decision making. Characterisation needs to be carefully planned to ensure the right information is gathered and that unnecessary over characterisation is avoided (as this may prove expensive and time-consuming).

Characterisation should be carried out:

- Where there is a lack of sufficient information or knowledge of the waste type.
- Where information is out of date or there is potential for significant impairment to safety as a result of changing waste properties.
- For quality assurance or checking.
- At stages when useful information can be obtained that might otherwise be lost.
- To confirm assumptions

It is the activity which supports decision making across the entire waste lifecycle from retrieval to disposal. Well-timed and appropriate characterisation therefore enables safe, timely, cost-effective and appropriate waste management.
5.1.1. Pre-treatment

Pre-treatment describes a number of different processes which are applied to a waste following retrieval to enable storage, packaging, transport and treatment. This may include waste segregation and sorting, size reduction, containerisation and encapsulation.

### Waste segregation - what is it and how should I do it?

Waste segregation and sorting is the process of separating wastes into different populations or groups depending on criteria such as waste type, dose rate, waste classification or waste route. Without effective segregation, materials can be mixed, resulting in lost opportunities to utilise the best hierarchy option. Ineffective segregation can also lead to unnecessary contamination through mixing of contaminated and clean waste.

For successful waste segregation:

- Waste should be segregated at or as close to the point of generation as possible.
- Segregation systems should be easy to use; colour coded containers and labels along with clear instructions are recommended.
- Activities should be planned to minimise the double handling of wastes.
- Individual waste packages should be provided that are suitable for the expected waste volumes and types; and are clearly labelled.
- Waste collation and collection should be routine and at a frequency that ensures waste volumes do not accumulate or create a safety risk.
- Operators and contractors should be trained and aware of the process for and value of effective segregation.
- Robust monitoring protocols and activity assessment tools should be available and used as appropriate.
- Procedures should be in place for identifying and managing non-conforming waste.

Segregation is an important enabling step as it will facilitate the application of the waste hierarchy as it allows for subsequent steps to be carried out, delivering cost savings through the appropriate routing of waste. It will also enable any non-radioactive or out-of-scope components to be recognised and managed separately, reducing the volume of LLW requiring management.

Encouraging waste segregation can be as simple as providing employees with an individual package for a small quantity of waste that is known to be generated by a particular operation. For example, a rag used to wipe contaminated oil from a mechanical plant may be known to be suitable for a particular treatment route and operators may be provided with a container appropriate for that treatment route.
For larger projects, particularly in decommissioning environments, planning is essential to ensure that effective segregation, as close to point as generation as possible, can be achieved safely and effectively. This may be through provision of smaller containers such as stillages and boxes at the work face for different waste groups, or the provision of laydown areas. Effective segregation can be more difficult for decommissioning projects where waste may have variable levels of contamination, differing material types, cross contamination is likely or where there may be access/space constraints. If segregation at the point of generation is not possible and transfer of waste to storage areas is more important, consideration should be given to how to complete this whilst still encouraging segregation and the use of a centralised sort and segregation facility should be considered.

Case Study: Segregation in EdF Torness Site Gas Circulator Maintenance Workshop

In an initiative to reduce the volume of active waste arisings from the Torness Gas Circulator Maintenance Workshop, a waste segregation process has been introduced. Waste is segregated by provenance (origin) into and then by waste type, to separate non-active and active waste. Non-active waste bags and items are monitored out of the contamination control area by hand-probe and then through final clearance monitoring using bag monitors. Introduction of this segregation initiative has decreased active waste arisings by over 50%.
Segregation can also support additional characterisation activities. It can simplify the method of direct measurement as it allows the measurement of larger volumes of waste in packages of waste for example, in 200 litre drums as opposed to having to measure each individual piece of waste. This is only possible however, when there is a high degree of confidence that all of the waste material within the container can be characterised with a single radionuclide fingerprint and the waste has come from a single source. Characterisation and segregation are thus intrinsically linked; each supports the other and the correct approaches are often facility or project dependant, and are often iterative.

**Containerisation – what is it and how should I do it?**

Containerisation is the process of initially packaging wastes following retrieval for temporary storage pending pre-treatment or pending transfer for treatment and disposal. This is an important enabling step as careful thought is needed on what type of container is used for temporary storage; questions to be considered include:

- Can the waste be containerised that enables retrieval for re-use or further segregation?
- Has the minimum safe packaging been selected that reduces the need for later re-packaging (and thus waste production)?
- Does the waste need to be containerised?
- Can the waste be put in a container that is compatible with treatment routes?

**Size reduction - what is it and how should I do it?**

Size reduction is the process of reducing the dimensions and simplifying the geometry of waste items to make them easier to store, package, transport and treat. A diverse range of size reduction techniques can be used from the use of simple hand tools to diamond wire cutting to use of lasers and plasma arc. Size reduction needs to be carefully planned to ensure that the right technique is used on the right material and that it is used at the right time. Size reduction can, like segregation, enable the use of different WH options and can also support segregation operations.

The type and extent of pre-treatment operations should be carefully considered to ensure that options for waste management are not limited or foreclosed unnecessarily.
6. Implementation of the Waste Hierarchy

This section describes the different elements of the WH and how they can be applied; including case studies to demonstrate good practice and descriptions of important technologies.

6.1. Prevent

The first step in the Waste Hierarchy is to prevent waste from being generated. Waste prevention can be maximised for new buildings and facilities, where it can be considered and incorporated as a fundamental principle in the design and operation of the facilities. For legacy and existing facilities, waste prevention is still useful as there are cost, time and environmental benefits in not having to manage waste as LLW.

How can I prevent the generation of LLW?

- Avoid taking materials into radioactively contaminated areas unless entirely necessary e.g. removal of packaging
- Implement “paperless offices” within radiologically controlled areas
- Retain and use equipment for as long as practicable (refurbish & repair rather than replacement)
- Donate/swap equipment and other resources with other sites or organisations
- Avoid the need for any unnecessary packaging for example lined stillages instead of individually wrapped items
- Locate staff offsite/ outside of classified areas
- Design facilities so that the maximum amount of equipment can be kept ‘out of cell’

6.2. Minimise

Waste minimisation is a fundamental principle of radioactive waste management and involves reducing, as far as practicable, the volume of waste and the radiological activity of waste that is generated from a process or project.

How can I minimise the volume and radiological activity of waste?

- Directly reducing the activity level of waste through decontamination (see section 7.2.1)
- Enhanced characterisation, where feasible, to enable reclassification of waste to become out-of-scope or exempt of regulation (see section 7.2.2)
- Gradually reducing the activity level of waste through decay storage to lower classifications (to out-of-scope levels or to a level that permits alternative management)
- Make choices on equipment, containers and plant that enable easier decontamination (e.g. the use of plastic pallets instead of wood pallets means that contamination can be better handled. Plastic pallets can more easily be decontaminated by using simple wiping techniques and so subsequent reuse is easier).
- Think carefully about how you package items and wastes to minimise the amount of packaging needed (for example, challenge whether you need to wrap items).
Think carefully at the beginning of the waste management process to assess how you can minimise the need for re-packaging wastes (for example, can you package waste on retrieval into an appropriate storage or transport package?).

6.2.1. Decontamination

Decontamination of facilities and materials has significant potential to minimise the amount of waste that needs to be managed as LLW. There are a range of decontamination techniques available which allow for the safe treatment of a variety of materials ranging in complexity from the simple washing and wiping of items, to high-pressure water jetting or the use of liquid nitrogen. A significant range of different materials can be decontaminated including metals, concrete and plastics. Specific examples of the compatibility of different surface decontamination techniques with material type are provided in Table 1.

Decontamination can be used for a variety of reasons:
- To remove contamination and lower the dose rate to enable man-access to specific plant areas or to enable more direct handling of wastes.
- To remove contamination to enable wastes to be managed at lower radiological classifications or using different waste routes.

Decontamination needs to be carefully planned to ensure that the process selected is safe, technically feasible (i.e. will deliver the desired outcome), efficient, cost effective and will not generate large volumes of secondary waste. Decontamination can be undertaken on-site (either in-situ or in specific decontamination facilities) or else within the supply chain. The choice of decontamination facility will be driven by the nature of the waste, the contamination, constraints and cost.

Case Study: Decontamination of Winfrith Post Irradiation Examination Facility

Decommissioning and demolition of the Post Irradiation Examination Facility at the Magnox Ltd Winfrith site took place between 2001 and 2008. This project involved the decontamination of the building fabric, using remote and manual techniques, to remove the contamination and to support the management of the resultant waste. Owing to the decontamination and the segregation practices, of the 10,000 tonnes of waste generated, most of it was classified as out-of-scope / exempt and the remaining material was managed as VLLW.
Table 1: Applicability of Surface Decontamination Techniques for Different Metal Types and Concrete

<table>
<thead>
<tr>
<th>Surface Decontamination Technique</th>
<th>Al/Cu/Mild Steel</th>
<th>Mild Steel (Coated)</th>
<th>Stainless Steel</th>
<th>Stainless Steel (Coated)</th>
<th>Concrete</th>
<th>Examples of Use</th>
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<tr>
<td>Surface Washing</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>Removing sludge from the surface of metallic items such as tanks</td>
</tr>
<tr>
<td>Surface Wiping</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>During operation and maintenance of building facilities such as scaffolding</td>
</tr>
<tr>
<td>Ultra-high Pressure Water Jetting</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>Pond decontamination at Magnox Ltd Bradwell and Hinkley A sites.</td>
</tr>
<tr>
<td>Shot-blasting</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▼</td>
<td>MEB (Multi Element Bottles) from Sellafield at the Studsvik Metals Recycling Facility (MRF); metallic processing at Sellafield Ltd Wheelabrator facility and Magnox Ltd Winfrith Abrasive Cleaning Machine,</td>
</tr>
<tr>
<td>Sponge Jetting</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>Decontamination of pond furniture at Magnox Ltd Hunterston A</td>
</tr>
<tr>
<td>Chemical (acids)</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>Surface decontamination of metallic waste At Dounreay.</td>
</tr>
</tbody>
</table>

▲ - Technology is applicable to the specific waste type
▲ - Technology is potentially applicable to the specific type of waste
▼ - Technology is not applicable to the specific waste type
6.2.2. Reclassification of waste
UK legislation enables radioactive waste to be released from regulatory control if it can be demonstrated that the waste does not present a significant hazard because of its very low levels of activity. This means that the waste can be disposed of through conventional routes. Comprehensive guidance to support the clearance and exemption of waste is available in the UK Nuclear Industry Code of Practice on Clearance and Exemption [Ref. 4].

The opportunity to reclassify waste as out-of-scope decreases the amount of waste that needs to be treated or disposed of as LLW or VLLW. High confidence is needed through characterisation, however, to ensure that wastes are sentenced appropriately.

6.3. Reuse
Reuse of materials arising from decommissioning provides an economically attractive source of material. Reuse can involve the direct reuse of equipment or plant by other teams on the same site or organisation; but can also involve the reuse of large volumes of bulk waste for other purposes.

6.3.1. Reuse of bulk waste (concrete, soil and spoil)
Concrete, spoil and soil provides one of the largest volumes of materials available for reuse. These materials have the opportunity to be processed and used in the construction industry as hardcore for void filling or landscaping (subject to appropriate regulatory agreement).
6.3.2. Reuse of items
Specific items such as equipment, vehicles and tools can be reused; subject to appropriate agreement.

Reuse of tools and equipment on a day-to-day basis in contaminated areas can reduce the unnecessary contamination of clean equipment and so reduce the volume of waste.

Within a site, equipment and items can be reused. For example, at the Magnox Ltd Wylfa site, materials have been reused on-site to extend the life of its plant. It only has 1 out of 2 reactors running and so they have made use of redundant material from reactor 2 to help maintain reactor 1. This includes reusing fuel and turbine blades from the reactor 2 plant.

Larger items, vehicles and equipment can be reused within a site or by a different organisation when they become redundant. For example, within the NDA estate, the opportunity to reuse plant and equipment across sites is supported by the NDA Asset Transfer Website, which identifies and advertises redundant equipment on one site that could be used elsewhere. Other organisations also may have similar internal systems which look to identify where equipment can be shared rather than new items purchased.
6.3.3. Reuse of containers and packaging

Containers and packaging is another area where items can be reused to reduce the amount of waste requiring treatment and disposal.

Iso-containers – used for the transport of waste – can be reused, subject to an appropriate maintenance and usage regime, before they are used for final disposal.

Other container types have been developed and are in routine use at sites around the UK that enable reuse. Containers such as stillages, boxes and wheelie bins are used for metallic and combustible waste treatment enabling loading at the workface, transfer to a conveyance (such as a vehicle or a isofreight container on a vehicle) and sent for treatment. The stillages, boxes and wheelie bins are emptied at the treatment facility and returned for reuse on another load.

Case Study: Chapelcross Skips to Sellafield Ltd

Cross organisation coordination is important in industry wide reuse and has resulted in Sellafield and Magnox jointly saving over £1 million. Rather than buying new skips to decommission legacy plant, Sellafield are reusing fuel skips from Magnox’s Chapelcross Site. The forty-two redundant Magnox skips have been transported to Sellafield to be used for shipping waste out of the Pile Fuel Storage Pond (PFSP). This is a win-win situation for both SLCs, with Magnox saving on costs of treating / disposing of the skips and Sellafield saving on the cost of buying new skips.

Figure 9 - A redundant Chapelcross skip being prepared for dispatch to Sellafield Ltd

Figure 10 - Stillages (left) and Wheelie Bins (right) in use
How can I reuse?

- Set up pools of stock equipment and tools for contaminated areas that remain in these areas for different teams to use (reducing the transfer of tools and equipment between contaminated areas).
- When an item has become redundant to you, check if other parts of your organisation have a use for it and make it available to them if they have.
- Within the NDA estate, if an item has become redundant to you and no one within your site or organisation can use it, add it to the NDA Asset Transfer Website.
- Adopt the use of re-usable containers for the packaging and transport of LLW.
- Have dialogue with the regulators about where and how you can reuse concrete, soil and spoil.

6.4. Recycle

Recycling is the process of converting waste into usable material. In the UK nuclear industry, recycling of LLW is focussed on metallic waste.

Metallic waste recycling involves either the surface decontamination of metallic waste for release for melting as out-of-scope scrap metal or the melting of VLLW or LLW contaminated metal.

In surface decontamination, metallic waste is subject to mechanical or chemical decontamination (for example, the shot-blasting of metal). This decontamination can mean, depending on the type of chemical and the efficiency of the process, that the waste can then be re-classified as out-of-scope and released to the open market for melting.

Technology: Metal melting

In melting of VLLW / LLW contaminated metal, the metal is heated until it melts creating three phases of material – the liquid metal, a semi-liquid slag phase and aerial effluent. This causes partitioning (separation) of the radionuclides into the slag or into the aerial effluent. The liquid metal is separated from the slag and cooled to form an ingot or block; and is typically classified as exempt waste. This can then be released to the open market to be fabricated into useful items.

Where the nature of the waste or the conditions mean that the outputs of the metal melt is a contaminated metal, this is fabricated into shielding blocks or waste containers for use in the nuclear industry. The use of metal melting significantly reduces the volume of radioactive waste that requires disposal.
How can I recycle LLW?

- Open and optimise use of waste routes for metallic treatment (using supply chain or own plant).
- Use arrangements for characterisation, retrieval, segregation and size reduction, packaging, storage and transport of waste to enable the recycling of metallic waste.
- Promote and encourage the use of the route to plant personnel.

6.5. **Reduce**

Reduction is different to waste minimisation – and minimisation of waste should have already been achieved or considered prior to this stage. Reduction involves physically reducing the volume of waste that needs to be disposed of. Reduction is normally used for organic wastes with the two main techniques being compaction (section 7.5.1) and thermal treatment (section 7.5.2). Segregation is therefore an important precursor to this stage to allow for correct routing of waste, depending upon on its radiochemical, chemical and physical characteristics.

Other reduction techniques that can be applied include efficient packaging of ISO containers destined for disposal. This reduces the overall number of containers that need to be consigned and the cost of disposal.

6.5.1. **Compaction**

Compaction is a process which applies pressure to waste to reduce its physical volume. Low-force compaction is used by a number of sites as an enabling technology for other treatment methods. It is normally used prior to incineration to maximise the utilisation of transport capacity.

6.5.2. **Shredding**

Shredding involves the use of mechanical equipment to finely cut up waste into much smaller dimensions. Shredding can be a beneficial tool for waste reduction as it creates a more homogeneously sized waste and creates waste that can be packed into containers with greater...
efficiency (reducing the number of disposal containers needed). Shredding is used at the Sellafield Ltd WAMAC plant.

6.5.3. Thermal Treatment

Thermal treatment uses heat to stabilise and reduce the volume of waste. Although incineration is the most commonly used technique, there are a range of other potential thermal techniques such as vitrification, pyrolysis and plasma treatment. These other thermal treatment techniques may be suitable for problematic wastes that are unsuitable for other thermal treatment processes due to specific hazardous or radiological properties.

Technology: Supercompaction

Supercompaction is often used as a final reduction technique before LLW is sent for disposal at the LLWR, reducing waste volumes by up to 70%. The waste is in the form of supercompacted pucks and is transferred for final disposal at the LLW Repository or the DSRL near-site repository. There are currently two UK facilities which provide commercial supercompaction treatment; WAMAC (Waste Monitoring and Compaction Plant) at Sellafield and Inutec’s mobile unit based at Winfrith; whilst the Dounreay site has its own supercompaction facility.

Technology: Incineration

Incineration is a thermal treatment process which is used for management of predominantly organic wastes such as plastics, textiles, cellulosic waste and oil / solvents. During incineration, the waste is subjected to high temperatures which cause the waste to be converted to ash, aerial effluent and heat.

In the UK, a technique known as co-incineration is used. In this process, LLW or VLLW being treated by incineration is treated with non-radioactive wastes as part of a continuous process. This creates a secondary solid waste (ash) that can be disposed of at appropriately permitted landfill sites. Batch process techniques are used at overseas incinerators, allowing the resulting LLW contaminated ash to be returned to the UK for disposal.
How can I reduce the volume of radioactive waste for disposal?

- Open and optimise use of waste routes for incineration, compaction and shredding (using supply chain or own plant).
- Use arrangements for characterisation, retrieval, segregation and size reduction, packaging, storage and transport of waste that allow incineration, compaction and shredding to be used.
- Promote the use of incineration over compaction and shredding, where applicable, as this delivers the most volume reduction prior to disposal.
- Promote and encourage the use of the routes to plant personnel.
- Investigate, and where appropriate, implement the use of thermal technologies for the management of problematic wastes.
- Pack containers as efficiently as possible to reduce the overall number of disposal containers required.

6.6. Dispose

Disposal capacity is a limited resource and so disposal of radioactive waste should always be considered as the option of last resort. There is a legal obligation to sufficiently assess whether disposal is the only option and that it is only done after minimisation and reduction techniques have been applied. It is recognised, however, that for some wastes disposal is the most appropriate waste management option.

Disposal of LLW and VLLW in the UK can be undertaken at a range of different facilities, depending on the properties of the waste and the waste originator.

**Technology: Disposal of VLLW and LLW**

**Appropriately permitted landfill sites**

Appropriately permitted commercial waste landfill sites are used for the disposal of some radioactive waste, such as VLLW. Due to the lower risks associated with this waste it does not require the same degree of engineered protection needed for LLW disposal.

**On-site disposal (Sellafield Ltd)**

Calder Landfill Extension Segregated Area (CLESA) is currently the only onsite disposal facility in the UK. It is located at Sellafield Site and used as a landfill for low activity waste. It accepts certain High Volume Very Low Level Waste (HV-VLLW) and lower activity LLW from the Sellafield site.
Low Level Waste Repository (LLWR)

The LLWR provides a final disposal option for solid LLW that cannot be treated and for residual wastes from treatment processes. It accepts LLW which meets the Waste Acceptance Criteria (WAC) for the site. The majority of waste is accepted in ISO containers which are grouted to make a monolithic block, and then placed in specially engineered vaults for long term disposal.

Near-site disposal (Dounreay)

Dounreay Site Restoration Limited (DRSL) has built a near-surface facility adjacent to the site for the disposal of VLLW and LLW. The facility will accept waste from the Dounreay Site and the MOD VULCAN establishment and will have up to six vaults. Some will be used for LLW and others for demolition LLW. Small LLW items are packed into drums and, where possible, high force compacted prior to being placed in disposal containers. The disposal containers will be grouted prior to emplacement in the vault. Demolition LLW is packaged in bags and placed in the vault in layers, with each layer having a granular in-fill over the top. Large LLW items will be packed straight into the ISOs or disposed directly to the vaults.

How can I appropriately dispose of radioactive waste?

- Challenge whether disposal is needed and is BAT – can the waste be managed at a lower level of the Waste Hierarchy? Does the waste need to be disposed of?
- Choose the best disposal facility for the waste based on its physical, chemical and radiological characteristics and your available options.
- Collect the necessary information that you will require to support disposal of the waste during the waste lifecycle.
- Use arrangements for characterisation, retrieval, segregation and size reduction, packaging, storage and transport of waste that allow for safe, timely disposal of the waste (where disposal is the best option for the waste).
7. Additional Information

Additional information on the Waste Hierarchy or techniques to support application of the Waste Hierarchy can be found at:

- Advice, guidance and support is available from Waste Services at LLW Repository Ltd where specific routes have been set up through their commercial frameworks. This service is accessible to all waste generators across the UK via a Waste Services Contract and includes metallic, VLLW, combustible, supercompaction and LLW routes, as well as access to alternative services and project support. Waste Services can be contacted via e-mail to customerservice@llwrsite.com.

- LLWR website (www.llwrsite.com) – particularly the National Waste Programme and Customer Portal information


- EARWG website (http://www.rwbestpractice.co.uk/)

- WRAP website (http://www.wrap.org.uk/)

- National Strategic BAT studies (www.llwrsite.com)


8. Abbreviations

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>ALARA</td>
<td>As Low As Reasonably Achievable</td>
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<tr>
<td>BAT</td>
<td>Best Available Technique</td>
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<tr>
<td>BPM</td>
<td>Best Practicable Means</td>
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<tr>
<td>CLESA</td>
<td>Calder Landfill Extension Segregated Area</td>
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<tr>
<td>DSRL</td>
<td>Dounreay Site Restoration Limited</td>
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<td>EA</td>
<td>Environment Agency</td>
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<td>HV-VLLW</td>
<td>High Volume Very Low Level Waste</td>
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<td>HHISO</td>
<td>Half Height International Standards Organisation Container</td>
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<td>LA-LLW</td>
<td>Low Activity Low Level Waste</td>
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<td>LLW</td>
<td>Low Level Waste</td>
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<td>LLWR</td>
<td>Low Level Waste Repository</td>
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<td>MEB</td>
<td>Multi Element Bottle</td>
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<td>MOD</td>
<td>Ministry of Defence</td>
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<td>MRF</td>
<td>Studsvik Metal Recycling Facility</td>
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<td>NDA</td>
<td>Nuclear Decommissioning Authority</td>
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<td>OPSZ</td>
<td>Outer Perimeter Security Zone</td>
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<td>PFSP</td>
<td>Pile Fuel Storage Pond</td>
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<td>RWM</td>
<td>Radioactive Waste Management Ltd</td>
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<td>SEPA</td>
<td>Scottish Environment Protection Agency</td>
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<td>SLC</td>
<td>Site Licensed Company</td>
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<td>VLLW</td>
<td>Very Low Level Waste</td>
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<td>WAC</td>
<td>Waste Acceptance Criteria</td>
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<td>WH</td>
<td>Waste Hierarchy</td>
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<td>WAMAC</td>
<td>Waste Monitoring and Compaction Plant</td>
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9. References

1. UK Nuclear Industry LLW Strategy for the Management of Solid Low Level Radioactive Waste, NDA, Issue 1, August 2010
2. Guidance on the scope of and exemptions from the radioactive substances legislation in the UK, Version 1.0, DECC / DEFRA / Devolved Administrations, September 2011