



# Retrieval of degraded irradiated fuel and conditioning for a safe storage the CEA experience

Presented by P. MICHAILLE (CEA/DAM/DPN)

from documents prepared by

V. Federici (CEA/DEN/DGI/SEDA)

J. Romeyer-Dherbey (CEA/DEN/DEC/SLS)

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## Summary

- Presentation of the Gas Cooled Reactors' (GCR) fuel retrieval **programme**
- The use of **STAR** for the GCR fuel treatment and conditioning
- The **future** of STAR as a R&D tool

# Status of the GCR spent fuel

- 2300 spent GCR fuel cartridges
- Irradiated more than 30 years ago
- Examined in Cadarache & Saclay centres
- Stored in steel canisters
- Dived in water pools (Cadarache) or stored in dry concrete shielding (Saclay)
- Presumably in a degraded state

# The CGR retrieval programme

- Began in **1995** with Cadarache fuel :
  - Retrieval from the INB-56 pools
  - Conditioning in STAR
  - Transportation to Marcoule for fuel processing
- Since **1997** : Marcoule plant shut down
  - Conditioning for CASCAD
  - Evacuation & storage
- End **2003** : end of the Cadarache programme
  - Beginning of the Saclay fuel retrieval
  - Then : some fuel elements of heavy water cooled reactor

# Risks

- Water/moisture soaked into some canisters
  - Possible production of uranium hydride
  - Risk of spontaneous **inflammation / explosion** when put in contact with air
  - Pool water **contamination**
- ➔ Transportation and reprocessing : **unsafe**

# INB-56 up-grading

- The **pools are in open air** ; water is contaminated
  - Erection of a building above the open air pools
  - Ventilation of the building
- No **fuel extraction** device
  - Tele-operated discharging machine
- Taking into account the **explosion risk**
  - Special pressure-resistant chamber for test
- **Transportation** precautions
  - X-ray examination of the fuel for sorting (degraded/sane, dry/wet)
  - Avoid contamination of the transport casks => rubber socket



# Purpose of STAR

- Treatment for securing the fuel
- Conditioning for transportation to reprocessing or storage

Facility for

Treatment

Securing

Reconditioning

Station de

Traitement

Assainissement

Reconditionnement

# GCR spent fuel characteristics

- From 0,5 up to 9,5 MWd/kg
- Magnesium cladding
- Metallic uranium
- Graphite core
- Up to 1,65 %  $^{235}\text{U}$
- Activity of 3 TBq/kg
- Dose rate : 0,1 Gy/h at 1 m



# Description of STAR facility

- 3 independent cells :
  - Cell 1 : highly contaminated
  - Cell 2 : slightly contaminated
  - Cell 3 : clean
- Leak tight transfer lock chambers
- 2 partitioned rear cells
- Shielded upper cell
- Numerous access hatches

# STAR facility conceptual design

- High **seismic** resistance :
  - Level IX on the MKSA scale
  - Isolating elastomer bearing pads
- Double **confinement** :
  - Static barrier ( cells – building)
  - Dynamic barriers :
    - Nuclear ventilation system
    - Cascaded depressurised system
    - High efficiency particles filters

# STAR facility conceptual design (2)

- $\alpha$ ,  $\beta$ ,  $\gamma$  tightness of the cells
- Efficient fire protection :
  - Fire and containment sectors
  - Fire detectors
  - Limitation of thermal loads
  - Inert gas atmosphere in cells
- Continuous monitoring & alarms management



# GCR fuel

## Reception & Preparation

- **Reception** of spent fuel casks
- **Identification** of the spent fuel canisters
- **Removal** of the magnesium cladding
- **Separation** : nuclear materials / cladding

# GCR fuel treatment in the furnace

- **Drying** at 100 °C
  - For liquid water removal
  - In order to prevent further fuel-water reactions
- **Pyrolysis** of Uranium hydride
  - Up to 430 °C under argon atmosphere
- **Oxidation** (partial) at 250 °C
  - The rate of O<sub>2</sub> is increased progressively from 5 % up to 20 %



# GCR reconditioning & evacuation process

- **Conditioning** in aluminium alloy canisters (designed for reprocessing at Marcoule)
- **Weighing** and **cleaning** (cell N° 2)
- **Interim storage** (cell N°3, in pits) then
  - Transportation to Marcoule for reprocessing until 1996
- **Containering** (stainless steel, tightly welded under neutral gas, checked by helitest)
  - Transportation to CASCAD facility

# Human means

- 25 persons in 5 teams :
  - 3 in front zone
  - 2 in rear zone
  
- 2 × 12 hours

## The future of STAR : a tool for R&D

In the frame of fuel development programs,  
**non destructive examinations** of PWR & FBR fuel elements are being performed during the completion of the GCR fuel retrieval campaign.

In the future STAR will be used as a fuel **examinations (including destructive)** hot cell , in complement to LECA facility.