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ABBREVIATIONS

ALARP	As Low As Reasonably Practicable
BAT	Best Available Techniques
DSP	Design Safety Principle
EPR	Evolutionary Power Reactor
ETB	Effluent (Waste) Treatment Building
GDF	Geological Disposal Facility
ILW	Intermediate Level Waste
ISF	Interim Storage Facility
LLW	Low Level Waste
NDA	Nuclear Decommissioning Authority
PCSR	Pre-Construction Safety Report
PSA	Probabilistic Safety Assessment
RAM	Radioactive Material
RWMD	Radioactive Waste Management Directorate

REFERENCES

1. Dry Interim Storage Facility for ILW. ELI0800226 Revision A BPE. EDF.

2. Solid Radioactive Waste Strategy Report (SRWSR). NESH-G/2008/en/0123 Revision A. AREVA NP. November 2008. Section 12.

3. NDA RWMD Report: Generic Repository Studies. Generic Waste Package Specification. Volume 1 – Specification. N/104. June 2005.

0. EXECUTIVE SUMMARY

This report demonstrates that the risks over the lifetime of an interim storage facility for intermediate level waste are as low as reasonably practicable. It provides complementary information to PCSR, UKEPR-0002-115 Issue 00 Sub-chapter 11.5 – Interim storage facilities and disposability for UK EPR.

1. INTRODUCTION

1.1 ITEMS ADDRESSED IN THE REPORT

To demonstrate risks are as low as reasonably practicable this report addresses the following :

- Design principles and safety aims for the storage facility;
- A demonstration that the need for active safety management during longer-term storage has been minimised;
- Identification of the characteristics of the waste packages and equipment needed to maintain integrity and handling over the storage period. The identified characteristics are analysed to see how they will evolve over the storage period. Provisions for waste packages or equipment that fails to meet the required characteristics are described.
- Details of the provisions and functions for retrieval and inspection of waste packages, including details of the inspection regime;
- Details of the changes necessary to the retrieval and inspection regime as materials age and their characteristics change;
- Plans for the facilities, and their functions, needed to retrieve the waste packages and prepare them for onward processing or disposal.

1.2 THE ILW INTERIM STORAGE FACILITY

The proposed interim storage facility for intermediate level waste (ILW) will have an operational lifetime of approximately one hundred years. In other respects, the interim storage facility (ISF) is conventional in design and presents no particularly novel safety issues for storage of this type of waste over the period of time normally covered by a U.K. safety case submission. It is therefore concluded that the key issues to be addressed are those relating to the adequate control of hazards and risks over the long term.

1.3 FUNCTION OF THE INSTALLATION

The Interim Storage Facility for ILW will have the following main functions:

- Receipt of ILW waste packages;
- Storage of ILW waste packages;
- Retrieval of ILW packages for inspection;
- Retrieval of ILW packages for final disposal;
- Retrieval for disposal of ‘ILW’ decayed to LLW levels;

Maintenance operations will also be carried out throughout the facility’s life.

1.4 DESIGN ASSUMPTIONS

The main design assumptions are:

- The interim storage facility will be located on or immediately adjacent to the EPR reactor site;
- The facility’s operational lifetime will be 100 years;
- Only ILW waste packages will be received;
- No defective packages will be accepted for storage;
- Some waste will decay to levels permitting reclassification and disposal as LLW during the operational life of the plant;
- The facility may require to be extended to accommodate reactor decommissioning wastes.

1.5 APPLICABILITY OF THE ALARP PRINCIPLE

The ALARP principle is applicable to all aspects of the design and operation of the storage facility. Its application should ensure that all hazards associated with normal operation of the facility and all risks associated with accidents occurring during its operation are restricted as low as reasonably practicable and that, so far as is reasonably practicable, the disposability of the stored ILW will not be compromised.

Similarly, from the viewpoint of environmental protection, it is considered that the principle of employing best available techniques (BAT) for environmental protection is applicable to all aspects of the facility’s design and operation which might adversely impact on the environment or the future management of the waste.

It is noted that both principles involve a similar cost benefit balance in that neither requires expenditure to be incurred that is ‘grossly disproportionate’ to the safety or environmental benefits accruing from the expenditure.

A commitment to the ALARP Principle as a fundamental requirement is provided in Chapter 3.1 (Section 3.1) of the Pre-Construction Safety Report (PCSR) and is codified in a Safety Design Objective, SDO-1, as follows:

'The radiation doses to workers and the general public from an EPR, under normal operating and postulated accident conditions, must be as low as reasonably practicable'.

1.6 APPROACH TO COMPLIANCE WITH THE ALARP PRINCIPLE

The approach adopted to ensure ALARP will be to ensure that all aspects of the design and mode of operation of the storage facility comply fully and demonstrably with applicable modern standards of good practice.

Where there are alternative design options available to meet these standards, these will be subjected to robust optioneering procedures.

A set of design safety principles (DSPs) will be generated, compliance with which will contribute to compliance with the relevant standards. While the storage facility remains at a 'concept' stage, these DSPs will necessarily be relatively generic in nature such that they would be applicable to any interim storage facility for radioactive wastes. However, as the concept is developed, more plant specific DSPs will be generated.

Finally, the achievement of ALARP will be facilitated through the setting of targets for normal operations exposures and accident risks compliant with UK modern standards. Such targets have already been defined as Safety Design Objectives for the EPR in Section 3.1 of Chapter 3.1 of the PCSR (SDOs 2 to 7).

1.7 MAIN HAZARDS AND RISKS

1.7.1 Sources of Hazards and Risks

The only inventory of radioactivity giving rise to hazards during normal operation and contributing to the risks from accidents is the packaged waste itself.

The principal operations which may result in exposure of members of the workforce or of the public either under normal or abnormal conditions are as follows:

- Receipt of the waste package at the ISF;
- Emplacement of the waste package within the ISF;
- Storage of the waste package;
- In-situ inspection and monitoring of the waste package;
- Retrieval of the waste package for inspection or final disposal;
- Ex-situ inspection of the waste package;
- Preparation of the waste package for final disposal;
- Maintenance of facilities and equipment.

Given the nature of the waste, criticality will not be an issue in the ISF.

1.7.2 Normal Operations Hazards

Members of the public may be exposed to radioactivity discharged under authorisation to the external environment in either liquid or gaseous effluents. Significant direct radiation exposure of members of the public is extremely unlikely due to the distance and shielding between their location and the radiation source.

No loose particulate contamination is expected to be present in the ISF during normal operations, as all radioactive material will be contained in packages that will have been thoroughly monitored for surface contamination at the EPR Effluent Treatment Building (ETB). Discharges of such materials are, therefore, expected to be very low and the airborne contamination hazard to the workers, insignificant.

The only significant source of external radiation presenting a hazard to workers will be the waste inventory itself.

Safety measures, such as ventilation during the operational period, will prevent the build up of gaseous contaminants (which are expected to be negligible) such as radon[1] and tritium, which might present an inhalation hazard to workers. However, these species will be discharged to atmosphere and represent a potential source of exposure to the public.

1.7.3 Accident Conditions

Under accident conditions, both groups might be exposed to the same types of hazards but with enhanced magnitude. The risks associated with these hazards would then be a function of the frequency of the fault sequences, which cause their realisation.

At the concept stage, potential fault sequences cannot be precisely defined due to a lack of available detail regarding the engineered design and managerial controls. However, a listing of potential internal and external hazards has been generated for the EPR via a process summarised in Section 1.2.3.5.1 of Chapter 3.1 of the PCSR.

1.7.3.1 Internal Hazards

These are defined as events originating within the facility boundary and having the potential to cause adverse conditions or damage within the facility. These are:

- Dropped loads or load collision;
- Fire;
- Loss of shielding;
- Internal flooding;
- Loss of electrical supplies.

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[1] Note: The nature of the waste is such that it will not emanate radon (i.e. no precursor nuclides present). However, naturally occurring radioactive isotopes (e.g. radon) may be present to a degree that will be location specific.

It is noted that some more energetic internal hazards identified for the reactor itself are unlikely to be significant for waste storage facilities.

It is recognised that the risks associated with these hazards may vary over the plant lifetime. This may be due to variation in operational frequency (e.g. due to increases in inspection frequency), initiating fault frequency (e.g. due to ageing of handling equipment) or fault sequence consequence (e.g. due to degradation of waste package impact withstand over time, or gradually reducing inventory due to radioactive decay).

1.7.3.2 External Hazards

These are natural or man-made hazards originating externally to the plant but having the potential to adversely affect the safety of the plant. These are:

- Natural Hazards;
    - Seismic events;
    - External flooding;
    - Extreme weather
- Man-made Hazards;
    - Aircraft impacts;
    - Other man-made hazards.

It is noted that this latter group of hazards are, to some extent, location specific.

It is again recognised that the risks associated with these hazards may vary over the lifetime of the facility due to potential deterioration with age of structures and systems.

1.8 ILW INTERIM STORAGE FACILITY (ISF)

There are two design options being considered for the ISF.

It is anticipated that both ILW ISF designs will have the following areas:

- A reception / retrieval hall with travelling crane and temporary storage area;
- A cell for monitoring the packages and their overpack (if necessary);
- A possible “dedicated” storage area for degraded packages;
- An interim storage hall with travelling crane;
- A control room.

It is assumed that non-compliant packages will not be transferred from the Effluent Treatment Building (ETB) to the ISF.

The first design option for an interim storage hall will allow storage of all packages in a single interim storage hall. The packages themselves will either be stacked on 3 levels in pyramids (providing better earthquake resistance but using a larger amount of space) or in columns (easier to move and monitor). To optimise the use of space, a single shielded containment cell will be used for both waste package inspection and defective waste package over packing. The sampling and over packaging cell is likely to be positioned between the interim storage hall and the reception / retrieval hall in order to use the transfer car as the means of handling. For this option the packages would be required to afford significant self-shielding and be of a design which would afford significant impact resistance.

Alternatively, the interim storage hall could also be designed to house multiple storage compartments below ground. In this case, the packages would be stored in individual shielded compartments allowing segregation and ease of inspection and affording a degree of physical protection. The packages stored under this option need not be as robust or heavily self-shielding.

Both ISF designs will be extendable:

- It is anticipated that the first extension will be constructed to house the decommissioning wastes after shutdown of the EPR approximately 60 years after commencement of operations;
- If required, due to changes in national standards and practices (e.g. the non-availability of a Geological Disposal Facility) a second extension may be required to house state of the art packaging / conditioning / monitoring facilities for the waste packages prior to shipment to the final disposal / solution facility.

For further information, the two ISF design options are discussed in the References [1] and [2] for single and multi storage compartment options respectively.

1.9 ILW WASTE PACKAGES

1.9.1 Possible Waste Package Types

The reference packages for ILW stored under the single compartment option are concrete containers of two sizes:

- C1 – a concrete container with an external volume of $2m^3$ (Φ: 1.4m, h: 1.3m). The volume of raw waste is in the range of 310 litres to 440 litres; and
- C4 – a concrete container with an external volume of $1.23m^3$ (Φ: 1.1m, h: 1.3m). The volume of raw waste is kept at 250 litres.

Both packages use qualified high-performance concrete (BHP) and a cap cast using the same formulation. They would make a minimal contribution to fire loading due to their non-combustible fabrication materials. They also possess significant inherent shielding such that the facility would not require additional bulk shielding to be operated to modern standards for operator dose uptake.

These two packages have a concrete thickness of 0.15m and are qualified according to ANDRA technical specifications to have the physical capability to last and confine radioactivity for more than 300 years. They have successfully passed drop tests from 1.2m. This packaging concept has been proposed to the Nuclear Decommissioning Authority (NDA) Radioactive Waste Management Directorate (RWMD).

Under the multi-compartment option several types of waste package may be stored in the ISF:

- 500 litre stainless steel drum (NDA specified)
- 3 m^3 stainless steel box (NDA specified)
- 200 litre drums
- Cast iron containers.
- 4 m boxes (NDA specified)

1.9.2 Waste Package Requirements

The main sources of ILW anticipated for storage in the ISF are:

- Spent Ion-exchange resins;
- Wet sludge (sumps, tanks);
- Spent filters;
- Operational waste; and
- Decommissioning wastes.

Waste processing operations will be carried out in the Effluent Treatment Building (ETB) of the EPR plant prior to arrival at the ISF. The facility will have its own testing and inspection arrangements to ensure that only compliant waste packages are transferred to the ISF.

Waste packaging standards will be based upon NDA RWMD's generic disposal concept [3]. The specification will also address the key issues such as the data to be recorded for each waste package and the quality management regime that needs to be applied to package manufacture.

2. SAFETY AIMS AND DESIGN SAFETY PRINCIPLES

2.1 INTRODUCTION

This section defines the high-level safety aims and objectives to be achieved by the storage facility design and mode of operation. It also identifies the Safety Functional Requirements and Design Safety Principles, which will require to be satisfied to meet those aims and objectives.

2.2 SAFETY AIMS AND OBJECTIVES

The primary safety aim is as follows:

'To ensure, so far as is reasonably practicable, the protection of all potentially affected groups of people and the environment throughout the storage facility's life-cycle and facilitate future safe management of the wastes'

A set of objectives underlying this aim is defined as follows:

- To restrict normal operations exposures on and off the site;
- To prevent accidents;
- To mitigate the consequences of accidents that do occur;
- To control the condition of wastes throughout the storage facility's life cycle.

2.3 SAFETY FUNCTIONAL REQUIREMENTS

Safety must be assured under normal operating and accident conditions. At this concept stage of design development, safety functional requirements can only be defined in broad terms. However, from knowledge of the processes to be undertaken and the hazards and risks to be controlled (see Section 1.7) the primary safety functions to be delivered are identified as follows:

- Normal Operations Functions;
  - o Maintain Containment of all radioactive materials (RAM);
  - o Restrict exposure to external radiation;
  - o Control discharges of RAM to the external environment;
  - o Maintain permissible environmental conditions within the ISF;
- Accident Conditions;
  - o Prevent loss of containment;
  - o Prevent loss of shielding;

- Prevent loss of control of environmental conditions for storage;
- Mitigate loss of containment;
- Mitigate loss of shielding;
- Mitigate loss of control of environmental conditions.

Note that although these are quoted as discrete requirements there is inevitably a degree of overlap between individual requirements.

The design will deliver these safety functional requirements to the degree that is reasonably practicable and thereby restrict doses and risks to ALARP levels.

2.4 DESIGN SAFETY PRINCIPLES

2.4.1 Introduction

This section details the set of design safety principles, which have been developed as the basis for design of the storage facility. Higher level, more fundamental design principles such as the requirement for the provision of defence in depth[2], adherence to the single failure criterion[3] and the classification of safety functions by safety significance provide the foundations of the Requesting Parties' safety approach to be implemented in all aspects of the EPR design. This approach is described in Chapter 3.1 of the PCSR.

Because of its 'concept' status, the design of the storage facility is not currently sufficiently detailed to permit the application of the most rigorous hazard identification techniques and the DSPs listed are therefore generally high level and applicable to the design of any modern interim storage facility. As the design is developed, the increase in available detail will permit more rigorous examination and the derivation of more plant-specific DSPs. Nevertheless, due cognisance of the DSPs in the development of the design will ensure compliance with modern standards of good practice for waste management and will contribute significantly to the delivery of compliance with the ALARP Principle throughout the facility's lifespan.

2.4.2 Optimisation

The design must be optimised both in relation to safety and environmental impact. Therefore, for all of the principles listed here, all required actions should employ the 'best available techniques' as defined by the environmental agencies and the principles should be complied with 'so far as is reasonably practicable' as defined by the HSE.

2.4.3 Design Safety Principles

The following DSPs have been defined based on UK regulatory guidance:

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[2] In the internationally accepted sense. See for example HSE SAPs06 and IAEA Standard NS-R-1.

[3] In the internationally accepted sense. See for example HSE SAPs06 and IAEA Standard NS-G-1.2

1. Radioactive waste should be stored in a passively safe condition such that the need for active safety systems to ensure safety is minimised.

2. The primary means of confining all radioactive inventories within the facility should be passive sealed containment systems.

3. Containment of significant radioactive inventories within the facility should be afforded by multiple engineered barriers.

4. The primary means of protection against external radiation should be passive shielding

5. The design should ensure that the wastes will be prevented at all times from mixing with other materials which may compromise subsequent safe and effective management or increase environmental impacts.

6. Wasteforms, packages and containers should be physically and chemically stable and compatible with handling, retrieval, transport, storage and the long-term management strategy for the waste including disposal.

7. Any operational limits and conditions required for safe storage and the need for review and revision over the facility lifetime should be identified through the development of the safety case and should take account of relevant factors such as:

    a. Environmental conditions (e.g. temperature, humidity, and contaminants);

    b. Heat generation;

    c. Gas generation;

    d. Radiological and criticality hazards

8. Monitoring, examination, inspection, and testing arrangements should be developed for the facility, equipment, stored waste and waste containers that take account of any potential for ageing and degradation;

9. The need for monitoring to ensure safety should be minimised.

10. Monitoring, recording and alarm systems should be used to report significant deviations from normal operating conditions as an aid to maintaining plant control and detecting leakage.

11. All aspects of the facility design should take account of the anticipated storage duration (including ageing and degradation) to ensure that the facility continues to meet its safety function.

12. The safe working life of all equipment and systems which perform a safety function or whose failure could affect the delivery of a safety function should be defined early in the design process providing an adequate margin over the intended operational life.

13. The storage environment should avoid degradation that may render the waste unsuitable for long-term management and/or disposal.

14. The storage facility should be designed and operated so that any individual packages can be inspected and retrieved within an appropriate period of time.

15. The design of the means of inspection of waste packages facilities and equipment should be such as to avoid the potential to compromise the integrity of the containment of the waste.

16. Appropriate provisions should be available for dealing with radioactive waste or its packaging that shows signs of unacceptable degradation.

17. The design and operation of all facilities and processes should facilitate the control and accountancy of radioactive waste at all times in the facility such that all waste is identified and an inventory established that should be reviewed and kept up to date.

18. Containers or packages used for the transfer or storage of radioactive waste within the facility should be clearly and uniquely marked for identification.

19. Each waste package should be characterized prior to storage in relation to its radioactive and fissile inventories, decay heat output and presence of contaminants to facilitate subsequent safe and effective management and suitability for processing for final disposal.

20. The design should afford suitable and sufficient design features, locations, equipment and arrangements to support radioactive waste characterisation, segregation and other waste management operations.

21. Where waste is being packaged into a form that is intended to be suitable for final disposal, it should be sufficiently characterised to properly inform subsequent decisions about its suitability for disposal.

22. Acceptance criteria should be established for admitting waste to the storage facility which should take account of requirements for storage, handling, and retrieval and the overall long-term management strategy, including disposal.

23. Arrangements should be made and implemented (which may include examination, testing and auditing) to ensure that incoming radioactive wastes meet the acceptance criteria. Arrangements should also be established for the safe management of any incoming radioactive waste that fails to meet the acceptance criteria.

24. Information should be recorded for all stored wastes which may be required for its future safe management.

25. The facility design and mode of operation should be such that secondary waste generation and discharges to the environment are minimised.

2.5 SAFETY CRITERIA

A system of normal operations dose and accident risk criteria has been developed for EPR, which are fully compatible with UK legislation and regulatory expectation. These are presented in Section 3 of Chapter 3.1 of the PCSR.

3. PRELIMINARY ASSESSMENT OF HAZARDS AND RISKS

3.1 INTRODUCTION

This section demonstrates that risks will be controlled to levels that are ALARP. It describes the means by which the design and its anticipated mode of operation will deliver the safety functional requirements identified in Section 2.3. It is again noted that the specific means of delivery of the safety function will vary between the possible design options.

Additionally, it outlines the means by which internal and external hazards will be controlled by design, identifies the classes of accident which are likely to be bounding in terms of radiological consequence and those which are likely to dominate the residual risk associated with the plant's operation.

3.2 NORMAL OPERATIONS SAFETY FUNCTIONAL REQUIREMENTS

3.2.1 Maintenance of Containment RAM

To ensure continuing adequate containment of all radioactive materials present within the facility, the storage structures, systems and components will be designed, fabricated and constructed in accordance with applicable standards of good engineering practice.

Containment of radioactive materials will be provided through the combination of:

- Passively safe (possibly immobilised) waste: Depending upon the waste type, its conditioned wasteform may serve as a first protection barrier against contamination spread (further details see Chapter 12.2.6 and 11.3.2.1 of [1] and [2].
- A robust storage container will ensure that potentially loose contamination will remain within the container. The container received from the Effluent Treatment Building will be designed to conform to a specification that will include criteria for retention of activity;
- The building envelope and building space extract ventilation will afford dynamic containment to prevent any possible migration of activity during accident scenarios from the building interior to the external environment.

In this context, dynamic containment refers to the provision of a containment compartment served by a dedicated extract ventilation system, which creates a depression within the compartment and ensures that air movement is from areas of lower to greater contamination hazard.

To ensure safety through passive containment, the focus of these engineered barriers is on the wasteform first (where applicable), then the container and finally, the store itself. The store building represents the final barrier of a series of barriers between the waste and the wider environment. While the multi-compartment option does, in theory, provide an additional barrier in the form of the compartment structure, it is considered that two layers of containment (as provided by the single compartment option) will be adequate for both normal and abnormal operating conditions given the strict controls in place on package inventories.

Since treatment of waste will occur in the ETB of the EPR plant, prior to receipt at the Interim Storage Facility, the barriers listed above are in place throughout the whole waste management process.

Monitoring and sampling will be performed during waste processing in the ETB. Consequently, during storage in the ISF, monitoring of all packages will not be required to be a standard procedure, but periodic checking of a sample of packages will be conducted. Detailed inspection will then be performed as necessary (e.g. if indicated from remote visual inspection).

3.2.2 Normal Operation Doses

3.2.2.1 Operator Doses

The total effective dose delivered to any worker will be the sum of the effective dose from external radiation and any committed effective dose delivered via exposure to any chronic airborne contamination hazard within the operational area.

During handling operations, appropriate shielded containers will be used to protect operators. In addition, standard handling operations and radiological monitoring of waste packages can be controlled remotely from the monitoring room, thus preventing unnecessary operator exposure. Within the ISF, a radiological zoning system will be applied in order to assure that preventative measures are taken for personnel protection and risk reduction.

For the multi-compartment option shielding thicknesses for walls and roofs of compartments will be optimised during the design process to ensure that worker doses from sources behind shielding will be maintained ALARP and within design objectives consistent with UK industry best practice.

In the single compartment option, the primary shielding will be provided by the structure of the packages themselves to a level which will permit operation without additional shielding of workers.

Dose uptake from this source should be very low in either case.

Under normal operating conditions, there will be no release of activity from stored waste packages or their outer surfaces. There is, therefore, little chance of waste package activity spreading to manned areas, and airborne activity levels will be negligible. Nevertheless, further protection is provided, under both options, by space extract ventilation of all operating areas.

The generation of airborne particulate contamination from within the packages is expected to be very low under either option. Gaseous nuclides such as tritium and radon may be produced and released should waste packages be vented. However, should packages be vented, internal filters will be provided to restrict the release of particulate material.

Real time airborne activity monitoring and confirmatory sampling regimes will afford further protection. These provisions will be optimised taking due account of the very low airborne hazard anticipated.

3.2.2.2 Public Doses

Because of the distance between the radiation sources in the facility and the closest point to which the public would have access, together with the effect of shielding, public doses from direct radiation will be negligible.

However, very low levels of radioactivity (e.g. tritium and naturally occurring radon) may be discharged to the external environment via gaseous discharges. Under normal operations, these will be made in strict compliance with authorisations based on potential doses to critical individuals via various possible environmental pathways. For this reason and because of the very low anticipated airborne activity and HEPA filtration provision, public exposures from discharged material are expected to be very low.

3.2.3 Restriction of External Radiation Exposure

The only significant sources of radiation will be the waste packages themselves.

In compliance with DSP 4, passive shielding provides the primary protection against external radiation exposure. In relation to workers, the most important shielding provisions are as follows:

- Inherent shielding of treated wastes which have been immobilised and / or inherent shielding of waste containers;
- Bulk shielding of cell structures and design of monitoring stations;
- Concrete building walls and roofs.

Whether, shielding is provided by the structure of the storage compartments or by the structure of the packages themselves, the thickness of shielding will be optimised with respect to normal operations exposures of ISF personnel.

These primary provisions will be complemented by a zoning system based on the level of radiological hazard potentially present. By control of access to these designated areas to an extent proportionate to the hazard, unnecessary exposure of personnel is avoided and unavoidable exposure controlled. Zone classifications range from those permitting free access to all personnel through those requiring the restriction of access to specified groups for limited periods to those permitting limited periods of entry only after source removal.

Further support to the dose restriction regime will be provided via radiation surveys.

Waste packages with a higher dose rate will be paced in the middle of a compartment and waste packages with a lower dose rate shall be put in the outer space of the compartments providing additional shielding to higher dose rate packages.

In relation to public exposures, the protection afforded by shielding will be equally effective. However, for this group, access to the site will be prevented and attenuation by distance will be an additional mitigating factor.

3.2.4 Restriction of Discharges

Discharges will only be made under formal authorisation and in compliance with the limits and conditions set down in the relevant authorisations.

No secondary wastes will be created without prior justification, and the best available techniques (BAT) will be employed to minimise those that are created. The design will employ BAT for the abatement of discharges of radioactivity to the environment. The strategy for disposal of all wastes will be holistic and will again employ BAT.

Under normal operating conditions, no significant discharges of artificial radioactivity are anticipated. However, discharges may contain alpha, beta and beta-gamma activity from naturally occurring radionuclides (e.g. radon). Monitoring of discharges will be carried out prior to the discharge stack, to confirm the continuing effectiveness of containment and abatement provisions.

No loose particulate contamination is expected within the ISF during normal conditions. Contamination should under no circumstances be spread outside of the ISF. To ensure this, the following preventative measures have been identified within the concept design:

- Containment by storage packages;
- Acceptance Conditions for surface contamination of packages;
- Use of approved waste containers only;
- Acceptance of passively safe waste forms only;
- Remote inspection of stored containers;
- Inspection of containers during scheduled inspections;
- Contamination control via ventilation system and monitoring systems with remote alarm;
- Storage of the waste package under controlled and corrosion prevention conditions;
- Dynamic containment by the ventilated storage hall envelope.

In the unlikely event of a leakage from a waste container, early warning monitoring systems will allow safe retrieval and transfer of a leaking container to a suitable treatment or repackaging location.

3.2.5 Maintaining Control of Environmental Conditions

It is necessary to provide adequate provision for the control of temperature and humidity within the ILW ISF for the following reasons:

- To ensure integrity of the waste package by maintaining temperature and humidity within an acceptable range to prevent degradation of the wasteform or package;
- To maintain the safety functional capability of structures and equipment whose rate of degradation may be accelerated by excessive temperatures;
- To maintain a working environment conducive to high operator reliability;
- To ensure that no unacceptable build up of hydrogen can occur due to radiolysis in the wastes.

In all cases, environmental control systems will be designed to have reliability commensurate with their importance to safety.

Design calculations will be performed for normal, off-normal and accident conditions to determine any necessary limits on environmental conditions, the delay to reach these limits under abnormal conditions and to determine the appropriate ratings for ventilation and air conditioning systems.

Whilst the ventilation system is the only active system potentially involved in the safety function of the storage building, it is not regarded as essential to maintaining safe conditions. Its failure would not cause any immediate effect in relation to package condition. This would only occur over a very extended period of time.

In relation to hydrogen production due to radiolysis, it is noted that this process is unavoidable given that hydrogenated materials will be present in the waste. However, it is not expected that this process will produce sufficient amounts of flammable gas to be a factor in determining the rating of ventilation systems. This will be confirmed by calculation as the design is developed.

In the single compartment option it is anticipated that the storage hall will be ventilated at all times by an active extract ventilation system.

In the multiple storage option, all storage compartments that are not involved in emplacement or retrieval operations will be left in a passive state (i.e. cut off from the ventilation system). During this passive state, the compartment remains fully enclosed and access of air that can result in changes of humidity within the compartment will be minimised through closure of all openings.

3.2.6 Maintaining Waste Integrity

3.2.6.1 Corrosion Aspects

The external surfaces of the waste package will be exposed to the prevailing atmospheric conditions within the storage hall or storage compartments. Two broad types of corrosion are relevant:

- General Corrosion. There is a wealth of evidence that suggests that stainless steel generally has very low corrosion rates within a well-defined range of atmospheric conditions. The ISF will be designed to operate within this range of conditions, therefore, the risk of package degradation due to general corrosion is considered negligible provided storage atmospheres are adequately controlled;

- Local Corrosion. Stress corrosion cracking, crevice corrosion and pitting corrosion may present problems for container longevity. These mechanisms are strongly related to container design and environmental conditions (e.g. presence of salts and other contaminants on surfaces, condensation and moisture levels). Consequently, the environmental conditions within the ISF will be strictly controlled to reduce the risks of container corrosion.

The safety objective that must be delivered by the design is to maintain the integrity of the waste package.

3.2.6.2 Radiolysis Aspects

The ILW containers may be affected by radiolytic production of gases potentially causing pressurisation of packages.

The amount of gas produced will depend on the exact radiological characteristics of the wastes and on the type of pre-storage conditioning undertaken. As previously stated, the production of gas is expected to be very low and it is anticipated that this phenomenon can be safely managed for long-term storage.

In order to avoid any risks from over-pressurisation, the following will be taken into account:

- The use of containment systems (waste cementation matrix, storage containers etc) with inherent withstand against any predictable increases in internal pressure;
- If necessary, containers may be passively vented in order to abate the container internal pressure; and
- The specification of the space extract system to ensure effective removal of any hydrogen generated via radiolysis.

3.3 ACCIDENT CONDITIONS SFRS

The requirement for any of the above measures will be determined through calculation whose results will be input into the design development process.

3.3.1 Loss of Containment

The following are considered to be the most likely potential initiating events (either singly or in combination) for fault sequences involving the breach of containment afforded for radioactive inventories.

- Degradation of primary containment
    - Age related mechanisms;
    - Chemically induced mechanisms;
    - Thermally induced mechanisms;
- Dropped loads and impact events;
- Fires;
- Flooding;
- Loss of power;
- External events;
    - Natural hazards;
    - Man-made hazards.

The events with the greatest harm potential will be those with the potential to affect the inventory of multiple waste packages.

Mitigation of the consequences of loss of containment events will be afforded by the containment and ventilation systems discussed earlier. Prevention of such accidents is discussed under the potential initiating events in Sections 3.3.4.1 to 3.3.5.2.

3.3.2 External Exposure

The only penetrating radiation of interest for these wastes is gamma radiation.

Three classes of potential fault sequences are identified:

- Catastrophic damage to plant shielding structures (multi-compartment option);
- Catastrophic impact damage to waste packages (both options);
- Inadvertent opening of shielding doors/plugs.

Plant shielding structures in the multi-compartment case will be fabricated from concrete. In the single compartment option, the shielding will be afforded by the packages themselves.

The only internal hazards, which could have such a consequence, are dropped load events involving waste package or other similarly massive equipment items. These will be prevented by the controls identified in Section 3.3.4.2.

The only external hazard, which could conceivably give rise to such a consequence, is seismic disturbance (which could also be an initiator for dropped load). For this accident scenario, a range of sophisticated approaches may be required to determine the hazard load. For these analyses, it will be ensured that the methods adopted are appropriate and conservative and the results will be subject to sensitivity analysis.

3.3.3 Criticality Accidents

Given the nature of the waste, which will not contain fissile species, criticality will not be an issue in an ISF.

3.3.4 Internal Hazards

3.3.4.1 Loss of Electrical Power Supply

Potentially loss of electrical power could give rise to several classes of fault sequence resulting in impairment of environmental conditions or dropped or impacted loads. However, the impact any loss of electrical supply would have on the corrosion of a waste package would be negligible due to the very long time scales required to pose a corrosion threat.

Reliable and timely emergency power will be provided. Provision will be made in the design so that, in the event of a loss of the primary source of electric power to instruments, control, service and operating systems, safe storage conditions will be maintained and continued functioning of all systems related to the safety functions of the facility will be permitted. It is noted that such back-up supplies will only be provided should the results of fault analysis for the developed design indicate a need for immediate restoration of power to maintain safe conditions.

All systems for lifting and transferring waste packages will be designed to ensure that loss of power results in failure to safety and the maintenance of the capability to return loads to a safe state.

3.3.4.2 Dropped Loads

Load handling of waste packages inevitably has an associated risk of loads being dropped or impacted. Such events could produce the following radiological consequences:

- Dispersal of waste package inventory;
- External radiation exposure of site workers.

Prevention

Such fault sequences will be prevented by:

- The design of high reliability lifting and handling equipment with intrinsic safety systems to terminate runaway load fault sequences safely;
- The design of equipment and structures to withstand seismic disturbance to a degree proportionate to the potential consequences of their failure;
- The inclusion in the design of mechanical locking systems and physical stops, anti-derailing and anti-lifting devices on cranes, trolleys, etc…
- The production and implementation of specific operating procedures to limit the lift heights for loads in general and waste packages in particular.

Waste package handling systems will be designed to ensure adequate safety under normal, off-normal and accident conditions and will be designed to established international standards for nuclear load lifting and transfer equipment. Specifically, in addition to being designed to minimise the likelihood of dropped or runaway loads and impacts, they will be designed to:

- Be able to put down the load safely under any foreseeable operational conditions;
- Retrieve a dropped waste package.

Mitigation

All areas where direct handling of waste packages is performed are classified as potentially contaminated and thus designed to limit the radiological impact of handling accidents through dynamic containment.

Under either option, the impact resistance and containment afforded by the containers will also serve to mitigate consequences. Where containers have been qualified against impact events of a specified magnitude, the design will prevent impacts of greater magnitude by design by, for example, the restriction of potential drop heights and impact energies.

Finally, mitigation will be afforded by multi-layer containment as described previously.

3.3.4.3 Internal Fires

Fires may result in release of activity from waste packages indirectly by damaging equipment and systems whose effective operation is necessary for safety or preventing operators from performing safety-related tasks or direct thermal challenge to package containment.

The facility will be designed to:

- Prevent fire ignition;
- Limit fire loading;
- Provide fire detection and suppression systems;
- Prevent fire spread;
- Prevent radioactive material spreading in the case of fire.

Suppression systems will only be included in the design if shown to be necessary by detailed fire assessment of the developed design.

Prevention

The general principle applied for fire prevention will be to restrict as far as possible the presence of ignition sources in areas where there are significant fire loadings, and strictly to limit fire loadings in areas with an unavoidably high density of potential ignition sources. This principle will be particularly strictly applied in areas where waste is handled or stored.

The primary contributor to fire loadings in many areas is likely to be electrical cabling which, itself, will present potential ignition sources. However, it is intended that the design will specify non-combustible electrical cabling. It is again emphasised that the waste packages employed under either option are fabricated from non-combustible materials. Any release generated by thermal challenge will result from increased wasteform temperatures via processes such as evaporation of water of crystallisation (for cementitious wasteforms) rather than from combustion of the wasteform.

Mitigation

Items important to safety and safety related items would be protected by systems designed to ensure early detection. Areas with high fire loadings will be equipped with automatic fire detection and suppression systems.

Fire spread will be prevented by the division of the facility into fire compartments segregated by non-combustible structures. Services running between areas will only be routed through dedicated fire seals.

It should also be noted that the packages themselves offer a significant level of fire resistance.

3.3.4.4 Degradation Mechanisms

Prevention

Such events may be brought about by a coincidence of unfavourable conditions over time. More detailed consideration is given to these mechanisms in Section 5. The primary means of prevention will include the following:

- Original specification of waste package;
- Definition of acceptance criteria for waste transferred to the storage facility;

- Control of storage environmental conditions;
- Traceability and identification of individual waste packages.

Unless those systems controlling the storage environment were to become unavailable for a very extended period, it is very unlikely that unacceptable levels of waste package degradation would occur.

Mitigation

Mitigation of the consequences of such events will primarily be achieved by the multi-layered passive and dynamic containment provisions and supporting monitoring arrangements described in Section 3.2.

Protection of workers would additionally be provided by space extract ventilation systems in occupied areas and monitoring for airborne contamination.

Discharges to the environment would be restricted by the provision of HEPA filtration prior to discharge**.**

3.3.4.5 Internal Flooding

Flooding within the ISF could be caused by the failure of piping, tanks and other types of leakage. However, due to the low water use within the facility, this is a very low frequency accident. The design will ensure that there are no water sources in the storage hall of the ISF and there will be physical separation between the storage hall and other parts of the facility.

Systems and components of the storage facility with the potential to cause flooding will be designed and located so that their failure will not to jeopardise the operation of systems important to safety thereby preventing the initiation of fault sequences with the potential to cause loss of containment. Water pipe runs will be located so as to avoid any risks of water ingress to the storage compartment locations (multi-compartment option) or to the storage hall under the single storage compartment option.

3.3.5 External Hazards

These are natural events or events linked to human activities originating from outside of the facility but which may have a detrimental effect on the facility's safety

External hazards have already been identified as possible initiators of fault sequences that could result in loss of waste package containment and/or shielding.

The general approach to designing for protection against external hazards is described here.

3.3.5.1 Natural External Hazards

The most potentially significant of this group of hazards are as follows:

- Seismic events;
- Extreme weather conditions;
    - Wind;

- Rain;
- Snow;
- Temperature;
- Lightning;

- Flooding (other than due to extreme weather);
  - River flooding
  - Tidal surges;
  - Tsunami.

These events will be considered on an individual basis and, where appropriate, their simultaneous or sequential occurrence will also be taken into account.

To a greater or lesser extent, the frequency / magnitude relationship for each of these hazards will be site specific. However, for the purposes of design development, a design basis event will be determined for each hazard type. The standard reference event in the UK has a conservatively assessed predicted frequency of being exceeded in magnitude of less than 1 E-4y^{-1}. However, where the worst case accident consequences resulting from external hazards are low, a less demanding design basis event may be defined. This is likely to be the case for the ISF due to its relatively low inventory and the robustness of the stored waste packages under either of the possible storage options.

Protection against this group of events will be through design of all systems, structures and components whose failure could lead to unacceptable radiological consequences to withstand the challenges defined by the design basis event by an appropriate margin of safety taking account of any identified potential cliff-edge effects. For flooding from external sources, particular attention will be paid in the design to the potential combination of natural phenomena. For example, in the case of flooding from the sea, extreme wind not only affects wave heights but can also elevate sea levels further through storm surge. Storm surge can be additive or subtractive, and must be combined with the highest and lowest predicted tides and with barometric effects.

It may be reasonable for the operational response to recognise some warning of extreme flooding, provided the necessary response measures can be initiated with sufficient margin.

In addition to external barrier defences such as sea walls, systems important to safety may be protected by their location at horizons within the facility above the maximum predicted flood level for the design basis event.

It is also noted that future climatic changes are likely to have an impact on the frequency/magnitude relationship for some external hazards. These are likely to include extreme temperatures, wind and flooding. In this field, the design process will take into account the latest available predictions from reliable sources over the facility’s projected lifetime including the decommissioning phase.

In the case of hazards, such as lightning, which are not amenable to the definition of a design basis event, protection will be assured by designing to appropriate codes and standards.

3.3.5.2 Man Made External Hazards

These are again likely to be site specific in some cases in relation to frequency and magnitude. Some sites may pose specific man-made hazards that others do not.

Such external hazards may include:

- Aircraft Impact (all classes of aircraft);
- External explosions;
- Missile generation;
- Hazardous gases (toxic, flammable or corrosive).

For aircraft impact accidents, the mechanical challenge to structures will depend principally on the mass, rigidity, velocity and engine location of the specific aircraft assumed to impact directly or skid onto the structure of the facility, and also the angle of incidence of the impact.

A further thermal challenge to structures systems and components will be posed in some scenarios by an intense aviation fuel fire. This will be more significant for the heavier classes of aircraft because of the quantity of fuel carried.

The total impact frequency for all aircraft classes will be assessed on the basis of an effective "target area" for the facility, taking account of the dimensions of the facility and adjacent buildings and structures, a representative range of angles of impact, and the aircraft impact frequency per unit area for the geographical area of the UK around the site. It may also be appropriate to take account of any ‘no-fly zone’ around the site.

Clearly both the target area and aircraft impact frequency will be highly site-specific due to the location of the nearest airfields, flight paths and military training zones as well as the disposition of buildings on the site.

Should the total aircraft impact frequency be assessed to be below than 1 E-7y^{-1}, this external hazard may be excluded from further consideration. However, if the assessed frequency is above this figure but below the design basis frequency threshold (1 E-5y^{-1}) the potential consequences of the combined impact, thermal and explosive challenge to structures systems and components systems will be investigated and means of minimising these by design considered.

It is extremely unlikely that the frequency will exceed the design basis event threshold and therefore, it is likely that the analysis will be restricted to PSA with the assessed risk from aircraft impacts included within the facility risk. It is noted that the possible effects on safety related equipment from a nearby (rather than direct) impact might need consideration.

Man-made hazards may arise, for example, from either the conveyance of hazardous materials on adjacent transport routes (pipeline, rail, road and sea) or adjacent permanent facilities, such as quarries. Since the nuclear licensed site also houses the reactor and may also house additional nuclear plants, potential hazards arising from these, which could affect the ILW ISF, will also be considered and designed against where appropriate.

Typical hazards, which may arise from industrial plants, may be from stored gas, fuel, explosives, pressure vessels or turbine disintegration. All potential sources of external missiles and explosion overpressures will be taken into account. However, the majority of such hazards will be site-specific and a comprehensive safety analysis will not be possible until the site is identified.

3.3.6 Key Structures and Systems

The most safety significant structures in the storage facility under either design option will require to be qualified against external events

Under either option, the structure of the storage hall building itself will require qualification. In addition, the stacking arrangements for stored packages will require to be seismically qualified under the single compartment option and the structure of the individual compartments will require seismic qualification under the multi compartment option.

Waste package lifting and transfer and handling systems will also be required to be designed to permit the necessary qualification under either option.

In regard to aircraft impacts, whose low frequency is likely to be taking them out of the design basis, the effects of mechanical challenge to the above systems will also be considered and minimised where reasonably practicable. The consideration of the effects of ingress of burning aviation fuel into the ISF and means of its prevention will also require to be considered.

3.4 SUMMARY HAZARD ASSESSMENT

3.4.1 Introduction

This section provides a high level discussion of the main radiological hazards and risks associated with the operation of a storage facility for ILW.

At this concept stage, a lack of engineering design detail and information regarding the demands placed on operators precludes the performance of detailed frequency assessment for probabilistic safety analysis (PSA) and the classification of faults as design basis faults.

However, it is possible to preliminarily identify classes of accidents which are likely to have the greatest harm potential and hence to require inclusion within the design basis and those likely to provide the dominant contributions to the residual risk from the facility.

3.4.2 Bounding Accidents

Initial assessments suggest that the bounding accidents within the ISF are dropped or impacted load events and fires involving multiple packages, resulting in losses of containment. Such events will also present difficulties for package retrieval. These accidents would result in a significant release to the building atmosphere. However, releases to the environment and consequent exposures of the public would generally be limited by the building containment other than for scenarios in which it was significantly damaged as a result of the accident (e.g. under seismic challenge).

The dropped package event could be initiated by either handling errors or a seismic event that results in the collapse of a stack of packages (single compartment option) or collapse of storage compartment structures onto packages (multi-compartment option). The worst case consequence in both cases will be failure of a waste package(s) and the release of some of the contents of the waste package(s) within the ISF. Building design will help minimise the impacts of a seismic disturbance.

Fire events could also theoretically result in the failure of multiple waste packages and the release of a fraction of their inventory to the ISF internal atmosphere. However, given the fact that fire loadings will be strictly limited by design, it is considered extremely unlikely that a fire of sufficient magnitude and of sufficient duration to significantly affect multiple packages could occur. Again building design will help minimise the impacts of fire by the use of engineered barriers and fire suppression systems. It is noted, that in this respect, the multi-compartment option would afford a greater degree of compartmentalisation. However, given the limited severity of credible fires, this may not represent a significant advantage over the single compartment model. In either case, damage to the building containment would be unlikely and significant mitigation of the releases to the external atmosphere by this structure would be expected.

The dropped package event during handling would result in release of a fraction of the contents of the dropped package and any other packages impacted. Such events could be initiated by human error (handling error) internal hazards or intrinsic failures of handling equipment or package lifting features. Such failures may not be capable of elimination by design and will, therefore require to be subject to probabilistic assessment.

Further assessment of all of these accident scenarios will be required which take into account: dose assessments for critical groups (workers and public); typical package inventory; accepted release fractions for raw and immobilised waste; accepted dispersion models etc. It is again noted that the consequences for the public from any accident within the facility are expected to be very small.

3.4.3 Summary of Preliminary Risk Assessment

A safety assessment is required as part of the licensing process to demonstrate that the storage facility complies with regulatory requirements. The assessment will need to demonstrate that doses and risks remain within established criteria and meet the ALARP principle. Safety will need to be assessed for both normal operations and foreseeable accident conditions. The safety assessment must consider incidents arising from both internal process related events (e.g. fire (within the building), dropped waste packages, age related failure of containment of the waste packages) and from external hazards (e.g. aircraft crash, earthquakes, external fires).

While the ILW store will contain large inventories of radioactivity, those wastes that are immobilised in a stable matrix should result in a low accident risk. Waste packages that are not immobilised in a stable matrix will result in a higher risk owing to their potential for greater releases of radioactivity in the event of an accident (other than for decommissioning wastes with inventories primarily due to activation). Reducing the number of such waste packages will reduce the accident risk. Accidents resulting in mechanical stress on a package will be mitigated by reducing lifting heights and prevented, as far as reasonably practicable by designing out potential drop load scenarios.

Possible causes of contamination are failure of a seal / sealing mechanism and failure of the package inspection (wipe test) and monitoring procedures prior to dispatch from the ETB. Engineered and administrative controls will be employed to prevent such events and thereby ensure that the likelihood of a contaminated waste package entering the ISF is very low.

Due to the operational lifetime of the ISF (one hundred years), degradation or failure of the waste package is a credible event that could negatively impact the retrievability of the waste package. Initiating events leading to this fault include: corrosion of the waste package container; gas generation in the waste matrix; decomposition of the waste package due to adverse changes in the wasteform; or an accident resulting in mechanical stress on the package in excess of its design capability. Waste package inspection arrangements and environmental monitoring within the ISF will be used to provide early detection and hence permit mitigation of package failures. The risk of corrosion can be further mitigated by use of materials that are not susceptible to corrosion and by controlling the environmental conditions within the store to maintain temperature and humidity conditions within acceptable levels. The final design of the ISF will incorporate good industry practice in these areas. In the event of a serious impact on the waste package, the ISF design will consider and optioneer types of equipment that may be used to aid recovery of the waste package.

Given the nature of the waste (low fissile material content), criticality is not an issue.

3.4.4 Facility Lifetime Risk Profile

The facility risk can be expected to vary over the operational lifetime of the plant as the nature and intensity of operations and the facility inventory varies.

Three main operational phases are anticipated:

- Waste Receipt;
- Waste Storage;
- Waste Export.

It is noted that some operations for retrieval for export of waste decayed to LLW levels may also be undertaken during the storage phase.

During the receipt phase, there will be a relatively high frequency of waste handling operations for the receipt and emplacement of waste in storage. The stored inventory will rise from zero to full capacity. Some operations to retrieve waste for inspection may be required.

During the storage phase, there will be a relatively very low frequency of waste handling operations other than any retrieval operations for inspection of waste. The store will be filled to capacity.

During the export phase, there will again be a high frequency of waste handling operations for retrieval for export and, if required, some retrieval operations for inspection of waste. Over this phase the stored inventory will gradually reduce from full capacity to zero.

The risk associated with stored waste will be approximately proportional to the inventory stored. Due to the low level of active operations, much of the risk will be associated with accidents initiated by external hazards or failures of systems required to maintain a safe storage environment. Provided degradation of the waste and essential environmental control systems is prevented, the risk per unit inventory stored should remain approximately constant throughout the plant’s operational life. Thus the risk associated with stored waste, will be expected to rise gradually over the receipt phase, remain constant over the storage phase and diminish gradually during the export phase.

The risk associated with waste handling will be a function of the frequency of waste handling operations (i.e. for receipt, ex-situ inspection or final export). Since retrieval operations essentially require the reverse procedure to emplacement operations the risks per operation should be similar. The risk associated with waste handling should, therefore remain roughly constant during the receipt phase, reduce to very low levels during the storage phase when the only contribution will be from retrieval for inspection and possible remediation, and then remain constant again during the export phase given a reasonably uniform export rate. The absolute value of waste handling risk for the export phase will depend on the rate of export achieved which in turn will depend on the handling capacity of the facilities for further treatment or final disposal.

The overall facility risk can therefore be expected to rise gradually during the receipt phase, remain constant over the storage phase and gradually diminish over the export phase.

It is emphasised that if permitted to, the effects of degradation of the waste packages, of the handling equipment, of structures and other safety-related equipment would cause a gradual, underlying rise in both storage and waste handling risks. However, this will be effectively prevented by the implementation of the strategies for maintenance, refurbishment and replacement, inspection of waste, equipment and structures and the preparation for commencement of the export phase.

4. MINIMISATION OF ACTIVE SAFETY MANAGEMENT

4.1 INTRODUCTION

This section describes how the dependence on active safety systems is minimised.

4.1.1 Key DSPs

Of the DSPs defined in Section 2.4 the most relevant to the restriction of dependence on active safety measures are DSPs 1 and 2:

1. *Radioactive waste should be stored in a passively safe condition such that the need for active safety systems to ensure safety is minimised; and*

    a. *The primary means of confining all radioactive inventories within the facility should be passive sealed containment systems*

A number of other DSPs also have relevance to the achievement of safety by predominantly passive means. These are DSPs:

3. Containment by multiple barriers

4. Passive Shielding

5. Prevention of mixing with other materials

6. Container stability over time

9. Minimisation of monitoring to ensure safety

22. Definition of acceptance Criteria

25. Minimisation of secondary waste

The remaining DSPs are of more indirect relevance to the attainment of the objective.

4.1.2 Passive Systems

A passive system is one that:

- Requires no services or input signal of any kind (electrical, pneumatic, fuel etc.) to fulfill its defined safety function;

- Is not required to provide any kind of output (e.g. electrical signal, changing magnetic field, mechanical movement, light or sound);

- Does not require any operator involvement to fulfil its safety function.

Any safety system, which does not meet all of these requirements, must then be classed as an active system.

It is noted that these requirements effectively defines all forms of monitoring as 'active'. The third requirement conforms to the fundamental principle that reliance on operator intervention to ensure safety should be minimised. This leads to the need to optimise the design in relation to the need for operator intervention to either maintain or reinstate safe conditions on the plant i.e. to minimise their involvement in the delivery of primary, normal operations SFRs or secondary, accident conditions SFRs.

It is noted that in some aspects of nuclear plant design, active systems such as ventilation are afforded as part of the means of maintaining safe conditions but that their failure will not produce unsafe conditions since the design will still deliver the safety function passively. The primary defence is the design characteristic, which delivers the SFR passively, and the active system is a secondary contributor to the defence in depth arrangements. Similarly, in some cases, the active systems required complement a passive system in delivering the SFR to the performance level specified in the design. Following failure of the active system, the passive system continues to deliver the safety function and maintain safe conditions.

4.1.3 Design Approach

In the design approach which will be adopted, the main routes to minimisation of dependence on active safety management are:

- Adoption of a primarily deterministic approach to the achievement of safety;
- Reliance on passive means and natural processes to deliver primary safety functions;
- Optimisation of the design with respect to operator involvement for the maintenance or reinstatement of safe conditions;
- Optimising the required frequency of periodical inspections and maintenance through robust design, definition of acceptance criteria, provision of adequate pre-storage characterisation facilities;
- Optimisation of the requirement for management of secondary (primarily no-active) wastes.

4.1.4 Monitoring

DSPs 8 and 9 present an apparent paradox. DSP 8 demands the provision of monitoring while DSP 9 appears to require the minimisation of monitoring. However, it is clear from earlier discussion that monitoring is a secondary defence and does not directly ensure safety by the preservation of normal operating conditions. Rather, monitoring represents good practice and constitutes part of the defence in depth arrangements. The essence of DSP 9 is that monitoring should not be a primary means of control. During the storage period, it is not essential to monitor operational parameters as a first line of defence against the creation of accident conditions.

4.2 PRINCIPAL MEANS OF ENSURING SAFETY

4.2.1 Radioactive Material Containment

This section discusses the means of maintaining containment of major inventory i.e. waste packages. It excludes the means of controlling environmental conditions, which are discussed later.

Reliance is placed upon primary and secondary passive containments to maintain safe conditions during storage. Depending upon the waste type, its conditioning (e.g. by cementation) serves as a first, but limited protection. The primary protection against contamination spread in both options is a robust storage container, which assures that potentially loose contamination stays within the container. In the multi compartment storage hall, the secondary barrier is the lidded concrete compartment. In the single compartment model, the second protection barrier is the building envelope itself. While the passive protection afforded by the building is supported by extract ventilation to provide a dynamic containment, the protection afforded is primarily passive in nature. It is also noted that the waste packages proposed for this option are of particularly robust construction and afford adequate containment on their own in a purely passive manner. Thus, the primary SFR is delivered by essentially passive means with a degree of redundancy for both options.

4.2.2 Protection against External Radiation

In the multi-compartment model, the primary protection against penetrating radiations will be afforded by the bulk shielding of the concrete structures forming the storage compartments. In the single compartment model, the intrinsic shielding of the self-shielded packages employed will perform the same function. In either case, the dose rates in occupied areas will be reduced to levels consistent with UK modern standards of good practice. For the single compartment model, the intrinsic shielding of the waste packages will permit a more ‘hands on’ approach to both package handling and inspection.

Thus, safety during storage is assured, under normal operating conditions, by purely passive means under either design option.

In all cases, for those operations requiring handling of unshielded waste packages out with shielded containment, shielding will be afforded by appropriate shielded transfer containers. This may also be the case for waste packages with internal shielding if surface dose rates are significant and this is found to be a reasonably practicable option.

4.2.3 Environmental Conditions within the ISF

The means of delivering the SFR for maintaining favourable environmental conditions for storage in the ISF is essentially the HVAC system. It is noted that while self-shielded packages in the single compartment option are always within a ventilated containment (the storage hall), the compartments in the alternative option are only ventilated during emplacement or retrieval of packages.

Hydrogen evolution by radiolysis is not expected to provide a significant risk under either option; only negligible levels are expected which will not produce specific ventilation requirements.

4.2.4 Control of Environmental Discharges

The primary means of preventing discharges to the atmosphere are passive since they are the containment barriers discussed in Section 3.2.1.

Aerial discharges of particulates are anticipated to be very small under normal operating conditions. However, these will be abated through the provision of HEPA filtration upstream of the discharge point. Although HEPA filters deliver their safety function in a passive fashion, it is necessary for the potentially contaminated air to be drawn or driven through the filter installations by ventilation.

Nevertheless, it must be acknowledged that the consequences of failure of the abatement arrangements described above would not result in any significant public exposures.

4.2.5 Control of Criticality Hazards

Given the nature of the waste, criticality will not be an issue in an ISF.

4.2.6 Internal Hazards

Internal hazards, which could remove safety functional capability of safety important systems include, dropped and impacted loads and fires.

These could directly affect waste package integrity in some cases or render unavailable systems (including engineered or operational systems) necessary to the maintenance or reinstatement of safe conditions.

4.2.6.1 Fire Hazard

In relation to fire, as discussed earlier, the primary protection is preventative i.e. the control through design of fire loadings and ignition sources. However, the approach to protecting waste inventory from direct thermal challenge will employ the passive means of dividing the plant into fire compartments by means of non-combustible barriers. This same approach will be employed for the protection of systems required for the maintenance of other aspects of plant safety. This design philosophy depends entirely on passive means of protection. Clearly, the single compartment option does not afford the same level of protection in this case as the multi-compartment option. However, this is not likely to be important since, realistically, it is very unlikely that a fire of sufficient severity to affect multiple packages could be supported by the very limited fire loading associated with either option.

4.2.6.2 Load Impact Hazards

In relation to dropped and impacted loads, these could, in the worst case lead to direct impact on the primary storage locations for waste.

While it is unlikely to be practicable to render lifting and transfer systems safe by completely passive means, an important contribution to safety will be made by passive systems such as:

- Physical stops on travel;
- Passive load attachment systems;
- Provision of multiple load paths;

- Engineered restraints on lift heights;
- Physical constraint of load travel paths.

Other important systems, while not purely passive, will rely on fail-safe technology such as emergency brakes and 'dead man's handles'.

However, given a failure to prevent uncontrolled load descent or lateral travel, protection will again, where appropriate, be afforded through qualification of potentially impacted structures and systems and the impact resistance of the packages themselves. In this respect the multi-compartment model appears to afford greater protection to stored waste due to the robustness of the individual storage compartments. However, it must again be pointed out that the packages themselves will be significantly more robust under the alternative option.

4.2.7 External Hazards

4.2.7.1 Natural Hazards

Seismic events and, to a lesser extent, other potentially disruptive natural phenomena, represent potentially the greatest challenge to the integrity of the stored waste. Catastrophic structural failures would have the potential under all options to remove the containment barriers afforded for the waste package inventory.

Additionally, such events could potentially remove the retrievability capability afforded by the design. This could occur by damage to compartments and/or waste packages.

The scenario may be exacerbated by the loss of integrity of the containment buildings and HEPA filtration installations, which form the final barrier against release to the environment.

Because of the very considerable harm potential of these scenarios, they will be addressed by the design such that the plant is deterministically safe by significant margins.

All structures, systems and components whose failure could cause or prevent the termination or mitigation of such fault sequences will be designed to withstand the challenge of the relevant design basis events and retain their safety functionality in a purely passive manner through their inherent robustness against mechanical challenge. For the multi-compartment option, this would apply to the storage building structure and the structures of the individual compartments. For the single compartment option, in addition to the storage building itself, the proposed stacking arrangements for the self-shield packages will require to be qualified against the design basis events. Given the appropriate qualification of structures and systems, the main safety functions relevant to external hazards will be delivered by passive means.

4.2.7.2 Man Made Hazards

The approach to protection against man-made external hazards mirrors that for natural events in that design basis events will be defined and structures, systems and components qualified against the challenge posed by such events or protected by structures which are themselves qualified. That is, the design process will adopt a deterministic approach relying primarily on passive protection.

4.3 OPTIMISATION OF INSPECTION AND MAINTENANCE REGIMES

4.3.1 Introduction

Inspection and maintenance are, by their nature, active safety management systems.

The design philosophy will be to avoid complexity in handling, storage, inspection and monitoring processes so that very little need for intrusive surveillance and maintenance is required.

Reducing the need for periodical inspections and maintenance (preventive and/or curative) will mainly be achieved by:

- Specification of waste package design and performance;
- Setting of acceptance criteria for items for storage (such as decay heat output);
- Pre-storage characterisation of items for storage to confirm compliance with acceptance criteria;
- Selection of appropriate process options;
- Avoidance of novel, untried processes and equipment;
- Appropriate equipment design (simple, reliable and robust);
- The anticipation of ageing aspects, and their prevention through maintaining favourable environmental conditions.

Each of the above will call heavily on the considerable body of international experience accumulated for similar facilities.

4.3.2 Process & Equipment Selection

Irrespective of whether active or passive processes are adopted, the choice of a specific process option can assist in restricting the need for safety related surveillance and maintenance.

In relation to selection of equipment, simple, reliable and robust systems of established provenance and compliant with international standards of good engineering practice will be selected. In this way, the operational life of systems and hence the requirement for intervention for maintenance and replacement will be optimised.

4.3.3 Ageing Phenomena

The understanding and anticipation of ageing phenomena (see Section 5) potentially affecting both stored inventory and safety related equipment will permit the optimisation of procedures, personnel training and monitoring and inspection regimes in relation to the prevention or control of degradation mechanisms with a potentially detrimental affect on safety.

4.4 OPTIMISATION OF WASTE MANAGEMENT REQUIREMENTS

Restricting the need for management of secondary wastes will have a direct, positive impact on the restriction of the need for active safety management, since less processing and surveillance will be required.

ILW ISFs do not produce significant amounts of process wastes under normal operating conditions.

It is noted that any secondary wastes will have much lower activity concentration than the stored waste. The restricted harm potential of fault sequences involving such materials means that the restriction of active safety management requirements, while still desirable, is of less importance to the safety of the facility as a whole than is the case for the management of the stored waste inventories.

4.5 OPTIMISATION OF MANNING REQUIREMENTS

The optimisation of the requirement for active safety management will produce a reduction in the number of operational staff required reducing the collective dose accrued and limiting reliance on operator intervention to ensure safety.

Furthermore, only a very gradual variation in parameters related to safety such as concrete temperatures and corrosion mechanisms is anticipated. This is supported by the accumulated international experience of operating similar facilities. This again indicates that the need for operational surveillance will not be burdensome under normal operating conditions.

Overall, the ISF will have very limited dependency on active safety management systems involving operator action to ensure safety.

5. MAINTENANCE OF WASTE PACKAGE AND EQUIPMENT INTEGRITY

5.1 INTRODUCTION

This section identifies the characteristics of the waste packages and equipment needed to maintain their integrity over the interim storage period.

The waste package design will take into account the potential occurrence of age-related degradation mechanisms which may affect the integrity of the waste packages (which will form the primary containment) or any other containment barrier, structure or system whose integrity will be important to maintaining the waste package integrity under normal and abnormal conditions over the extended storage period. A list of potential waste packages is provided in Section 1.9.1. Safety must be guaranteed during passive storage and any waste package handling operations required for retrieval for inspection or final disposal.

Considerable experience has been accumulated both nationally and internationally, which will permit confident prediction of materials behaviour over time and which can therefore be fed into the development of characterisation, storage, inspection and monitoring regimes.

Of primary concern is the maintenance of an effective primary containment barrier to retain radioactivity during normal operations and to contribute to the containment of activity under accident conditions. Under both storage options primary containment will be afforded by the combination of the wasteform and container structure i.e. the waste package.

Safe retrieval during and after the storage period will depend not only on the waste package integrity but also on the structural integrity of any additional waste package storage container and the condition of the handling equipment employed.

Because the continued integrity of these systems will be central to the continuing validity of the safety case for the facility, their condition will be regularly reviewed. In particular these will be among the subjects for review under the periodic review of safety required by Nuclear Site Licence Condition 15.

5.2 POTENTIAL WASTE PACKAGE DAMAGE MECHANISMS

The condition of the waste package and much of its behaviour during transfer and storage will be determined by the environmental conditions in its storage location, the nature of the wastes and chemical contamination levels on the package.

Some of these factors are listed below:

- Temperature;
- Humidity;
- Chemical contamination of package surfaces;
- Presence of corrosive chemical species or their precursors in the waste;

- Pressurisation by radiolytic gases.

Therefore, the definition of appropriate acceptance criteria, and storage environmental conditions will help minimise degradation of the waste packages over time.

5.3 WASTE PACKAGE INTEGRITY DURING STORAGE

The primary consideration in maintaining waste package integrity in the long term is the maintenance of a storage environment conducive to the preservation of the waste package through the provision of an appropriate storage atmosphere.

If experience of operation of the facility and other similar facilities indicates that degradation of waste package integrity is an issue over the long term, the design of equipment that may be required to ensure the safe recovery of the waste packages will be considered, optioneered and optimised.

5.4 OTHER SAFETY RELATED SYSTEMS

To guarantee operability of the ISF, equipment for handling and inspection of waste containers must maintain functionality. Due to the long design life of the ISF, the following equipment is considered “consumable” over a regular utilisation period of twenty to forty years:

- Electric / electronic equipment (cameras, switches, detectors, motors, cabling etc);
- Mechanical and electromechanical equipment that is subject to wear (lifting gear, steel wires, grabs etc).

This equipment has to be repaired or replaced in accordance with schedules and procedures based on an understanding of the failure behaviour of the individual system types accruing from experience on similar plants and from experience gained over many years on the facility itself.

In relation to civil structures, which will mainly be fabricated from concrete, it is not intended to replace these over the operating life of the facility. The properties of these materials are well known, as are the degradation mechanisms that could potentially affect them over the long term. The approach for these structures will be to ensure longevity through their original specification and to remediate promptly any degradation revealed by inspection.

5.5 DAMAGED OR DEGRADED WASTE PACKAGES

5.5.1 Introduction

Waste processing operations will be carried out in the ETB prior to arrival at the ISF. The ETB will have its own testing and inspection arrangements to ensure that only compliant waste packages are transferred to the ISF.

If age-related degradation of any waste package is identified, the waste packages will be overpacked in containers suitable for extended storage and compatible with standard handling procedures.

5.5.2 Damaged Waste Package Identification

Visual inspection (employing CCTV) of the waste packages will identify degraded waste packages. Airborne activity monitoring will also indicate the presence in storage of any seriously degraded packages. No personnel access will be required for visual inspection and therefore, dose uptake by operators will be minimal. It is noted that the shielding of self-shielded packages under the single compartment option may be sufficiently effective to permit direct inspection of packages. However, the benefit of potentially more effective inspection would require to be balanced against the dose uptake accruing from such an approach to ensure that the inspection regime accorded with the ALARP Principle.

5.6 OPTIONS FOR LONG TERM INTERIM STORAGE OF DAMAGED WASTE PACKAGES

The monitoring area will provide facilities for nuclide determination, dose rate monitoring, contamination monitoring and inspection of waste packages before and after storage if required. This room will also be used to undertake any repackaging that is required for some wastes to permit their disposal as LLW; and over-packing of degraded ILW packages.

6. RETRIEVAL AND INSPECTION OF WASTE PACKAGES

6.1 INTRODUCTION

This section describes the provisions and functions necessary for the retrieval and inspection of waste packages and potential inspection regimes. It also considers changes to the retrieval and inspection regimes as materials age and their characteristics change.

Details of the ISF concept options are presented in References [1] and [2].

6.2 OVERVIEW

6.2.1 Design Safety Principles

The primary DSP to be addressed in relation to retrieval of waste is DSP 14:

'The storage facility should be designed and operated so that any individual packages can be inspected and retrieved within an appropriate period of time'.

The primary DSP to be addressed in relation to inspection of stored waste packages is DSP 8:

'Monitoring, examination, inspection, and testing arrangements should be developed for the facility, equipment, stored waste and waste containers that take account of any potential for ageing and degradation'

Two classes of inspection are envisaged. Firstly the design will ensure that effective and safe means of in-situ inspection of the waste in its storage location will be afforded. Secondly, ex-situ means of inspection will be provided for waste packages retrieved from their storage location either because in-situ inspection or indirect monitoring results (e.g. for airborne activity or airborne discharges) indicate that their integrity has become suspect or because it is required to comply with the inspection regime devised to meet regulatory expectation.

In compliance with DSP 15, the means of in-situ inspection will be designed to be non-intrusive minimising the potential for damage to the waste package and its containment. Similarly the equipment for retrieval of waste packages for ex-situ inspection, if required, will be designed to avoid damage to the waste package to be retrieved.

To ensure that the waste package remains retrievable so that it may be removed to specialised facilities for inspection, the design will ensure that:

- Account is taken of potential age-related degradation effects which might diminish its structural strength or containment integrity (DSP 6);

- The waste package and any containers employed will be designed to be compatible with their storage environment taking account of the longevity required of them and hence suitable for handling and to ensure that the waste package will be effectively separated from any materials which might affect its integrity over the long-term (DSPs 5, 11,12, 13);

- Monitoring will be carried out of the storage environment to ensure early detection of failed waste packages at a stage when safe retrieval remains possible (DSP 8); and

- Procedures and equipment are always available for the safe retrieval of waste packages whose containment or structural integrity is suspect (DSP 16).

A great deal of experience is available regarding the properties of waste packages and their performance over extended periods in storage conditions. The original specifications for the waste packages will guarantee compliance with the acceptance conditions for the ISF. This will be supported by rigorous quality procedures at all stages of design, procurement and manufacture.

In addition, the first and second requirement will not only require a knowledge of potential degradation mechanisms (described elsewhere in this report) but a detailed knowledge of the storage environment to which the individual waste packages have been exposed over the storage period. This will require the continuous monitoring or regular sampling of the properties of the storage areas' atmospheres and the secure recording of the resulting data (see Section 7 and DSPs 8, 17 and 18).

6.2.2 Retrievability

Suspect waste packages will be overpacked. In complying with DSPs 11 and 12, attention must also be paid to the condition of the equipment required for retrieval. It will be equally important to ensure that lifting and handling equipment remains capable of transferring the retrieved waste package with a degree of reliability that remains adequate for the restriction of the frequency and hence of the risk from dropped load events. This again will be primarily ensured by the original specification for the equipment but also by the implementation of a maintenance regime compliant with the philosophy described in Section 7. However, where significant deterioration in structural strength of a waste package is suspected, particularly in relation to lifting attachments, it may be necessary to employ specialised equipment for retrieval to give additional support and possibly additional containment to the retrieved item.

Waste packages that are identified as degraded during inspection will be transported for repacking. The waste packages will be retrieved using appropriate handling equipment.

At the end of the interim storage period, the procedure to send the waste to the final repository will be as follows:

- Move the packages situated on top of the packages to be inspected to enable access;

- Identify and arrange the packages;

- After identification, move the package of interest to the inspection area to proceed with pre-shipment inspections (visual, dose rate, surface contamination);

- Place the package onto the transfer car to the reception hall;

- Load the package onto the truck or the train using the travelling crane;

- Export the package by road or train.

6.2.3 Monitoring

Monitoring will not necessarily identify specific waste packages as being suspect in relation to their containment. However, its results will be employed to trigger closer inspection of individual waste packages to identify those which are suspect and may require retrieval to the sampling cell for either further, more detailed inspection, or for remediation to render them suitable for continuing storage.

During the storage lifetime, the waste packages will be visually inspected (remotely but possibly directly for self-shielded packages). Depending upon the results of visual monitoring, it will be possible to retrieve the waste package for further investigation. The ventilation off-gas will also be monitored for activity.

6.2.4 Characterisation

For inspection, either in-situ or ex-situ to be fully effective, benchmark data obtained prior to storage will be required regarding the condition, properties and history of each waste package. Means of obtaining these data will be required for compliance with DSP 19. These data must be suitable for informing decisions on retrieval for final disposal (DSP 21) and will also facilitate decision-making regarding the need for retrieval for inspection and suitability for retrieval employing standard equipment. Suitable facilities will be afforded by the design to permit the necessary characterisation to be performed (DSP 20). These data will be required for comparison with acceptance conditions prior to acceptance of the waste package for interim storage. This will be obtained from inspections carried out prior to or during its storage in the ISF. This data will require to be securely recorded and readily retrievable employing systems meeting the requirements set out in Section 7.4.

6.2.5 Accountancy & Records

A key requirement in enabling the retrieval of specific waste packages for inspection will be the ability to determine quickly the precise location of any identified package and to confirm its identity once located. This will be enabled by the maintenance of records of location completed at the time of initial emplacement and updated during the storage period to reflect any change of location and by the marking of waste packages and any overpacks required employed with unique identifiers (DSP 18).

The maintenance of paper files will be undertaken in order to mitigate problems caused by the rapid obsolescence of electronic systems and software (see also Section 7.4.3).

6.3 INSPECTION AND MONITORING REGIME

6.3.1 Optimisation of the Regime

Provided the risks from the regime adopted are shown to be below a pre-defined limit on tolerability, acceptability will depend on the demonstration that the inspection regime has been optimised such that the perceived benefits of inspection are not outweighed by the disbenefits (particularly the radiological and conventional risks) associated with following that strategy. The balancing of risks associated with alternative inspection regimes will be an integral part of the process to ensure compliance with the ALARP Principle throughout the facility's life.

The primary potential radiological disbenefits relevant to the choice of option will be:

- Normal operations doses to workers and the public:
  - Background doses from stored waste packages;
  - Doses from waste package transfer operations; and
  - Doses from inspection and possible remediation operations.
- Accident risks to workers and the public:
  - Accidents during waste package transfer operations;
  - Accidents involving stored packages;
    - During in-situ inspection procedures; and
    - During retrieval of packages.
  - Accidents during ex-situ inspection operations and possible remediation operations

In relation to accidents, the primary concern will be with the potential for dropped loads onto a waste package or an internal fire (see Section 3.3.4.3).

The decision making process is likely to be based on the relative assessed magnitude of these potential contributors to risk (noting that for normal operation, radiological risk is proportional to dose). These will each be proportional to the frequency of inspection operations. It is this frequency that will need to be optimised in order to optimise the risks associated with inspection. This will include consideration of the balance of risks and benefits of in-situ inspection and retrieval for ex-situ inspection.

It should be noted that the contributors to risk identified above may have different relative magnitudes under the two storage options under consideration. For example, the somewhat more robust construction and greater inherent shielding of the packages for the single compartment option would tend to restrict risks from normal operations doses and impact accidents below the corresponding levels for the multi-compartment option given a similar inspection frequency.

At this time it would be difficult to assess an absolute value for risk associated with the retrieval of a single waste package. However, it should be possible to estimate the magnitude of the accident and normal operations risks associated with retrieval relative to the risk of emplacement of a single waste package.

6.3.2 Elements of the Regime

6.3.2.1 Effluent Treatment Building Inspection

The first stage of the inspection regime takes place while the waste package is still in the ETB when techniques for the detection of damaged or non-compliant waste packages are employed. This also provides input to the necessary characterisation procedure, which must precede interim storage.

6.3.2.2 Receipt at the Interim Storage Facility

The first opportunity for inspection of waste packages for interim storage forms part of the receipt procedures at the ISF. These activities will include wipe tests, inspection of integrity and documentation checks.

6.3.2.3 Waste Package Monitoring and Inspection during Interim Storage

While waste packages are stored in the ISF, their visual inspection by camera will be possible. This may be more readily achievable for the single compartment option which may even permit direct inspection. This may be carried out on a regular scheduled basis for all stored packages or be triggered by abnormal activity monitoring results. The exact approach adopted will be based on extensive experience of storage of ILW and will take account of expectations expressed by the nuclear regulator. As always, the regime will be optimised.

Monitoring results will betray any significant containment failure of stored waste packages.

6.4 IMPLICATIONS OF STORAGE DURATION FOR THE INSPECTION REGIME

Due to the very extended period for which waste packages will require to be stored prior to final export from the ISF, the waste package inspection regime will require to be reviewed over time to ensure that the risks from storage and those associated with final export will remain ALARP.

Factors requiring to be taken into account in the optimisation of the regime may alter over time. Clearly, in theory, if there are age-related degradation mechanisms which may affect the stored waste packages or the equipment employed for its inspection or handling, the significance of these would be expected to increase over time. However, that is not to say that they will necessarily become significant in the absolute sense. The implication for the risk-balancing decision making process is that, firstly, more frequent retrievals for ex-situ examination might be necessary if there is a real expectation of material changes in the waste packages. Such increased failure probability would also increase the risks associated with continuing storage (i.e. non-retrieval) including those associated with in-situ inspection. However, given that the structural integrity of waste packages and the equipment employed to retrieve them may also have degraded over time, an increase in the probability of dropped loads per retrieval operation may also be anticipated.

Clearly there are a number of competing factors to be considered in developing an inspection strategy for the longer term and these can only be meaningfully compared on the basis of robust research data and continuing operational experience.

The primary concern will be the behaviour over time of the primary containment and lifting features afforded by the package. Significant degradation over time could increase the likelihood and potential consequences of a dropped load loss of containment accident. However, the properties of these materials are well known and documented and will be specified in the waste package specifications.

The research data available to date relating specifically to ILW waste indicates that degradation under the storage concept being considered, under suitable environmental conditions, is unlikely to be a major issue over such storage periods.

Other safety related items whose failure rate dictates accident frequency and risk are waste package handling systems. However, again, these items will be fabricated from stainless steels. Further, these items of equipment will be accessible for maintenance, refurbishment and even, if necessary, replacement. Therefore, there is no reason to suppose that risks associated with their failure will significantly increase over the storage period provided an appropriate preventative maintenance philosophy (such as that described in Section 7) is adopted.

It is concluded, that the ALARP Principle can only be satisfied in relation to the risks from the operation of the facility by adopting a flexible inspection regime, which is optimised on the basis of feedback from operational experience and continuing research programmes.

7. FINAL RETRIEVAL AND PREPARATION OF WASTE PACKAGES

7.1 INTRODUCTION

This section addresses plans for the facilities, and their functions, needed to retrieve the waste packages and prepare them for onward processing or disposal.

7.2 KEY DSPS

The DSPs of particular importance in relation to final export of ILW from the ISF are DSPs 13 and 16.

DSP 13 *'The storage environment should avoid degradation that may render the waste unsuitable for long-term management and/or disposal'*

DSP 16 *'Appropriate provisions should be available for dealing with radioactive waste or its packaging that shows signs of unacceptable degradation'*

Meeting these DSPs by design will ensure that it will be possible to retrieve all stored waste packages in a condition suitable for the intended operations to prepare them for disposal.

Additional DSPs whose purpose is to ensure that stored wastes are maintained in an un-degraded condition have been discussed in earlier sections.

Further issues of importance relating to the final retrieval and processing for disposal are the need for accurate records of the waste packages' initial condition on receipt and the results of inspections during interim storage to give sufficient confidence that retrieval and preparation for disposal can be safely undertaken. This will in turn require that robust initial characterisation has been carried out prior to or on receipt into the interim storage facility and that a robust system of acceptance conditions has been developed on the basis of a sound understanding of the potential degradation processes which might adversely affect integrity under very long-term storage and the conditions necessary to minimise those effects. Finally, it will be essential that there is no ambiguity as to the identity of each stored item and its location such that it is certain that the correct item is retrieved and the recorded data relating to condition certainly refers to that particular item.

The above issues will be addressed by compliance with the following DSPs in particular:

- Characterisation;
  - DSP 19: Characterisation prior to storage;
  - DSP 20: Facilities for characterisation;
  - DSP 21: Characterisation for final disposal; and
  - DSP 23: Inspection against acceptance conditions.
- Acceptance Conditions;

  - DSP 22: Definition of acceptance conditions.
- Records;
  - DSP 18: Unique identification; and
  - DSP 24: Unique Recording of information.

7.3 MAINTENANCE STRATEGIES

In addition to maintaining the condition of the waste packages over the extended storage period, it is essential that the machinery and facilities required for the handling operations are maintained (and if necessary refurbished or replaced) over the interim store's lifetime to ensure that final retrieval operations can be carried out safely and with operational efficiency. In accordance with good engineering practice, routine maintenance, refurbishment and component replacement schedules will be determined on the basis of an understanding of the failure behaviour and useful operational lives of specific systems and will adopt an anticipatory and preventive approach.

Most importantly the design of all waste handling and transfer systems will be designed to have appropriate longevity and integrity and reliability commensurate with their importance to safety. It will also ensure that no damage to the waste packages occurs during its handling which could compromise its integrity. In particular the design of such systems will:

- Avoid features which could damage waste packages during handling operations (see DSP 15);
- Include safety systems (preferably passive or at least fail-safe) to avoid drop of waste package, or load drop onto the waste packages;
- Provide handling operation areas located to avoid travelling above the waste packages;
- Include engineered features to limit travel speeds;
- Include redundant power sources and diverse emergency systems (to a degree commensurate with their importance to safety);
- Include engineered provisions to ensure that loads can be safely put down under following any reasonably foreseeable intrinsic failures or internal or external hazards;
- Include interlock systems, physical travel limitations and load sensor based cut-outs to prevent or halt dangerous operation; and
- Ensure that they are located such as to facilitate access for maintenance, provide adequate space for effective maintenance, restrict hazards to maintainers and minimise the risk of inadvertent damage to other safety related systems.

During active operation of the ISF, it will also be essential to maintain the availability of:

- Diagnostic and testing facilities for equipment known to exhibit wear-out failure mechanisms;

- Suitable workshop facilities for repair, refurbishment or replacement of faulty or age-degraded components; and

- A spare parts management system with the maintained stock of items based on an understanding of the failure behaviour and useful operational life of the item and its operational and safety importance.

The final point will be of particular importance given the very long operational life of the facility. Obsolescence of components and systems will require to be anticipated and systems put in place to identify and safety justify potential alternative means of delivering function.

An additional issue pertinent to the operation of facilities over very long time periods is the maintenance of a suitably qualified and experienced workforce, with familiarity with the systems to be operated and maintained. This is particularly important since the demands on the work force will vary considerably over the various phases of the facility's operation with considerably more demand during the relatively intensive receipt and emplacement and final retrieval phases of operation in comparison with the relatively low demands over the several decades of passive storage operations. This will be addressed through a policy addressing recruitment, retention and training of personnel to ensure adequate resourcing during each operational phase.

7.4 DATA RETENTION AND RECORD MAINTENANCE

Suitable and sufficient records of stored waste and associated facilities will be made and managed so as to provide continuing assurance in relation to the potential environmental impact and radiological risks associated with the operation of the plant. Particularly important, in this context will be the retention of data pertinent to the final retrieval and preparation for disposal of stored waste. This will be essential data for the development of the safety justifications for these final activities.

The data collection and record keeping system will meet the following performance objectives:

- Provide comprehensive and accurate baseline information about the condition of the facility's stored waste packages and equipment;

- Provide historical information about operational management of the facility and maintenance history data;

- Provide the means for the secure storage of this information;

- Provide the means for timely and accurate retrieval of the information when required; and

- Provide adequate tools for data analysis.

7.4.1 Baseline Data

The baseline data of particular importance and interest will concern:

- Waste packages' characteristics, including ETB history, transport data and all information obtained prior to storage via the initial characterisation process;

- Individual waste package locations within the storage compartments; and

- Design specifications and drawings and manufacturer's data (including material data, manufacturing procedures) to permit the manufacturing of any replacement component or system over the lifetime of the facility.

7.4.2 Operating and Maintenance History Data

Operating and maintenance data relating to the following will require to be retained and managed:

- Process conditions during handling and storage required for safe and reliable operation of all aspects of the facility;

- Data obtained from continuous monitoring and sampling;

- Timing of maintenance actions (including identification of failures, malfunctions and repair actions) to optimise operating conditions;

- Date, type and description of maintenance actions to provide continuous feedback on the effectiveness of preventive maintenance to enable optimisation of the maintenance strategy; and

- Identification of the occurrence of age-related degradation effects on components and materials. Assessment of this data may provide early detection of ageing phenomena, permit intervention to prevent potential operational problems and safety-related failures and, again, produce feedback input to optimisation of the maintenance strategy.

7.4.3 Secure Storage of Information

A wide range of data collection and record keeping systems is commonly used in nuclear facilities.

A number of factors will be relevant to the selection of the most appropriate system for the proposed facility. However, it is essential that the selected systems afford the following features:

- Redundancy, and segregation of records; and

- Diversity of recording systems.

Maintaining redundant sets of records in several places not only removes the risk of complete loss of records through common cause events but also will assist in the retention of adequate expertise so that the stored information may be retrieved and used efficiently to address any situation.

It is inevitable that, over the very extended period that the information will be of use, significant developments will take place in information storage and management technologies just as has been witnessed over the past decades. Employing diverse recording and management systems (e.g. hard copies, electronic files on hard drives and portable media, diverse software for data management and analysis) will facilitate keeping up with the evolution of technologies (including software and hardware) to keep the system capable of information retrieval at any time, even at the time of the final operations at the ISF. The employment of diversity in this area will again reduce the potential for loss of all records through some common cause such as viral infection. In particular, paper files will be used in parallel to electronic files in order to allow retrieval of information in case of obsolescence of electronic systems and software.

7.5 PREPARATION FOR ONWARD PROCESSING OF STORED WASTE PACKAGES

The baseline strategy for the interim solid ILW storage facility requires that it must cater for safe and secure storage of ILW arising from EPR plant for 100 years.

This requirement entails not only the safe storage of waste during the 60 years for which the reactor will operate, but also the required surveillance and monitoring during the remaining 40 years of storage before export for further processing or disposal.

Due to the reduced number of site operations over the final decades of storage, far fewer staff will be on site. However, assuming that final transfer to a final disposal facility takes place before decommissioning of the ISF, staffing levels at the ISF may not require significant increase, but nevertheless, would need to be reviewed.

It follows that carrying out the required operations for final export will require the implementation of a preparatory phase, whose main stages can be outlined as follows:

1. Starting over a year before final export, staffing of the interim facility must be reviewed with a view to building up to the necessary levels for safe and efficient operation. This will include increasing the numbers of suitably qualified and experienced personnel in a number of disciplines (e.g. maintenance personnel, workshop workers, lifting and handling equipment operators, supervisory personnel, safety specialists),

2. Retrieval and processing of large amounts of data from the record keeping system including:

    a. Data on the waste package locations and characterisation;

    b. Data on the procedures for waste package retrieval, checking and export;

    c. Data on all equipment linked to waste package storage and retrieval;

    d. Manufacturing data files (in case of failed equipment requiring complete replacement).

3. All of the above data must be thoroughly analysed before any export operation can take place, in particular to identify any suspicious waste package and adapt the procedure accordingly;

4. Technical review of all equipment necessary for exporting waste packages;

5. Identification of waste packages reclassified to LLW and their onward transport to LLW storage;
6. Transport containers review: technical review of the transport containers for waste package export, checking:
    a. Technical characteristics for compatibility with the interim facility's preparation room equipment, handling crane capacity etc.;
    b. The internal structures and furniture of the waste packages in relation to the provision of safe transport conditions.

At the end of the preparation phase:

- The facility will be appropriately manned;
- All export equipment will be operational;
- Suspect waste packages will have been identified and evaluated;
- Appropriate procedures for dealing with all waste packages will have been developed;
- An adequate fleet of transport containers will be available at the facility to meet the required waste package export flow rate.

Before a waste package is exported to the final disposal facility, the waste will be prepared if required (e.g. overpacked, re-conditioned etc), in the second extension to the ISF to meet the requirements of the formal Letter of Compliance (or its successor) for acceptance at the final disposal facility.

7.6 EXPORT PROCEDURES

This section briefly outlines the arrangements and procedures for final export of the waste packages from the ISF.

At the end of the interim storage period, the procedure to send the waste to the final repository will be as follows:

- Move the packages situated on top of the package to be inspected in order to assess it;
- Identify and arrange the packages;
- After identification, move the package of interest to the inspection area to proceed with pre-shipment inspections;
- Identify waste packages to be reclassified as LLW and prepare for onward transport to LLW storage;
- The package is loaded onto the truck using the travelling crane; and
- The package is exported by road or train.

A package identified as non-compliant or suspect when checking upon arrival will be overpacked in the monitoring and overpacking cell, before being transferred to the dedicated storage area until its transport to a final repository.