Design of an Interim Storage Facility for the CEA Long-lived Intermediate- and High-level and Irradiating Waste – 9209

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ABSTRACT

The French radioactive waste management act of 2006 (known as the TSN law - Nuclear matter Transparency and Safety) calls for the creation and commissioning of a deep geological repository for long-lived intemediate- and high-level waste by 2025. Until its opening, waste management must be ensured. At present, the CEA has storage facilities for long-lived intermediate- and high-level waste (CEDRA, located in Cadarache), but which impose limits for dose rate and fissile material mass. Some waste thus remains without storage solutions. Since 2004, CEA operational units have carried out an assessment of the storage requirements for all the producers of current and future waste. The needs were then compared with the existing solutions to judge the advisability or not of creating a new waste disposal route. The study highlighted the need to create a new interim storage facility adapted to IL and HL wastes' characteristics.

The facility's design and dimensions are based on this assessment, which had made it possible to draw up a quantitative and qualitative waste inventory. The radiological (activity, dose rate and fissile material), chemical (toxic, reactive, radiolysable materials) and thermal characteristics are defined with as much accuracy as possible, also recording the origin of the data selected. The originality of this project lies in sourcing the waste inventory well upstream, in order to design a facility which meets the various needs while avoiding being oversize.

The interim storage facility, called DIADEM, will be built at Marcoule in the Rhône Valley. At the end of 2014 it will provide sufficient capacity for 1800 containers. A fifty-year operating lifetime is planned.

INTRODUCTION

The emergence of the DIADEM project results from a waste inventory established for the various CEA nuclear facilities. The inventory was carried out to identify long-lived intermediate- and high-level waste without a disposal route, either existing or to be produced through to 2035, resulting from research programmes, legacy waste or cleansing or dismantling operations.

The design and the dimensions of the facility are based on this inventory. It will be built on the Marcoule site, as most of the waste will come from facilities located on this site (cleansing and of dismantling of the Pilot Workshop of Marcoule and the Phénix reactor). To meet these facilities' needs, it will have to be operational by the end of 2014.

This document, after a description of the CEA method implemented to establish an inventory of the waste to be stored in DIADEM (principal data for the design and the dimensioning of the facility), also presents the design principles retained for this new interim storage facility.

Constitution of the Waste Inventory

A. *Inventory method*

Over recent years, the CEA has developed inventory methods to optimize waste management. The objective is to gather all relevant information about radioactive waste from the facilities producing it. This method is based on the collection of information, traceability of the data's origin, and the management of assumptions when the level of information is not sufficient.

Once established, the inventory is updated periodically to take into account upward or downward changes. Such evolutions can concern waste quantities or characteristics. The updates make it possible to accurately dimension the facility and thus, to optimize the costs.

The first role of the waste inventory is to indicate the number of containers necessary, in order to be able to dimension the storage. It also plays a decisive role in deciding on the facility's design, while emphasizing its specific requirements.

B. *Inventory results*

The quantity of waste to be stored was estimated to be 260 tons. It is mainly activated waste resulting from research reactors such as spent fuel cladding (rods and end caps) or from research programs on fuels, liquid waste processing and equipment dismantling.

This waste will come from the CEA centres at Marcoule, Cadarache, Grenoble, Saclay and Fontenay-Aux-Roses. The quantity to be stored is distributed as follows: approximately 15 tons from Cadarache, 12 tons from Fontenay-Aux-Roses, 7 tons from Grenoble, 208 tons from Marcoule and 18 tons from Saclay.

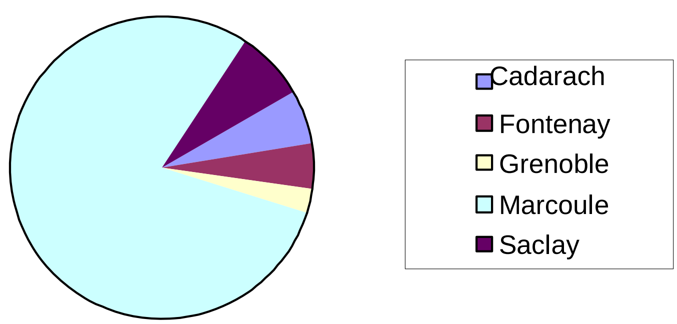

Fig. 1. CEA waste inventories from non-military sites

Some of the waste has already been produced and is currently in containers placed in safe interim storage facilities that are scheduled for shutdown. For this waste, economic reasons mean separation operations are not feasible, and it must be stored as is. In this case, it is vital to collect as much information as possible in order to describe the waste accurately and to design the best-adapted storage conditions.

Other waste includes equipment to be dismantled from research reactors and research laboratories. For this future waste, separation operations are still possible.

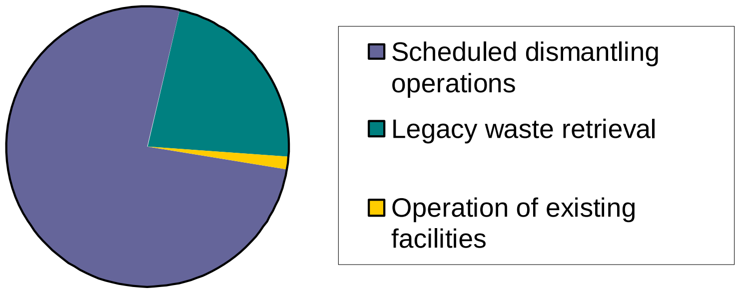

Fig. 2. Origins of listed waste

Listed waste can be divided into two categories:

1. The low-level waste (LLW) which could be sent to the ANDRA surface disposal site at the *Centre de l'Aube* (CSA) after decay (radioactivity related to ^{60}Co, with a half-life of 5 years),
2. The long-lived intermediate-level waste (ILW) which will be sent to the geological repository.

Depending on their origins, the main waste characteristics include:

- The presence of radiolysable materials (PVC, polyethylene, resins). These materials are degraded under radiation leading to the production of various gases, especially hydrogen,
- The presence of fissile materials,
- A strong radioactivity due to alpha emitters,
- A significant dose rate,
- A high thermal power.

Concerning the production of hydrogen, the inventory work will make it possible to precisely determine the expected volume, which depends on the composition of waste materials, the radiological spectra and the radioactivity.

The table below shows the main characteristics of the waste to be stored:

Type of waste	Main radionuclides	Specific activity per container (1)	Contact dose rate (1)	Thermal power per container (1)	Fissile material per container (1)
Metals (Aluminium, steel, stainless steel) Plastics (Polyethylene, vinyl, PVC) Ion exchange resins	Co-60 Cs-137 Nor-63 Fe-55 Pu-238 Pu-239 Pu-240 Am-214	10 to 300 TBq	10 to700 Gy/h	6 to 150 W	0 to 200 gr

(1) The containers are presented in the following paragraphs.

The radioactivity to be stored in DIADEM is considered to be in the range between 30.000 and 40.000 TBq.

C. Waste conditioning

The elements collected made it possible to define a conditioning best adapted to the waste. The final containers will be cylindrical, with an external volume of 200 liters and 430 liters, and will be made of stainless steel. The facilities of origin will be responsible for the conditioning operations. The CEA decided not to carry out any waste processing (by compacting or cementing, for example), so that final packing can be implemented at the end of the interim storage, once the specifications of the geological disposal are decided on. This also means it will be also easier to carry out complementary characterizations if necessary.

D. Period of assumption of responsibility

After having estimated the number of containers and the period of production with each producer, the flow of incoming containers was established year by year. This is spread from 2014 to 2038, with the busiest period from 2014 to 2023 corresponding to the dismantling of the Phénix reactor and the Pilot Workshop of Marcoule, and the denuclearization of the CEA centres at Fontenay-Aux-Roses.

The facility preliminary plan established during the feasibility phase was modelled using software to simulate the operation of the facility compared to the incoming flow. The objective of such simulations was to check the appropriate dimensioning of the facility, in particular the capacity of the machines. The flow study will be systematically brought up to date depending on any changes to the inventory.

Definition of the Design Principles

A. Principal functions of the facility

A functional analysis of the facility identified the functions necessary for its operation, and for organizing, characterizing, and/or preparing the waste to obtain the product expected by the user. The functional analysis was based on the waste inventory and the safety options necessary to ensure the facility's safety.

The following design principles were specified:

- The containers could be stored for 50 years,
- The containers will be stored in vertical shafts, to avoid criticality risk,
- The wells will be ventilated mechanically to extract radiolysis gases and the heat released by the thermal containers,
- The container status will be checked periodically. These non-destructive checks will be carried out in a special cell, and will include a visual control of container integrity. The radiological control of the container will be measurements of dose rate and of surface contamination.
- The producers will be responsible for characterizing the containers, after which the DIADEM facility will record the characteristics of each container placed in storage. This data will be particularly useful during retrieval of the containers prior to their transfer to the geological repository.

Storage in shafts was adopted:

- To control the criticality risk,
- To evacuate radiolysis gases,
- To remove heat released from the waste,
- To limit contamination in the event of container deterioration,
- To allow easy retrieval of a container for in-storage surveillance purposes.

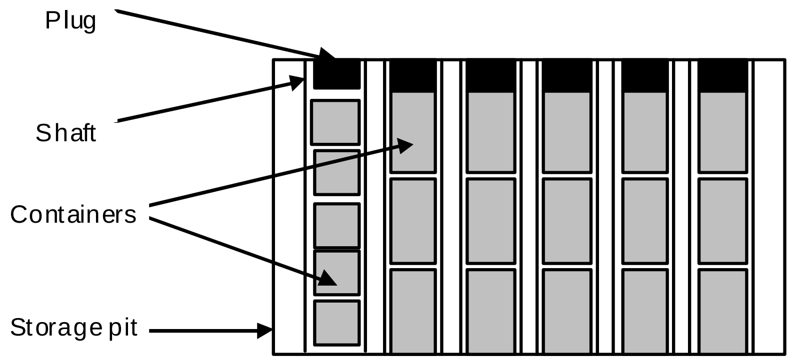

Fig. 3. Illustration of in-well storage principle

B. Facility dimensioning

Based on the inventory, the number of containers to be stored was estimated to be:
- 1350 containers of 200 liters,
- 275 containers of 430 liters.

With this estimate a margin of approximately 10% is added, giving dimensioning for storage at 1800 locations.

The container dose rates have a significant impact on the structural dimensions. The concrete floors and walls of the building will be about 1 meter thick, to both protect the personnel from ionizing radiation, and to ensure the behaviour of the building in case of earthquake.

The thermal power, up to 150 W by container, makes shaft ventilation necessary not only to prevent a temperature rise resulting in thermal decomposition of the waste, but also to avoid heating the walls of the interim storage vault.

This ventilation is also required due to the presence of radiolyzable materials. The ventilation system will extract the radiolysis gases and maintain the atmosphere below the explosion threshold. To facilitate the release of radiolysis gases, the radiolyzable waste containers will be fitted with a stainless steel mesh filter that allows hydrogen and other off-gases to leave the container. This will prevent any internal pressure rise that could result in deformation and make it difficult to retrieve the containers after interim storage, and any risk of hydrogen accumulation inside the container that could lead to an explosion if the threshold were reached.

The criticality risk arising from the presence of fissile material (no more than 10 kg of ^{235}U and Plutonium) will be controlled by limiting the fissile material content to a maximum of 200 g per container, and by the interim storage geometry. The spacing between shafts and their stability will guarantee sub criticality under normal operating conditions or in the event of an earthquake.

C. Facility overview

On the arrival of the containers in the facility, a radiological control (dose rate at contact and surface contamination) will be carried out. They will be then taken to the wells using a mobile transfer airlock. The stacking of the containers was defined according to their mechanical resistance. The 200 liter containers will be piled up on 8 levels and the 430 liter containers on 4 levels. Figures 4, 5 and 6 present a draft view of the facility resulting from this functional analysis.

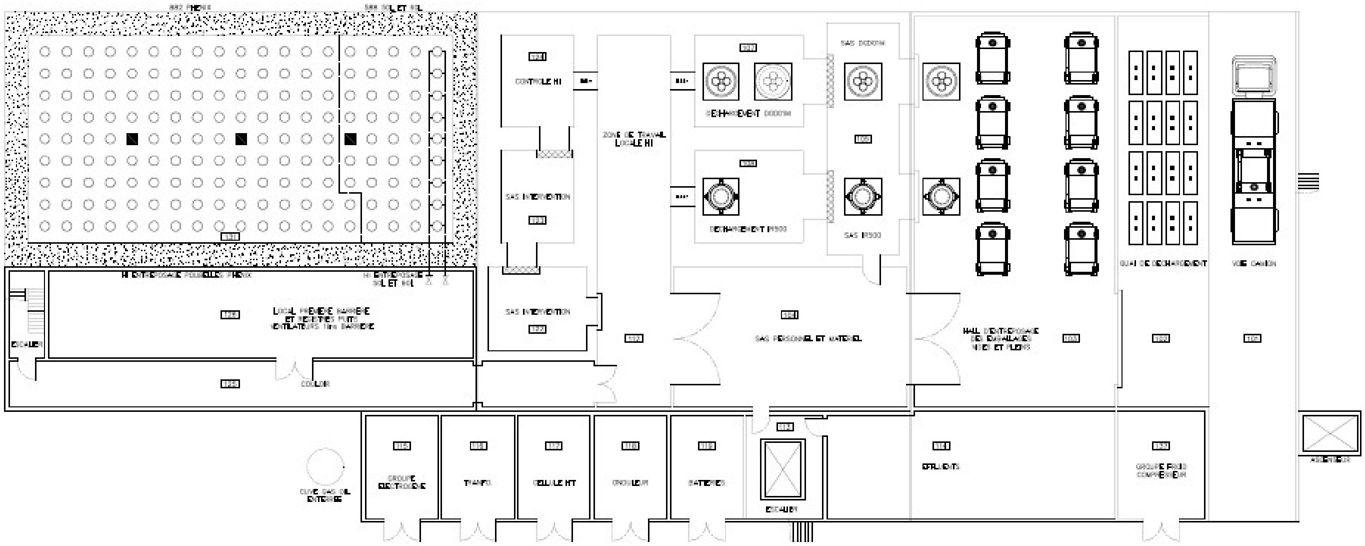

Fig. 4. View of top level 0

From right to left: unloading bay for transport cask trucks; transport cask cover storage; temporary storage zone for waiting casks; cask unloading cell; container inspection cell; container interim storage hall (shafts).

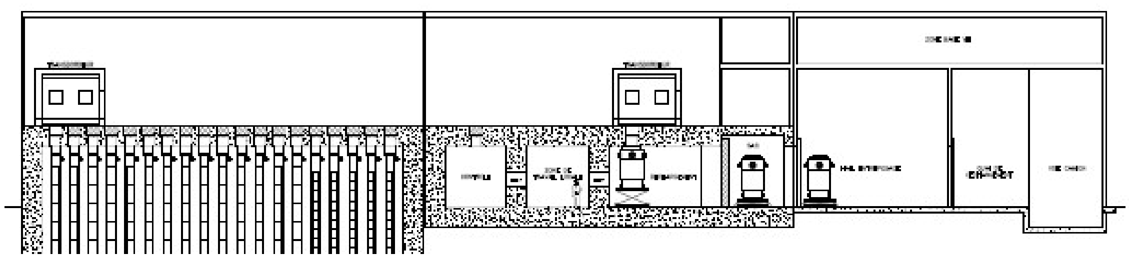

Fig. 5 Longitudinal cross-section

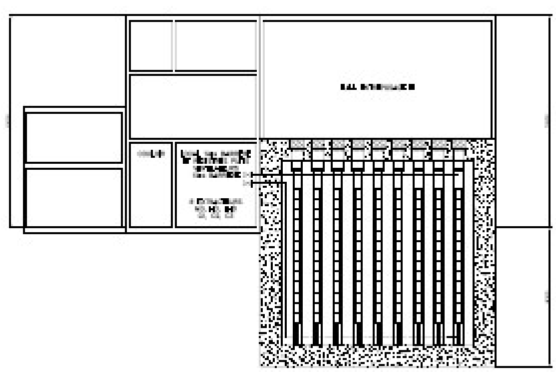

Fig. 6 Lateral cross-section

To ensure contamination containment, two barriers will be implemented:

- During storage, the first barrier will be ensured by the shaft and its plug; the second by the storage vault.
- During transfer operations, the first barrier will be ensured by the mobile transfer airlock; the second by the storage zone hall.
- When lowering container into the shaft (plug removed), the first barrier will be ensured by the mobile transfer airlock and the well; the second by the storage vault.

PROSPECTS

From these design choices, final studies (Summary Preliminary Draft and Detailed Preliminary Draft) will be carried out in 2009 and 2010. The inventory will be updated at the beginning of each stage to take into account the most recent changes.

According to the schedule, the building works should begin by the end of 2010.