Nuclear Decommissioning Authority

# Industry Guidance

# Interim Storage of Higher Activity Waste Packages – Extended Summary

**Effective from November 2012**

# Interim Storage — Extended Summary

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## FOREWORD

Waste storage is an essential component of the higher activity waste (HAW) management lifecycle and provides a safe, secure environment for waste packages awaiting final disposal.

A system of robust storage arrangements provides high confidence that packages will be disposable at the end of the storage period and will be unaffected by any variance in the availability of disposal routes. In line with UK and Scottish Policies and CoRWM recommendations, NDA will ensure that its strategy allows for the safe and secure storage of the waste for a period of at least 100 years. The NDA's 2009 UK Radioactive Higher Activity Waste Storage Review also recognised the importance of an integrated and standard approach to HAW storage.

As the UK's nuclear clean-up mission progresses, additional packaged HAW will be held within interim storage facilities reflecting the status of the waste retrievals, waste processing and indeed, the disposal programmes. Hence, the packaged HAW is of high intrinsic value in terms of environmental, safety and security benefit and cost and programme investment. Therefore, it is highly appropriate that the industry takes the right precautions in managing the storage system and ensuring the waste packages remain in a disposable form.

To support the strategic position of a robust storage programme, including a more co-ordinated approach, the NDA welcomed the opportunity to take the lead in setting up a cross-industry Integrated Project Team (IPT), which was responsible for delivering the Industry Guidance on the storage of packaged HAW.

The Guidance has been developed, over the last three years, by representatives from all the NDA's Site Licence Companies (SLCs) with packaged HAW, RWMD, EDF Energy, MOD, AWE and supply chain organisations through the NDA's Direct Research Portfolio. The Regulators and CoRWM observed the development of the Guidance and provided input by attending workshops and commenting on draft versions.

The first issue was published in August 2011 for a period of 'road-testing' by industry and other stakeholders. Following updating, based on this feedback, the Guidance was re-launched at an industry seminar on HAW storage in September 2012. It is expected that SLCs will implement the Guidance to maintain and improve existing waste storage systems and when planning new stores. Other organisations will continue to be able to freely access and use the Guidance.

It is intended that the Guidance remains fit-for-purpose through continual improvement and will be re-issued when necessary. If you have any comments on the Guidance, please email these to strategy@nda.gov.uk.

James McKinney, Head of Integrated Waste Management, NDA

November 2012

# Interim Storage — Extended Summary

## ABSTRACT

A cross-industry team assembled by the NDA has developed this Industry Guidance on the interim storage of packaged higher activity waste (HAW). Since 2009, the project team has engaged with the industry through workshops, commissioned development work and interacted with Store Operators and Regulators. It is intended that the Guidance will be used by those involved in managing any aspect of current and future UK stores of packaged HAW.

The Guidance seeks to cover all the significant technical issues arising from interim storage of packaged HAW, be practicable in implementation, and relevant to all UK storage system designs. The Guidance is arranged into two inter-related components:

(a) an 'Extended Summary', this document, which provides higher level overview of the Guidance;
(b) an 'Integrated Approach', which provides the detailed Guidance with references to underpinning work including R&D and further guidance available elsewhere.

The Guidance comprises of four primary sections that cover the key elements of a robust approach to interim storage. These sections are: package performance and design; store performance and design; operation of the storage system and provision of assurance of the system over an intergenerational timescale.

To accommodate the diversity of UK HAW, the Guidance describes six common principles and 26 approaches covering the lifecycle of interim storage and variation in HAW properties. When these are implemented as a coherent set then the Guidance forms an 'integrated approach' to interim storage that may be especially useful to the design and planning of new stores. When specific approaches are applied, in the context of an existing storage system, then the Guidance may be used to improve existing arrangements through comparison with identified good practices and toolkits based on operational feedback.

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## 1. Introduction

**(a) Background**. In 2006, the Committee on Radioactive Waste Management (CoRWM) recommended to Government that a robust programme of interim storage must play an integral part in the UK's long-term management strategy for higher activity waste HAW [1]. A later review, in 2009, on interim storage arrangements recommended that more needed to be done to demonstrate that interim storage is robust to the uncertainties surrounding implementation of the disposal route and that a more strategic approach is necessary [2].

The Government [3], including the Devolved Administrations, accepted this recommendation from CoRWM and noted the proposed formation of an Integrated Project Team (IPT) led by the Nuclear Decommissioning Authority (NDA). This would address many of the technical issues identified by CoRWM and by the NDA's own review on storage [4]. Thus, the IPT's work programme included consideration of areas such as:

- package performance;
- package monitoring and inspection;
- store longevity including facility monitoring and inspection;
- store environmental controls;
- package reworking.

The IPT comprised of representatives from across the industry. This included the NDA, their Radioactive Waste Management Directorate (RWMD) and all the civil nuclear licensees with HAW storage requirements, i.e. Sellafield Ltd, Magnox Ltd, Dounreay Site Restoration Ltd, Research Sites Restoration Ltd, and EDF Energy. Other licensees participated as associates, including: the Atomic Weapons Establishment, GE Healthcare, and Springfields Fuels Limited. In addition, the IPT benefitted from significant input from technical specialists largely through the NDA's Direct Research Portfolio (DRP) with additional support from the RWMD and Site Licence Company (SLC) research programmes.

The Regulators, including those organisations now represented in the Health and Safety Executive's (HSE) Office for Nuclear Regulation (ONR), the Environment Agency (EA), and the Scottish Environment Protection Agency (SEPA), and CoRWM were observers to the work programme.

The concluding output from the IPT work programme was incorporated into 'Industry Guidance'. The first issue was published in August 2011 for a period of 'road-testing' by industry and other stakeholders. Following updating it is expected that SLCs will implement the Guidance to maintain and improve existing waste-storage systems and when planning new stores. Other organisations will continue to be able to access and use the Guidance.

The Guidance, in line with UK and Scottish Policies and CoRWM recommendations, seeks to support NDA strategy that allows for the safe and secure storage for a period of at least 100 years.

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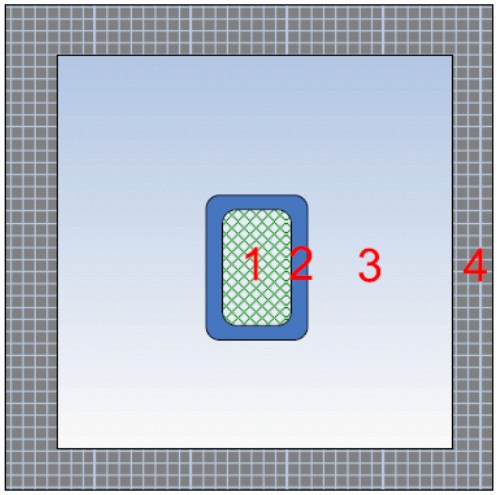
**(b)** **Overview.** The Guidance is arranged into two inter-related components:

- **Extended Summary**, contained in this document which provides a high level overview of the Guidance;
- **Integrated Approach**, which provides practicable whole lifecycle guidance for current and prospective Store Operators. An accompanying database provides further details about UK waste-storage systems to support dissemination between Store Operators.

The Guidance sets out to support implementation of interim storage arrangements in the UK and at site level. Robust storage requires a thorough understanding of the overall waste storage system, see below, the processes that may affect its integrity over time and the interactions and relationship between its components. While it is recognised that the challenge from managing the waste packages and stores differ between and within sites, the Guidance describes practicable and proportionate methods (i.e. 'approaches') and options for solutions (i.e. 'toolkits') which are based on a common set of principles which recognise that each store's context is different. Additionally, 'good practices', based on feedback from operational stores, R&D studies and Regulators, are highlighted.




**Packaged waste storage – physical & environmental layers of protection**

1. The conditioned wasteform is the primary barrier.

2. The waste container is the secondary barrier.

3. Control of the store environment is important in maintaining integrity of the waste form and waste container.

4. The store structure is the final layer of weather/atmosphere protection for the waste package and also is an important element in the physical security of the waste.

**(c)** **Aims**. The strategic aims of the Guidance are to:

- **standardise the overall approach** to interim storage based on maximising package and store performance, while minimising the need for package reworking;
- **promote cross-industry working** and establish common approaches for long-term management of waste packages in interim storage;
- **inform store planning and design**, and monitoring and inspection programmes;
- **enhance the recognition** of the important relationship between waste packaging, storage, transport and disposal by stakeholders;
- **improve the visibility** of the wide range of work generated by the IPT to Regulators and other stakeholders.

**(d) Scope.** The Guidance covers the interim storage of packaged HAW across the UK. Scottish HAW Policy [5] refers to the long-term management of HAW being in near-surface facilities. It also states that storage facilities should have the capability to last for at least 100 years, with the capability of extension beyond this. This is broadly the same as the position for new interim storage facilities in England and Wales. Thus, the Guidance can be applied equally to stores in Scotland too. The following aspects define the wider scope of the Guidance:

- **Surface stores**, which have been, or will be, purpose built or adapted to store HAW packages.
- **Storage periods of up to about 100 years**, within a surface store, with consideration beyond this limited to qualitative consideration as appropriate.
- **HAW packages**, within surface stores for up to about 100 years, which are subject to assessment through the NDA's Radioactive Waste Management Directorate (RWMD) Letter of Compliance (LoC) process, and which:
  (i) have been or are planned to be conditioned for disposal or long-term storage; or
  (ii) although currently unconditioned may require future conditioning, e.g. for disposal; and
  (iii) have been demonstrated to be appropriately 'passively safe' to the Regulators.

While not the intention, stakeholders have noted that the Guidance may also be usefully applied, in part, to other types of storage systems. For example: near-surface stores with packages stored below ground level; stores containing dry spent fuel and nuclear materials; long-term stores for LLW packages; and stores exclusively for short-lived Intermediate Level Waste (ILW), which will become LLW during the storage period.

# 2. Integrated Approach Overview

Section 2 of the Guidance describes how, through an integrated and iterative approach, the Guidance may be deployed to help determine a design for the overall storage system. The integrated approach is shown figuratively in the diagram below. The Guidance may also be applied to:

- an existing storage system as a benchmarking exercise, or to optimise its operation or develop contingencies as part of risk management;
- identify underlying work and contacts to support development of new tools and encourage dissemination of lessons learned.

The approach accounts for the fundamental factors that drive different storage system designs such as the properties of the waste groups to be stored. For example, contact-handleable packages will typically be more readily managed and maintained than those limited to remote access only.

While financial factors are outside the scope of the Guidance, a balance will need to be established between the lifecycle costs of the storage system compared with the risk mitigated and the value of the asset managed; this will need to be agreed with appropriate stakeholders including the Regulators and NDA.

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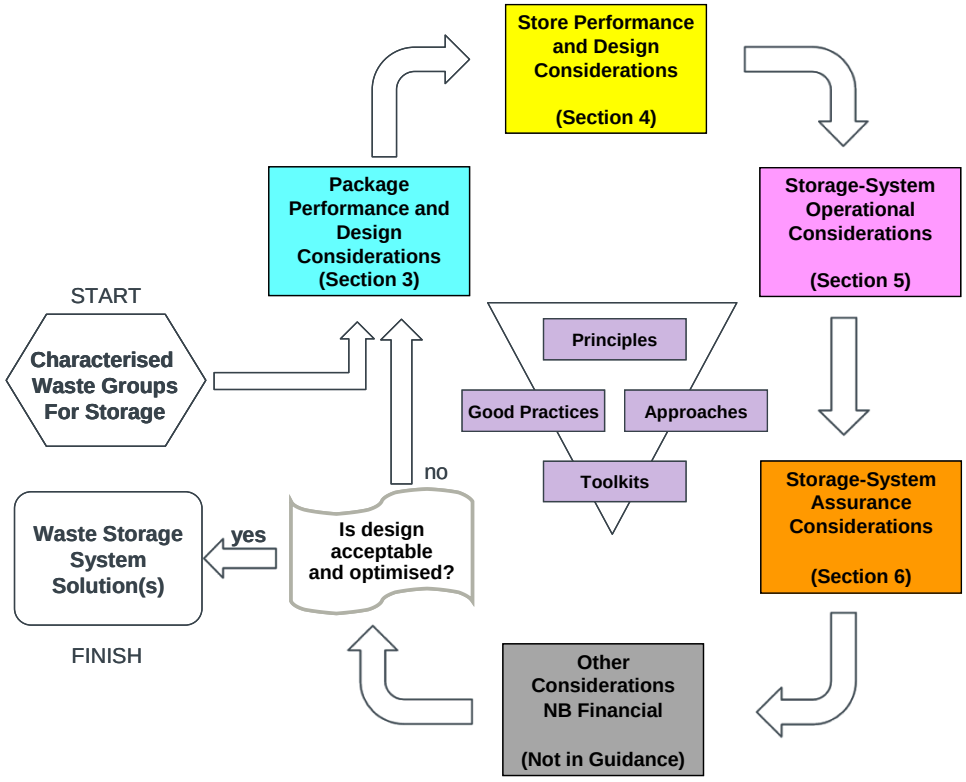
In addition to the overall integrated approach, there are six generic good practices – including engagements with stakeholders, use of common terminology and engagement with peer groups; three generic approaches – covering package performance, integrated human factors and making changes to existing storage systems and one generic toolkit. These are applicable across the waste storage system.




## 3. Waste Package Performance and Design

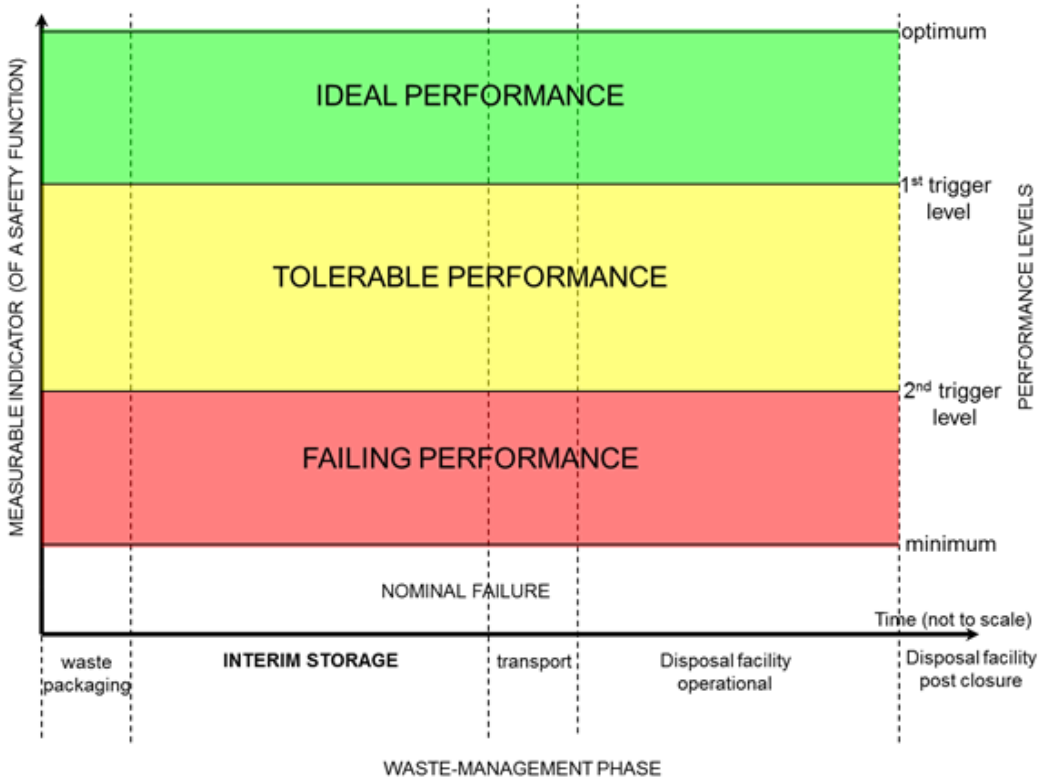
Section 3 of the Guidance outlines six good practices, three approaches and five toolkits to promote robust package performance and design during interim storage. These include:

(a) A **package design** approach, outlining steps to establish a robust package design including toolkits of existing 'proven' container designs, materials, encapsulants and emerging innovations. It also identifies good practice to establish the long-term performance of new materials and the importance of maintaining transportability.

(b) Application of the **package performance** approach across the waste management lifecycle. This 'goal-post' setting approach is based on nine fundamental safety functions provided by the package, evolutionary processes that may affect safety-function performance during storage and measurable indicators of these processes. The performance of each safety function can then be assessed to be within three primary performance zones: (i) Ideal, (ii) Tolerable or (iii) Failing, as shown below.

(c) A **package evolution assessment** approach to identify how packages may evolve with time, based on the latest research findings from RWMD led work. It includes a toolkit of computer-based models.

(d) A **lifetime package care and management** approach, which details important steps to preserve the integrity of the package from manufacture of the container through to import of the package into a store.




# 4. Store Performance and Design

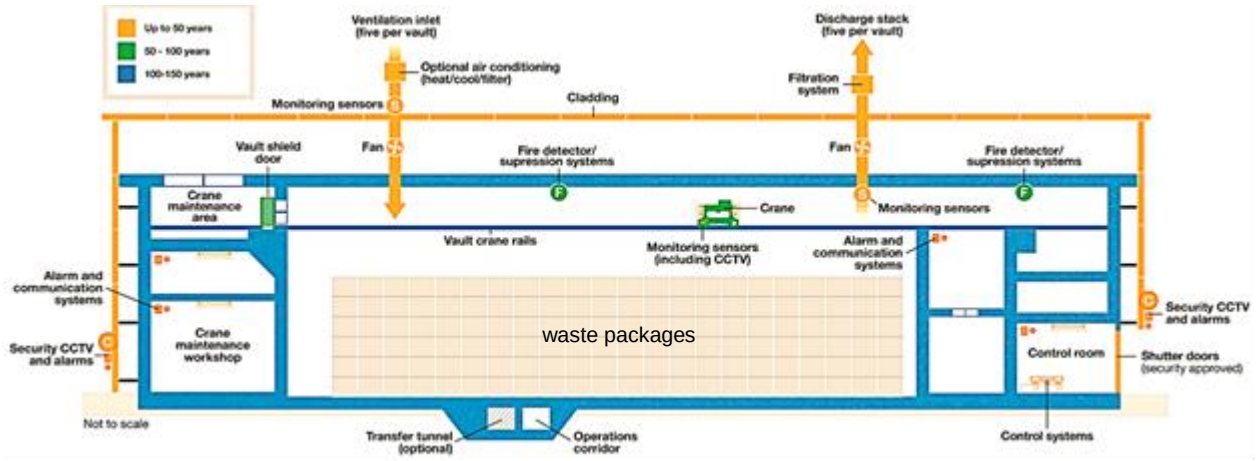
Section 4 of the Guidance outlines six good practices, four approaches and six toolkits to promote robust store performance and design. These include:

(a) A **store design** approach, outlining steps to establish a robust design, including a toolkit of existing designs, consideration of location and robustness to foreseeable hazards, including climate change effects. Additional factors include the number of packages and their inherent hazards and whether shielding is required. Consideration of the need to build-in inspection and reworking cells for packages, and ease of monitoring is also highlighted.

(b) A **store longevity** approach which, through the systematic identification of its life-limiting features and design life components, establishes the longevity of an existing or future store, see diagram below, to meet a target lifetime of at least 100 years.

(c) An **environmental control** approach which includes controlling: temperature and relative humidity; moisture; salt deposition and other contaminants; and microbial and animal activity. Basic ventilation requirements are also described.

(d) An environmental **Operational Limits and Conditions** (OLCs) approach to support the development of store-specific OLCs for salt deposition, relative humidity and temperature controls. Two different ways to control relative humidity are outlined by either keeping well below the deliquescence point of any deposited salts or well above to dilute any solutions.




# 5. Storage System Operations

Section 5 of the Guidance outlines seven good practices, eight approaches and four toolkits to promote robust waste storage system operations. These include:

(a) Approaches for **package movements**, which outline important steps during: import; storage, and export to maintain safe, efficient and effective operations.

(b) An **emplacement approach,** outlining steps to improve store operations and system performance, and prepare for efficient package export. In establishing an emplacement approach, it is necessary to balance the need for effective inspection and monitoring, environmental control and package export capability. It is considered good practice to set aside space in stores to accommodate any out-of-specification packages.

(c) An approach to maintain **package safety functions** that outlines steps to balance package performance risks with proportionate intervention including several credible reworking techniques to restore safety functions where necessary. The hierarchy – with the principal objective to prevent the need for potential rework – is shown below.

(d) An approach to determine when a store's **environmental conditions** may benefit from being changed to protect package and store life-limiting components.

(e) Approaches to maintain **store life-limiting features** and **extend store lifetimes** including a toolkit of credible repair techniques.

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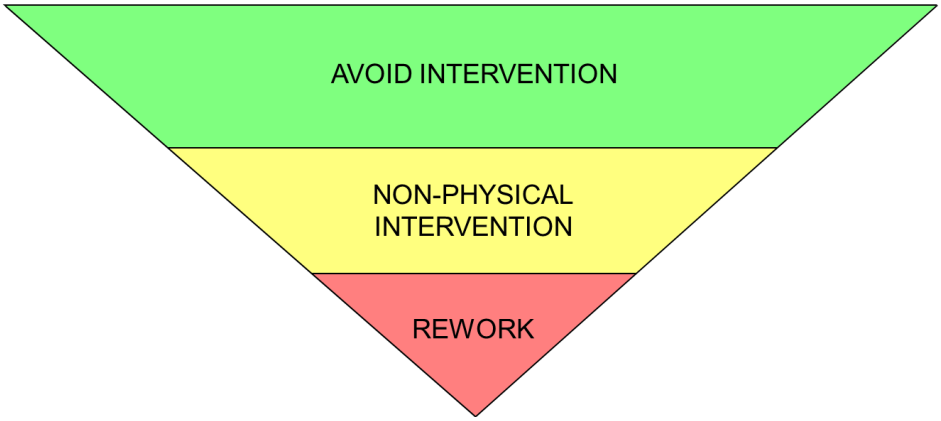


## 6. Storage System Assurance

Section 6 of the Guidance outlines five good practices, eight approaches and seven toolkits to assure the waste storage system across its lifecycle. These include:

(a) An approach to **baseline** the waste storage system so that ongoing monitoring and inspection results can be properly interpreted. This includes a toolkit with practicable techniques.

(b) A systematic approach to **monitor and inspect** the storage system with toolkits identified. This approach includes selection criteria concerning: relevance to the safety functions, practicability and provision of reliable and interpretable information to aid determination of suitable tools.

(c) A statistically based approach to define **monitoring and inspection rates** to achieve a defined level of confidence over the storage period.

(d) An approach to establish strategic **archives** in stores of materials that could be used to help assure the longevity of the system. This includes spares of bespoke equipment, samples of life-limiting components and representative inactive waste package simulants.

(e) An approach to optimally deploy inactive samples and simulants, including **dummy packages**. Such packages, when planned properly, can provide a low cost and low dose supplement to the monitoring and inspection of active packages. Guidance provided includes when samples should be added, retained and discarded from an overall co-ordinated programme and an approved testing regime to extract relevant information. Many of these samples are over 30 years old. A database of the samples has been developed.

(f) The beneficial role of audits, such as RWMD **periodic LoC reviews**, is developed as an approach.

(g) The fundamental importance of effective **knowledge managemen**t is outlined within an approach.

(h) An approach to maintain **human resources and skills** is provided. This includes outlining initiatives by the NDA and other UK-wide initiatives.

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## 7. Summary

The Guidance's four main sections (3-6), principles, good practices, approaches and toolkits are intended to provide a robust and integrated approach to storage as outlined below.

**(a) Six Principles:**

| | | | |
|---|---|---|---|
| A | Cradle-to-grave lifecycle | D | Prevention is better than cure |
| B | Right Package ↔ Right Store | E | Foresight in design |
| C | Minimising waste generation | F | Effective knowledge management |

**(b) 30 Good Practices concerning:**

| | | | |
|---|---|---|---|
| 1 | Stakeholder engagement | 16 | Store design – environmental controls |
| 2 | Technical terminology | 17 | Store design – contaminants |
| 3 | Technical competence | 18 | Operational limits and conditions |
| 4 | Human factors | 19 | Import contaminant checks |
| 5 | Research and development | 20 | Minimising movements – opportunities |
| 6 | Peer groups | 21 | Package sentencing groups |
| 7 | Package designs | 22 | Maintaining contingency space |
| 8 | Package materials | 23 | Maintaining intervention plans |
| 9 | Maintaining transportability | 24 | Access to rework facilities |
| 10 | Package evolutionary processes | 25 | Extending store operational lives |
| 11 | Package care and management – controlled | 26 | Establishing system baselines |
| 12 | Package care and management – uncontrolled | 27 | Recording system performance |
| 13 | Local planning constraints | 28 | Monitoring and inspection rates |
| 14 | Store design – monitorability | 29 | Maintaining an archive |
| 15 | Store design – life-limiting components | 30 | Deployment of dummy packages |

**(c) 26 Approaches concerning:**

| | | | |
|---|---|---|---|
| 1 | Package Performance | 14 | Package Emplacement |
| 2 | Integrated Human Factors | 15 | Maintaining Package Safety Functions |
| 3 | Modifications to Existing Stores | 16 | Maintaining Environmental Conditions |
| 4 | Selecting Package Designs | 17 | Maintaining Store Life-limiting Features |
| 5 | Package Evolution and Assessment | 18 | Extending Store Lifetimes |
| 6 | Lifetime Package Care and Management | 19 | Baselining |
| 7 | Development of Outline Store Design | 20 | Monitoring and Inspection (Techniques) |
| 8 | Store Longevity | 21 | Monitoring and Inspection (Rates) |
| 9 | Environmental Controls | 22 | Archiving |
| 10 | Environmental Operational Limits and Conditions | 23 | Inactive Samples and Simulants |
| 11 | Package Movements – Import | 24 | Auditing |
| 12 | Package Movements – Operations | 25 | Knowledge Management |
| 13 | Package Movements – Export | 26 | Human Resources |

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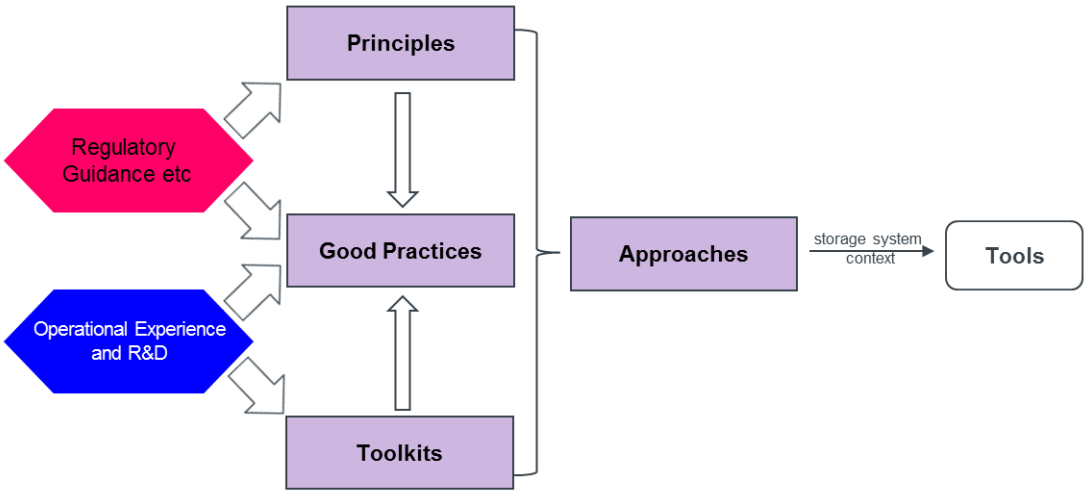
**(d) 23 Toolkits concerning:**

| | | | |
|---|---|---|---|
| 1 | Human factors | 13 | Non-physical package intervention |
| 2 | Basic container designs | 14 | Physical package intervention |
| 3 | Container materials | 15 | Environmental control changes |
| 4 | Encapsulants | 16 | Life-limiting component repairs |
| 5 | Package evolution models | 17 | Baselining |
| 6 | Packaging innovations | 18 | Sample types |
| 7 | Outline store designs | 19 | Package inspection and monitoring |
| 8 | Store life-limiting features | 20 | Environmental condition monitoring |
| 9 | Temperature and relative humidity controls | 21 | Monitoring life-limiting components – unshielded stores |
| 10 | Moisture controls | 22 | Monitoring life-limiting components – shielded stores |
| 11 | Contaminant controls | 23 | Monitoring and Inspection rate models |
| 12 | Microbial and animal controls | | |

**(e)** **User-selected tools**, according to the waste storage system context, can be derived following the process shown below based on the inter-relationship of the Guidance principles, good practices, toolkits and approaches:



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## References


1. Committee on Radioactive Waste Management, *Managing our Radioactive Waste Safely. CoRWMs Recommendation to Government*, CoRWM Doc 700, July 2006.
2. Committee on Radioactive Waste Management, *Interim Storage of Higher Activity Wastes and the Management of Spent Fuels, Plutonium and Uranium*, CoRWM Doc 2500, March 2009.
3. UK Government and Devolved Administration, *Response to the Committee on Radioactive Waste Management (CoRWM) Report on 'Interim Storage of Higher Activity Wastes and the Management of Spent Fuels, Plutonium and Uranium*, July 2009.
4. Nuclear Decommissioning Authority, *UK Radioactive Higher Activity Waste Storage Review*, Issue 1, March 2009.
5. Scottish Government, *Scotland's Higher Activity Radioactive Waste Policy 2011*, January 2011.