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THE CASCAD SPENT FUEL DRY STORAGE FACILITY

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INTRODUCTION

France has a wide variety of experimental spent fuels with characteristics that make them substantially different from LWR spent fuel discharged from commercial reactors. Reprocessing such fuels would thus require the development and construction of special facilities, which is not advantageous for the available industrial reprocessing plants.

The French Atomic Energy Commission (CEA) has consequently opted for long-term interim storage of these spent fuels over a period of 50 years.

Comparative studies of different storage concepts have been conducted on the basis of safety (mainly containment barriers and cooling), economic, modular design and operating flexibility criteria. These studies have shown that dry storage in a concrete vault cooled by natural convection is the best solution.

A research and development program including theoretical investigations and mock-up tests confirmed the feasibility of cooling by natural convection and the validity of design rules applied for fuel storage.

A facility called CASCAD was built at the CEA's Cadarache Nuclear Research Center, where it has been operational since mid-1990.

This paper describes the CASCAD facility and indicates how its concept can be applied to storage of LWR fuel assemblies.

DESIGN CRITERIA OF THE CASCAD FACILITY

The following main principles and criteria were adopted:

<u>Storage time</u>
Interim storage is planned for a period of 50 years, after which spent fuel will be retrieved for reprocessing or final disposal.

Fuel cooling

Storage pits in which spent fuel is inserted are cooled by a single natural convection system (see Figure 1). The system is self-regulating so that air flow is matched to the heat load of the facility.

Design criteria adopted for CASCAD are:
. maximum power per pit : 600 W,
. number of pits : 319,
. total power : 130 kW,
. maximum air inlet temperature : 35.5°C
. concrete temperature (max.):80°C.

Containment

Fuel containment integrity is continuously ensured by means of three barriers:
- the fuel cladding or a leaktight fuel canister as the first barrier;
- the pit as the second barrier during storage;
- the walls of the handling cell and the "nuclear" ventilation providing the dynamic containment during handling operations.

The integrity of the first containment barrier can be monitored by sampling the internal atmosphere of the pits using a system mounted on the seal plate of each storage pit.

Other safety aspects

Nuclear safety is guaranteed simply and easily by forestalling the usual hazards:
- criticality by spacing the storage pits;
- earthquake by the dimensioning of the civil works, structures and handling equipment;
- radiation exposure by biological shielding to meet requirements for maximum dose rate at work station (0.25 mrem/h).

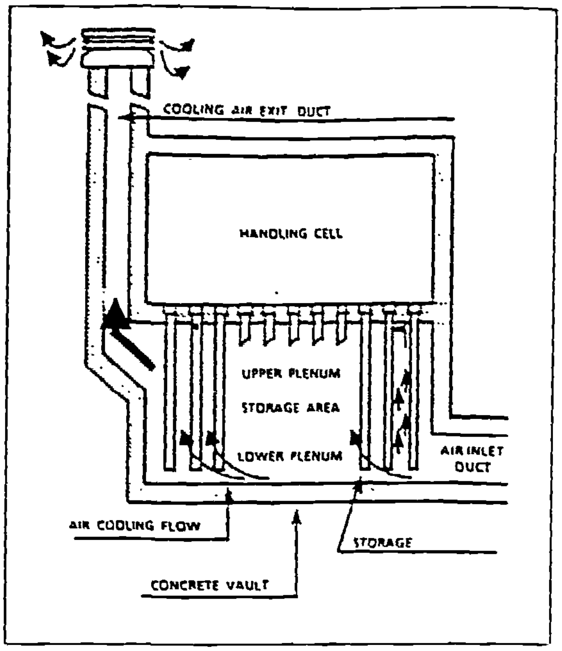

Figure 1 : Principle of passive natural convection air cooling system

HEAT TRANSFER STUDIES

The natural convection cooling system must ensure compliance with the maximum permissible temperatures both for the fuel assemblies and the structures. It has consequently been the subject of specific development programs.

Numerous calculations using qualified computer codes such as the last version of ASCONA, called COBRA, were performed to determine the maximum fuel rod cladding temperature versus the released power and the rod temperature as a function of container or pit temperature.

Additionally, mock-up studies were undertaken to confirm the theoretical investigations:
- a 0.12 scale mock-up, representing the vault with its air intake,

the lower plenum, the pits, the upper plenum and the stack. It confirmed the satisfactory general operation of the facility with: no hot spots, low air and pit temperatures, cooling guaranteed at partial load irrespective of location in the vault.
- a full scale pit mock-up confirming the validity of the heat transfer studies.

DESCRIPTION OF THE FACILITY

Description of the building

The entire facility covers a ground area of about 850 m2. It is designed to withstand a Safe Shutdown Earthquake (SSE) with a magnitude of IX on the MSK scale.

Main premises

The building (Figure 2) consists of a semi-buried interim storage vault containing 319 storage pits under a fuel handling cell. The handling cell is used to load the storage baskets and insert them into the pits.

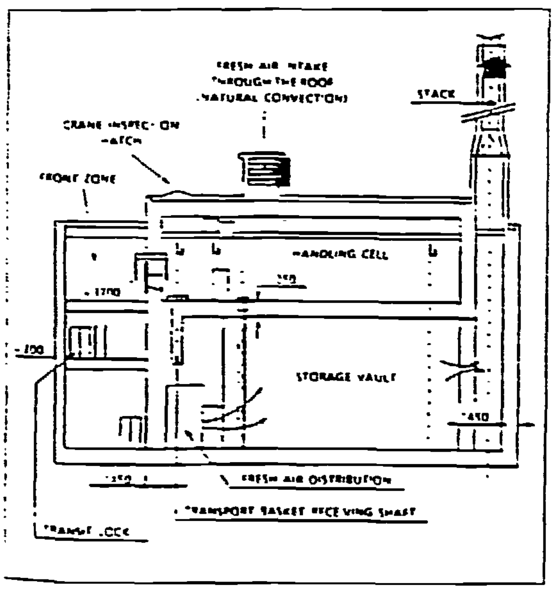

Figure 2 : Cross section of vault

The vault connects to the outside through an air intake in the roof and a stack designed to remove hot air.

The building is designed to accommodate a future extension for an interim storage cell and a handling cell.

Technical premises

The main body of the building is surrounded, on three levels, with technical rooms for bringing the transport packages into the handling cell (truck lock, reception room), for handling the fuel (front zone), and for installing miscellaneous equipment.

Interim storage pit

The top of the pit has a removable stainless steel clad concrete shield plug of suitable thickness and shape (Figure 3). It is closed and sealed to gases by a seal plate bolted with a double metal seal ring.

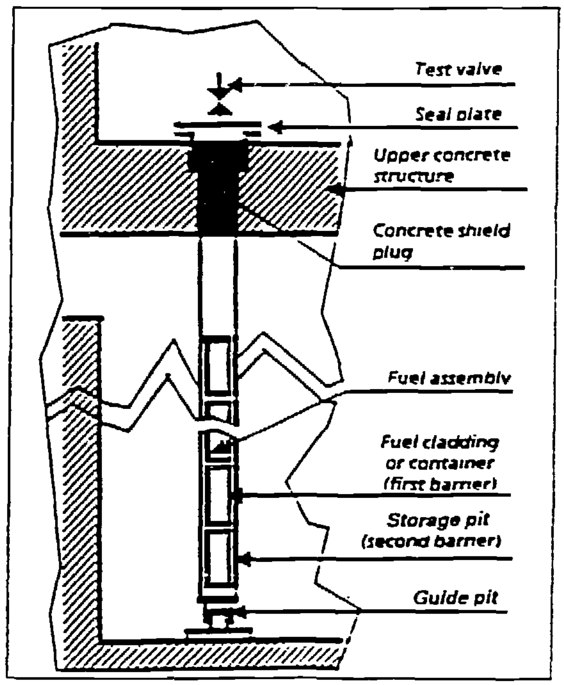

Figure 3 : Storage pit

Each pit is equipped at the base with a removable shock absorber designed to withstand the effects of the drop of a basket loaded with fuel. Certain pits are equipped with temperature probes placed at different levels to monitor the operation of natural convection.

These pits are designed to withstand the effects of an SSE while maintaining their tightness, and to enable subsequent retrieval of the fuel.

The base of the pits is fixed by a slide to the building raft. Of the 319 pits, only 315 are used permanently. The remaining ones serve for emergency and handling operations.

<u>Ventilation</u>

The building has a conventional nuclear ventilation system in the operating premises classified as monitored or controlled areas. The nuclear ventilation air circuit and the natural convection cooling air circuit of the vault are completely independent.

DESCRIPTION OF OPERATIONS

The handling operations are described in the sequence shown in Figure 4.

During the interim storage period, the internal atmosphere of each pit is sampled regularly by a special device mounted on the plug of each pit.

Since the canisters containing the fuel assemblies are filled with helium, detection of the gas indicates a canister defect.

Defective canisters are removed to an outside installation for treatment.

The leaktightness of the pits is controlled by slight negative pressure.

If defective pits are detected, the canisters will be transferred to one of the four pits always kept empty for handling purposes.

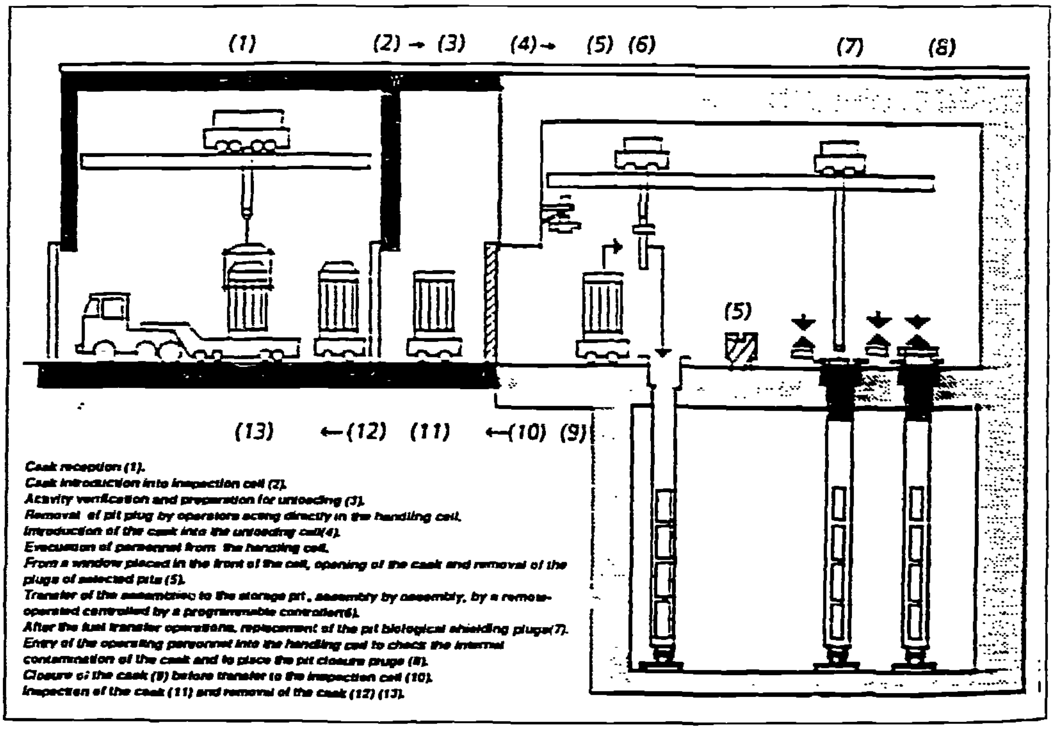

Figure 3 : Fuel handling operations

The radioactivity of the air released by the natural convection stack is monitored continuously. If any activity is detected, the cooling air is diverted to an auxiliary circuit equipped with a bank of HEPA filters and an exhaust fan designed to compensate the pressure drops of the circuit. A search is made to identify the defective pit, and the fuel is then transferred from this pit to one of the four service pits.

Initial operating results

The first package containing spent fuel was unloaded on May 31, 1990.

The first unloading confirmed the validity of design rules adopted for the installation, namely minimum personnel exposure, non-contamination of the fuel handling cell, fuel cooling by natural convection, and operation by two operators.

APPLICATION OF THE CASCAD CONCEPT TO LWR FUEL ASSEMBLIES

The basic principles implemented at the CASCAD facility can be used to store LWR fuel assemblies. This involves meeting two requirements:

- incoming fuel assemblies must first be cooled for at least five years;
- fuel assemblies must be placed in leaktight canisters with no trace of external contamination.

Canisterization can be performed either at the reactor or in an installation associated with the storage building.

The canisters are designed to hold four PWR assemblies or twelve BWR assemblies. Use of a neutron-absorbing material in the canisters ensures the subcriticality of the storage unit, even in accident situations (e.g., water in the pits). The closure method will be adapted to the needs of the user (canister with threaded or welded lid).

Depending on user requirements, the capacity of the CASCAD modules will vary between 250 and 500 MTHM for a maximum heat release of 1 MW per module. The storage zone of a 500 MTHM module of PWR fuel assemblies will occupy a ground space of 15 x 22 m. The operating sequence for fuel handling is identical to the one described above.

Countries prone to reprocessing their spent fuel in the future should be inclined to consider the applicability of this safe, compact and low-cost storage design for their own use.

CONCLUSION

The completion and active commissioning of the CASCAD fuel storage vault facility has demonstrated the technological and economic advantages of the concept.