Guidance for the Management of Lower Active Waste (LAW)

September 2016

Contents

Foreword

The Low Level Waste Repository (LLWR) Ltd. has published this document to provide initial insight, at a high level, on guidance for the management of Low Active Waste (LAW) across the UK's nuclear industry. It should therefore be read in conjunction with more specific guidance on LAW routing and consignment requirements as provided by National Strategy, processes developed through the National Waste Programme (NWP) office and LLWR guidance documents, all of which are referenced.

The main purpose of this document is to provide LLWR personnel with a useful reference guide to support audit and assurance activities conducted at external facilities. A secondary purpose is to initiate and facilitate further cross industry discussion to help raise standards for the management of lower active waste in an effort to reduce risks, in particular that of waste mis-consignment and maximise efficiency.

Both industry (consignors and consignees) and the Regulators, i.e., the Office for Nuclear Regulation (ONR), the Environment Agency, the Scottish Environment Protection Agency (SEPA) and Natural Resources Wales (NRW) have worked collaboratively to produce existing regulatory guidance for the management of Higher Active Wastes (HAW). As the management of LAW shares a high degree of commonality with that of HAW, that guidance was used as a starting point for this document. As such, with some aspects it may be seen that duplication exists and in others it may be determined that it is not appropriate. However, it has been included for completeness to not only provide a useful tool to support assurance activities associated with LAW, but to also promote debate and further discussion to produce guidance that is aligned to the needs of all stakeholders.

Therefore, this guidance is a live document that will be reviewed on a regular basis with involvement from all relevant stakeholders to incorporate learning from past experience, advances in techniques and technology, and any other constructive feedback. The ultimate goal is to have a single document that both industry and the regulators all use on a regular basis for the management of LAW.

Executive Summary

This document's aim, which has utilised as its basis the guidance for Higher Active Radioactive Waste (HAW) management, is to provide a high level initial guidance covering the management of Lower Activity Radioactive Wastes (LAW). In all instances this document should be read in conjunction with more specific guidance on LAW routing and consignment requirements as provided by National Strategy, processes developed through the National Waste Programme (NWP) office and LLWR guidance documents.

The document describes standards, practices, regulatory process and expectations, with the intention to promote debate and discussion in the following key areas to ultimately realise guidance for LAW aligned to industry needs:

Section 1: Regulatory/Compliance Processes

This section gives guidance on the regulatory framework and processes associated with the management of LAW and details how compliance will be measured.

Section 2: Integrated Waste Strategies (IWS)

This section details the expectation for LAW consignors to produce the solid LAW components of an integrated waste strategy and what it should contain.

Section 3: Best Available Techniques (BAT) / Best Practicable Means (BPM)

BAT/BPM assessments (hereafter referred to as BAT) are a well-established process used to demonstrate that a balanced judgement has been undertaken to both identify and implement appropriate techniques for LAW management. This section provides an overview with respect to the production, content, maintenance and reviews of Best Available Techniques (BAT) assessments, cognisant of BPEO/BPM requirements in other UK areas, and provides links to further guidance.

Section 4: Waste Management

This section provides an overview of waste minimisation, characterisation and segregation which are central to establishing and updating a radioactive waste inventory, applying the waste management hierarchy and optimising waste management. They are also key to ensuring waste routing is both appropriate and remains compliant with relevant acceptance criteria.

Section 5: Waste Consignment

This section provides an overview of the expectations relating to the actual activities required to consign waste for either treatment or disposal once LAW management strategies have been decided, cognisant with guidance established in the previous section.

Section 6: Storage

This section takes its lead from the requirements for HAW storage. Where, if raw waste is stored, it should be contained in a manner that avoids deterioration and allows retrieval for processing and eventual disposal, whilst maintaining standards of safety and environmental protection. Storage in many cases may not be seen as an aspect of LAW management, as in general it is covered under Environmental Permitting and Licence Conditions, where accumulation and treatment/disposal limitations are stipulated. However, more cases are being highlighted where waste is being stored to allow decay to meet business needs and maximise opportunities for management. Decay

storage may therefore become a crucial part of the long-term management strategy by providing an extendable safe and secure means to hold waste and ensure protection of the public and environment, prior to final treatment/disposal.

Section 7: Managing information and records relating to radioactive waste

Effective management of knowledge and records associated with waste is an important aspect of radioactive waste management. It is essential to ensure that consignors and consignees, both now and in the future, are equipped with the knowledge and records they need to manage radioactive waste safely, over long timescales and through organisational change. This guidance covers existing national and international standards and practices for managing information. It also discusses some of the specific issues associated with managing information about radioactive waste over the long term.

Introduction

Scope

In the UK solid radioactive wastes are defined in three categories, low, intermediate and high level wastes, where Low Active Wastes (LAW), or Low Level Waste (LLW) as it is more commonly known, is itself a wide category covering waste having very low levels of activity to waste which may require engineered shielding. The intent of this document is to provide initial insight, at a high level, on guidance for the management of Low Active Waste (LAW) across the UK's nuclear industry.

In the UK the majority of LLW, which can be sub-divided into operational and decommissioning related material, originates from nuclear sites undertaking the following activities:

- Fuel fabrication and uranium enrichment
- Nuclear power generation
- Spent fuel reprocessing
- Decommissioning and clean-up of nuclear sites
- Nuclear energy research and development
- Ministry of Defence activities
- Manufacture of radioactive medical products.

Operational LLW typically arises from routine monitoring and maintenance activities, and includes plastic, paper, tissue, clothing, wood and metallic items. Decommissioning LLW mostly comprises building rubble, soil and various metal plant, equipment and items.

Radioactive substances and material that are not currently classified as radioactive waste, such as spent nuclear fuel, plutonium, uranium or other such radioactive fuels and materials are outside the scope of this guidance.

Advice about the disposal of those categories of radioactive waste that are not covered in this guidance can be obtained from regulatory authorities.

Licensees and permit holders are required to apply the same safety and environmental standards to all activities involving radioactive materials whether or not the material involved is declared as radioactive waste.

Objective and aims of the guidance

The objective of this guidance is to provide advice and promote further discussion with respect to:

- the regulatory process associated with the management of lower activity radioactive waste in the UK
- the production, content, maintenance and review of waste strategies and management cases
- techniques for waste minimisation, characterisation and segregation
- the conditioning of lower activity wastes, waste disposability, waste treatability and the assessment thereof
- the storage of lower activity radioactive waste
- the management of knowledge and records relating to radioactive waste in the United Kingdom.

The main aim of the guidance is to support risk mitigation for mis-consignment of waste by providing a source of information to LLWR audit and assurance personnel, nuclear site licensees and environmental permit holders. It also seeks to provide guidance on achieving overall compliance with applicable policy and legislation for the management of LLW.

When applying this guidance, licensees and permit holders should have due regard to:

- ONR's principles for assessing nuclear safety cases, as detailed in the Safety Assessment Principles[1]
- ONR Technical Assessment Guide on 'As Low As Reasonably Practicable' (ALARP)[2]
- For England and Wales the principles for the regulation of radioactive substances as detailed in Radioactive Substances Regulation: Environmental Principles[3,4] and Principles of optimisation in the management and disposal of radioactive waste[5]
- Best Available Techniques (BAT) for the Management of the Generation and Disposal of Radioactive Waste[6]
- For Scotland SEPA's guidance on the principle of optimisation as detailed in satisfying the ALARA requirement and the role of Best Practicable Means[7].

Government policy

The Government maintains and continues to develop a policy and regulatory framework which ensures that:

- Radioactive wastes are not unnecessarily created
- Such wastes as are created are safely and appropriately managed and treated
- They are then safely disposed of at appropriate times and in appropriate ways.

The fundamental aim is to ensure that radioactive waste is managed in a way that protects the public, workforce and environment; and safeguards the interest of existing and future generations and the wider environment in a manner that commands public confidence and takes due account of costs.

The Government requires that the regulators ensure that the policy and regulatory framework is properly implemented in accordance with their statutory powers. Within the framework, the producers and owners of radioactive waste are responsible for developing their own waste management strategies, consulting the Government, regulatory bodies and disposal organisations as appropriate.

The management of lower level wastes in the UK is not to be prescriptive but utilise multiple techniques in line with both the Policy for the Long Term Management of Solid Low Level Radioactive Waste[8] and the UK Strategy for the Management of Solid Low Level Waste from the Nuclear Industry[9].

Key applicable legislation

As required by the legislation detailed in this section, facilities and activities for predisposal management of radioactive waste, including decommissioning activities, shall be subject to safety and environmental impact assessments to demonstrate that they are adequately safe and, more specifically, that they will be in compliance with safety and environmental requirements established by the regulators. Further comprehensive detail of legislation required for LLW management can be found in Guidance on UK Low Level Waste Management Legislation[10].

Nuclear Installations Act 1965

The Nuclear Installations Act 1965 (NIA65) requires any operator of a defined nuclear installation to be licensed and gives ONR the powers to *'attach to the licence such conditions as may appear to be necessary or desirable in the interest of safety'* or *'as it may think fit with respect to the handling treatment and disposal of nuclear matter'.* The sections of the Nuclear Installations Act relating to the licence and inspection of sites (sections 1, 3–6, 22 and 24A) are 'relevant statutory provisions' under the Energy Act 2013. These sections are subject to regulation and enforcement by ONR.

Licence Conditions

There are 36 standard licence conditions (LCs), as detailed in the ONR Licensed Conditions Handbook[11] attached to all nuclear site licences. All the licence conditions apply and are relevant to activities involving management of radioactive waste. However, a number of licence conditions are particularly relevant to this guidance. These are:

- *Licence Condition 4* requires that no nuclear matter is stored on the site except in accordance with adequate arrangements made by the licensee for this purpose
- *Licence Condition 5* requires that nuclear matter (other than excepted matter and radioactive waste) cannot be consigned to any place in the United Kingdom other than a relevant site except with the consent of ONR
- *Licence Condition 32* requires adequate arrangements for minimising so far as is reasonably practicable the rate of production and total quantity of radioactive waste accumulated on the site at any time and for recording the waste so accumulated
- *Licence Condition 33* requires that radioactive waste is disposed of in accordance with an environmental permit
- *Licence Condition 34* requires the licensee to ensure, so far as is reasonably practicable, that radioactive material and radioactive waste on the site is at all times adequately controlled or contained so that it cannot leak or otherwise escape from such control or containment
- *Licence Condition 35* requires the licensee to make and implement adequate arrangements for the decommissioning of any plant or process that may affect safety. Insofar as decommissioning and radioactive waste management are interlinked activities, this is a relevant licence condition to this guidance.

Health and Safety at Work etc. Act 1974 (HASW74)

Section 2 of HASW74 requires *'every employer to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all his employees'*. Section 3 of the Act requires *'every employer to conduct his undertaking in such a way as to ensure, so far as is reasonably practicable, that the persons not in his employment who may be affected thereby are not thereby exposed to risks to their health or safety'*. The fundamental requirement is that the operator shall take measures to reduce risks as low as reasonably practicable (ALARP).

Environmental Legislation

The primary role of the environment agencies is to ensure the long-term protection of the public and the environment. This entails ensuring waste is managed in a sustainable way, taking into account long-term environmental considerations. The agencies carry out this duty under section 37(3) of the Environment Act 1995[12].

The Environment Agency takes a leading role in protecting and improving the environment in England, while the Scottish Environment Protection Agency (SEPA) and Natural Resources Wales (NRW) have similar responsibilities in Scotland and in Wales. The environment agencies regulate radioactive disposals (including the discharge of gaseous and aqueous radioactive wastes) and the transfer of radioactive wastes between nuclear sites.
The legislation under which the environment agencies regulate is different. In England and Wales, the Environment Agency and NRW regulate the disposal of radioactive waste from nuclear licence sites under the Environmental Permitting (England and Wales) Regulations 2010 (EPR10). In Scotland, the SEPA administers the Radioactive Substances Act 1993 (RSA93), which has similar requirements to EPR10.

Before granting or significantly varying an authorisation already granted, the appropriate environment agency will wish to ensure that a systematic and proportionate examination has been made of the options for waste management (having regard to the waste hierarchy) and that the waste management strategy chosen represents the optimum to provide proper protection for people and the environment. Waste management strategies should be determined by application of best available techniques (BAT) or best practicable means (BPM) as appropriate to the legislative regime.

Other relevant guidance

The ONR's Safety Assessment Principles (SAPs)[1] provide the underlying basis for regulatory judgements made by ONR. Relevant principles include:

- SAP RW.1: A strategy should be produced and implemented for the management of radioactive waste on a site
- SAP RW.2: The generation of radioactive waste should be prevented or, where this is not reasonably practicable, minimised in terms of quantity and activity
- SAP RW.3: The total quantity of radioactive waste accumulated on site at any time should be minimised so far as is reasonably practicable
- SAP RW.4: Radioactive waste should be characterised and segregated to facilitate subsequent safe and effective management
- SAP RW.5: Radioactive waste should be stored in accordance with good engineering practice and in a passively safe condition
- SAP RW.6: Radiological hazards should be reduced systematically and progressively. The waste should be processed into a passive safe state as soon as reasonably practicable
- SAP RW.7: Information that might be needed for the current and future safe management of radioactive waste should be recorded and preserved.

For England and Wales the principles for the regulation of radioactive substances as detailed in Radioactive Substances Regulation: Environmental Principles. Relevant principles include:

- Principle RSMDP3 - Use of BAT to minimise waste, states *"The best available techniques should be used to ensure that production of radioactive waste is prevented and where that is not practicable minimised with regard to activity and quantity"*
- Principle RSMDP8 - Segregation of wastes, states *"The best available techniques should be used to prevent the mixing of radioactive substances with other materials, including other radioactive substances, where such mixing might compromise subsequent effective management or increase environmental impacts or risks."*
- Principle RSMDP9 - Characterisation, states *"Radioactive substances should be characterised using the best available techniques so as to facilitate their subsequent management, including waste disposal."*

These principles do not apply in Scotland; guidance in this area can be found on the SEPA website[13].

Section 1: Regulatory/Compliance Processes

The objective of this part of the guidance is to give an insight into the regulatory and compliance process associated with the management of LAW on nuclear licensed sites in the UK.

The aim is to advise licensees on how they may obtain both regulatory and LLWR acceptance of their proposals and subsequently demonstrate compliance for LAW management by detailing:

- a clear and transparent regulatory process involving early dialogue between the nuclear industry, the regulators, the Nuclear Decommissioning Authority (NDA) and LLWR
- Regulator and LLWR (including Service Providers) assurance activities undertaken to provide scrutiny of process to ensure both legislative and process compliance.

The process is designed to be flexible and efficient, and to avoid undue delay. It assumes there will be early and continuing interaction with the regulators/LLWR during the development of proposals.

Joint working and early interactions between Stakeholders

Early interaction and joint working between all stakeholders is important for efficiently regulating and demonstrating compliance of LAW management on nuclear licensed sites. Interaction is especially important at the strategy development, options assessment and concept stages, where licensees, as the waste producer, can seek both regulator and LLWR advice about:

- improving safety and environmental protection
- resolving, any significant regulatory issues at this early stage
- assessing waste management option
- reducing business risk (e.g. waste mis-consignment)
- enabling all stakeholders to plan their resource commitments.

Licensees should communicate to regulators and LLWR as soon as possible:

- any issues[a] known or considered likely to be significant
- reasons for their actions or intentions, including any third-party requirements
- the options being considered, their merits and the reasons for preferring the selected option (BAT)
- any dependencies on future actions by third parties. (Licensees should not await the outcomes of third-party action before revealing proposals that are conditional on third parties)
- who is empowered to represent the licensee on the issues
- any changes to the above
- any initial suggestions for regulatory hold points (beyond which a licensee cannot proceed without regulatory agreement).

[a] The matters to be addressed during stakeholder interactions are generally described in this document as ‘issues’. This term should be interpreted very broadly. It may for example include an operator’s proposed courses of action, new projects or activities, events and investigations of interest to regulators, including responses to regulatory requirements. Similarly, on a regulator’s part, it may for example include any particular regulatory concerns, investigations and audits and their outcomes, and changes to regulatory processes.

A combination of joint working and early identification and resolution of issues is essential to delivering effective regulation and compliance.

The Regulators and LLWR will notify licensees as soon as practicable:

- which issues are of interest to them
- which issues they regard as key
- the planned regulatory/compliance processes
- the implications for the involvement of statutory consultees and views on the involvement of other stakeholders
- the intended end points of the regulatory/compliance processes
- any changes to the above.

The intention is to avoid unnecessary delays, conflicts or duplication of activities in nuclear safety and environmental requirements. If a significant problem arises, the regulator/LLWR will inform the licensee of the relevant issues, together with the process and schedule for resolution.

The nuclear site licence and safety cases

ONR regulates radioactive waste management on nuclear licensed sites through the nuclear site licence. One of the licence conditions of the nuclear site licence is that the licensee must have a detailed safety case substantiating the safety of the plant throughout its life, and considering the waste that will be generated. Any subsequent alteration to the site facilities or operations, such as the modification of existing plant/processes or the construction of new plant, requires the licensee to review and amend the safety case and for ONR to grant permission where appropriate. Application for permission is made using the licensee's arrangements under the appropriate licence condition or as a result of ONR specifying the need for such an application. Licensees must have in place a safety and environmental case for each plant, substantiating adequate safety and environmental protection throughout the plant's life.

Best Available Techniques (BAT) / Best Practicable Means (BPM)

BAT/BPM assessments (hereafter referred to as BAT) are a well-established process used to demonstrate that a balanced judgement has been undertaken to both identify and implement appropriate techniques for the optimised management of LAW. The level of effort expended to resolve an issue, and to record the selection process should be proportionate to the scale of the challenge, the range of options available and the extent to which established good practice can be used to assist in the decision making process.

The BAT should provide transparency by indicating how the key decisions have been arrived at for management of the LAW covered, including waste routing options in line with the waste hierarchy. It should cover the period from waste generation, through the conditioning, storage and up to the removal of the waste from site for eventual treatment/disposal.

Further guidance on BAT Assessments can be found in Section 3 of this guidance.

Environmental Permit/Disposal Authorisation

Before waste can be consigned to LLWR or to any treatment service provider or alternate disposal site, the waste producer must be in possession of an Environmental Permit issued by the Environment Agency (EA) under the Environmental Permitting Regulations 2010, or a Disposal Authorisation issued by the Scottish Environmental Protection Agency (SEPA) under the Radioactive Substances Act 1993. The permit or disposal authorisation must include a condition

which allows the transfer of waste to another provider. This is likely to be a general condition which allows transfer of waste to any other holder of an appropriate environmental permit. This condition is likely to have limits on the amount of radioactivity which may be transferred.

Regulatory Requirements

Compliance

Under the following licence conditions, as detailed in ONR's License Condition Handbook[11], the licensee is required to:

- ensure that no nuclear matter is stored on the site except in accordance with adequate arrangements made by the licensee for this purpose (LC4)
- make and implement adequate arrangements for minimising so far as is reasonably practicable the rate of production and total quantity of radioactive waste accumulated on the site at any time and for recording the waste so accumulated (LC32)
- make and implement adequate arrangements for the decommissioning of any plant or process which may affect safety (LC35)
- make arrangements for the production and implementation of decommissioning
- programmes for each plant (LC35).

When assessing such adequacy ONR will take advice from the Environment Agency, NRW or SEPA or as appropriate. Where relevant, the BAT may also be referred to in assessing the compliance with any Licence Condition.

Permissioning

If required by the licensee's arrangements or ONR (in consultation with the appropriate environment agency), a project will be subject to formal regulatory submission under Licence Conditions 19, 20, 21, or 22. In most cases involving formal submission, the process will be staged, i.e. there will be arrangements for continuing dialogue and identified hold points beyond which a licensee cannot proceed without regulatory agreement. These formal hold points and the associated timescales are a matter for discussion and agreement between the licensee and ONR, in conjunction with the appropriate environment agency, on a case-by-case basis. At each hold point, ONR will provide a clearly documented decision.

The system of agreed hold points aims to provide a staged approach to formal permission, rather than a timetable for interaction with the regulators. Hold points would normally apply prior to important stages such as adoption of significant changes in LAW management strategy, the start of construction, commissioning, modification or operation.

BAT Assessments

BAT applies throughout the lifetime of a process, from design to implementation, operation, maintenance and decommissioning and therefore should be introduced at the earliest possible stage. The output of BAT assessments must be practicable and compliant with safety and environmental requirements (legal and policy). In demonstrating BAT, reference should be made to relevant standards, guidance and good practice.

Regulatory Assessment

When assessing proposals, prior to their commencement, the regulator will refer to the following documents:

- legislative requirements
- relevant parts of this guidance
- ONR's Safety Assessment Principles[1]
- the EA and NRW's Radioactive Substances Regulation Environmental Principles [3,4]
- the Environment Agency's principles of Optimisation[5]
- SEPA's guidance Satisfying the ALARA requirement and the role of Best Practicable Means[6]
- NDA's integrated waste strategy specification[14].

For issues affecting disposability, ONR will ask the Environment Agency or SEPA to assess the proposals and provide advice, under the provisions of the Environment Act 1995[12].

Regulators may undertake periodic audit and inspection, as part of normal regulatory activities of LAW operations, to ensure waste is being managed in accordance with the stipulated arrangements. These will be carried out on plant/areas used to manage, package, condition and store the waste and observed non-compliance may lead to enforcement action under existing regulatory powers and may entail:

- evidence that appropriate management systems are in place to control the LAW management to the required specification, and that these systems are adhered to in practice
- evidence that characterisation information and records of the radioactive and non-radioactive properties of LAW, are adequate to allow assessment whether they are likely to be acceptable for treatment and/or final disposal
- evidence that controls are in place, and working, to ensure that no unacceptable items or materials are contained within the packages produced for treatment/disposal
- evidence that LAW meet the specifications defined in the safety case for the plant concerned. For LAW that does not meet the specifications, mitigating evidence that:-
    - appropriate actions have been taken to ensure their continuing safe management
    - a strategy has been developed to ensure that the wastes can be disposed to an appropriate facility, for example by repackaging in packages which meet the defined specifications
    - appropriate action to have been taken, or planned, to reduce or eliminate the causes of non-compliant LAW
- evidence that LAW is being stored in appropriate conditions to ensure its acceptability for treatment/disposal is not compromised and the necessary maintenance of storage facilities is being carried out to ensure that waste is being managed to specification and that appropriate storage conditions are maintained
- evidence that data and information records in respect to LAW management are being produced, maintained, and stored in a way which allows access and retrieval; so that future safety and environmental assessments can be carried out and that the wastes remain acceptable for treatment and or disposal
- evidence that licensees are optimising their approach to waste management and consider it good practice to develop and use an integrated waste strategy (IWS). Where an IWS has been developed the BAT should describe how the management of the waste stream(s) under consideration is consistent with the IWS.

Involvement of third parties

The involvement of third parties can aid the regulatory process. Although the prime responsibility for safety and environmental protection lies with the licensee, and the responsibility for regulation lies with the regulators, other bodies should be involved in radioactive waste management. The following bodies should be involved in the collaborative working process, where appropriate:

- NDA, which has a statutory duty to define a strategy for the decommissioning of nuclear sites for which it is responsible and fund the work done by the licensees on these sites
- the Ministry of Defence, which defines the overall strategy for the sites that it owns and funds the work done there
- LLWR as operators of the LLW Repository strategic integrator of radioactive waste diversion facilities, who define the acceptance criteria for waste
- other parties who may receive radioactive material from or send it to the site.

The regulators will work with these organisations to achieve high-quality radioactive waste management outcomes.

LLWR Requirements

As operators of the LLW Repository near Drigg, Cumbria and a strategic integrator of diversion services LLWR stipulate a number of requirements to access their services. These are detailed in LLW Treatment and Disposal Routes – Accessing the Waste Services[15] and various other documents available on the LLWR website[16].

Accessing the Waste Services

The waste acceptance procedure is set out in an overview document available on the LLWR website[16]. This tells waste producers how to consign waste to the treatment and disposal facilities and gives an overview of the operation of the LLW Repository, the LLWR waste services, and the contractual arrangements between LLW Repository Ltd and its customers.

A number of pre-requisites are necessary to access the waste services:

- Environmental Permit / Disposal Authorisation
- Agreement in Principle
- Signed Waste Services Contract
- Completed Waste Forecasting Form
- Completed Waste Characterisation Form(s)
- Completed Waste Assurance Form.

Whilst these pre requisites are contractual some also form the basis of how compliance with acceptance criteria is demonstrated and, in turn, mitigation of mis-consignment.

Assurance Activities

LLWR undertake periodic audit and inspection as part of their assurance activities as set out in the LLWR Waste Assurance Strategy, to ensure waste management is compliant with agreed arrangements and standards in line with the treatment/disposal acceptance criteria. This guidance is used to support these audit and assurance activities.

Audit and inspections adopt a risk based approach in that they target consignors that are high users, consign radionuclides specific to receiving facilities safety cases, or have exhibited issues with consignment.

These issues with waste consignments are recorded, assessed and trended, based on risk and ranked in a three tier approach which gives the risk clarity as follows:

- CAT1 – Intolerable: *Denoting that the issue has breached or would have breached regulations if not stopped (receiving site/facility permit; transport regulations) or is significant safety risk*

- CAT2 – Tolerable: *Denoting where an issue has been highlighted, but remains within the site/facility permit and safe working arrangements*
- CAT3 – Manageable: *Denoting an issue has been raised which is well within regulatory/permit/safety envelope but could cause misunderstanding*.

Risk is further broken down into specific areas of concern covering

- Packaging *(e.g ISO Container, Skips, Drums etc) – issues including damage, incorrect usage and manufacturing and design issues.*
- Documentation/Data issues
- Transport - *incorrect transport used and/or arrangements*
- Service Issues - *problems with the service*
- Miscellaneous - *not covered by other qualification*
- External radiological contamination - *on either packaging or transport vehicle*
- Verification Monitoring - *highlighted issues which require investigation.*

In respect to mis-consignment of waste this is therefore covered by the Documentation/Data and covers both issues with consignment paperwork and the physical aspects. Whilst all issues are used as a driver to facilitate audit and inspection the Documentation/Data criteria specifically highlights the potential for mis-consignment of waste. Indeed, LLWR define mis-consignment of waste as that being out with the waste formally declared, where the declaration will be made via some form of data/documentation.

Audit and Inspection is undertaken cognisant of LLWR requirements and, whilst observed non-compliance cannot lead to regulatory enforcement, they can ultimately lead to embargo of waste acceptance to LLWR treatment and disposal services and may entail the requirement for the waste consignor to provide:

- evidence that appropriate management systems as detailed in the Waste Assurance Form are in place to control the LAW management, and that these systems are adhered to in practice
- evidence that waste characterisation for LAW as detailed in the LLWR approved Waste Characterisation Forms relate to the waste and data within them is being used appropriately for waste consigned for treatment and/or final disposal
- evidence that controls are in place, and working, to ensure that no unacceptable items or materials are contained within the packages produced for treatment/disposal
- evidence that LAW is being stored in appropriate conditions to ensure its acceptability for treatment/disposal is not compromised and the necessary maintenance of storage facilities is being carried out to ensure that waste is being managed to specification and that appropriate storage conditions are maintained
- evidence that data and information records in respect to LAW management are being produced, maintained, and stored in a way which allows access and retrieval. So that future safety and environmental assessments can be carried out and that the wastes remain acceptable for treatment and or disposal
- evidence that licensees are optimising their approach to waste management and consider it good practice to develop and use an integrated waste strategy (IWS). Where an IWS has been developed the BAT should describe how the management of the waste stream(s) under consideration is consistent with the IWS.

LLWR's audit and inspection programme is produced annually and whilst, it is targeted using a risk based approach, it remains flexible to allow action in respect to emerging issues, particularly those relating to mis-consignment.

Section 2: Integrated Waste Strategies (IWS)

An integrated waste strategy (IWS) aims to describe:

- Where are we today
- Where do we want to get to and by when
- What actions are needed to get there

An IWS should therefore summarise the direction of travel and the key milestones that will occur within the short, medium and longer time periods, up to site end state. By necessity it sits within a complex map of other strategies and documents. The relationship between the IWS and waste inventory (both site and UK Radioactive Waste Inventory) is of particular importance because the inventory sets out the scope of radioactive waste to be managed.

The interface between the IWS and the site lifetime plan (or equivalent) is also important because the plan will set out the detailed actions for managing waste and therefore implementing the strategy. In addition, the plan for achieving the strategic objectives identified in the IWS should be detailed in a Joint Waste Management Plan (JWMP) to ensure alignment with the national LLW strategy as part of the National Waste Programme (NWP).

In line with UK policy, regulators expect the licensees to produce and maintain an IWS that represents an overview of their approach to the current and future management of all wastes generated on or received by the site(s).

The IWS should include all waste related activities on site, ranging from operational through to decommissioning activities, with wastes arising from contaminated land management included. The strategy should not be restricted to the consideration of material that the licensee currently regards as waste, it should include all material that may become waste in the future.

An IWS should demonstrate that the waste can be appropriately managed at the time and rate at which it will arise. Regulators and other stakeholders should be involved during the development of the IWS.

An IWS should be consistent with relevant good practice and should take account of interdependencies between waste streams and processes. The IWS should link with the licensee's decommissioning strategy and other relevant strategies. The IWS should demonstrate:

- consistency with government policy and regulatory expectations, including the Government's overall policy aims on sustainable development
- compliance with relevant legal obligations (e.g. licence conditions and instruments, authorisations, permits, consents)
- that the hazards posed by historic wastes are adequately characterised, controlled and progressively reduced
- the existence of a strategy in line with relevant good practice for the management of all the wastes over the whole lifecycle of the site
- the application of the waste management hierarchy
- that all radioactive wastes on site have been identified and assigned long-term management and/ or disposal routes.

The strategies should be adequate to allow licensees to cost their radioactive waste management and disposal liabilities and make appropriate financial provision for meeting them. From a safety and environmental regulatory point of view it is not necessary to set out the costs in the IWS.

If a licensee is responsible for a number of sites, then it may be appropriate to produce a corporate strategy supported by a series of site-specific strategies. Consideration should also be given as to how the strategy links to those of other licensees where there may be shared resources or where waste is transferred to or from another licensee.

As far as practicable, the IWS should be written to avoid the need for protective or commercial marking. If information requiring such markings is necessary as part of the IWS, then the protectively-marked information should be clearly identified (for example in a separate appendix) so that the rest of the document can be published in an unrestricted form.

The IWS should contain sufficient information to be self-standing and wherever relevant, provide links to other more detailed, supporting documents. An IWS should use appropriate and consistent quality assurance arrangements that include criteria and specifications for data and information, taking account of health, safety, environmental and security management systems as appropriate.

NDA has produced specifications[14] for integrated waste strategies for application on its sites. The regulators view these as examples of relevant good practice.

Strategic Options Study

It is anticipated that a strategic options study would be conducted to identify a strategy for a specific waste stream (or parts thereof); which ensures that opportunities for waste minimisation are maximised as far as is practicable throughout the lifecycle, from operations to commissioning.

Where appropriate, re-use and recycling of radioactive wastes should be given precedence over options for waste disposal. This is considered particularly important when a site enters its decommissioning phase because of the increased potential for solid waste volumes to be generated when materials from contaminated facilities, plant and land need to be managed.

A licensee's strategic options study should consider a range of options consistent with the concept of the waste hierarchy, including means for recycling and reuse of the materials, and decontamination and segregation, rather than simply a means for bulk waste disposal.

An example of how such a strategic options study may be carried out is given in[5] and supported by an Industry Code of Practice[6].

Section 3: Best Available Techniques (BAT)

Waste producers in the main fully understand both the requirement of and how to undertake Best Available Techniques (BAT) assessments, as detailed in the Industry Code of Practise on BAT[6], with respect to the production, content, maintenance and review of Best Available Techniques (BAT).

Whilst the use of Best Practicable Environmental Option (BPEO) and Best Practicable Means (BPM) continues to be a requirement by the Scottish Environment Protection Agency (SEPA) and the Northern Ireland Environment Agency, the Environment Agency (EA) and SEPA consider that the requirements to use BPEO/BPM are equivalent to the requirements to use BAT and that the obligations of waste producers are the same.

Different regulatory regimes in the field of radiological protection use different terminology and have their own guidance on this topic, namely:

- reducing risks as low as reasonably practicable (ALARP)

- use of best available techniques (BAT)
- use of best practicable means (BPM) and best practicable environment option (BPEO).

However, all of the above involve the same process, i.e. making a judgement between options by comparing benefits in terms of safety, environmental protection etc, and costs in terms of time, effort or money (EA, 2010)

Therefore, the guidance is applicable to Scotland and Northern Ireland. As defined by the Environment Agency, Environment Agency (2010) RSR: Principles of optimisation in the management and disposal of radioactive waste.

Identification and implementation of BAT implies a balanced judgement of the benefit derived from a measure and the cost or effort of its introduction. The level of effort expended to resolve an issue, and to record the selection process, should be proportional to the scale of the challenge, the range of options available and the extent to which established good practice can be used to assist in the decision making process. Nonetheless, guidance and precedent make clear that practicable measures to further reduce health, safety and environmental impacts can be ruled out as not reasonable only if the money, time, trouble or other costs involved would be *"grossly disproportionate"* to the benefit. The following principles should also be taken into account:

- sustainable development
- waste hierarchy and waste form
- the precautionary principle
- the proximity principle.

Subject to meeting regulatory obligations, the identification and application of BAT takes into account all relevant circumstances.

The identification of BAT is an important element within the decision making process, but does not necessarily represent the final decision. For instance, a study may be inconclusive, in that more than one approach may be regarded as essentially equivalent. In such a case, an element of judgement is required. Likewise, a decision may be influenced by other factors, either known at the time of the initial assessment or emerging subsequently. For instance, there may be reasons for implementing a disproportionate response. Where this is the case, the specific drivers need to be identified to avoid setting this as a new benchmark. This reinforces the need to document information, including constraints and assumptions, throughout the assessment process. Subject to meeting regulatory obligations at all times, there may also be a balance to be reached across site-wide initiatives, recognising that the balance of priorities may lie with achieving the biggest benefit or detriment reduction within a finite pool of resources.

Purpose

The primary purpose of a BAT study is to demonstrate optimisation of waste management options whilst maintaining doses to people As Low As Reasonably Achievable (ALARA).

The optimisation requirement covers all aspects of activities leading to the generation and disposal of radioactive waste. Optimisation is achieved through the use of specific permit conditions requiring the application of Best Available Techniques (BAT), where BAT means both the technology used and the way in which the installation is designed, built, maintained, operated and dismantled. Therefore, in principle, the regulation of radioactive waste disposal embraces all aspects of nuclear site processes - not just waste management - which have a bearing on radioactive waste production and which relate to the foreseeable disposal of those wastes at some stage. Therefore, it follows that BAT should be identified early in any process and implemented throughout its lifetime.

Review

It should be borne in mind that what constitutes Best Practice, BAT and optimisation will change with time, both as a result of technological developments and in light of policy, regulatory and societal changes. A programme of reviewing BAT may therefore be required, depending upon the timescale over which a process or operation will remain in place. This will be determined by a number of factors, including:

- function of the programme or process
- availability of new guidance, relevant good practice or techniques
- the current stage of a project
- timescale for which the programme or process applies.

For any programme or process which applies for several years, reviews should be undertaken at appropriate intervals to identify developments in guidance or techniques. The requirement to undertake a review of BAT should be identified as part of the conclusions to any study.

The availability of new techniques does not mean that they will automatically represent BAT. In particular, modification of existing processes, or retro-fitting of new processes within existing systems will require further detailed consideration. A technique or approach which represents BAT for a new application will not always represent the optimal approach when applied retrospectively.

Once BAT has been identified, it will form the basis for recommendations to the relevant decision takers. If the outcome of a BAT assessment is highly significant (for instance, in terms of novel or potentially contentious outcomes, or where previously unbudgeted capital expenditure is required), it may be appropriate that the study is subject to an agreed level of independent review prior to the decision taking.

A series of national strategic level optioneering studies providing guidance and technical underpinning for waste producers to inform their own local BAT / BPM assessments can be found on the LLWR website[16] under National Waste Programme.

- Strategic BAT –
  - National Strategic BAT for organic LLW – Jan 2014
  - National Strategic BAT for LLW metals – Mar 2015
  - National Strategic BAT for Soil, Concrete, Rubble, and Granular Material Low Level Waste – May 2016
  - LLW Asbestos and Asbestos Containing Waste – Gate B (Preferred Options) Study Report
- BAT Resource Guide – Oct 2015
  This guide provides information to waste producers and other stakeholders on the sources of information that could be used when undertaking a BAT/BPM assessment
- Nuclear industry code of practice (NiCoP) on the BAT
  This NiCoP presents the principles, processes and practices that should be used when identifying and implementing BAT for the management of radioactive waste.

Section 4: Waste Management

The successful implementation of a LAW management strategy requires that several activities are planned, undertaken and reviewed. Among these activities waste minimisation, characterisation and segregation are key to establishing and updating a radioactive waste inventory, applying the waste management hierarchy and optimising waste management. Opportunities for waste

minimisation, characterisation and segregation should be considered in all stages of waste management. For the purposes of this guidance, waste minimisation, characterisation and segregation are discussed as separate activities, but in reality form part of an integrated process for management of waste streams.

Minimisation

Minimisation of waste (both in terms of volume and activity) is fundamental good practice in LAW management. It should be considered during the design of facilities and applied during all of the basic steps. Effective methods of minimising the accumulation of LAW include the clearance of waste that is exempt from regulatory control and the reuse or recycling of radioactive material.

Minimisation is an important initial step in LAW management and, therefore, licensees' procedures should seek to design, construct, operate and decommission plant in such a manner that both the waste volume and radioactivity are minimised.

Characterisation

Characterisation of waste involves determining its physical, chemical, biological and radiological properties. Radioactive waste should be characterised at appropriate stages to determine the best method of managing the waste, either treatment or disposal and for establishing records of the waste properties.

Waste characterisation should also form an integrated part of an overall waste strategy in support of the waste throughout its lifecycle. The drivers for the characterisation may differ throughout the lifecycle but the overall purpose should be to support the long-term management option (re-use, recycle, treatment or disposal). However, at each stage characterisation activities should be undertaken for a specified purpose with cognisance of the next stage and later stages in the lifecycle.

With regard to planning an overall waste characterisation strategy, the International Atomic Energy Agency's (IAEA's) Strategy and methodology for radioactive waste characterisation[17] notes that activities in the various stages of the lifecycle may have significant effects on the cost and efficiency of the overall characterisation programme, in that:

- characterisation is generally much easier and cheaper in the earlier stages of the lifecycle e.g. waste properties that could easily be measured in the raw waste state may be difficult or impossible to measure after some treatment stages, particularly after conditioning has been undertaken;
- if waste streams are appropriately segregated and controlled early in the lifecycle, then a greater proportion of the wastes may fall into the simple and stable waste type; and
- whereas if raw waste streams are mixed and valuable history lost, more of the waste will fall into the complex and variable type, requiring more intensive and costly characterisation.

Segregation

Segregation is an activity where types of waste or material (radioactive or exempt) are separated or are kept separate based on radiological, chemical and/or physical properties, to facilitate handling and/or processing and/or disposal. It should also consider separation based on waste routing (metallic treatment, incineration, permitted disposal etc.).

Segregation of waste materials at source provides an efficient means of managing LAW in relation to their ultimate routing. A mixed waste stream may prove more challenging to manage and may have options foreclosed when compared to segregated waste materials.

Waste minimisation

Waste minimisation is central to government radioactive waste management policy and is recognised in international guidance as a fundamental principle of radioactive waste management[8]. Waste minimisation is also a regulatory requirement:

- Licence Condition 32 requires the licensee to make and implement adequate arrangements for minimising so far as is reasonably practicable the rate of production and total quantity of radioactive waste accumulated on site
- The standard EPR10 permit and RSA93 authorisation conditions require wastes to be minimised. Waste minimisation is fundamental to radioactive waste management.

Steps should be taken to avoid the unnecessary creation of radioactive waste and to minimise the production and accumulation of those wastes that are created, in terms of both the activity and volume. Minimising the generation of waste contributes to effective waste management and reduces the risks arising from such waste.

Waste minimisation and control of waste should be taken into account at all stages in the lifecycle of a facility, starting at the planning and design stage through to operation, decommissioning and site clearance. This will require developing commissioning, operational and decommissioning arrangements that avoid the creation of radioactive waste or reduce to the minimum radioactive waste generated during the lifetime of the facility.

In addition to enacting the waste hierarch reducing radioactive waste at source is an important means of waste minimisation. Consideration should also be given to the design of the facility and to operational features for waste minimisation. This includes the following aspects:

- the careful selection of materials, processes and structures, systems and components for the facility
- the selection of design options that favour waste minimisation when the facility is eventually decommissioned
- the use of effective and reliable techniques and equipment
- the effective containment of radioactive waste and minimisation of contamination
- the decontamination of zones and equipment and the prevention of the spread of contamination.

Waste hierarchy

The waste hierarchy is a stepwise approach to achieving waste minimisation to promote sustainability that considers the lifecycles of both the processes that create waste and the waste that is produced from them. The hierarchy, as set out in the latest European Directive 2008/ 98/ EC on Waste (the Waste Framework Directive)[18] encourages the adoption of options for managing waste in the following order of priority:

- Prevention: Creation of waste should be prevented, or reduced at source (i.e. minimised), as far as possible to secure the conservation of nature and resources, in particular waste that cannot be managed using current techniques, or techniques under current development
- Preparing for reuse: Where waste cannot be prevented, waste materials or products should, where appropriate, be reused directly or refurbished then reused
- Recycling: Waste materials should be recycled or processed into a form that allows them to be reclaimed as a secondary raw material, where appropriate

- Disposal (including Treatment): Only if waste cannot be prevented, reused, recycled or recovered should it be disposed of into the environment and this should only be undertaken in a controlled and authorised manner.

These principles have been adopted in the UK government policy on LLW management[8]. The regulators consider that, so far as is reasonably practicable, they should be applied during the planning, design, construction, manufacture, commissioning, operational and decommissioning stages of a facility. Applying the waste management hierarchy to radioactive waste generally requires:

- not creating waste where practicable
- reducing waste arisings (both by activity and by volume) to the minimum through the appropriate design and operation of processes and equipment and making effective use of techniques such as waste characterisation, sorting and segregation, volume reduction (e.g. by supercompaction) and surface contamination removal
- otherwise minimising quantities of radioactive waste requiring disposal through decay storage, reuse and/or recycling, and incineration
- disposal.

The objective should be to deal with potential arisings at the highest practicable level of this hierarchy, for example, reducing waste arisings should take precedence over disposal. Avoiding the creation of radioactive waste in the first instance and, secondly, minimising the generation of unavoidable waste is one of the foremost principles of good waste management.

It is recognised that there are limitations to the application of the waste hierarchy in the management of legacy wastes. For example, avoidance of waste creation does not apply to radioactive wastes that have already been created as a result of historical activities. In such cases, avoidance should be considered in respect of any secondary wastes which might arise during the storage, treatment and conditioning of the legacy wastes and further guidance on application of the waste management hierarchy, is available on the LLWR website[16].

Minimisation of both activity and volume

As far as reasonably practicable, radioactive waste should be reduced at source. Waste minimisation should take account of the volume and activity of radioactive waste generated and any secondary waste arising from subsequent treatment and conditioning of that waste. Useful strategies for waste minimisation include:

- reducing the volume of radioactive waste to be managed, by suitable segregation
- planning of activities and the use of suitable equipment for handling waste, so as to control the generation of secondary waste
- decontamination of material, together with the control of secondary waste arising from decontamination
- recycling and reuse of materials and structures, systems and components.

The chemical and physical characteristics of the waste should also be controlled at the source to facilitate subsequent processing and help minimise production of secondary waste. Factors that should be considered in judging what is reasonably practicable include the magnitude of radiological hazard, the potential for the hazard to be realised, the potential dose uptake and the cost.

Waste minimisation through continuous improvement

Waste minimisation should be maintained in operating plant through continuous improvement. At an operating plant, there remains considerable potential for significant reductions in radioactive waste generation through the application of relevant waste minimisation practices. It is acknowledged that significant design changes to operating facilities to minimise radioactive waste arisings may not be a cost-effective option. Nevertheless, reviews of operational processes and implementation of improvements can lead to waste minimisation benefits.

Waste minimisation can be achieved through a process of continuous improvement initiated by a commitment from senior management as part of the licensee's policy on radioactive waste management. The continuous improvement programme needs to commit adequate resources to waste minimisation, for example by setting up a dedicated team tasked with identifying and ranking waste generation practices and reviewing and feeding back into operational procedures. This should be linked to objective performance measures and tracking of performance.

Problematic wastes and waste forms

The Problematic Waste Integrated Project Team defines problematic wastes as: '*those wastes for which no defined waste management route is either available or currently planned in detail, or for which existing solutions are suboptimal'.* Therefore, wherever practicable, waste minimisation should be applied to ensure that production of problematic wastes and waste forms is kept to a minimum.

Record keeping

Recording quantities and activities of different waste streams provides the basis for monitoring the effectiveness of radioactive waste minimisation measures. Trends in radioactive waste generation should be monitored and the effectiveness of applied waste minimisation measures demonstrated. There should be regular reviews of opportunities for further reduction of radioactive waste arisings. See section 7 on records management for additional information.

Environmental management system

Waste minimisation forms part of the objectives of an environmental management system. Accreditation to an appropriate standard may be used as an indication of commitment to waste minimisation. At the time of writing the following British and International standards provide core information for Environmental management systems[19].

Waste characterisation

A systematic approach to waste characterisation should be adopted in order to acquire data that sufficient to support waste management decisions throughout the waste lifecycle. This might be achieved, for example, by adopting an approach based on Data Quality Objectives, which define the quality and quantity of data that are required in the decision context (e.g. the Data Quality Objectives process developed by the US Environmental Protection Agency[20], provides a systematic, stepwise approach to the collection of data to support waste management decisions and has been applied to waste characterisation programmes.)

An important aspect is finding the balance between the impacts and cost of data gathering and the effects of uncertainties in data on the resulting decisions. It is particularly important to ensure that the resources are committed only in situations where the output will provide net benefits.

A strategy for waste characterisation covering the stages from raw waste retrieval through to treatment or disposal should be developed by the waste producer and should also include any

conditioning and decay storage options as applicable. The characterisation programme should be supported, where practicable, by a suitable waste sampling plan that is designed to provide a statistically robust data set. Where comprehensive sampling and characterisation is not practicable, for example due to dose considerations, this should be explained and arguments should be presented as to why any alternative approach is considered appropriate.

Appropriate quality assurance arrangements should be adopted throughout the waste characterisation process and beyond to ensure records retention and knowledge management. This should encompass appropriate method development and documentation, staff training, and verification and validation of measurements. Ultimately the aim should be to ensure that all resulting characterisation data is fully traceable and underpinned.

A wide range of approaches to waste characterisation are possible and use should be made of appropriate endorsed industry codes of practice. In general, preference should be given, where practicable, to direct measurement and determination of waste characteristics. This might be achieved using destructive and/or non-destructive techniques applied either in situ or using retrieved waste samples.

Where practicalities dictate, reliance may also be necessary on other lines of evidence, such as knowledge of the provenance and history of the raw waste (where supported by records), knowledge of waste evolution, the use of simulants and modelling techniques. Whatever approach is adopted, it should provide corroborated data with suitable uncertainty bounds that are sufficient to demonstrate that the waste meets the relevant waste acceptance criteria. The waste characterisation approach and procedures should be appropriately documented and subject to approval against the Waste Acceptance Criteria of the receiving facility, ultimately by the facility operators as permit holders.

Characterisation and associated records generated by the waste producer must be appropriately managed (refer to section 7) as this data may eventually need to be passed on to other organisations (including regulatory bodies) which subsequently handle, treat, store, transport or dispose of the waste.

Characterisation for subsequent management and disposal

Development of an IWS is contingent upon the availability of information relating to the nature and quantity of wastes. The radiological, physical, chemical and biological properties of waste should be known in sufficient detail so as to provide a sound foundation for its safe and effective management from generation through to treatment/disposal. Waste characterisation will be required, for example, to inform decisions about the design, operation, maintenance and decommissioning of facilities; handling, storage, processing and transport of radioactive wastes; remediation of contaminated land; the treatability and/or disposability of wastes. Waste should be characterised so as to inform decisions about its subsequent management and treatment/disposal.

Waste characterisation information will be required at an early stage to support any optioneering studies and to ensure that the waste management hierarchy can be applied appropriately. The characterisation challenge for a given wastestream may vary depending on the nature of the waste and the waste routing that is selected. Characterisation information and requirements might usefully discriminate between options for the future management and treatment/disposal of that waste.

While adequate waste characterisation is essential, unnecessary over characterisation resulting in inappropriate cost, occupational radiation exposure and secondary waste generation should be avoided. Provision should be made at the earliest stage for identifying, assessing and dealing with radioactive waste that does not meet existing process specifications or treatment/disposal criteria.

Inventory

Radioactive waste should be identified and an appropriate inventory established. This should be properly documented for each wastestream, with the data undergoing periodic review and update accordingly. The establishment and maintenance of a radioactive waste inventory by waste producers is required for a number of reasons, in particular:

- to assist the waste producer in planning waste management by providing underpinning data for lifetime plans and integrated waste strategies
- to assist in the maintenance of a UK radioactive waste inventory[21,22] which can be used by those government departments and agencies involved in radioactive waste management strategy and regulation and the NDA, which is responsible for the development of long-term management solutions for these wastes
- to assist the UK in fulfilling its requirements under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management[23,24].

Characterisation from generation through to treatment/disposal

Further waste characterisation should be considered at appropriate stages from generation through to treatment/disposal and should be carried out:

- where there is a lack of sufficient information or knowledge to support a BAT assessment and where further information is required to support subsequent phases of management
- where information might be out of date or where there is the potential for significant impairment to the safety case as a result of changing waste properties
- to ensure when specific waste routing for treatment is employed that both the physical and chemical properties meet the stipulated criteria and that the radionuclide content and radionuclide fingerprint content/ratios are appropriate and valid
- for quality assurance or checking
- at stages when useful information can be obtained that might otherwise be lost.

Characterisation data may be gathered on a progressive basis through the relevant stages of waste management, but there should be sufficient confidence at each stage to support decisions. Characterisation opportunities are perhaps greatest at the time of raw waste generation (i.e. characterisation at source). Characterisation opportunities may be limited for existing wastes, although opportunities may arise at the time of raw waste retrieval for subsequent processing.

Where waste is being conditioned it should be sufficiently characterised to inform subsequent decisions about its suitability for further treatment or disposal. Detailed characterisation is likely to be problematic following waste conditioning and non-destructive techniques may provide limited details. Significant package reworking may be required if detailed characterisation is required following waste conditioning and such situations should be avoided.

Certain wastes (raw or conditioned) might evolve or degrade over time. Understanding such effects, the implications, and any necessary mitigation is important.

Radiological, physical, chemical and biological properties

Radioactive waste should be appropriately characterised in terms of its radiological, physical, chemical and biological properties and this should provide sufficiently accurate and precise information to support the BAT assessment, including the anticipated requirements for transport, potential treatment and disposal in so far as these are known.

Waste characterisation information should encompass the following:

a) Radioactivity

The radioactivity content of the waste should be known with sufficient accuracy and precision to meet any limits defined within the relevant BAT assessment. It should also be known in order to meet any existing Waste Acceptance Criteria (WAC) of facilities to which it is being, or may be, routed, in so far as these are known.

Consideration should be given to assessing the suitability of the radionuclide content (fingerprint) in regards to the routing of waste. Specifically, if the wastestream itself undergoes segregation (e.g. metallic items removed for treatment), does this result in the fingerprint being compromised in that a particular radionuclide which may be negligible in the overall wastestream become highly significant in the segregated waste items.

The radioactivity content of the waste should be known so that it can be robustly classified in terms of the waste category (i.e. as exempt waste, very low level waste (VLLW) or low-level waste (LLW)). Knowledge of the radioactive properties of the waste will assist in assessing whether decay to a lower waste category is possible within a reasonable timescale, and therefore inform decisions on its future management and routing for treatment/disposal.

The requirements may extend to defining the activities of specific radionuclides that are significant, either at the individual consignment or wastestream scale. An accurate knowledge of the radioactivity content of individual waste consignments is particularly important in terms of:

- waste transport, compliance with transport regulations
- waste routing, compliance with the Waste Acceptance Criteria of the intended treatment/disposal facility
- ability to effectively treat waste at a treatment facility.

b) Dose rate

Dose rates should be known in sufficient detail to indicate adherence to both characterisation and BAT assumptions. This is particularly important where dose rate is used to provide correlation to the radionuclide content via the use of robust and underpinned conversion factors.

Package external dose rates should be known so that compliance with the limits for transport and the facilities in which they will be handled, treated and/or disposed can be demonstrated.

c) Surface contamination

For wastes destined for treatment the amount and extent of any non-fixed surface contamination should be known. Transferable radioactive contamination on the exterior of the waste items should be maintained within limits established for receiving facilities where these wastes are to be handled.

d) Fissile content

For wastes containing fissile matter the nature and quantity of the fissile materials and any other waste components that may influence the neutron reactivity of the system (e.g.

neutron moderating or absorbing material) should be known in sufficient detail to enable assessment of the criticality hazard in order to facilitate safe management and treatment/disposal arrangements. Waste package fissile limits are discussed specifically and in greater detail in section 5 (Waste Consignment) of this document.

e) Chemical properties

The bulk composition and chemical properties of the waste should be understood to the extent that any chemical hazards or challenges posed by the waste can be assessed and made safe if applicable. Specific information with regard to the following will be required, where applicable:

Organic components: this should include organic components that present a hazard based on their inherent toxicity, might degrade/decompose to yield gases (such as carbon dioxide, hydrogen and methane), might be radioactive, explosive or present a flammability hazard, might influence the neutron reactivity of the system (e.g. effective neutron moderators), or which might degrade to form species which can enhance or promote the mobility of radionuclides in the treatment/disposal environment.

Reactive components: any waste components that might be expected to react within the waste matrix or within the container should be identified, such that any threat posed to the integrity of the waste can be assessed. Reactive components might include metals that may react with the waste matrix (forming reaction products causing expansion of the waste form and disruption of the waste package), gases which may be radioactive and/or flammable, ion exchange resins that may react with the waste matrix, graphite which may have associated Wigner energy, materials which may significantly influence the pH of the waste form and any materials that may challenge the integrity of the waste container via chemical reactions in the long term.

Explosive, flammable, combustible, corrosive and pyrophoric materials: any such components should be identified. This extends to any waste components which might evolve to form materials with such properties in the long term, or the presence of any materials that would be classed as dangerous goods for transport purposes or material covered under the relevant Hazardous[25], and Special Waste Regulations[26] (in Scotland).

f) Physical properties

The bulk physical properties of the waste should be understood to the extent that any risks posed by the waste can be assessed and such that compliance with any acceptance criteria can be demonstrated. Such information might be required, for example, to support any waste handling and stacking operations.

Knowledge of the following physical properties might be required:

- the physical dimensions and weight of the waste
- the physical form of the waste e.g. homogeneity and morphology
- the presence of any mobile, volatile, readily dispersible, or leachable fractions
- the presence of any free liquids or pressurised gases in the raw waste requiring exclusion prior to consignment.

g) Biological properties

The biological properties of the waste should be understood in terms of:

- The presence of substances within the waste, which through microbial degradation might result in the production of significant volumes of gas and/or acidic species. This would extend to the presence of any significant quantities of putrescible matter;
- The possibility that the waste will promote and/or support microbial-induced corrosion of metallic containers
- Any specific biological hazards, such as might occur via the presence of pathogenic or infectious species (this is likely to be relevant only to contaminated medical wastes).

Waste segregation

Segregation of LAW involves accumulating together those materials with similar characteristics, and avoiding mixing wastes with different characteristics. The IAEA Safety Glossary[27] defines segregation as *"An activity where types of waste or material (radioactive or exempt) are separated or are kept separate on the basis of radiological, chemical and/or physical properties, to facilitate waste handling and/or processing."* So far as is reasonably practicable radioactive waste should be segregated to facilitate subsequent safe and effective management.

Emphasis should be placed on the segregation of different types of waste to reduce the volume and specific activity of radioactive waste and facilitate its management and eventual disposal. Specific drivers for waste segregation might include:

- facilitating application of the waste management hierarchy by enabling, reuse, recycling or reclassification to more easily treated/disposed radioactive waste
- separation of short-lived wastes to enable decay storage
- removal of items which need special treatment
- removal of items that do not conform to Waste Acceptance Criteria for those facilities where the waste is to be treated or disposed of
- separation of waste materials that may react together to challenge the integrity of the wasteform or container significantly
- categorisation of waste into various wastestreams which are similar in terms of their properties, conditioning requirements and/or management arrangements
- simplification or facilitation of particular waste management operations.

Early and appropriate segregation can contribute significantly to the safe and effective management of LAW. As segregation is most efficient if it is taken into account at the process design stage, any opportunities for waste segregation should be an important consideration. Waste segregation should be performed as close to the point of generation as is reasonably practicable. Early and appropriate segregation can contribute significantly to the effective and safe management of radioactive waste.

There may be cases in which waste segregation may offer potential benefits but is not pursued in practice e.g. due to it being impractical and/or disproportionately costly. In such cases the BAT should substantiate why waste segregation is not being pursued.

Mixing of wastes need not be precluded where this can be shown to provide net benefits in terms of health, safety and environment. However, dilution of waste (e.g. deliberate mixing of clean/exempt waste with radioactive waste) should not be undertaken. Blending of radioactive waste (e.g. deliberate mixing of borderline ILW with LLW) may be deemed BAT where it enables the timely reduction of high hazards and risks or significantly reduces worker dose and/or cost.

Where segregation is to be pursued, the BAT should demonstrate provision of suitable and sufficient design features, locations, equipment and arrangements to support segregation operations.

Section 5: Waste Consignment

Once LAW management strategies have been decided in line with the guidance in Section 4 attention can be turned to the actual activities required to consign LAW via the routing for either treatment or disposal.

Waste Conditioning

Conditioning of radioactive waste requires mitigation (e.g. carried out as part of process to make the waste safe) and involves transforming the LAW it into a form suitable for handling, transportation, re-use, treatment and/or disposal. It should not be undertaken for the sole purpose for the transforming of higher activity wastes to enable re-categorisation and subsequent treatment/disposal, unless supported by a regulatory endorsed BAT case for doing so.

Conditioning may be accomplished in a single stage (e.g. within one facility) or may be achieved through multiple stages. Where a multi-stage conditioning route is chosen risks and environmental impacts during and between all stages should be reduced so far as is reasonably practicable and should be appropriately balanced. Any conditioning process should take into account and not foreclose possible future treatment/disposal options.

If conditioned then LAW should be in forms that are acceptable to the requirements for onward recycling or re-use, treatment and/or disposal such that the nature and properties of the conditioned waste product are compatible with the Waste Acceptance Criteria (WAC) of the receiving facility. Indeed it is a requirement of most EPR permits.

A wide range of technical, engineering and management considerations are relevant to waste conditioning programmes to ensure that the conditioned waste is fit for purpose. Relevant considerations include, but are not limited to, the following:

- the nature of the waste and its characterisation (related aspects are covered in the previous section)
- when to condition the waste; consider if activity associated with the waste is suitable for recycling or needs to be immobilised within a waste container and the method of waste immobilisation
- the design, manufacture, appropriate nature and quality assurance of waste containers to be used
- the conditioning process, including the relevant plant specifications, design and operation, to ensure the production of ‘fit for purpose’ conditioned waste;
- understanding potential evolution or degradation mechanisms, the implications and any necessary mitigation
- quality assurance arrangements over all stages of management
- waste records and their long-term retention (related aspects are covered in section 7 of this guidance).

When to condition waste

LAW should only be conditioned as part of an integrated waste strategy to realise a waste form that is suitable for treatment and/or disposal. Whilst this can include decay storage to re-categorise waste or the addition of a matrix in order to render the waste safe, it precludes the addition of a matrix solely for the purpose of waste re-categorisation unless this is justified by a regulatory endorsed BAT case.

Recognised specific drivers for conditioning may be where:

- wastes are held in deteriorating facilities and retrieval is necessary
- wastes have been identified suitable for recycling and reuse
- existing waste storage arrangements need to be improved
- provisions can be made to condition the waste as it arises and the accumulation of raw wastes can be prevented
- conditioning plant is available that has the capacity and functionality to condition the waste, thus providing an opportunity for appropriate, timely and cost effective waste conditioning
- a disposal route already exists and waste requires conditioning to facilitate safe transport to the disposal site and to meet the waste acceptance criteria at the disposal facility.

Waste conditioning approaches

The environmental regulators have published guidance on the principles of optimisation in the management and disposal of radioactive waste[5,6] . The optimisation requirement applies not only to the conditioning process itself but throughout the lifetime of the conditioned waste. To decide which conditioning process to use the licensee should identify the available options and choose the one which best meets the optimisation requirement for the subsequent waste treatment/disposal.

The overall conditioning process should be technically underpinned and this may require programmes of experimental and developmental work and/or reliance on established knowledge and operational experience. Development work may need to include both inactive and active development trials which may include both small-scale and full-scale trials. The combined development programme will need to demonstrate that the conditioning process will produce fit-for-purpose, quality-assured waste products and that the process can accommodate any potential variations in waste feeds.

Preparing wastes for conditioning

The need for and benefits of pre-treatment processes which includes sorting and segregation, whilst not appropriate for all wastes, should be evaluated prior to conditioning. In particular pre-treatment should be considered for the purpose of:

- significantly reducing LAW disposal volumes
- significantly reducing risks and/or uncertainties for future waste management
- the recycling of metallic wastes for beneficial reuse
- removing or suppressing chemical reactivity or biological degradation within the waste that could present a challenge to its management, treatment and eventual disposal
- drying wastes to minimise the risk of corrosion and gas generation.

Waste immobilisation

The immobilisation of readily mobilised or dispersible waste is usually achieved by conversion of the raw waste into a solid wasteform, usually for disposal, as a part of the waste conditioning process and will generally be required for wastes that contain free liquids, slurries, sludges or readily dispersible particulate material.

Whilst these wastes in their raw form may not be permitted against the receiving facilities WAC it is feasible that a process rendering these raw wastes safe results in an acceptable waste form. It should be noted that conversion to solid waste solely to meet the receiving facilities WAC requirements requires justification through a regulatory endorsed BAT case.

The immobilisation process should be selected by the licensee as part of the overall options appraisal on the basis of the properties of the waste to be treated, the hazard that it presents, the requirement to make safe and after considering alternatives (e.g. encapsulation of ion-exchange resins). Following immobilisation the resulting wasteform should be shown to restrict the movement of radioactive and hazardous waste constituents as expected.

Waste containers

The waste container should provide appropriate containment of the waste through all phases of waste management consistent with the relevant requirements of the receiving facility required. The container should be selected based on the waste route and transportation requirements. Where waste is being routed for treatment consideration should be given to the container type for potential re-use and, conversely, where it is being routed for disposal it should be compliance with the disposal facilities WAC. Ideally, the treatment provider may have the capability to provide packages that best fit their WAC and facility operating parameters. Where possible, consignors should use the receiving facilities own packages.

Waste containers should incorporate suitable design features to ensure the safety functions required are maintained for package handling through the successive phases of waste management, including off-site transport and eventual treatment/disposal. There may be significant advantages in adopting standardised fit-for-purpose container designs.

Where gas generation is anticipated containers should be designed appropriately to include features to avoid over-pressurisation (e.g. gas vents) but to retain particulates (e.g. filters in the gas venting system).

The waste container, including any integral handling or lifting features should be suitably resistant to processes that could adversely alter material properties and cause early failure. For metallic containers this should include resistance to general and local corrosion mechanisms. This may be achieved through an appropriate combination or choice of materials, suitable storage conditions, protective coatings and/or other methods.

Containers should be manufactured to defined specifications within an appropriate quality assurance regime as required by the container design authority. Handling and storage of containers prior to use should be managed to minimise the possibility of surface contamination (e.g. by corrosive agents) in line with the container packing and handling instructions.

The location and the exact contents of each waste package should be known at all times. To facilitate this each container should be marked with a unique identifier linked to its appropriate package and location records. Package identifiers will need to remain legible especially for packages containing waste destined for recycling, which may not be processed for a number of months/years.

The design life of waste container should be consistent with the national strategies for waste management and should encompass the timescales associated with the future phases of waste management, including storage, transport and treatment/disposal, as anticipated at the time of manufacture.

Identification of any potential container degradation mechanisms that may threaten container usage or safety functions will be expected as a part of the management of LAW. Such information should be used to inform monitoring and inspection strategies and to underpin early thinking as to what remediation measures may be required.

Particular approaches to maximise longevity include the following:

- sorting and segregation of mixed wastes that may be mutually incompatible (see section 4)
- removing or reducing waste reactivity by treatment prior to or during waste loading
- using waste conditioning matrices that are inert or beneficial with respect to the container material and the waste
- periodic inspection followed by appropriate remedial action, where necessary. This could include remediation of container faults to mitigate further degradation, or checking of waste containers for signs of corrosion (followed by appropriate remedial actions where problems are identified).

Waste inventory

The radionuclide, chemically reactive, biologically degradable, hazardous and challenging materials content of each waste package should be known in sufficient detail and with sufficient accuracy to meet any treatment/disposal requirements and the aim should be to fully characterise the waste (see Section 4) taking into account the information needs for both treatment and/or disposal.

Where treatment is being undertaken, radionuclide, chemically reactive, biologically degradable, hazardous and challenging materials content information should be readily available, to the treatment facility, to enable both the treatment and compile the radionuclide, chemically reactive, biologically degradable, hazardous and challenging materials content of secondary waste requiring disposal.

Knowledge of the content of each waste package should extend through measurement and/or assessment to an understanding of:

- the radionuclide inventory of the package (noting this is needed for treatment, handling purposes and to define the total inventory for a disposal facility)
- package dose rates
- contamination levels on external container surfaces
- organic waste constituents particularly those that present a hazard based on their inherent toxicity, their ability degrade to yield gases that may be toxic, or present a flammability hazard, influence the neutron reactivity of the system, degrade to form species which challenge the integrity of the waste container or enhance/ promote the mobility of radionuclides in the disposal environment
- chemically reactive constituents, particularly those that react adversely within the waste matrix, with the container or with each other (e.g. include metals or ion exchange materials that may react with the waste matrix and disrupt the waste package by an increase in volume), graphite (potential Wigner energy), and materials which significantly influence the pH of the wasteform or challenge the container integrity
- explosive, flammable, combustible, corrosive and pyrophoric materials: including any waste constituents which have potential to evolve to form these materials
- any materials that would be classed as dangerous goods for transport purposes or material covered under the Hazardous Waste (England and Wales) Regulations[25] and the Special Waste Regulations[26] (in Scotland).

Good record keeping is particularly important given information and records may be required over extended timescales to support on-going waste management and disposal (see section 7) and should be readily available for audit and inspection (see section 1).

Fissile material

Criticality safety principles apply to the processing, handling, storage, conditioning, transport, treatment and disposal of waste containing fissile material, and whilst this may not strictly pertain to LAW it is included in this guidance for completeness.

Facility safety cases will need to demonstrate acceptable sub-criticality margins during storage taking account of possible accident conditions (e.g. flooding), and any uncertainties that may exist. Engineered controls may include safe geometry, structural separation and the use of neutron absorber materials (i.e. neutron reactivity poisons), where appropriate. Safety cases for multiple fissile units in storage arrays should take account of neutronic interactions between the units.

Waste package fissile limits should be defined such that criticality events are not credible. Limits should be derived via assessments to cover the handling, storage, transport and treatment/disposal phases of waste management in line with the receiving facilities permit for either treatment or final disposal of the waste

It may be appropriate to characterise wastestreams according to their intrinsic neutron absorption and moderation properties. Reduction in the uncertainty in the quantities of neutron absorbers and moderators present in the waste may in turn lead to an increase in permissible levels of fissile material per waste package.

Package design and loadings should be such that a criticality event is not credible against identified faults during operations and transport for both normal and accident scenarios. Whenever transported the fissile content of the waste, its packaging and condition must be such as to satisfy the requirements of the waste transport regulations.

Waste conditioning operations should be suitably controlled so as to ensure compliance with the relevant waste package fissile limit. Where the fissile content of the waste is determined during the conditioning operation sampling error and assay system error should be considered in calculations to determine operational compliance with fissile mass limits. Following conditioning the fissile content of the waste package should be known with sufficient accuracy to ensure compliance with the relevant fissile limits.

Waste package specifications

The Low Level Waste Repository Limited (LLWR) disposal concept is underpinned by a suite of documentation on waste package specifications and guidance produced by the LLWR packaging licence authority. The waste package specifications are owned by LLWR/NDA. Early engagement with both the regulators and LLWR is essential for waste which does not meet the standard published waste package specifications. The current guidance can be found on the LLWR Web Site[16]. In addition, waste treatment suppliers may also provide access to waste packages that best suit their facilities. Guidance on the use of such packages can be obtained from the LLWR Waste Management Services team.

Information and records relating to waste consignment

An integral aspect of preventing mis-consignment is the requirement to correctly identify and label waste items within a consignment, ensuring that the physical, chemical and radionuclide content is applicable to the treatment/disposal route and linked to characterisation of the waste.

Quality management should be applied to all aspects of preparing of LAW consignments and the Quality Management System (QMS) should comply with a suitable quality standard (e.g. ISO

9001:2015[28]) and it is the responsibility of the licensee to provide the necessary assurances related to the quality of the waste consignment.

Information and records should be assembled for and about each waste consignment (referenced by a unique identifier) containing all relevant details of the consignment including:

- waste description and origin
- volume and weight of the waste
- waste history, including decay storage if applicable
- conditioning, if applicable
- radionuclide inventory including assessment
- physical/chemical inventory
- packaging processes and containers in which the waste is placed
- process records
- specific safety and other criteria such as those imposed, for example, by criticality compliance, international safeguards and hazardous waste regulations
- administrative information, including records of authorisation for final disposal.

Arrangements for assuring the quality of processed waste should be addressed in the consignor's quality management system and should detail audits to be undertaken (see section1) at appropriate intervals to provide confirmation that the overall process, resultant products and records are compliant.

Further guidance on information management requirements are provided in section 7.

Specific considerations for disposal

Considerations for LLW disposal at the LLW Repository or VLLW disposal at permitted landfill, should encompass any potential interactions of significance between the waste and the disposal environment, be able to demonstrate compliance with the facilities WAC and include:

- the composition of the waste, e.g. its radionuclide inventory and the presence of any reactive or toxic constituents, is known in sufficient detail to allow future compliance with the safety case and corresponding WAC
- The waste within the container matches documentation, e.g. photographic evidence of waste corroborates disposal manifests
- the waste can be safely handled and managed within the facility during emplacement and prior to facility closure.

Specific considerations for waste diversion

Considerations for LAW treatment at permitted facilities (e.g. metals recycling, incinerators) should encompass any potential interactions of significance between the waste and the environment within the treatment facility and be able to demonstrate compliance with the facilities WAC. Potential impacts of the waste on the performance of the facility should include assurance that:

- the composition of the waste, e.g. its radionuclide inventory and the presence of any reactive or toxic constituents, is known in sufficient detail to demonstrate compliance with the safety case and corresponding WAC
- The waste within the container matches documentation, e.g. photographic evidence of waste corroborates manifests
- the waste can be safely handled and managed within the facility during treatment
- any resultant secondary waste will be compliant with receiving facilities

- Not only will this help mitigate any safety/environmental risks, but also alleviates commercial risks associated with the treatment/conditioning of the waste.

Section: 6 Interim Storage

Storage in many cases may not be seen as an aspect of LAW management, as in general it is covered under Environmental Permitting and Licence Conditions, where accumulation and treatment/disposal limitations are stipulated. However, more cases are being highlighted where waste is being interim stored to allow decay in order to meet business needs and maximise opportunities for treatment or disposal. Decay storage may therefore become a crucial part of the long-term management strategy by providing an extendable safe and secure means to hold waste and ensure protection of the public and environment, prior to final treatment/disposal.

As the fundamental requirement for the interim storage of LAW are in general the same for that of HAW then the principles for the requirements for HAW storage where, if raw waste is stored, it should be contained in a manner that avoids deterioration and allows retrieval for processing and eventual disposal, whilst maintaining standards of safety and environmental protection can be applied. Such arrangements may assume a single store to cover the entire period or may provide for replacement or refurbishments of stores at appropriate intervals.

This section of the guidance is worded in a manner that presupposes that the radioactive waste has been fully characterised prior to packing for interim storage and that the waste meets the requirements, as far as reasonably known, for future processing. LAW should be contained in a manner that avoids deterioration and allows retrieval for processing and eventual treatment/disposal, whilst maintaining standards of safety and environmental protection.

Inspection

Periodic inspection of the packages used for the storage of the waste should be undertaken to ensure the package remains in an acceptable condition. This is typically achieved through visual inspections including routine maintenance (as per the package and handling instructions for the appropriate package – see LLWR website[16]), to confirm that any such degradation will not affect the ability to retrieve and process the waste as planned.

There are many reasons why it may be appropriate to store waste for varying periods of time. Examples include the following:

- to allow for the decay of short lived radionuclides to a level at which the radioactive waste can be released for treatment/disposal as LAW
- to collect and accumulate a sufficient amount of radioactive waste prior to its transfer to another facility for treatment and conditioning
- whilst awaiting processing/treatment (e.g. metallic)
- to collect and accumulate a sufficient amount of radioactive waste prior to its consignment.

Interim storage

LAW requiring interim storage should be stored in accordance with the relevant site permit and is required to be in a form that is physically and chemically stable and stored in a manner that allows for retrieval for onward treatment/disposal.

To achieve interim safe storage and minimise the risk that a waste package will require intervention prior to onward treatment or final disposal, following requirements should be fulfilled:

- the waste provenance should be fully known
- the waste form and its container should be resistant to degradation
- environmental protection should be appropriate to minimise container degradation
- the storage environment should optimise the waste package life
- the waste packages should be easily inspected
- the waste packages should be retrievable for onward processing
- the lifetime of the storage building should be appropriate for the storage period prior to onward processing.

In designing a waste storage facility (building, structure or area) impacts of the environment must be considered on the waste/waste containers along with the ability to receive, handle, inspect or monitor waste/waste containers. The design of the storage facility should therefore be fit for purpose, taking into account the expected time required for storage, any hazards posed by the stored wastes and any effects which would cause deterioration of the waste or container over the storage period.

Where there is a potential for water and ground water ingress, storage facilities should include features to monitor for water and groundwater ingress and the means of collecting and removing any water that enters the facility. Any discharge to the environment of water collected from the inside of the storage facility that could have been in contact with radioactive waste will need to be managed.

Acceptance criteria should be set for the storage facility subject to the Environmental Permit, include arrangements to assure compliance. These should include the suitability of the waste packages for handling, retrieval and onward waste management cognisant of any potential future treatment/disposal requirements.

Inspection and assurance

Processes and procedures detailing auditing, inspection and testing, should be designed and implemented to ensure that waste packages meet the acceptance criteria for storage on receipt. Before being placed in storage, waste packages should be monitored and inspected to establish the baseline condition and arrangements should be in place, either at the storage facility or other suitable facility to deal safely with non-conforming waste packages.

At any point it is found that the radioactive waste does not meet the criteria for either further treatment or final disposal then any processing required should be undertaken in a proportionate and timely manner. Contingency plans should be prepared for packages that do not meet the acceptance criteria for the storage facility.
A waste package monitoring programme should be developed and implemented to confirm that waste packages and storage facilities remain in an acceptable condition for continuing safe storage and retrieval prior to final treatment/disposal.

It is not inconceivable that storage prior to treatment/disposal may last for a number of years and comprehensive information and records need to be assembled as part of the storage arrangements.

Records

Licence Condition 32 – Accumulation of radioactive waste requires that records be kept of radioactive waste accumulated on nuclear licensed sites. Licensees are required to make and maintain adequate records of the inventory and management actions associated with the radioactive waste stored. The information contained on these records should include:

- details of packaging
- operational history of processes and stores
- records of non-compliances with specifications
- records of any relevant incidents.

Records should be kept in such a way that sufficient information can be extracted for both current and future needs for each individual waste package. They need to be securely retained and to be accessible when required.

Detailed guidance on managing information and records relating to radioactive waste can be found in section 7.

Section 7 Managing information and records relating to radioactive waste

The safe management of LAW both now and in the future requires the maintenance of adequate records ensure the processes involved, particularly as these processes from generation to the subsequent treatment/disposal entail it will be necessary to transfer records.

At any point in time the records must be sufficient to address the needs of all stakeholders, including the waste owners/producers, waste management facility operators, regulators, government, and the public and future generations.

There are currently national and international standards and practices for managing radioactive waste-related records in the long term. Whilst not all may be pertinent to LAW records or quoted in this document the intention is to provide some guidance. Where long timescales are involved standards and practices will be subject to review and revision and licensees should be mindful of this through the application of their own procedures to ensure that new standards and practices are identified and implemented as appropriate.

Every organisation responsible for managing radioactive waste must establish and implement a system to create, maintain and manage comprehensive, accurate and reliable records. Such systems should be designed with due consideration of all stages of the waste lifecycle including any necessary transfers of records from or to other parties. Stakeholders should work together to establish common systems and approaches and to ensure that records can be transferred without compromise.

The ONR's Safety Assessment Principles (SAPs)[1] provide the underlying basis for regulatory judgements made by ONR. RW.7 expects that *"information that might be required now and in the future for the safe management of radioactive waste should be recorded and preserved."*

The environment agency's Environmental Principles apply in England[3] and Wales[4]. RSMDP14 expects that sufficient records relating to radioactive substances and associated facilities should be made and managed so as:

- to facilitate the subsequent management of those substances and facilities
- to demonstrate whether compliance with requirements and standards has been achieved
- to provide information and continuing assurance about the environmental impact and risks of the operations undertaken, including waste disposal.

Timeframes

An information management system should meet the demands likely to be inherent in the next generation of waste custodians. The current generation should not impose an approach that might foreclose future opportunities for the effective transfer of information and records particularly as it is impossible to predict the needs of or the technology available to society over a long timeframe.

The processes applied to manage and store records both short and long-term will vary depending on usage and it is important that such records are managed such that they can be accessed at any time.

Procedures should be implemented for keeping records under review and this should take into account the continuing relevance of the information, the suitability of the medium on which it is stored and the needs and expectations of stakeholders.

Specific guidance on authorisation of disposal facilities[29,30] expects that *"During the period of authorisation of a disposal facility, the records will be needed by the organisation exercising control and, potentially, by the regulators. We shall expect the operator to make arrangements at the end of the period of authorisation for the records to be included in the public archive."*

Information and records management policy and strategy

The Lord Chancellor's code[31] provides a framework for relevant authorities to manage their records and states:

- Authorities should have in place organisational arrangements that support records management
- The records management function should be recognised as a specific corporate programme within an authority and should receive the necessary levels of organisational support to ensure effectiveness
- Authorities should have in place a records management policy, either as a separate policy or as part of a wider information or knowledge management policy. The policy should be endorsed by senior management, for example at board level, and should be readily available to staff at all levels.

Guidance on authorisation of disposal facilities[29,30] expects that *"The developer/operator will need to set up and maintain a comprehensive system for recording information on all aspects of the project affecting the environmental safety case".* The information to be recorded should include:

- decisions taken and the reasons for them, data and results from the site investigation and characterisation programme
- design documents, drawings and engineering details of the facility as constructed
- records of waste form and characterisation
- records of waste emplacements and their location in the facility
- other operational information
- details of facility closure
- results of monitoring and assessment at all stages of the project.

Codes and standards which provide advice and guidance on records systems should be consulted and implemented as appropriate. At the time of writing the following British and International standards provide core information for a records system:

- Records Management. General[32];

- Records Management. Guidelines[33] (an implementation guide to records management);
- Storage requirements for archive and library materials[34];
- Management system for records - fundamentals and vocabulary[35]
- Management system for records - requirements[36].

Organisations should establish and implement a comprehensive policy for managing their radioactive waste information and records. The policy adopted needs to ensure that records are assembled and maintained in a secure form that is readily auditable and accessible. The records should be reliable, comprehensive and cover the full lifecycle of the radioactive waste.

The policy should make reference to the procedures and standards applicable to the information and records management function and to any related policies (e.g. the use of information technology within the organisation). An important function of the policy is to clearly define responsibilities.

Having established their policy the organisation should develop and implement an appropriate strategy that identifies measures to protect records relating to radioactive waste over the long term. Guidance can be found in existing national and international guidance, for example British Standards on Record Management[32,33] and IAEA guidance[37,38,39,40].

Information and records management systems and procedures

The management system should comply with the international standard relating to the requirements for quality management systems ISO 9001[28] and ensure that sufficient data and information is being recorded and stored so that future safety and environmental assessments can be carried out. It should also ensure that data and information is recorded in a way which allows access and retrieval over the long time periods that may be associated with management of radioactive waste. Information and records management should be regarded as an integral part of the organisation's culture.

Elements of an information management system will include:

- identifying the information to be included
- how information is collected e.g. format, transmittal, receipt, acceptability
- how information is managed e.g. location, retrieval, review and retention schedules, long-term preservation, information transfer
- measures to protect information (short and long-term considerations) e.g. document storage and archive requirements, access control, security and confidentiality requirements, control of modification of records, reproduction or transfer to alternative storage format, national (nuclear) archives requirements.

The transfer of records must be planned and controlled and consideration given on how the information it provides is to be transferred in the future. This consideration alone may influence the storage media, the language and the quality of the information. Therefore operators should also ensure that information generated on their behalf (e.g. by contractors) is produced in accordance with predefined specifications and that transfer of such information is also planned and controlled.

The consignor is responsible for ensuring the record is complete, in accordance with the requirements determined through dialogue with the recipient and other stakeholders. Records containing supporting information (such as glossaries) should be linked to the primary record.

Some records (e.g. a photograph) allow direct access to the information, while others (e.g. a computer file) require some type of processing. Additional records may need to be created to explain the relevance and use of the primary record.

Digital records may, in addition, require a degree of preparation prior to transfer to ensure the information is retrievable in a form that can be 'translated' and understood. Standard formats should be used wherever possible.

There is an inherent threat that the information contained in some records will become inaccessible in the future. This may be as a result of damage to or loss of the record, changes in the technology needed to read the record (particularly relevant to electronic records), or changes in terminology and language.

The risks associated with some of these threats may be considered low today, but they will inevitably increase with time. Risk management strategies, including a risk register identifying and including specific threats for the long term, their likelihood of occurring and the potential consequences relating to information and records must therefore be established and actively maintained.

Records management: specific issues relating to managing records for the long-term

This section is included solely to provide awareness of specific issues with media used for records that producers/holders should be cognisant of. Information contained in a record should be accessible in a form that can be used and understood both now and in the future. Measures should be implemented to ensure that information continues to be accessible particularly where digital media are used. All records have different characteristics requiring different management approaches (described in the following sub-sections). A sustainable and effective record can be regarded as a combination of four elements each of which should first be considered individually then as a whole:

- The recording medium – the selected medium should be readily available at reasonable cost and not require sophisticated preservation techniques that rely on unusual technologies or challenging storage environments
- The primary data should be in a format that is 'fit for purpose', of appropriate quality, and accessible to contemporary and future users
- The metadata should comply with the British Standard[41] and is essential for the long-term preservation and access requirements
- Where information providing context is essential to aid interpretation the explicit links to these sources of information should be maintained.

It is government policy to place permanent records for public archive onto digital or electronic media[42]. This may present a challenge to preserving radioactive waste information for a very long time. The NDA is looking to establish standards, procedures and guidance for its national nuclear archive so that steps can be taken to produce records to the required standard, where practicable.

Paper records

There is extensive experience in preserving paper-based records and clear guidelines are provided in British Standards[43,44,45]. With the exception of incidents such as fire or flooding, paper records tend to deteriorate quite gradually, providing adequate time for the licensee to migrate the information onto alternative media in a controlled way. The following should be considered when working with paper-based records:

- Most of the paper in daily use contains lignin which attacks the wood fibres, and there is increasing use of recycled paper (which has unproven long-term performance). Organisations should consider the need to migrate the information on to archive-grade paper[46], or ensure that when lower-grade paper is used the record is monitored at suitable intervals to identify when migration is needed. The information management system should specify the approach to be taken
- Laser printing and photocopying are the most practical and common techniques for transferring text on to paper and should take due regard of British standards for permanence[44]
- Paper records should be kept under conditions designed to minimise handling, in an environment where temperature and humidity are controlled and exposure to light, gaseous contamination, particulates, vermin and fungal growths are minimised.

Specific procedures should be considered and, where appropriate, adopted to maximise long-term performance and minimise potential damage of paper records.

Materials that are often filed with paper records (such as staples, paper clips, treasury tags, PVC covers) should be removed during preparation for long-term storage as they can cause or accelerate degradation.

Digital records

Licensees across the UK nuclear industry should strive towards using compatible systems that can enable accurate transfer of digital information without the need to transcribe data.

The integrity of reports containing text, diagrams, drawings and images created using a number of file formats will be difficult to protect against changes in technology. Where such records are to be preserved in electronic form they should be in an appropriate file format that has the greatest potential to be accessible in the future. The Portable Document Format (PDF) is currently regarded by records management experts to be the preferred format. British Standards[46,47,48,49] provide guidance on the application of the PDF format, which has been specifically developed to address the long-term challenge.

Where off-site facilities are used for preserving records, the organisations responsible should implement appropriate security measures to prevent unauthorised access.

Records management should involve experts in information security.

Generic IAEA guidance on digital records can be found in IAEA safety guides[38,39].

Microform records

Microform (microfilm, microfiche and aperture cards) is popular for recording large volumes of information and data. There are a number of film types available but for long-term storage silver-halide film should be used as it is less prone to fading when exposed to light.

Procedures should be in place to protect the integrity of microform, such as minimising its exposure to dust, dirt, chemicals, fingerprints and light. These procedures need to be considered when handling, packaging, and storing microform records.

Further information on the use of microforms can be found in the British Standard[50].

Records storage facilities

General

Regulator guidance for Licence Condition 6: Documents, records, authorities and certificates[51] expects that *"documents and records should be securely stored and maintained in such a way that they are readily retrievable in facilities that provide a suitable environment to minimise deterioration or damage and to prevent loss."*

Records with long-term value should be identified and prepared for long-term management as soon as practicable. They should be reviewed to ensure they are complete (e.g. that they include information providing context, links to other information sources and explanations of specialist terminology and abbreviations) before they are moved to an archive.

Licensees should ensure an audit trail is established and maintained to ensure a record can be traced in particular when records are transferred.

During waste management operations records will be kept on the originating site and arrangements should be implemented to store operational records safely and have in place procedures to prepare and transfer any records expected to be archived when operations are completed.

There are a number of standards[35,36] and guidance[51] documents relating to minimum standards for record storage facilities and operators should use available standards and guidance to judge the suitability of present and proposed storage and archive facilities.

Where records are transferred to an off-site archive operated by a third party it must be ensured that the records are managed to a standard appropriate for their long-term preservation and accessibility. The case for using any off-site archive should include an assessment of the ability of the archive to meet the minimum requirements set out in British and international standards[34,35,36].

Responsibility for records relating to waste remains with the originator (even if the records are physically located with a third party) until such a time that they transfer that waste and associated information and records to another custodian (e.g. to the operator of a disposal facility).

National records management facilities: the national nuclear archive

The Nuclear Decommissioning Authority (NDA) is committed to establishing a national nuclear archive, currently under construction at Dounreay, for the long-term storage of records relating to the UK civil nuclear industry.

A strategy for operating the national nuclear archive will therefore be pursued and developed by regulators and the NDA to provide the specific requirements of records from both NDA-controlled sites and non-NDA nuclear sites.

The National Archives provide guidance[52] on standards and best practice for records and information managers in all organisations that create or hold public records.

Record review

Record review should be undertaken against a written procedure which should detail the steps taken to ensure the records remain valid and the criteria to be fulfilled before a record can be closed. Every record should be reviewed before it is formally closed and especially prior to destruction or transfer for long term preservation. This should take into account factors if there will

be further processing of the waste or if the waste has been consigned for disposal. Any decision to destroy a record should be properly documented and this documentation maintained as part of the continuing records.

The nature of the information, recording medium, storage conditions and handling will be factors in determining the review period and the review will confirm the following:

- the case for preserving the record remains valid and the information contained in the record mains relevant
- The information is accessible to the reader
- Unusual or specialist terminology, colloquialisms and abbreviations are explained
- Materials that can harm the record medium or its content are removed
- The record medium remains fit for purpose
- Information sources referenced in the record and necessary for its interpretation remain accessible
- Security and protective markings are correct.

Security and the protection of sensitive information and records

Information and records relating to civil nuclear activities

ONR regulates security arrangements within the civil nuclear industry including the protection of sensitive nuclear information and the government's protective marking system applies throughout the civil nuclear industry. In addition companies operating in the civil nuclear industry are also required to comply with Government IT security policy with ONR as the accreditation authority.

As information and records relating to radioactive waste may contain sensitive information they need to be protected accordingly; and waste records and information providing context may attract differing security classifications. This potential conflict should be highlighted and suitable measures instigated to ensure that necessary linkages between information and records are maintained

Information that needs to be protected in the interests of national security requires a protective marking in accordance with the protective security and classification manual. This does not extend to information that has previously been made available to the public anywhere in the world. ONR should be consulted for further guidance.

Classification of civil nuclear information

Organisations subject to regulation by ONR should ensure that their information classification policy is consistent with ONR's requirements on the use of protective markings. This extends to those categories of sensitive nuclear information that require protection and the level of protective marking to be applied. It includes information held on computer systems relating to nuclear material, other radioactive material (including radioactive sources) and radioactive material designated as waste.

Planned reviews of records held should include consideration of the need to retain protectively marked material at its original level. Originators, other specialists and records reviewers should exercise a degree of judgement, according to the sensitivity of the information and any time-dependence this may have, in making decisions to downgrade.

Information and records relating to MOD nuclear activities

Information and records relating to MoD nuclear activities, which need to be protected in the interests of national security, require a protective marking in accordance with the security and classification policy issued on behalf of the Secretary of State for Defence.

Disclosure of information

The policy relating to protective marking of sensitive nuclear information should not be confused with disclosure policy or the requirement to protect commercial or other official data. Finding a Balance[53] provides general guidance to a wider audience in relation to enquiries under the Freedom of Information Act 2000 or the Freedom of Information (Scotland) Act 2002. The guidance is intended to prevent the disclosure of information that could assist a person or group planning theft, blackmail, sabotage and other malevolent or illegal acts. It identifies categories of information that should not be disclosed, provides reasons for protecting this information and indicates the protective marking afforded to such information.

Abbreviations and Glossary

Where possible, the following standard definitions have been taken from:

- IAEA safety glossary[27]
- The UK LLW policy[8]

ALARA	As Low As Reasonably Achievable
ALARP	As Low As Reasonably Practicable
BAT	Best Available Techniques
BPEO	Best Practicable Environmental Option
BPM	Best Practicable Means
EA	Environment Agency
HSE	Health and Safety Executive
IAEA	International Atomic Energy Authority
LC	Licence Condition - A condition attached to a licence issued under the Nuclear Installations Act
LLW	Low-level radioactive waste - Radioactive waste having a radioactive content not exceeding 4 gigabecquerels per tonne (GBq/ te) of alpha and 12 GBq/ te of beta/ gamma activity.
LLWR	Low Level Waste Repository: The UK's national low level waste disposal facility
Metadata	Are 'data about data'. Metadata enables a resource to be found by indicating what the resource is about and how it can be assessed with a series of structured descriptions.
NDA	Nuclear Decommissioning Authority
NRW	Natural Resource Wales
ONR	Office for Nuclear Regulation
SAPs	Safety Assessment Principles
SEPA	Scottish Environment Protection Agency
VLLW	Very Low Level Waste
WAC	Waste Acceptance Criteria - Criteria specified by the operator/regulator for radioactive waste to be accepted by a treatment/disposal facility.

Further reading

Guidance and documents from the regulators, NDA and Industry

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