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Résumé : This document was co-written with Matthieu PETIT (Assystem). This document presents a concise and redily understandable description of the design, construction, and operation of the proposed pool-base interim storage facility for intermediate level waste from an EPR plant.

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SYNTHESIS

PURPOSE

The purpose of this document is to show that the design, implementation and operation of an interim storage facility for ILW (Intermediate Level Waste) are technically feasible in compliance with the environmental and safety requirements of the United Kingdom.

DESIGN REQUIREMENTS

The facility is designed to receive packages for interim storage of ILW arising from 60 years of operation of a single EPR nuclear reactor.

The waste will be received for interim storage already conditioned. This will primarily be in one of two types of package:

- C1PG packages (Ø 1400mm h 1300mm) encapsulated by qualified high-performance concrete (BHP) and a cap cast using the same formulation. Total parcel mass varies between 4.5 and 6.4 tons, of which 10 to 40 % is waste;
- C4PG packages (Ø 1100mm h 1300mm) of the same nature as the C1PG but smaller.

Other packages are also possible.

The facility is designed to store 1200 C1PG packages and 600 C4PG packages for up to 100 years. Taking into account radioactive decay to LLW the facility could be smaller.

Some space is available for specific requirements, such as overpackaging of a potentially defective package.

Currently, there is no final repository (Geological Disposal Facility) for Intermediate Level Waste in the United Kingdom. As required in the Environment Agency (EA) guidance, the storage facility will be built so as to adapt to all situations at the end of the storage phase (for example the retrieval of the waste packages).

DESIGN CHOICES

C1PG and C4PG are EDF ILW reference packages. EDF uses these packages for the 58 reactors of the current nuclear fleet.

The interim storage facility design is based on the EDF ICEDA facility, an interim storage facility project for ILW contained in such packages.

All the packages will be stored in a single interim storage hall.

The packages can be stacked on 3 levels in pyramids (providing better earthquake resistance but using a larger amount of space) or in columns (easier to monitor and move).

The number of waste package handling operations will be minimised through performing package inspection and monitoring tasks with equipment mounted on a travelling crane.

To optimise the use of space, a single shielded containment cell will be used for both waste package inspection and defective waste package overpackaging. The sampling and overpackaging cell has been positioned between the interim storage hall and the reception/retrieval hall in order to use the transfer car as the means of handling.

The described facility includes one interim storage hall but can be designed to be extendable to include an additional interim storage hall (in the case of waste management being required for two or more nuclear power plant units).

FACILITY DESIGN DESCRIPTION

In order to receive, send and inspect the packages, the facility has a reception/retrieval hall (25m long, 10m wide and 9m high) that includes:

- An area suitable for the import and export of waste packages by road or rail transport,
- A temporary storage area, which is also used to inspect the packages,
- A transfer area which is the link between the reception hall and the interim storage hall,
- A storage area for the travelling crane and the handling device for the lifting of packages,
- A travelling crane equipped with a load cell and a camera.

In order to store the packages and to survey them, the facility has an interim storage hall (58m long, 35m wide and 9m high), which includes:

- The transfer area which is the link between the reception hall and the interim storage hall,
- Waste package storage areas,
- Storage area for overpacked non-compliant packages (in case of loss of integrity),
- A cell for monitoring packages and their overpackaging if necessary,
- A storage area for the travelling crane and the handling device for the lifting of packages,
- A travelling crane equipped with a camera and a bar code reader.

In order to transfer the packages between the reception/retrieval hall and the interim storage hall, the facility has a transfer car (11m long, 2.50m wide and 2m high).

In order to monitor the packages, and overpack them in the event of loss of integrity, the facility has a sampling and overpackaging cell. This cell is located between the reception/retrieval and the interim storage halls. Biological shielding ensures that the sampling cell is a low dose rate area.

The facility also requires a number of auxiliary systems and facilities, such as electrical power unit, ventilation system unit, maintenance area and stack. These are not described in this study. Some of them could be shared with the EPR. The detailed design of these auxiliary systems will be performed at the site specific stage according to the requirements presented in the present report. The safety characteristics of the detailed design of the facility will ensure ALARP. All environmental aspects will utilise BAT.

A complete diagram of the facility is shown below.

SAFETY

The facility will be designed, constructed and operated to comply with Ionising Radiation Regulations (IRR 99). In order to minimise radiation doses to workers and the public, the facility will include the following safety functions:

- The facility will provide containment for radioactive material. In most instances the primary containment will be provided by the waste packages (which have a design life of 300 years) and secondary containment by the facility structure in case of hall contamination,
- The monitoring and inspection cell will provide primary containment for the purpose of reworking out-of-specification waste packages.
- The facility will limit the radiation exposure of workers and the public through the provision of shielding and also the site boundary will be appropriately positioned to minimise gamma doses at the site fence.
- The facility will be maintained at a reduced pressure through the use of a filtered ventilation system to prevent the spread of contamination.

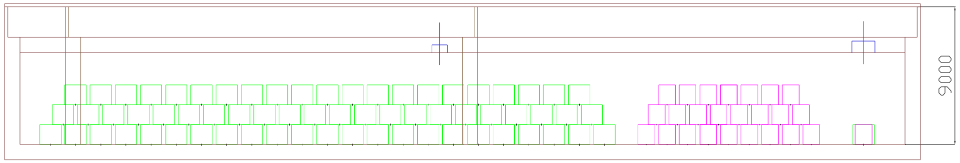
Thus in the unlikely event of loss of containment from a waste package, worker and public exposures will be therefore minimised. The risk of loss of containment from a waste package will be minimised by:

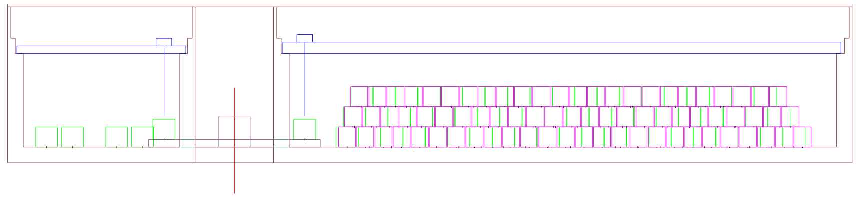
- Minimising waste package handling operations and minimising the lift height of packages where package movements cannot be avoided;
- Inspection and monitoring of the waste packages in the storage hall to allow early interventions if any package defects are identified. Suspect packages can then be transferred to the sampling and overpackaging cells for a more in-depth examination and package remediation measures implemented if necessary.
- The waste packages are designed to be robust against being dropped – no lift heights in the facility will exceed the rated drop height of a package.
- The facility will be robust against foreseeable external hazards such as earthquake, loss of electrical power and severe weather.

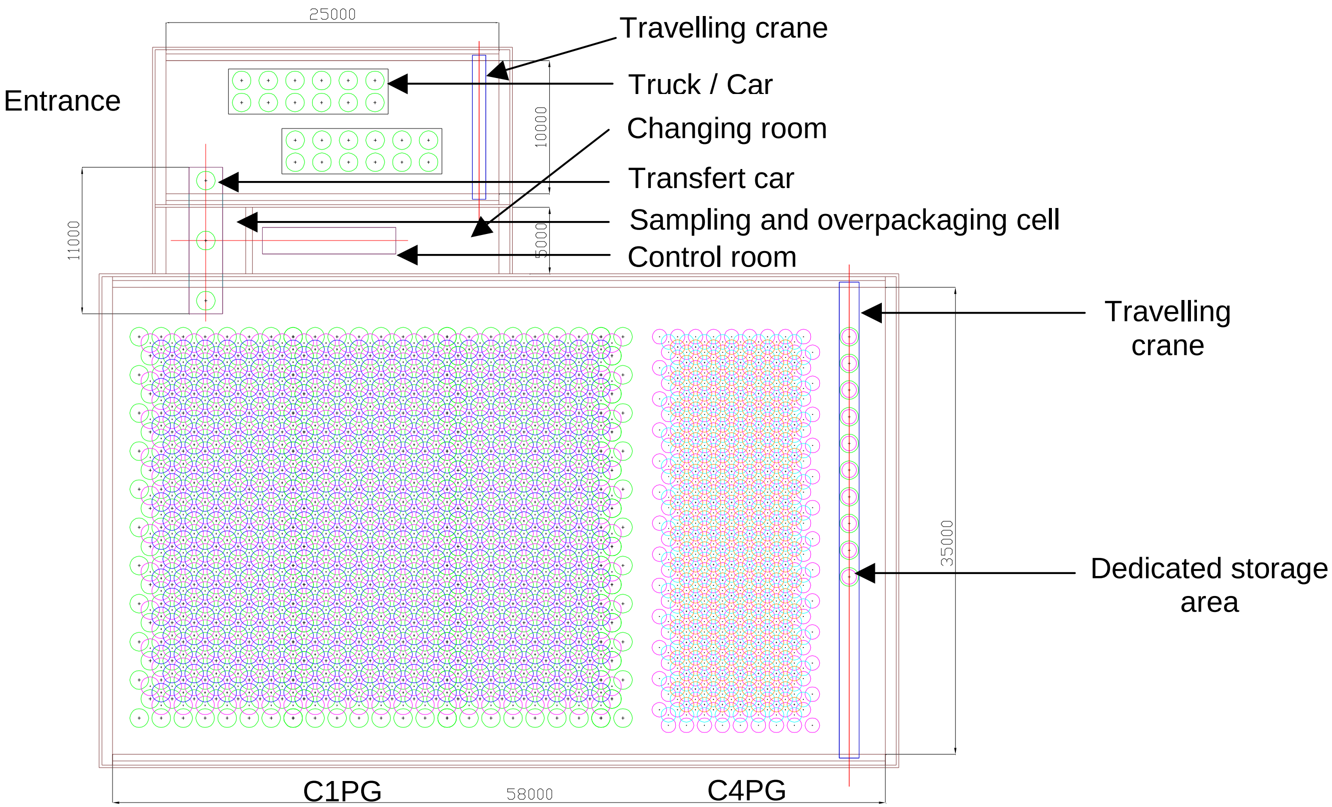
CONCLUSION

In conclusion, it can be stated that interim storage for ILW in C1PG and C4PG reference packages is a proven technology, which is able to meet all storage requirements (maintain packages integrity, no package degradation, etc.) through robust engineering.

Dry Interim Storage facility for ILW







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1 UPDATE

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2 PURPOSE OF THIS DOCUMENT

This document describes the facility provided at the EPR site for the interim storage of the ILW operational arisings. This waste is the result of 60 years' operation of an EPR nuclear reactor and is packaged in appropriate storage packages for a period up to 100 years. There is currently no final repository for the ILW within the UK and hence an on-site interim storage facility is required. An ILW repository is expected to be operational during the 100 year design life of the storage facility. Long term interim storage may also provide benefits in reducing the volume of waste consigned to an ILW repository through radioactive decay and reclassification of the waste to LLW.

Many interim storage facilities already exist worldwide (see annex 3) that conform to the environmental and safety requirements of the United Kingdom.

The purpose of this document is to show that the design, implementation and operation of an interim storage facility for ILW are technically feasible in compliance with the environmental and safety requirements of the United Kingdom.

The facility will be maintainable during 100 years.

3 DESIGN REQUIREMENTS

3.1 INTERIM STORAGE OF ILW

The site is designed to receive packages for interim storage of ILW resulting from 60 years of operation of an EPR nuclear reactor.

The on-surface storage of Low and Intermediate Level Waste is based on one containment barrier, the package (containing the waste).

Moreover, the buildings of the interim storage installations, along with a ventilation system, may constitute an additional barrier to complete the package in the event of its failure.

This document presents two buildings for the treatment of ILW:

- The first one is designed to receive and store for 100 years all the packages coming from the EPR,
- The second one (see §5.3) takes into account the decay of the packages, so some waste will be sent to a LLW final repository after a few years storage.

3.2 THE CONCERNED WASTE

3.2.1 Nature

See chapter 6.3 of the PCER.

3.2.2 Packaging

The waste received for interim storage will have been conditioned in two types of packages:

- C1PG packages constituted by qualified high-performance concrete (BHP) and a cap cast using the same formulation. The total mass of the parcel varies between 4.5 and 6.4 tons of which 10 to 40 % is waste;
- C4PG packages of the same nature as the C1PG but less voluminous.

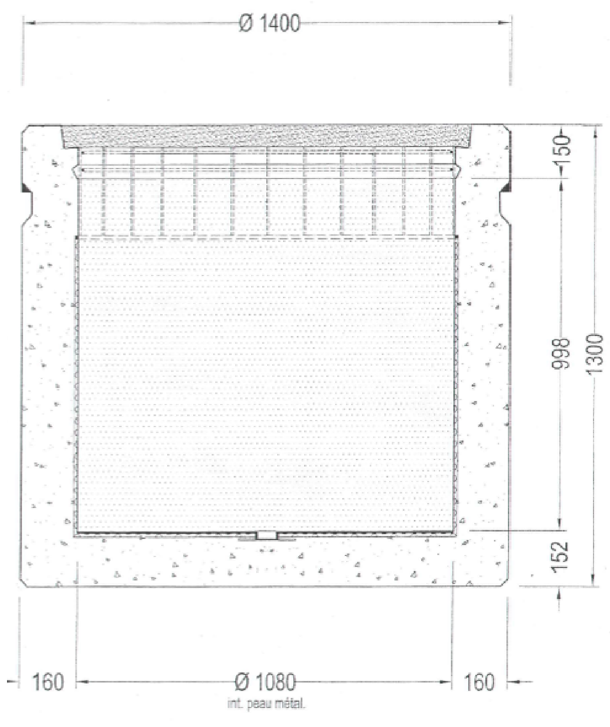
These two types of packages are used by EDF for the 58 units of the nuclear fleet and will be used at the EPR unit in Flamanville. This packaging concept has been proposed to NDA (Nuclear Decommissioning Authority) RWMD (Radioactive Waste Management Directorate) for acceptance.

3.2.2.1 C1PG

Dimensions:

- Diameter: 1400 mm,
- Height: 1300 mm,
- Volume: 2m^3,
- Weight: between 4.5 and 6.4t.

Schéma d'un conteneur C1PG



3.2.2.2 C4PG

Dimension:

- Diameter: 1100 mm,
- Height: 1300 mm,
- Volume: 1.23m^3,
- Weight: between 3 and 4t.

3.2.3 Package lifetime

The packages are manufactured in order to maintain their status of radiological barrier for more than 300 years. Furthermore, packages have a minimal calorific load and are able to withstand falls of a height of the package.

3.2.4 Inventory

The waste is treated, packaged and encapsulated in the Waste Treatment Building of the EPR. The interim storage facility receives only the final form.

The operation of an EPR nuclear reactor generates 47m^3 (rounded to 50) of ILW each year. This waste is packaged in:

- 8 C1PG packages of ion-exchange resins (15.5m^3/ year);
- 2 C1PG packages of wet sludge > 2mSv/h (3.25m^3/ year);
- 6 C1PG packages and 10 C4PG packages (23.6m^3/ year);
- 3 C1PG packages of operational waste > 2mSv/h (4.6m^3/year).

0ver 60 years of reactor operation, this is equivalent to nearly 3000m^3 of waste packages stored:

- 1200 C1PG packages,
- 600 C4PG packages,
- 10 metal boxes used as specific packages.

In the case of an optimised building taking into account the decay of packages allowing their retrieval, the inventory is in § 5.3.

3.2.5 Flow of packages

Throughout the 60 years of operation of the EPR unit, packages arrive at the interim storage facility at a rate of about thirty packages a year. After acceptance testing, each package is identified then stored. Package handling may be necessary for inspection and/or the retrieval. At the end of the facility's life, the packages will be prepared to be exported to their final repository.

3.2.6 Residual power

3.2.6.1 Thermal power

See § 4.2.6.5.

3.2.6.2 Activity

The maximal activity of the packages is 1.34TBq in ^{60}Co.

3.2.6.3 Surface contamination

The limits for non-fixed contamination on a waste package are:

- < 0.4 Bq/cm² β-γ,
- < 0.04 Bq/cm² α.

3.2.7 Consideration of defective packages

In the event that the controls on entrance to the building reveal that a package is non-compliant, this one will be overpackaged and stored in the dedicated storage area. If a non-compliance on a package is detected during storage, it will also be sent to a special area called "dedicated storage." Packages with a lack of containment will be overpacked in metal boxes. The area, which can store 10 packages, is a dedicated area where these packages are stored until they leave the facility.

3.3 BASIC STORAGE TECHNOLOGIES

3.3.1 The site location

The analysis considers that the interim storage facility for ILW is located at the reactor site. The location of the ILW store within the EPR site is not yet defined although this information is not needed to demonstrate the acceptability of the facility within a generic site envelope. The detailed site design and site safety case will take into account the location of the ILW store on a specific site.

This document outlines the ILW storage facility for a single reactor EPR site. However the storage facility can be extended to accommodate additional waste.

The facility will be able to adapt to all situations at the end of the storage phase (retrieval of the waste packages).

<u>Shared systems with the EPR site</u>

The main systems which can be shared with the location site are:

- Site security,
- Roads,
- Power supplies and generation,
- Grid supply,
- Other water supplies.

There are few systems which could be shared mainly because the interim storage facility will continue to function for 40 years after the shutdown of the nuclear plant unit, but they can be shared while the EPR is in operation.

A number of these systems will be reduced or removed following nuclear plant closure. The initial design of the interim storage will include provision for appropriate replacement of these systems.

3.3.2 Design

3.3.2.1 Integration of a possible extension

The described facility includes one interim storage hall but may be extended by an additional interim storage hall (in the event of waste management for two or more nuclear power plant units).

Below are presented two diagrams including an interim storage hall and a possible extension. The second interim storage hall can be added either at the end of the first one (Diagram 1) or on the other side of the reception/retrieval hall (Diagram 2).

The choice will be made during the detailed design studies.

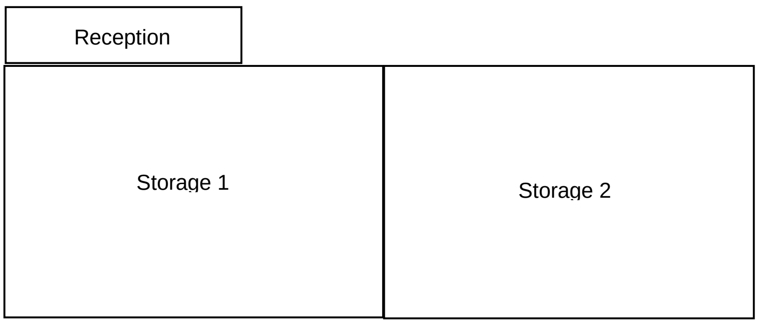


Diagram 1

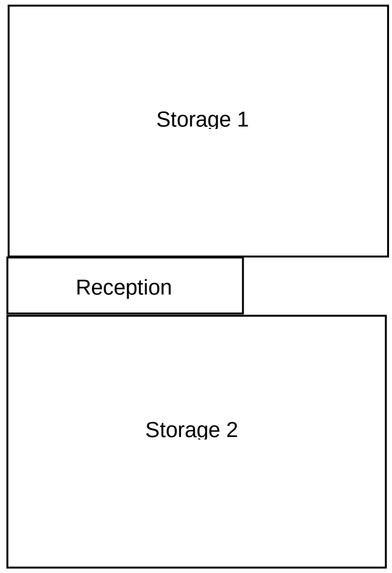


Diagram 2

3.3.2.2 Package stacking

The facility is designed with triple stacking in order to build on the experience of the ICEDA facility. Furthermore, the other storage facilities contain much lighter packages (see annex 3).

Three options were considered for the stacking of the packages:

- Use of wells (see annex 3 CEDRA),
- Stacking in pyramids (see annex 3 ICEDA),
- Stacking in columns.

The well option was not considered in this study because this assessment is based on ICEDA project.

Pyramid and column stacking can both be used. Pyramid stacking offers better earthquake resistance. Column stacking, however, reduces the number of handling operations and allows package surveillance by means of a detector associated with the travelling crane. Furthermore, moving a package in a pyramid stacking configuration may require the movement of 10 packages, while with column stacking, only 2 packages may need to be moved.

Pyramid stacking was retained in the present study because it leads to the bounding envelope value of the area required (2030m² for pyramid stacking, 1820m² for column stacking).

3.3.2.3 Non-compliant package management

In order to minimise the facility footprint, waste package sampling procedures will be performed in the overpackaging cell. Inspection and overpackaging require the containment of a waste package to be deliberately breached and so risk of spread of contamination in this area is the highest in this part of the facility.

The sampling and overpackaging cell is located between the reception/retrieval and the interim storage halls so that all packages that are entering or leaving the facility must go through the sampling cell.

3.3.2.4 Package arrangement within the interim store

The most active packages (dose rate> 2mSv / h) will not be isolated in a distinct area because of their small number (less than 3 C1PG per year). They can easily be stored within the middle of the hall to benefit from the shielding provided by the surrounding packages (See annex 3 CEDRA).

Furthermore, the C1PG and the C4PG will be stored in the same hall, but each on one side. This allows greater flexibility for changing the proportions of C1PG and C4PG received.

3.3.2.5 Package monitoring

In order to reduce the number of package handling operations, it was decided to conduct surveillance of the status of packages without moving them. If the in-store surveillance reports anything unusual, suspect packages will be transferred to the sampling cell, where an in-depth examination of the package can take place. During the storage lifetime, the following package characteristics are monitored:

- Dose rates;
- Non-fixed contamination;
- Integrity of the packages by visual inspection;
- Monitoring of the ventilation off-gas for activity.

3.3.2.6 Package identification and weighing

Also in order to limit the handling of packages, a bar code reader to identify the packages and a load cell are incorporated into the travelling crane of the interim storage hall.

3.3.2.7 Requirements related to transportation

Concrete packages are directly transported on a transport platform, without secondary packaging (if dose rate is under 2mSv/h). Packages are transported by truck (possibility to have 8 C1PG or 12 C4PG) or by train (possibility to have 11 C1PG or 18 C4PG) ; the choice will be made during the detailed design studies. Packages are mainly transported within the limits of the nuclear site, between the Waste Treatment Building and the ILW storage facility. Within 100 years, the packages will be transported to their final repository according to the international transport requirements (with overpackaging if the dose rate is too high).

4 OVERVIEW OF UK POLICIES AND GUIDANCE

4.1 LEGISLATION

The main legislation governing the safety of Interim Storage Facilities is the Health and Safety at Work etc. Act 1974 (HSWA74), the associated relevant statutory provisions of the Nuclear Installations Act 1965 (as amended) (NIA65) and the Ionising Radiations Regulations 1999 (IRR99). Environmental protection is afforded through the regulation of the management of radioactive materials and radioactive waste, for which the principal legislation includes NIA65 and the Radioactive Substances Act, 1993 (as amended by the Environment Act 1995) (RSA93).

4.2 SAFETY ASSESSMENT METHODOLOGY

4.2.1 Safety Principles

The safety principles consist mainly in the interposition between radioactive substances and the environment of some physical barriers to ensure a sufficient containment intended to limit the radiological consequences in normal or accidental operation to below the specified limits.

Thus, the number and quality of the barriers depend on the potential risk caused by the presence and use of radioactive substances.

For all these barriers, it is necessary to:

- Ensure and maintain sufficient containment and integrity throughout the operating situations taken into consideration for the design of the installation and which could have unacceptable consequences for the environment,
- Ensure surveillance of their performance,
- Ensure the recovery and a possible treatment of their loss of integrity so as to sufficiently reduce discharges of radioactive substances.

The following describes the regulatory compliance strategy that will be employed as a fundamental part of the store design and operation.

4.2.2 Safety goals

The safety and radioprotection goals assigned to the storage facilities are the safety of workers and the public, along with environmental protection against the risk of spread of radioactive materials and the risk of external exposure to ionizing radiation.

4.2.3 Functional objectives

In addition to the safety goals, the functional objectives assigned to the storage facilities are:

- Retrieval of radioactive materials stored,
- Adequate knowledge of these radioactive materials for all the possible situations.

These are met by ensuring the integrity of the waste packages (or overpacks in the case of defective packages).

It may be noted the following arrangements taken into account by the operator:

- Long-term preservation of building biological protections,
- Surveillance of package changes during storage,
- Precise source term management: entrance and exit control, movements traceability,
- Possibility of recovery, within a reasonable period, of any radioactive materials released into the facility after an accident.

4.2.4 Safety functions

The general safety functions of an interim storage facility for radioactive waste are:

- Containment of radioactive substances, through the interposition of sufficient systems of containment between the source of activity and the public and the environment,
- Limitation of exposure of the public and external environment to ionising radiation.

These safety functions will be a fundamental part of the plant and system design. Where possible, risks will be eliminated or minimised by design through use of :

- Passive systems where possible,
- Engineered control systems that maintain plant operational parameters within a safety envelope,
- Safety systems that reduce the frequency or limit the consequences of fault sequences, and that achieve and maintain a defined safe state,
- Engineered plant monitoring and alarms,
- Engineered automatic safety systems will mitigate/minimise hazards by providing protective measures,
- Mechanical protective systems will be used where practicable,
- All items will be accessible for operation and maintenance where possible.

A table listing the main safety arrangements is presented in annex 4.

4.2.4.1 Containment

The fulfilment of the “radioactive substances containment” safety function in an interim storage facility for ILW is based on the creation of one containment system interposed between the radioactive substance (radioactive waste) and the workers, the public and environment in all phases of the process.

- This containment system is the package,
- A second containment system is provided by the walls of the retrieval/reception and interim storage halls with a ventilation system which can be contaminated (dynamic containment) (See §3.1).

Thus, in the event of loss of package integrity during storage, radioactive substances remain confined in the following way :

- Particles and effluents are confined inside the building due to the adopted design,
- The ventilation system ensures dynamic containment until decontamination of the area,
- Gases are collected by the building's ventilation system and filtered before release.

4.2.4.2 Limitation of public and external environment exposure

The fulfilment of the "limitation of public and external environment exposure to ionising radiation" safety function is based on arrangements involving the interposition of barriers between the radiation sources and the public or in removing the radiation sources from the edge of the site to limit the dose rate at the site boundary to the statutory value (1mSv/year).

The collection of gaseous and liquid effluents produced within the facility is also part of the arrangement to limit public and environmental exposure.

4.2.4.3 Criticality control

Because of the absence of fissile materials in the received waste, this risk does not apply to the facility.

4.2.4.4 Residual power removal

As mentioned in §3.2.6.1, this power is so low that there is no need for a specific heat removal system (other than the ventilation system).

4.2.5 Safety requirements

The safety requirements associated with the storage installations are:

- Requirements related to the risks of failure of components involved in the performance of the safety functions (intrinsic components failure, aging components, etc.),
- Requirements related to events of internal origin: mechanical hazards (handling, rupture of high energy lines, internal missiles), explosion, fire, internal flooding and chemical and toxic hazards,
- Requirements related to events of external origin: human origin (aircraft crashes, industrial environment), natural origin (earthquakes, flooding of external origin, extreme weather, lighting and forest fire).

4.2.6 External hazard requirements

4.2.6.1 Seismic hazard

Determination of the seismic hazard is to be taken into account in facility design. The seismology and geology of the area around the site, along with the geology of the site itself will be evaluated to derive a design basis earthquake (DBE).

The studies will:

- Establish information on historical and instrumentally recorded earthquakes that have occurred in the region,
- Be proportionate to the radiological hazard posed by the site, while covering those aspects that could affect the estimation of the seismic hazard at the site,
- Enable buildings, structures and plant in the nuclear facility to be designed to withstand safely the ground motions involved, if needed.

An Operating Basis Earthquake (OBE) will also be determined. No structure, system or component important to safety will be impaired by the repeated occurrence of ground motions at the OBE level.

When determining the effect of a seismic event on any facility, the simultaneous effect of that event on any other facility or installation in the vicinity, and on the safety of any system or service that may have a bearing on safety, will also be taken into account.

4.2.6.2 Flooding of external origin

Interim Storage Facilities will withstand flooding conditions that meet the design basis event criteria.

The area around the site will be evaluated to determine the potential for flooding due to external hazards like precipitation, high tides, storm surges, barometric effects, overflowing of rivers and upstream structures, coastal erosion, seiches and tsunamis.

The design basis flood will take into account, as appropriate, the combined effects of high tide, wind effects, wave actions, duration of the flood and flow conditions.

4.2.6.3 Extreme weather

Interim Storage Facilities will withstand extreme weather conditions that meet the design basis event criteria.

Types of extreme weather will include abnormal wind loadings, wind-blown debris, accumulated ice and snow deposits, lightning, extremes of high and low temperature, humidity and drought.

The design basis event will take into account reasonable combinations of extreme weather conditions that may be expected to occur, and of the effect of failure of any non-nuclear hazardous installations off-site and other Interim Storage Facilities, on- or off-site, during such conditions.

The reasonably foreseeable effects of climate change over the lifetime of the facility will be taken into account.

4.2.6.4 Aircraft crashes

The risk resulting from the air traffic, as well as the possible consequences of a large aircraft crash will be taken into account consistently with what is done for the buildings of the nuclear island.

With regard to the air traffic, the predicted frequency of aircraft crashes will be determined, for the site, on the basis of the most recent available data related to general, military and commercial aviation. The need for the implementation of protective design measures will be defined on this probabilistic basis, in accordance with the nuclear island design approach.

In addition, the event of a large commercial aircraft will be postulated, regardless of its probability. The analysis of the possible consequences will include all effects (notably related to fuel) and will take into account the detailed design of the facility as well as its precise location on the site.

Protective measures will be implemented where necessary to achieve the same safety level requested for the nuclear island.

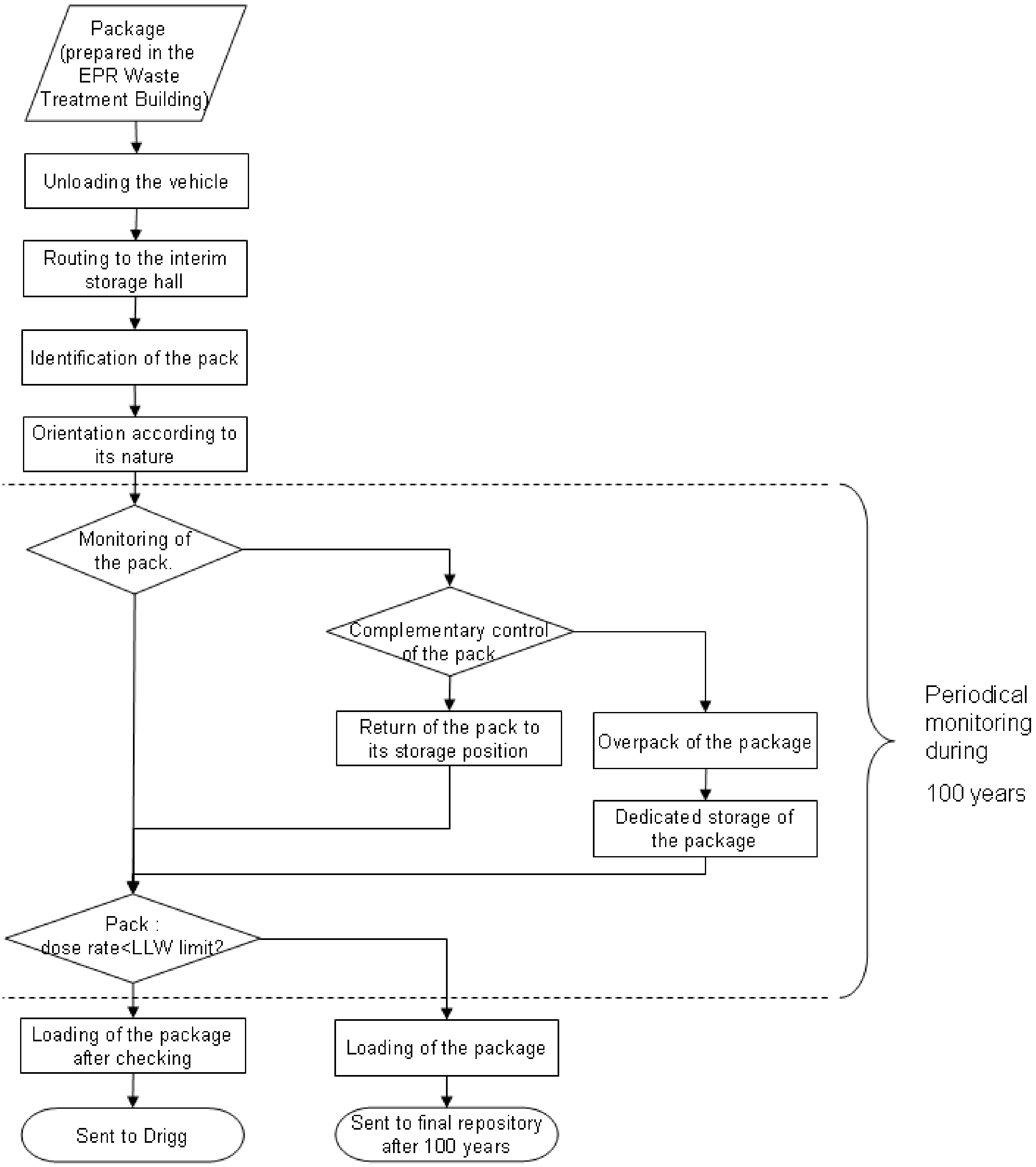
4.2.6.5 Heat sink

Since the residual thermal heat is negligible, no additional cooling is expected to supplement the ventilation system of storage area.

5 DESCRIPTION OF A DRY INTERIM STORAGE INSTALLATION FOR ILW

5.1 FACILITY OPERATION PHASE DESCRIPTION

See diagram below:



5.1.1 Package reception

This occurs as described bellow:

- Arrival of the truck or train,
- Closing of the hall door,
- Opening of the cover,
- Handling of the packages with the travelling crane and the handling device,
- Placing of the package in the temporary storage area in order to process the control (see section §5.1.2),
- Placing of the package on the transfer car,
- Return of the travelling crane and the handling device to their storage area.

5.1.2 Package control

Before unloading the packages, following controls will be made:

- Correct completion of the RMEF (Radioactive Material Expedition File),
- Consistency between the package index card and the transferred computer data.

After unloading and before putting the packages on the transfer car, the following checks will be performed:

- Mass : using independent scales or a crane load cell,
- Dose rate: using a ratemeter,
- Surface contamination: using smears and a contamination meter.

The package is then identified before being sent to the interim storage hall by the transfer car. Identification is made by a bar code reader, associated with the travelling crane of the interim storage hall.

5.1.3 Package transfer

This is accomplished using a transfer car ensuring the passage of the packages between the reception/expedition hall and the interim storage hall.

5.1.4 Package guidance and interim storage

Guidance is decided based on 4 criteria:

- Dose rate: the packages > 2mSv/h are placed at the centre of the hall,
- Mass: heavier packages will be stored preferably at low levels,
- Type of package: C1PG are directed to one side of the hall, C4PG to the other,
- Non-compliant packages: this case will be treated below (see §5.1.7).

The procedure is the same whatever the location chosen for the package:

- Handling of the package using the travelling crane and the handling device,
- Identification of the package with the bar code, the position is then recorded in the computer system, along with all the data concerning the package,
- Transfer of the package to its defined storage position,
- Positioning of the package at its location using the camera fitted to the travelling crane,
- Return of the travelling crane and the handling device to their storage area.

5.1.5 Package surveillance

In case of column stacking, the space between 2 packages allows for each package to be checked using a probe on the travelling crane. The use of a camera or ratemeter allows package changes to be monitored over time. Moreover an atmospheric surveillance system warns workers in the event of probable package containment failure.

In case of pyramid stacking, it is more difficult to check the packages without moving them. Surveillance is therefore performed without moving the packages, by monitoring the contamination and dose rate in the interim storage hall.

If there is a doubt concerning a package's containment, undergoes an additional inspection according to the following procedure:

- Move the packages situated on top of the package to be inspected in order to free it,
- Identification and arrangement of the packages on a line from left to right,
- After identification, move the concerned package to the sampling area to proceed with additional inspections (visual, dose rate, surface contamination),
- Depending on results, processing as a non-compliant package (overpackaging and storing in the dedicated storage area), or return to original location,
- Repositioning of all moved packages.

5.1.6 Preparation for the retrieval of the packages

When the time comes to send waste to the final repository, the procedure will be as follows:

- Move the packages situated on top of the package to be inspected in order to free it,
- Identification and arrangement of the packages on line from left to right,
- After identification, move the concerned package to the inspection area to proceed with pre-shipment inspections (visual, dose rate, surface contamination),
- Place the package on the transfer car to the reception hall,
- Load the package on the truck or the train using the travelling crane,
- Export the package by road or train.

5.1.7 Case of non-compliant packages

A package identified as non-compliant when checking upon arrival is overpackaged in the monitoring and overpackaging cell then carried to the dedicated storage area until its transport to a final repository.

A stored package for which the change in the dose rate or the surface contamination highlights a defective containment is overpackaged in the monitoring and overpackaging cell then carried to the dedicated storage area until its transport to a final repository.

5.2 FACILITY DESIGN DESCRIPTION

5.2.1 Brief description of a typical installation

A typical interim storage facility for ILW packages includes the following areas :

- A reception/retrieval hall which includes a travelling crane and a temporary storage area,
- A cell for the monitoring of packages and their overpack if necessary,
- A “dedicated storage” area for non-compliant packages,
- An interim storage hall with travelling crane,
- A control room.

A scheme of the complete facility is provided in annex 2.

The facility will also include following auxiliary installations:

- An effluent treatment unit,
- An electrical power unit,
- A ventilation system unit,
- A maintenance area,
- A stack with suitable rejected activity monitoring devices.

These installations are not described in this study, but they will be similar to what exists for the EPR unit; they will be designed with the suitable level of safety, following ALARP (As Low As Reasonably Practicable) and BAT (Best Available Techniques) principles.

5.2.2 Description of the type of waste

Reminder of requirements: see §3.2.

5.2.3 Description and characteristics of an interim storage facility for ILW packages

5.2.3.1 Description and main features of the reception/retrieval hall

5.2.3.1.1 Functions

- Reception of the packages,
- Inspection of the packages,
- Retrieval of the packages.

5.2.3.1.2 Description

This hall includes:

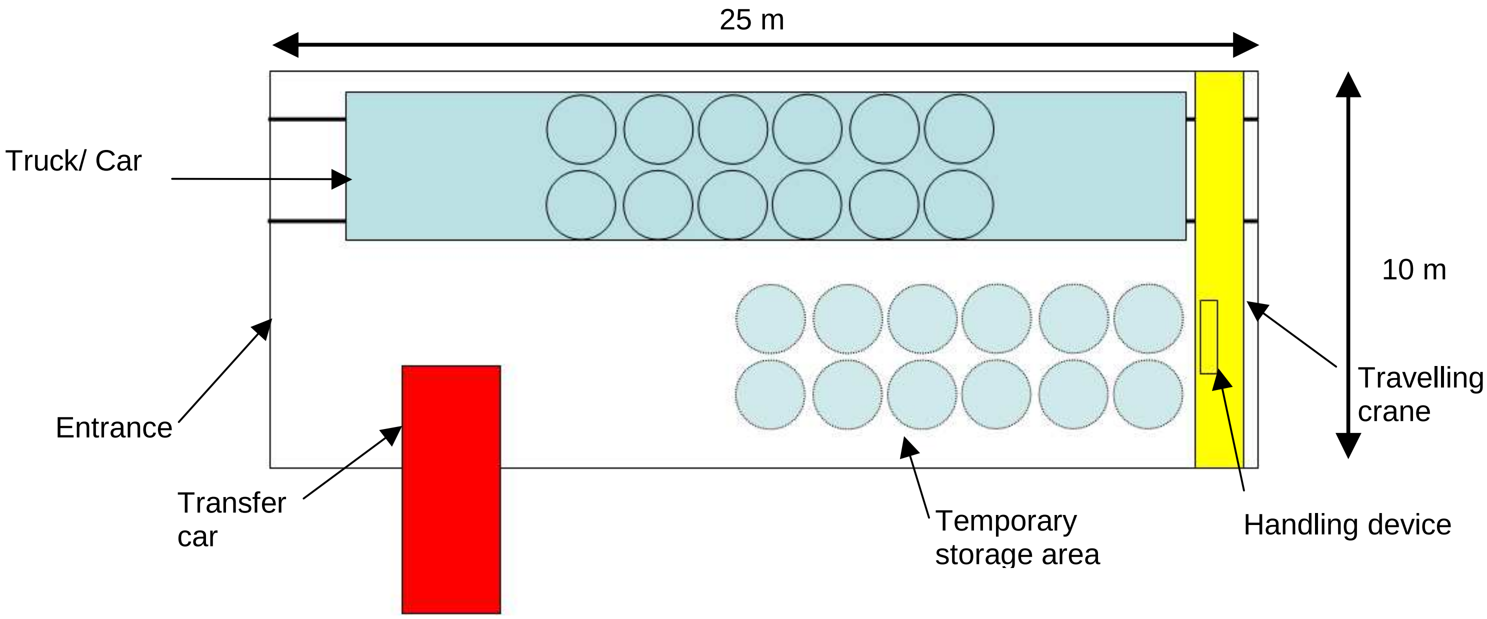
- An area suitable for accommodating the means of transport (truck and train),
- A temporary storage area (capacity of 11 C1PG or 18 C4PG), this area is also used to inspect the packages,
- A transfer area which is the link between the reception hall and the interim storage hall,
- A storage area for the travelling crane and the handling device (for the lifting of packages),
- A travelling crane equipped with a scale and camera.

Dimensions of the reception/retrieval hall:

- Length: 20m,
- Width: 8m,
- Height: 6m,

- Capacity: 1 train car + 12 C1PG (temporary storage area must be able to host all the packages transported on a train car).

The approximate dimensions of these various compartments are visible on the diagram below:



5.2.3.1.3 Safety objectives and key safety features

- To prevent the dispersal of contamination: Package is the barrier,
- Prevent staff and members of the public from receiving a dose of ionizing radiation: Packages and walls are the barriers,
- To prevent mechanical damage to the packages.

5.2.3.2 Description and main features of the interim storage hall

5.2.3.2.1 Functions

- Package storage,
- Package surveillance.

5.2.3.2.2 Description

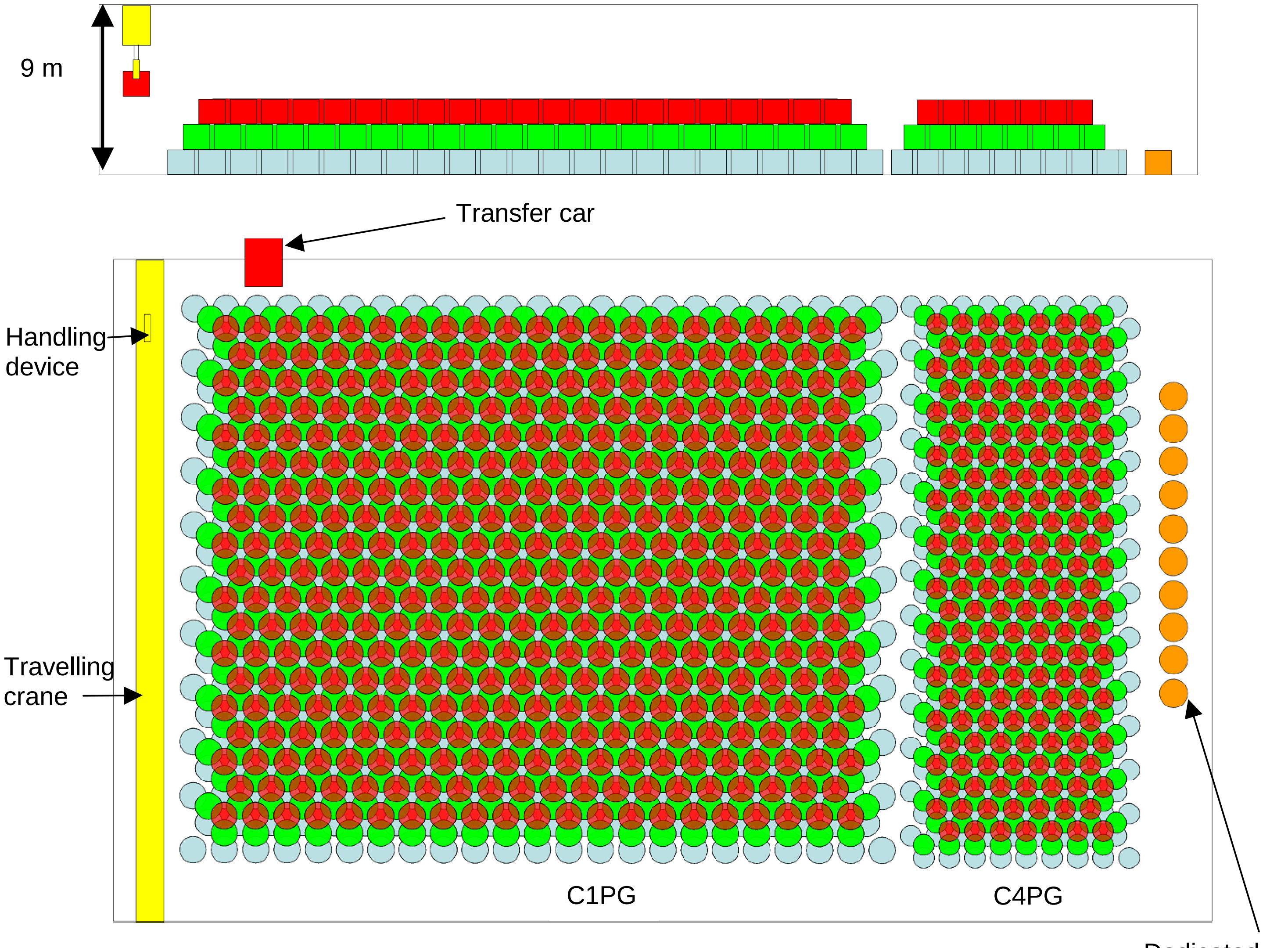
This hall includes:

- The transfer area which is the link between the reception hall and the interim storage hall,
- The storage areas for C1PG et C4PG (designed to host the packages created during 60 years of EPR operation),
- The dedicated storage area,
- A path over which the packages are handled,
- A storage area for the travelling crane and the handling device for the lifting of packages,
- A travelling crane equipped with a camera and a bar code reader,
- Remote operated equipment.

Dimensions of the interim storage hall:

- Length: 58 m,
- Width: 35m,
- Height: 9m.

The characteristics of these various compartments are shown on the following diagrams:



5.2.3.2.3 Safety objectives and key safety features

- To prevent the dispersal of contamination: Package is the barrier,
- To prevent staff and members of the public from receiving a dose of ionizing radiation: Packages and walls are the barriers,
- To prevent mechanical damage to the packages.

5.2.3.3 Transfer from the reception hall to the interim storage hall

A transfer car is provided to bring the packages from the reception/retrieval hall to the interim storage hall.

Dimensions of the transfer area:

- Length: 11m
- Width: 2.50m
- Height: 2m

5.2.3.4 Sampling and overpackaging cell

5.2.3.4.1 Functions

- Package inspection
- Overpackaging of non-compliant packages,

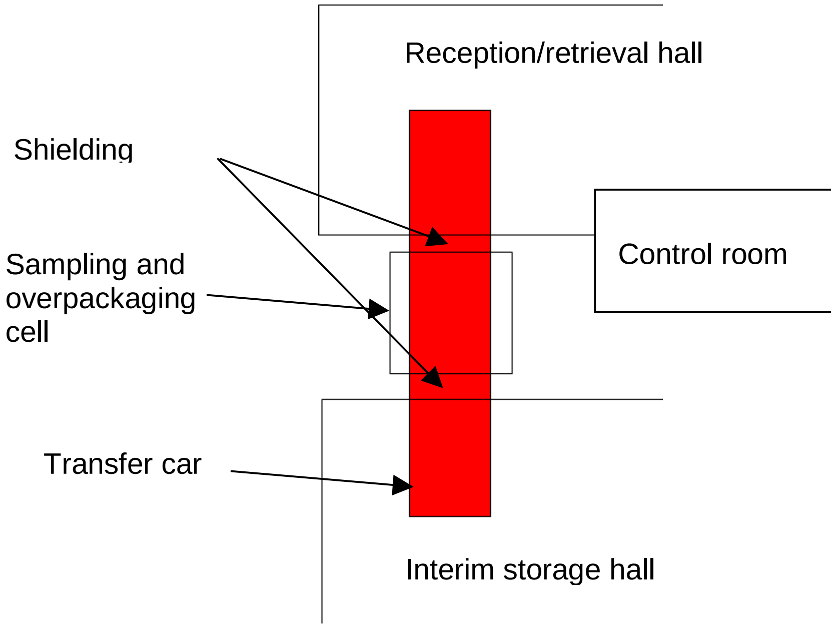
5.2.3.4.2 Description

To limit risks arising from an excessive number of handling operations, surveillance can be performed without moving any package. Any suspicious package, however, is forwarded to the sampling cell to undergo further examination and to be overpacked if the containment no longer appears to be guaranteed.

A handling device allows overpackage encapsulation prior to closure.

This cell is located between the reception/retrieval hall and the interim storage hall, the package is moved with the transfer car. Biological protections (the walls and two shielding doors) ensure that the sampling cell is a low dose rate area.

The characteristics of these various compartments are shown on the following diagram:



5.2.3.4.3 Safety objectives and key safety features

- To prevent the dispersal of contamination : → Package is the barrier,
- To prevent staff and members of the public from receiving a dose of ionising radiation : → Packages and walls are the barriers,
- To prevent mechanical damage to the packages.

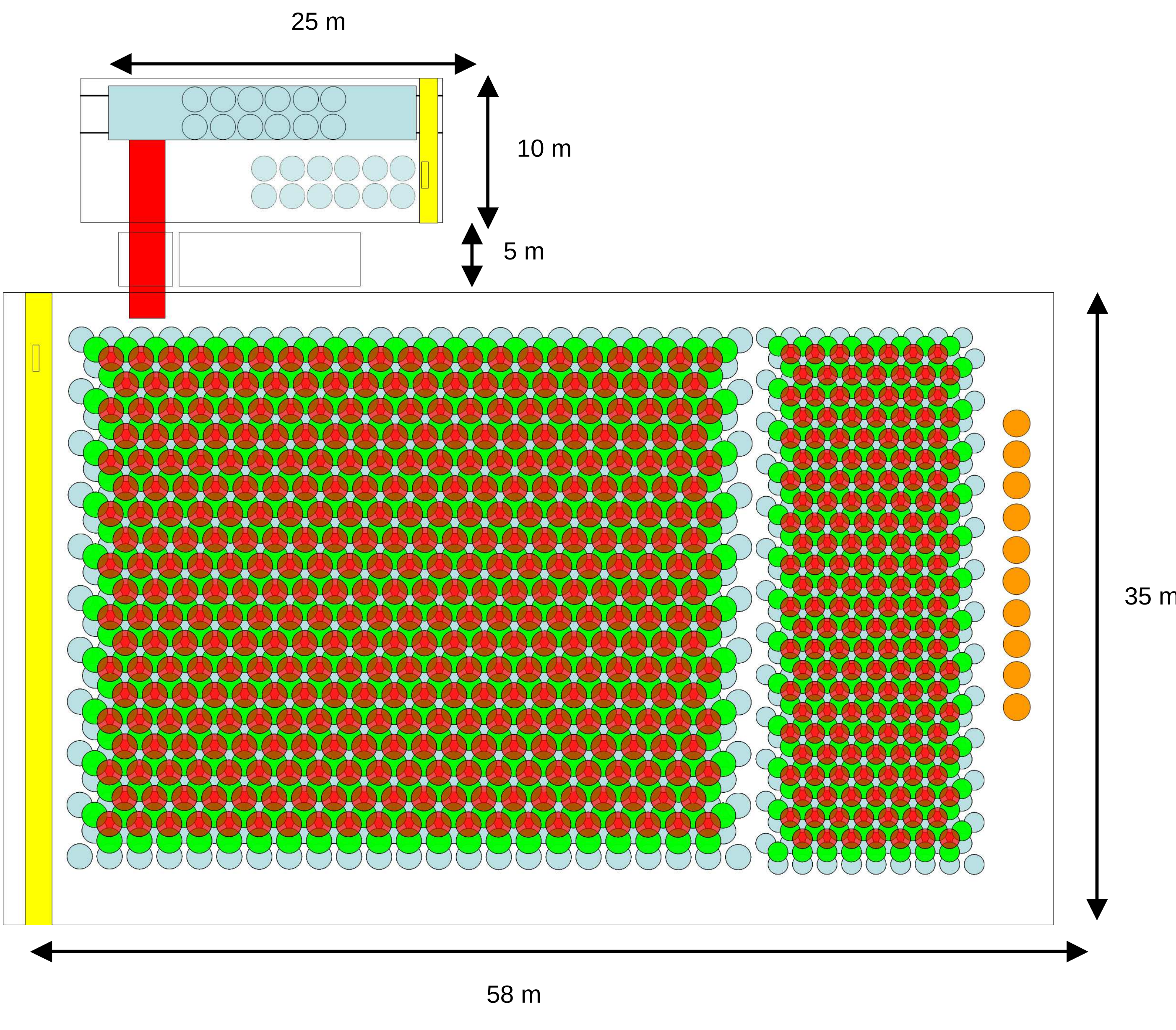
5.2.3.5 Control room

All the activities in the interim storage hall and the sampling cell are conducted from a control room located between the three buildings presented above with a sufficient shielding composed by the walls and leaded glazing.

Dimensions of the control room:

- Length: 10 m,
- Width: 3 m,
- Height: 2.50 m.

All facility dimensions are shown on the diagram below:



5.2.3.5.1 Safety objectives and key safety features

- To prevent the dispersal of contamination : → Overpack is the barrier,
- To prevent staff and members of the public from receiving a dose of ionising radiation : → Overpacks and walls are the barriers,
- To prevent mechanical damage to the packages : → Compliance with UK regulations for the travelling crane

5.2.4 Related equipment

5.2.4.1 Containment

Static containment for premises is assured mainly by the package. The conventional status of the area allows operation without dynamic containment.

Any detection of atmospheric and/or surface contamination will trigger operation of the ventilation system until the area has been cleaned up.

5.2.4.2 The monitoring unit of the contamination

The ventilation system and stack are fitted with sensors that record the activity circulating in the ducts and that are released to the atmosphere.

This monitoring highlights any probable loss of containment on a package and locates, approximately, the relative position of this package.

5.2.4.3 Effluent treatment

Package radiolysis should not be significant with the wastes.

Liquid effluent is mainly water from the nuclear changing room.

See §6.2.1.

5.3 TAKING DECAY INTO ACCOUNT

Considering radioactive waste decay over the century of the facility lifetime, it is assumed that some waste could be exported to a LLW final repository after a few years of storage. In this context, the facility could be scaled to host not 3,000 m^3 of packages but only 650 m^3.

The dimensions of the interim storage hall would be significantly reduced (length 35m, width 15m, height 9m). However, the storage and the layout should take into account respectively package sorting and retrieval (2,350 m^3).

The dedicated storage area would have then following dimensions:

- Length: 15m
- Width: 7m
- Height: 9m.

The operational process remains the same but package surveillance allows the designation of what may be exported to a final LLW repository.

6 PRELIMINARY RISK ANALYSIS

6.1 SAFETY REQUIREMENTS

6.1.1 Internal hazards of nuclear origin

6.1.1.1 Dispersal of radioactive substances

This is to prevent the release of radioactive substances into the environment. This risk is linked to the loss of containment. In the facility, dispersal management is based on one containment barrier between radioactive substances and environment. Another barrier can be added in order to achieve a better safety level.

6.1.1.1.1 Interim storage hall

The containment barrier is constituted by the waste packages (or the overpacks in the case of non-compliant packages). Indeed they are designed to withstand the various constraints to which they may be subjected (corrosion, irradiation, etc.),

Additionally, in the event of loss of package integrity during the storage, a second containment barrier composed of the storage hall walls and the ventilation system will be used.

6.1.1.1.2 Sampling and overpackaging cell

- The containment barrier is made up of the steel overpacks of the waste packages whose integrity is regularly monitored,
- A second containment barrier is needed, requiring, for its static component, the walls and, for its dynamic component, a ventilation system.

6.1.1.1.3 Handling operations

They are performed in such a manner as to minimise risks of loss of containment (enhanced reliability handling devices when package qualification heights are exceeded).

Additionally, the number of handling operations is reduced by the facility design and modus operandi used (bar code reader linked to the travelling crane).

6.1.1.1.4 Incidental functioning

As seen at the §6.1.1.1.1, the facility comprises a ventilation system which can be contaminated that can be used in the event of loss of a package's integrity. But the ventilation during operations is conventional.

The loss of a package's integrity will be detected by the sensors in the ventilation ducts. In this event, the ventilation system is triggered.

It returns to normal operation once the cause of the contamination has been detected and treated and the no contamination status is confirmed.

6.1.1.2 Ionizing radiation exposure

6.1.1.2.1 Internal exposure

There is a risk when a worker is required to work in a contaminated atmosphere. This occurs in cases of radioactive substance dispersal. Consequently, it is directly connected to the dispersal risk treated before.

6.1.1.2.2 External exposure

This risk is connected to the presence of irradiating substances in the installation.

Protection of the public consists in placing a barrier between the irradiating substances and the environment. This shielding is constituted by the storage hall walls and by the nature of the packages (concrete).

Moreover, dose rate measurements are made both in contact with the packages and at the site boundary.

The dose limit is 1mSv/year for the public and 2mSv/year for classified workers (NIREX).

6.1.1.3 Criticality

This risk can result only from the presence of fissile material.

6.1.2 Internal hazards of non-nuclear origin

6.1.2.1 Toxic substances dispersal

Not applicable.

6.1.2.2 Fire

A fire is an uncontrolled development of a combustion reaction that requires the simultaneous presence of fuel, oxidizer and activation energy (source of ignition).

The preliminary analysis of the fire event in the installation is based on the principle of the defence in depth:

- Prevention,
- Surveillance,
- Limitation of consequences.

The structure of buildings will be only slightly affected in case of fire.

Prevention of the fire risk requires a design time limitation of the calorific potential for the rooms that contain nuclear substances. Therefore, non-combustible or fire-retardant and heat-resistant materials will be used throughout the facility

Taking into account the low calorific potential of the installation, a risk analysis will be carried out during basic design, to mitigate the fire risk (surveillance, fire fighting means, containment, identification of the safety related equipments, etc.).

In the installation, there are concrete walls and concrete packages. So the only combustibles are the electric cables for the travelling crane, they will be qualified to mitigate the fire risk.

6.1.2.3 Chemical risk

Not applicable.

6.1.2.4 Mechanical handing risk

This risk is very important for the installation because of the use of travelling cranes for transportation of the packages.

The maximum level of risk that is acceptable per year for the event “dropped load from a height greater than package handling height” will be determined with consideration for the package’s radiological state.

Under all considerations integrity of the handling equipment is relied on to meet this condition. The design of all handling machines ensures the retention of the package in case of loss of power. Also travelling cranes are designed such that packages or the building are not damaged in the event of an earthquake. Finally, the hoist design prevents release before the load is set down.

6.1.2.5 Internal flooding

This risk is associated with the possible ingress of water into the facilities.

Because no water is required in the process, this risk is not considered. The risk due to the water from changing room will be studied during the detailed design studies.

6.1.2.6 Internal explosion

This risk is associated with the phenomenon of radiolysis leading to the creation of hydrogen gas that is not fully retained in the packages.

The ventilation system ensures air circulation in the interim storage and dedicated storage halls in order to avoid the accumulation of hydrogen. Furthermore, the steel overpacks are fitted with a system which allows the removal of hydrogen whilst maintaining the containment.

All electrical power sources switchboards, batteries and cabinets will be physically protected and separated from the rooms containing radioactive substances.

6.1.2.7 Loss of function, fluids

This risk is associated with the design and stability of the systems that comprise the facility. It is limited to the loss of ventilation in the rooms where the packages are stored and to the loss of power.

6.1.2.7.1 Loss of ventilation

The ventilation system will be backed up in order to avoid any concentration of hydrogen in the event of loss of normal power supply.

Moreover, the rooms provide a static containment in the event of loss of ventilation.

6.1.2.7.2 Loss of power supply

Concerning safety-related equipment, normal mains power is duplicated by a back up power supply. An emergency diesel generator may also be required to mitigate any loss of external power by automatic coupling.

6.1.2.8 Human factor

Human activities on the facility in operation are as follows:

- Package handling,
- Facility surveillance.

Generally speaking, any event that may directly or indirectly affect the safety functions (mainly the containment) will be considered as a handling incident or accident that can affect the integrity of the packages.

Handling and maintenance activities using handling equipment are sensitive activities from a human error point of view.

Centralised operations control is performed by operators trained, not only in the activities to be carried out, but also in overall facility safety.

6.1.3 Events of external origin

6.1.3.1 Earthquake

This risk depends on the location of the facility.

In the event of an earthquake, the provisions aimed at limiting the impact are to design the building and a portion of the safety-related equipment to “Safe Shutdown Earthquake” standards.

The reception/retrieval and interim storage halls are designed to resist to an earthquake. Package stacking is also designed to preserve its overall structure in case of earthquake. Travelling cranes of the reception/retrieval and storage halls maintain the packages and do not impact on the packages or building.

6.1.3.2 Flooding of external origin

The facility will be designed to withstand flooding conditions that meet the design basis event criteria.

The area around the site will be evaluated to determine the potential for flooding due to external hazards, e.g. precipitation, high tides, storm surges, barometric effects, overflowing of rivers and upstream structures, coastal erosion and tsunamis.

The design basis flood will take account, as appropriate, of the combined effects of high tide, wind effects, wave actions, duration of the flood and flow conditions.

6.1.3.3 Extreme weather

This risk, linked to the weather at the facility’s location (snow, wind, outside temperature), is estimated based on historical conditions encountered.

6.1.3.4 Aircraft crashes

See § 4.2.6.4

6.1.3.5 Industrial environment and communications

An inventory is drawn up of installations near the facility which may present an external hazard risk.

The same applies for routes of communication (roads, railroad, sea or river routes), in particular those along which hazardous materials may transit. A probabilistic safety assessment will be conducted at the site specific stage to determine the risk.

6.1.3.6 Security

The protection of the facility will be included in the EPR security plan.

6.2 ENVIRONMENT DISCHARGE PREDICTION

6.2.1 Discharges in normal operation

6.2.1.1 Liquid effluent

Liquid effluent will be limited to the effluent coming from the lavatories (and hot changing room). It will be collected and directed towards the liquid waste treatment plant that is shared with the EPR.

6.2.1.2 Gaseous releases

In normal operation, this concerns the exhaust air from the contained areas (interim storage and dedicated storage halls). These discharges can originate from a possible surface contamination of the packages.

The releases are collected by the ventilation systems, filtered and rejected to the facility's stack. This latter is fitted with suitable released activity monitoring devices.

6.2.1.3 Solid waste

The waste produced by the facility will be treated by the EPR waste treatment plant. Operational waste arising from the facility are VLLW and LLW.

6.2.2 Radiological impact of the discharges in normal operation

The radiological consequences of gaseous and liquid discharges from the whole facility will be monitored through samples collected in the vicinity of the facility in a manner similar to what is foreseen for the EPR site.

6.3 RADIOLOGICAL PROTECTION

The radiological protection of workers against ionising radiations is the main goal of radiological protection in a radioactive waste storage facility.

This goal is reflected in the implementation of a radiological protection approach which includes all the technical and organisational arrangements implemented in order to satisfy the three fundamental principles of the protection of workers against ionising radiations, optimisation of protection and limitation of individual exposure.

Based on this approach, an evaluation of the individual and collective projected dose rate is established, according to the ALARP principle and taking into account economic and social factors, as well as a radiological zoning corresponding to this projected evaluation.

The facility will be built in compliance with the IRR 99 (Ionising Radiations Regulations 1999).

The main goals of radiological protection, in normal operation, are as follows:

- The effective doses received by external exposure, are as low as reasonably practicable and in any case, lower than the limits set by the regulations which do not constitute an objective itself,
- The maintenance of a maximum surface contamination in compliance with the PCSR, in areas with permanent activity that are classified as restricted work areas,
- The absence of internal exposure of workers.

7 CONCLUSION

This document has described the proposed interim storage facility for Intermediate Level Waste generated by one EPR unit for 60 years of operation.

The document described the UK legislation and safety requirements that will be met by the facility, and the methodology that will be followed for the detailed design studies of the facility.

It has confirmed that the proposed design will be performed following ALARP and BAT principles. Although the detailed design is not complete, none of the features are novel, they all employ proven technology. The review of UK legislation and safety requirements to be applied to the store, along with the description of the key safety features, demonstrates that the proposal is licensable in the UK.

The design, operation and safety features of the facility will conform to UK legislation.

ANNEX 1: DEFINITIONS

AFR-RS (Away-From-Reactor on Reactor Site): Spent fuel storage away from and independent of the reactor(s) but still on the licensed site of the reactor.

ALARP: As Low as Reasonably Practicable

ANDRA: Agence Nationale pour la gestion des Déchets Radioactifs
→ National Agency for Radioactive Waste Management

ANSTO: Australian Nuclear Science and Technology Organisation.

BAT : Best Available Techniques.

CEDRA: Conditionnement et Entreposage de Déchets Radioactifs
→ Radioactive waste packaging and interim storage.

Container: A general term for a receptacle designed to hold nuclear waste to facilitate movement and storage or for eventual disposal.

Containment: Retention of radioactive material such that it is prevented from dispersing into the environment or so that it is only released at acceptable rates. It can also be a structure used to provide such retention of radioactive material.

DCP: Dounreay Cementation Plant.

DIADEM: Déchets Irradiants ou Alpha et de Démantèlement
→ Alpha or irradiating and dismantling waste.

Dry storage: Storage of radioactive waste in a gas environment such as air or inert gas.

EPR: The European Pressurized Reactor is a type of Pressurized Water Reactor.

ICEDA: Installation de Conditionnement et d'Entreposage de Déchets Activés
→ Packaging and interim storage installation for radioactive waste.

Interim storage: Storage of nuclear waste until it is retrieved for further processing. The storage period ends when the waste is placed in a repository.

LLW / VLLW: (Very) Low Level Waste.

Nuclear safety: Measures to avoid accidents in the operation of nuclear reactors and in the production and disposal of nuclear weapons and of nuclear wastes.

NDA: Nuclear Decommissioning Authority.

Radioactive waste: Material containing the unusable radioactive by products of the scientific, military, and industrial applications of nuclear energy.

Repository: A designated site engineered for the definitive disposal of radioactive waste.

RWMD: Radioactive Waste Management Directorate.

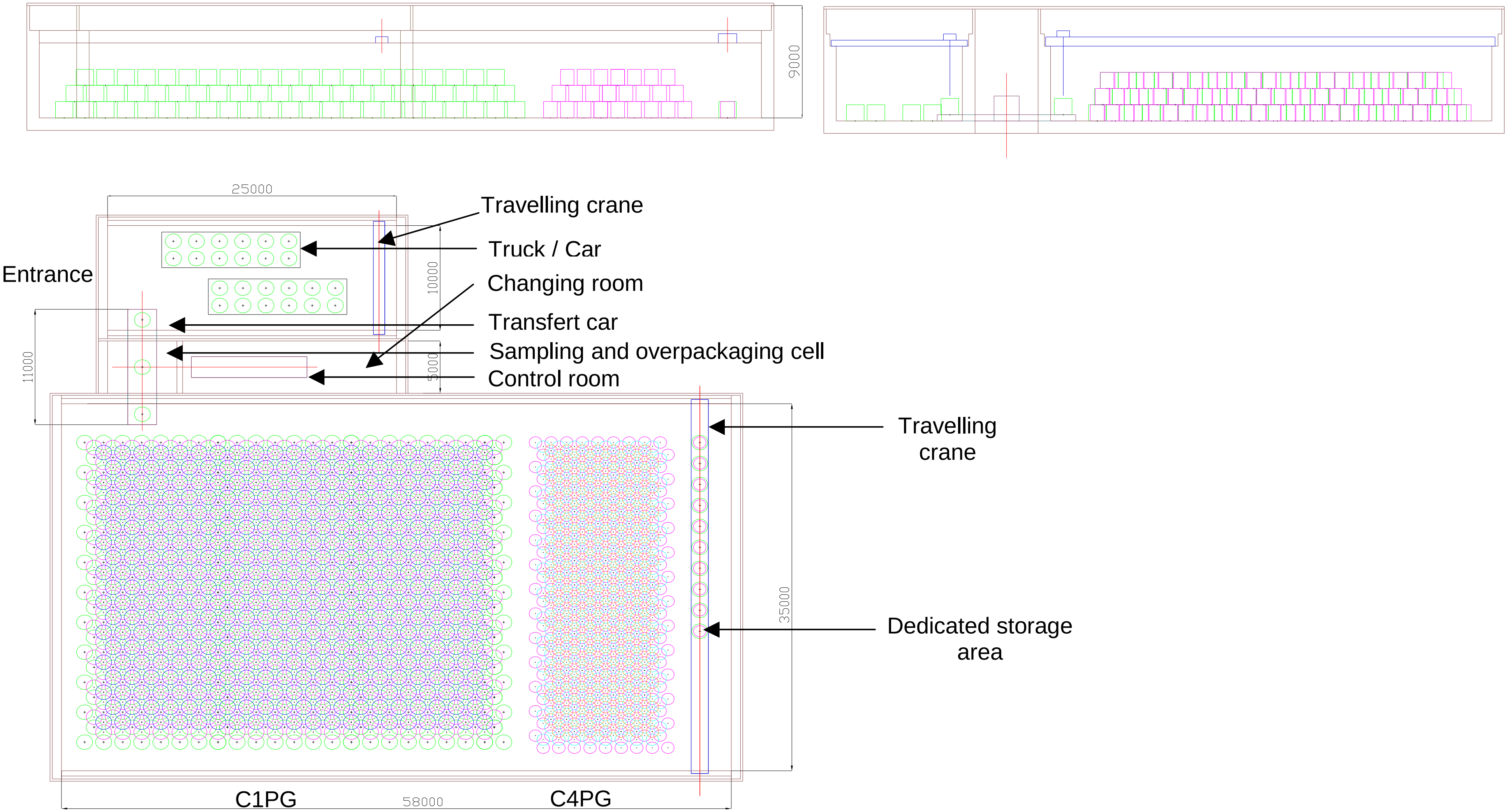
SFR: Swedish Final Repository.

Storage facility: A facility used for the storage of radioactive waste.

ANNEX 2 : GENERAL OUTLINE OF THE INTERIM STORAGE FACILITY FOR ILW

(in mm)

Dry Interim Storage facility for ILW



ANNEX 3: INTERNATIONAL FEEDBACK

ICEDA (FRANCE, IN PROJECT)

This facility will store for 50 years' of Class B waste in C1PG packages.

Thus, 4,000 m^3 of packages will be divided in two halls and stored on 3 levels according to a pyramidal geometry in order to ensure greater stability in the event of an earthquake.

Upon creation of a suitable final repository, waste will be exported, the facility was designed for a lifespan of 50 years.

The construction of this facility will cost several tens of million euros.

CEDRA (FRANCE, ACTIVE)

This facility hosts ILW in two types of packages:

- 10,000 m^3 of 870L concrete-steel barrels stored in halls and piled in 4-level columns, the most active packages are arranged in the centre so less active packages act as an additional biological protection,
- 2,350m^3 of 500L concrete-steel barrels which of the less active join the storage hall, the most active are piled on 6 levels in wells.

Upon creation of a suitable final repository, waste will be exported; the facility was designed for a lifespan of 50 years.

DIADEM (FRANCE, IN PROJECT)

This facility in project will host strongly irradiating waste in storage wells. The waste will be stacked on several levels, the number of levels depending on the volume and mass of the stored waste.

LA HAGUE (FRANCE, ACTIVE)

The activities require an interim storage in concrete-fibre packages. These are stored in a renovated hall in columns of several levels.

Additionally, the Coques Compaction Workshop stores all steel packages created during its operation in wells.

DCP (UNITED KINGDOM, ACTIVE)

The DCP receives overpack and stores unconditioned solid ILW in stainless steel 200-litre drums. The main function of the plant is to encapsulate liquid ILW into solid cement from within a stainless steel drum.

MAGNOX (UNITED KINGDOM, ACTIVE)

As at DCP, ILW is encapsulated in steel drums.

HIMDALEN (NORWAY, ACTIVE)

The facility is a “rock cavern” facility with 4 caverns accessed by a 150m-long tunnel excavated from the crystalline rock. In each cavern, there are 2 sarcophaguses that contain 210L drums of waste. Once positioned, the drums are encased in concrete to provide a new floor for the following layer. When a sarcophagus is filled a concrete roof will be placed on top with a water tight seal.

The process was initiated in 1989 and the facility is expected to be in operation until the year 2030. The capacity is 10,000 drums (2,100 m^3).

ANSTO MANAGING RADIOACTIVE WASTE (AUSTRALIAN GOVERNMENT)

Solid ILW generated by ANSTO is stored below ground in specially designed concrete pits within retrievable packages.

Currently, liquid ILW is stored in shielded tanks. The ILW is being processed into a solid form that is suitable for storage for up to 50 years in specially designed concrete pits. ANSTO is also working on a project to convert this ILW into a more durable solid form that will be suitable for long-term storage and disposal.

ANNEX 4: SUMMARY TABLE OF THE MAIN SAFETY ARRANGEMENTS

Function: reception	**Safety Functions**	**Safety systems and arrangements**	**Surveillance**
Waiting	Containment	Package integrity	No surveillance
	Exposure	Package's concrete, distance to the facility's limit	Dose rate measurements at the site boundary
Package reception	Containment	Main system: Package integrity Additional system: Reception/retrieval hall	Surface contamination measurements by smear test Hall atmosphere surveillance
	Exposure	Package, building, distance to the facility's limit	Dose rate measurements at the limit of the facility
Function: interim storage	**Safety Functions**	**Safety systems and arrangements**	**Surveillance**
Interim storage for contained packages	Containment	Main system: Package integrity Additional system: Interim storage hall	hall atmosphere surveillance
	Exposure	Package's concrete, building, distance to the facility's limit	Dose rate measurements at the limit of the facility
Non-compliant package management	Containment	1st system: Steel overpack **Additional system: Interim storage hall, possibly dynamic containment lock**	Surface contamination measurements by smear test Hall atmosphere surveillance
	Exposure	Package's concrete, overpack, building, distance to the facility's limit	Dose rate measurements at the limit of the facility
Function: retrieval	**Safety Functions**	**Safety systems and arrangements**	**Surveillance**
Retrieval preparation	Containment	Main system: Package integrity Additional system: Reception/retrieval hall	Surface contamination measurements by smear test Hall atmosphere surveillance
	Exposure	Package's concrete, building, distance to the facility's limit	Dose rate measurements at the limit of the facility