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# Spent fuels conditioning and irradiated nuclear fuel elements examination :

## The STAR facility and its abilities

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### 1 - INTRODUCTION AND OBJECTIVES

The STAR facility, a high activity laboratory located at the Cadarache Nuclear Research Center, is now ready to be operated.

Initially built for the treatment, cleaning and conditioning of spent fuels issued from Gas Cooled Reactors (GCR), STAR was added a new aim during the year 1992 with examination abilities of PWR and FBR irradiated fuel elements :

- The main objective is related to about 2300 spent GCR fuel cartridges, which were irradiated more than 20 years ago in EDF or CEA Uranium Graphite Gas cooled reactors, and then examined in the Saclay or Cadarache centers. These fuel elements have been since stored in steel canisters, dived in water pools (Cadarache) or placed in dry concrete shieldings (Saclay).

  During the storage in pools, water soaking in canisters led, for a significant percentage of these stored fuel elements, to severe chemical interaction, in particular an uranium hydride production. Those hydrides produce spontaneous inflammation of fuel particles when in contact with air, which makes transportation and reprocessing not directly feasible because unsafe.

  The purpose of the STAR facility and of the associated processes is therefore to separate the nuclear fuel from the clad remains, to chemically stabilize the nuclear material and to condition it in sealed canisters, convenient for road transportation and final reprocessing specifications at the UP1 Marcoule plant.

  This cleansing campaign is foreseen to be about 4 years long (~ 600 canisters per year).

- The additional objective deals with non-destructive or destructive examinations and tests on PWR rods or FBR pins - in the frame of fuel development programs (CAPRA, MOX, high burnup fraction...). This objective will be partly carried out during the completion of the GCR fuel wastes cleansing campaign. Once this mission ended, the STAR laboratory will be entirely devoted to such examinations.

### 2 - THE STAR FACILITY CONCEPTUAL DESIGN

The STAR facility has been conceived in order to take profit of existing laboratories operational experience, to comply with the latest safety design rules and to allow further developments and R & D works on various fuel types. Main corresponding options ~~selected by the design team~~ are described hereafter :

(i) Operational experience feed back

- 3 Independant cells, with leaktight transfer lock chambers.
- 2 partitionned rear cells, for fuel elements admission.
- A shielded upper cell, that covers the 3 main ones for maintenance or material access.
- Numerous access hatches, allowing reception of various vertical or horizontal casks.
- Total removability of all the in cell devices, through the upper cell. This removability was validated during the construction period.
- Cell walls are coated with a stainless steel liner, in order to make easier further decontamination works.

### (ii) Compliance with up-to-date safety design rules

- High seismic resistance : In order to better comply with the prevailing seismic conditions of the Cadarache Center (level IX on the MKSA scale), the STAR laboratory is built on isolating elastomer bearing pads (see fig. 1). In case of earthquake, they allow the whole building to slowly move, following both horizontal directions.

- Double containment : STAR provides two fully independant barriers against radioactive dissemination : the cells with their liner, and the building envelope. Those two static barriers are equipped each with its own ventilation system. They provide depression cascades, on one hand in the cells from the most contaminated (-240 Pa in cell 1) to the less one (-200 Pa in cell 3) and, on the other hand, from -80 Pa, to -20 Pa in the working areas, according to their dissemination potential. Cells ventilation discharges are prefiltered, and then directed on two redundant high efficiency filters stages.

- $\alpha, \beta, \gamma$ tightness of the cells, and the related high sensitive radiation monitoring systems, make STAR able to receive high $\alpha$ contents fuels (actinides), whatever their irradiation level in reactor.

- Efficient fire protection : By conception, cells are designed as a "fire and containment sector" with adequate fire dampers and 3 various types of fire detectors per cell (thermovelocimetry, ionisation and optical detection). In addition, thermal loads are limited (less than 200 $MJ/m^2$ inside the cells, 400 $MJ/m^2$ in the facility). Inert gas atmosphere in cells (argon or nitrogen) allow to handle pyrophoric or instable in air materials.

### (iii) Adaptation to further operational needs

Versatility to allow easy adaptation to further operational needs (R & D for fuel development, reconditioning of fuels...), was a constant objective for the design options selection :

- Large cells dimensions (up to 9m), for a total hot cells area of 60 square meters.
- Oversized shielding (1,20m hematite concrete).
- Individual selection of the cells atmosphere (Air, Nitrogen or Argon).
- Capability to receive both horizontal or vertical transfer casks (IL40, IL42...).
- Large storage equipments.
- Reservations for future examination cells, to be built in the laboratory basement.

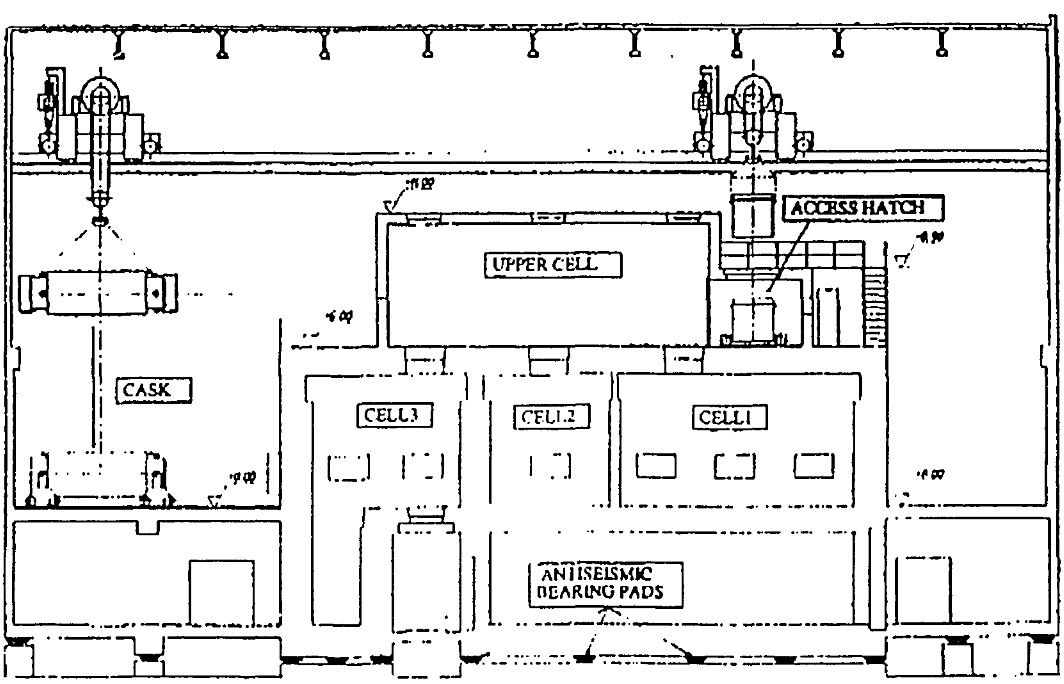


Fig. 1 - Building arrangement on anti seismic bearing pads

## 3 - *DESCRIPTION OF THE GCR SPENT FUEL RECONDITIONING PROCESS*

The GCR spent fuel reconditioning process has been developped by CEA and validated at the LECA. It includes following operations, obviously performed in hot cells by remote handling :

1 - Extraction of the canisters from the storage pool - preidentification and control - Transportation by shielded casks to the STAR facility.
2 - Reception of the casks - and canister transfer to the treatment cell.
3 - Canisters identification, opening and content identification.
4 - Mechanical removal of the magnesium cladding.
5 - Separation of nuclear material from clad remains - Conditioning of Mg claddings for specific disposal. Nuclear materials are then put into an oven specially designed to fullfill the following steps, and able to withstand the effects of an hydrogen explosion.
6 - Drying at 100 °C, with an argon coverage.
7 - Hydride destruction at 430 °C, with an argon coverage, under atmospheric pressure : (reaction : $UH3 \rightarrow U + 3/2 H_2$).
8 - Partial oxidation of metallic uranium particles since they remain readily flammable : This operation is carried out at 250 °C, with $O_2$ injection, and under varying pressure (1 to 4,5 bar), up to obtain a stable product with a 20 % $O_2$ coverage gas - ie the oxygen concentration in air.
9 - Conditioning of the stabilized nuclear material in Aluminium alloy (AG3) canisters. These are fitted with soluble windows (in Magnesium) - and leaktight welded. The AG3 canister as well as their magnesium windows are designed with regard to the UP1 reprocessing plant requirements.
10 - Transfer of the plugged canisters to cell number 2 for weighing, optional decontamination and tightness control.
11 - Transfer to cell 3 for interim storage and evacuation by shielded casks (8 or 12 canisters bearing baskets) to the UP1 reprocessing plant

In order to confine at best the contamination, all operations from the reception to the canister closure are performed in a single, large cell (cell 1 - 9m x 3m, see fig. 2).

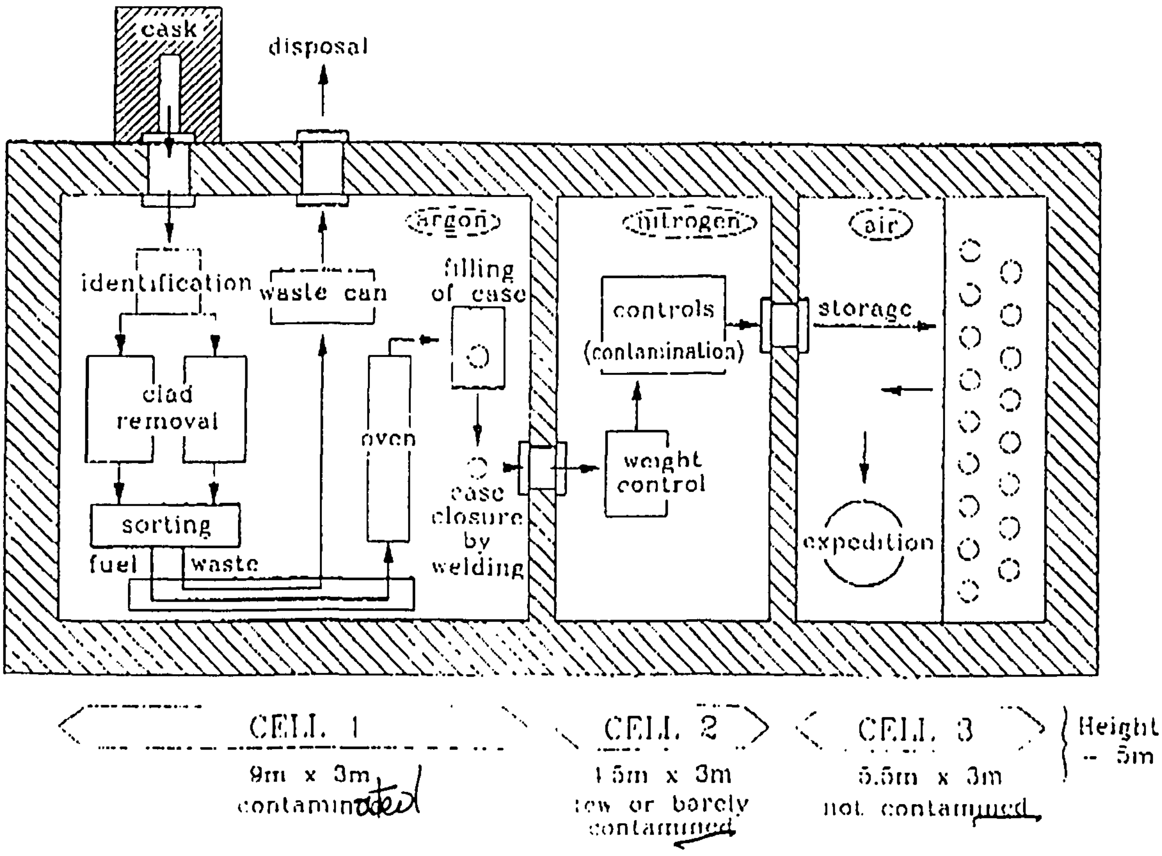


Fig. 2 - GCR process : Tools arrangement

The cell 1 is kept under argon atmosphere, because of the pyrophoric properties of tho processed materials. Accordingly, canisters are transferred from cell 1 to cell 2 thanks to a lock chamber. Cell 2 is placed under nitrogen atmospere to prevent massive air admission and likely fire hazards in cell 1 in case of lock chamber failure.

The last cell (cell 3 - 5,5m x 3m) merely devoted to intermediate storage of filled canisters, and their evacuation towards the UP1 reprocessing plant, is operated under air, and is barely contaminated.

## 4 - EXAMINATION OF IRRADIATED FUEL ELEMENTS

We have seen that an additional purpose of STAR is examination of irradiated both PWR and FBR fuel elements. As a matter of fact, non destructive examination equipments for PWR fuel rods have already been installed in the cell 3 (fig. 3) :

. Examination channel, allowing rods presentation to the non destructive examination (NDE) systems.
. NDE systems (X rays, eddy currents, gamma spectrometry, visual examination and metrology).

Some destructive examination devices, such as cutting and gas sampling are, as well, set in the cell number 2. Concern for the respect of the low level contamination implied by the spent GCR fuels conditioning process is integrated in the design of these devices. For instance, the cutting machine possesses its own ventilation system inside the cell 2.

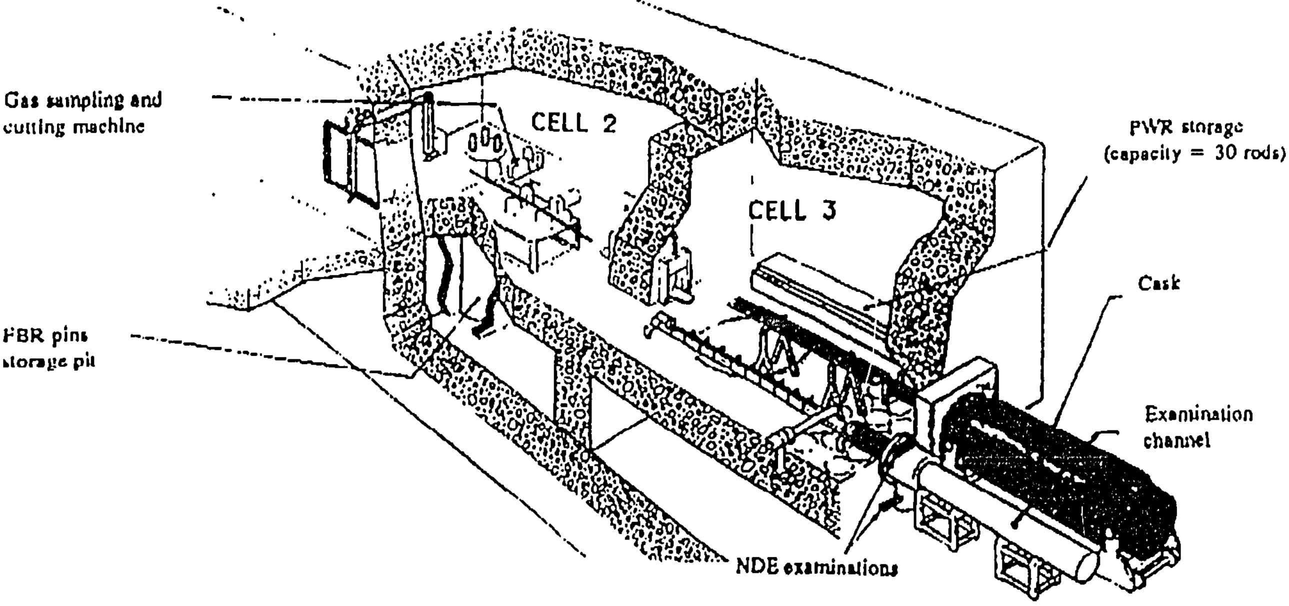


Fig. 3 - Equipments for LWR and FBR fuel examination

## 5 - CONCLUSION

The STAR facility now makes ready its staff to reach the nominal productivity. Use of the stabilization process will allow the CEA to purge its research centers from the remaining spent GCR fuels and to send them to reprocessing plants during the next 4 years.

Versatile and up to date conception and equipments will then lead the STAR facility to become a CEA chief fuel examination hot laboratory in the next decades.