FROM RESEARCH TO INDUSTRY

SAFE REPACKAGING OF NUCLEAR FUELS STORED UNDERWATER

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SUMMARY

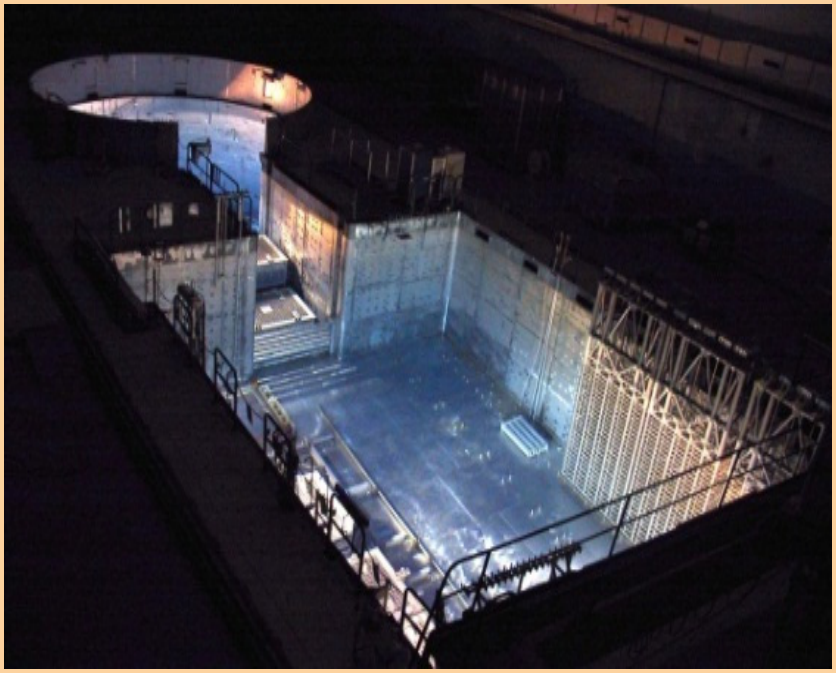
- Nuclear facilities involved
- Types of containers to repackage
- Risk of radiolysis
- Repackaging process in the STAR facility
- Dryness criterion
- Results of the repackaging project

Nuclear facilities involved

Nuclear facilities involved

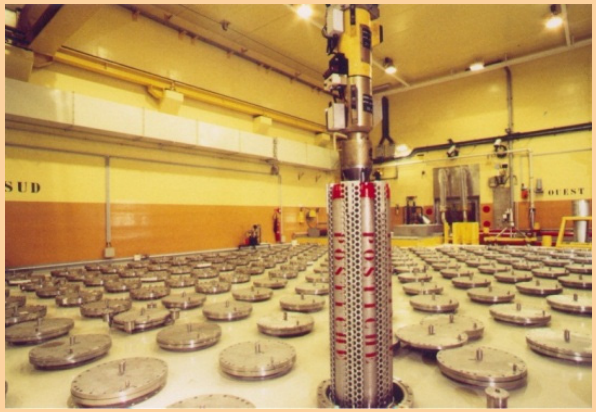
- PEGASE facility

- This pool-type research reactor operated from 1963 to 1980.
- It is used for the underwater storage of spent fuel.
- Removal of the spent fuel began in 2003 following the facility safety review.
- 136 spent fuel containers were removed between 2011 and 2016.



Nuclear facilities involved

- CASCAD facility



- First commissioned in 1990.
- It is used for the dry storage of spent fuels at the CEA.

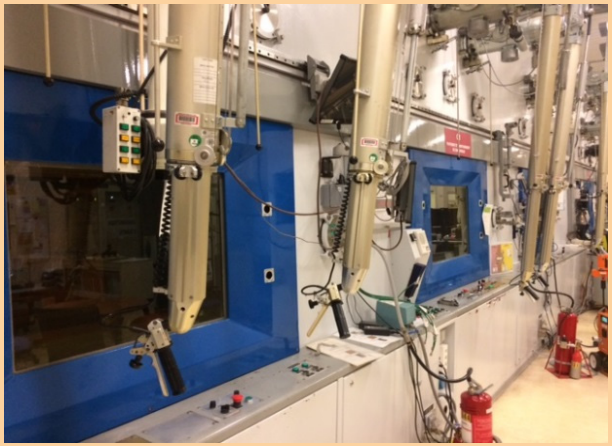
Types of containers in storage:
N2/ C2 and AA194/ C194

Nuclear facilities involved

- STAR facility

- First commissioned in 1994.

- The hot laboratory is used to repackage spent fuel. ⇒

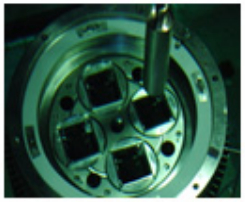


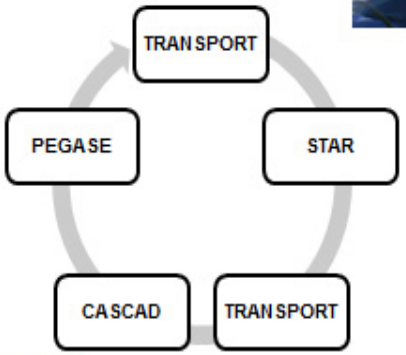
⇒ Hot cell with remotely operated equipment which are used to repackage containers in the PEGASE facility.

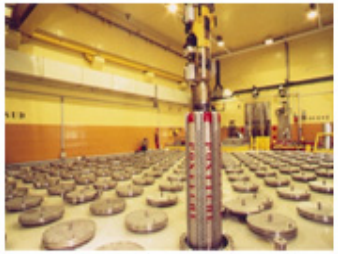
Nuclear facilities involved

Fuel handled in PEGASE

PEGASE facility







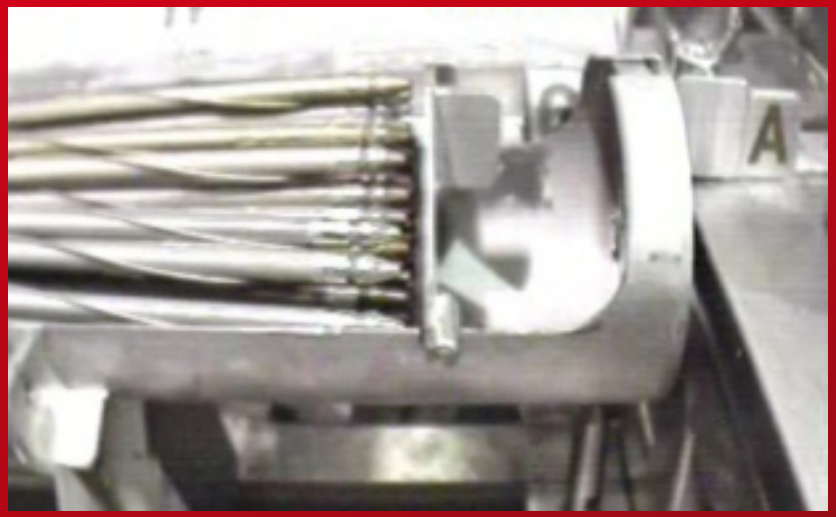
Transport from PEGASE -> STAR

Repackaging of STAR containers

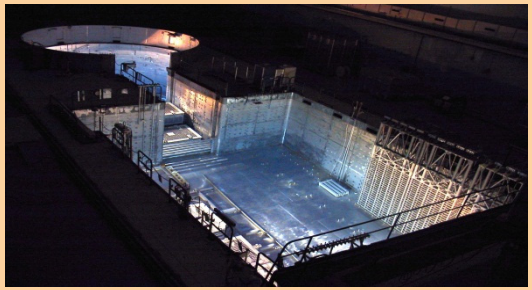
Transport from STAR -> CASCAD

Fuel placed in pit storage in CASCAD

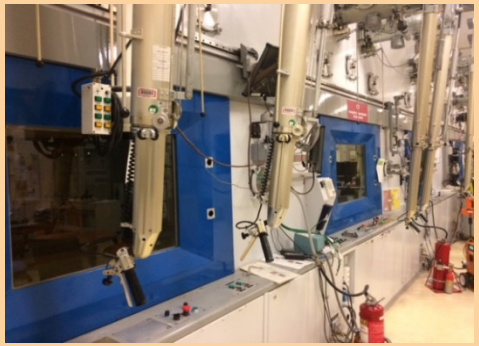
Types of containers to repackage



Types of containers to repackage



PEGASE



Characteristics of the **STAR** facility

Type of container	Length (mm)	Diameter (mm)
AA308	1658	100
AA194	1885	100
AA241	840	145

Type of container	Length	Diameter
N2 (primary casing)	628	126
C2 (primary casing)	744	336
AA194 (primary casing)	1885	100
C194 (secondary casing)	2076	118

Types of containers to repackage

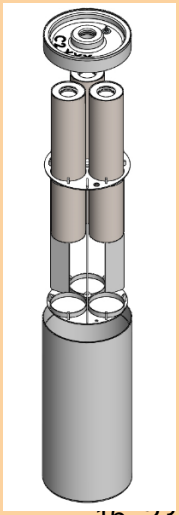
Different photos of casings

336 mm

744 mm

C2 Containers

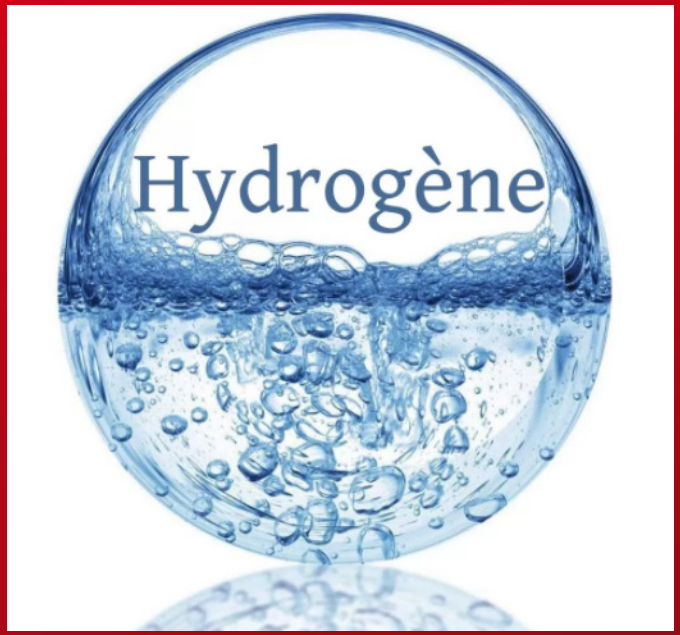
3 x **N2**
Inside C2



C194 Containers

2076 mm

Risk of radiolysis

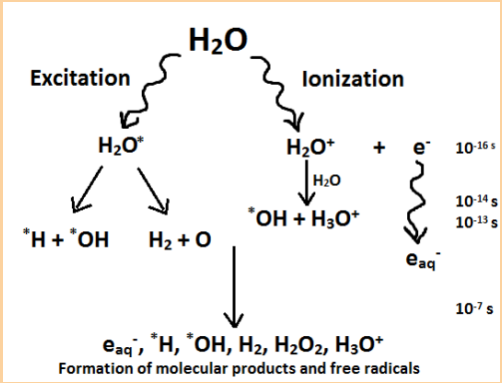


Risk of radiolysis

- In the PEGASE facility

  - Fuel containers that have been stored underwater for several years may no longer be leaktight: corrosion, manufacturing defects, impacts, etc.

  - Water can leak into the container and cause radiolysis under the effect of the radiation.



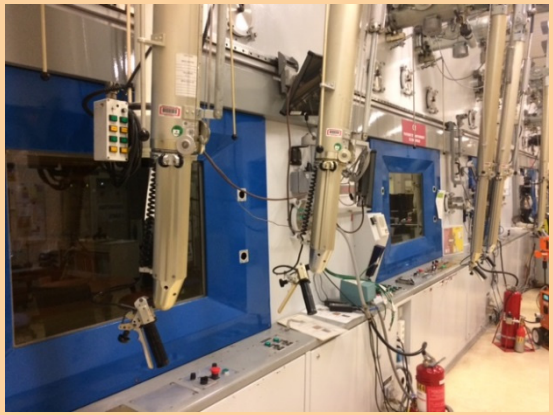
Potential presence of hydrogen in the containers to be repackaged

Risk of radiolysis

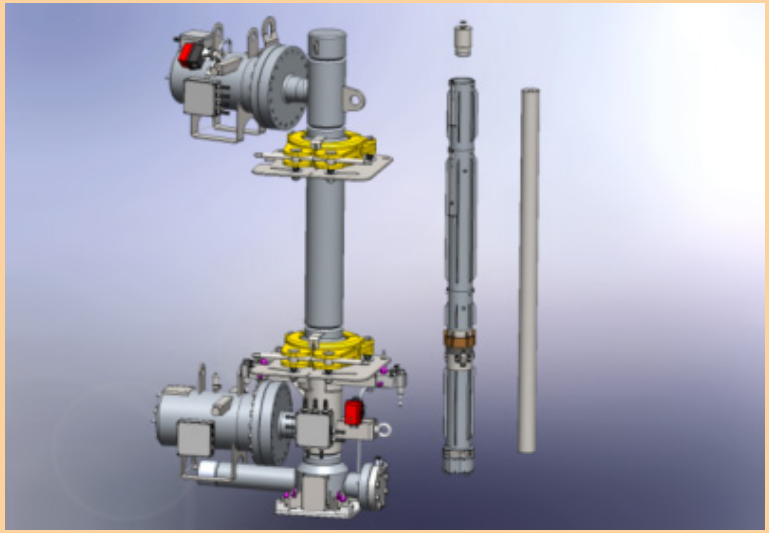
- In the STAR facility

- Spent fuels from the PEGASE facility are perforated in the STAR facility

- There is therefore a risk of explosion/ inflammation when perforating the container.



Specifically developed perforating machine

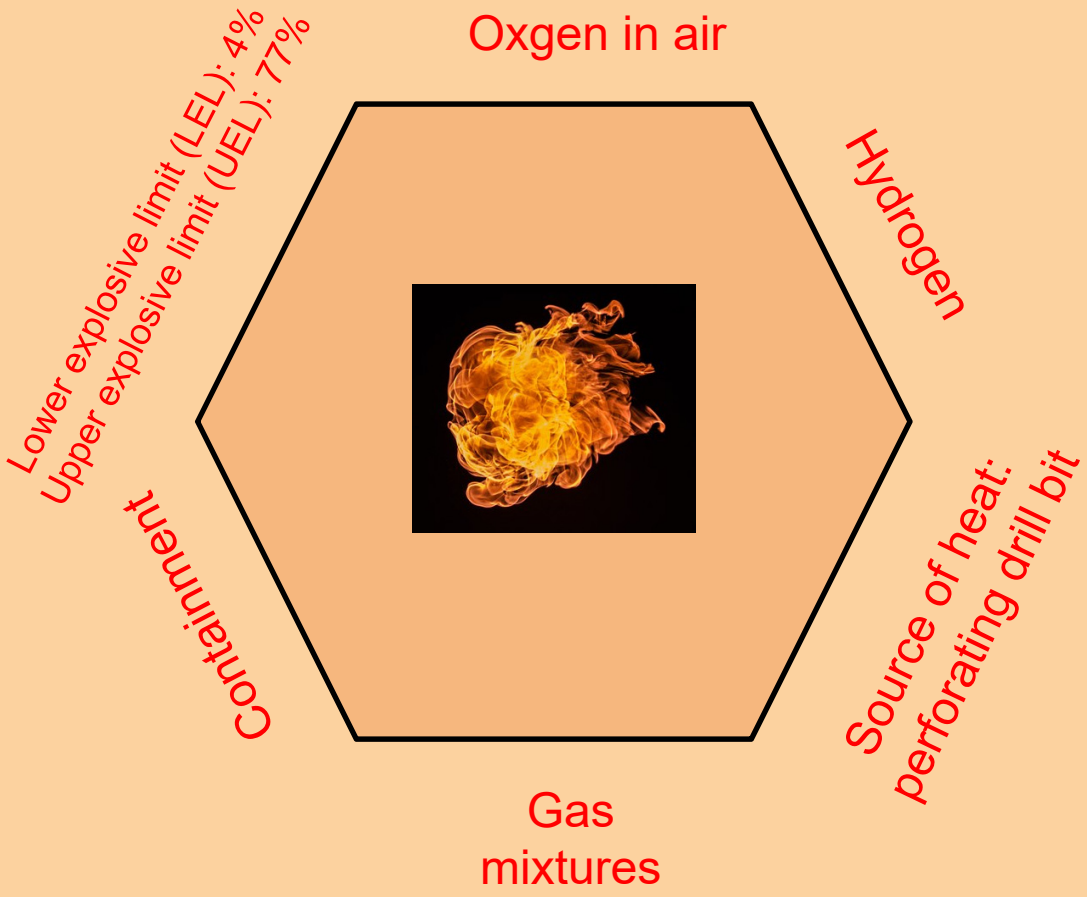


4 m high

2 tonnes

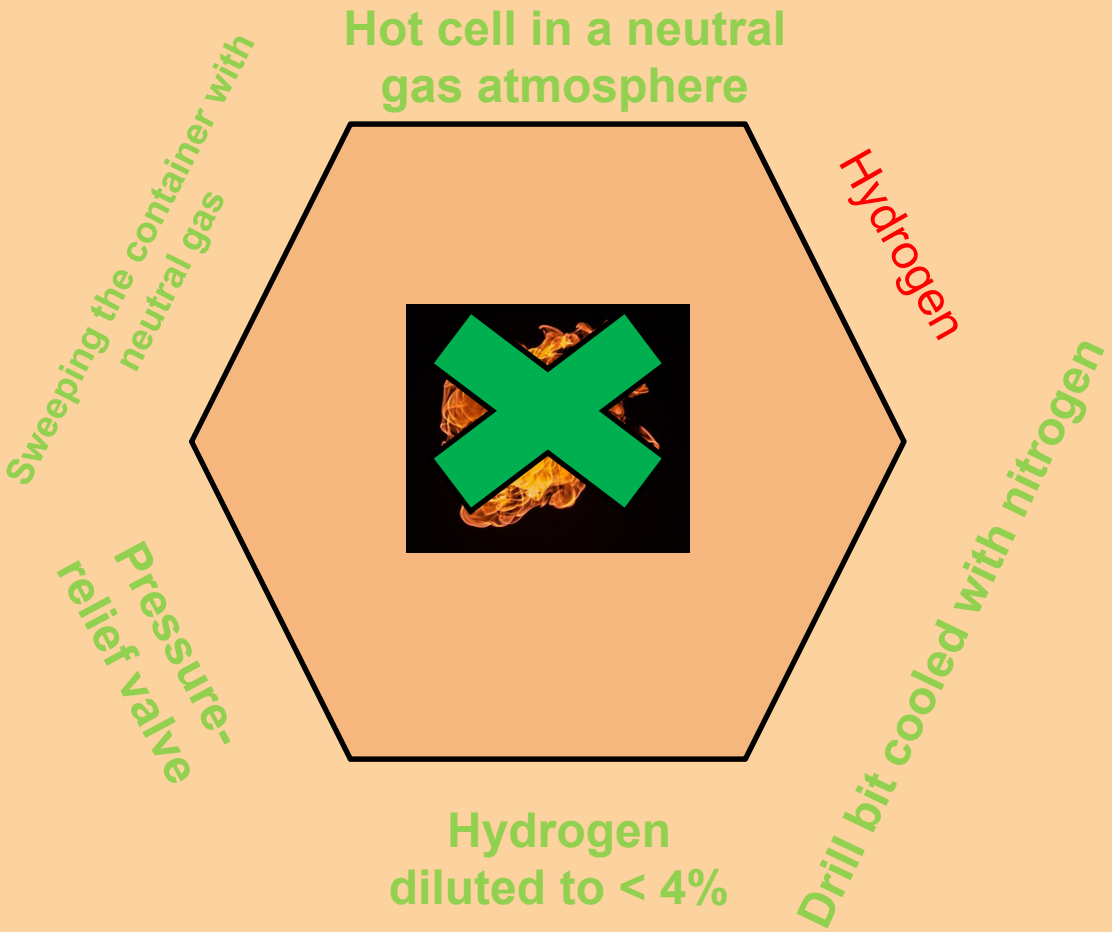
Risk of radiolysis

Risk of explosion



Risk of radiolysis

Eliminating the risk of explosion

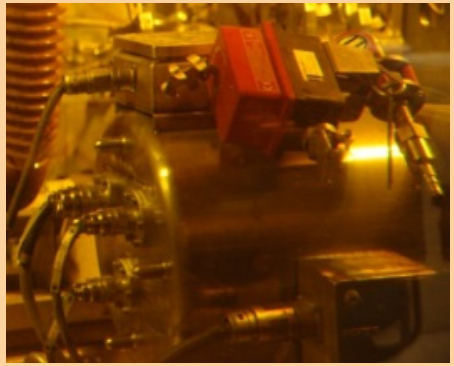


Repackaging process in the STAR facility

Repackaging process in the STAR facility

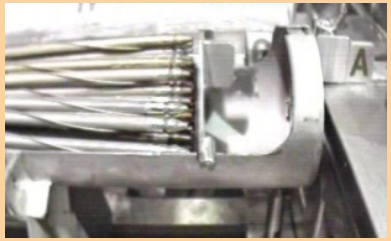
Fuel from PEGASE delivered to STAR

Spent fuel placed in the hot cell

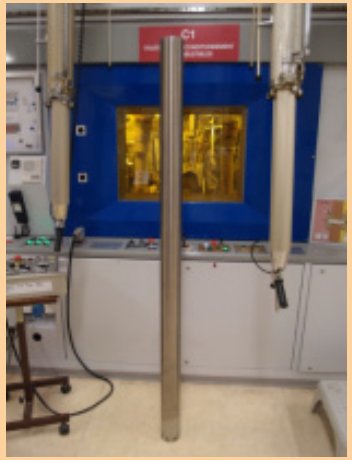


Perforating the casing

Drying and dryness test

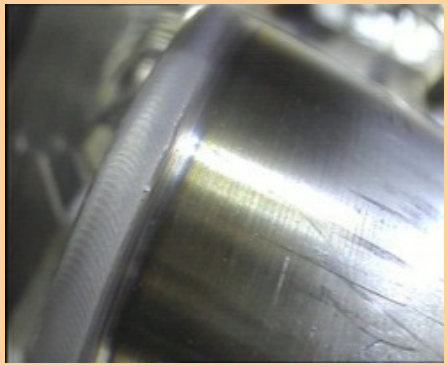


Cutting the fuels to suitable lengths

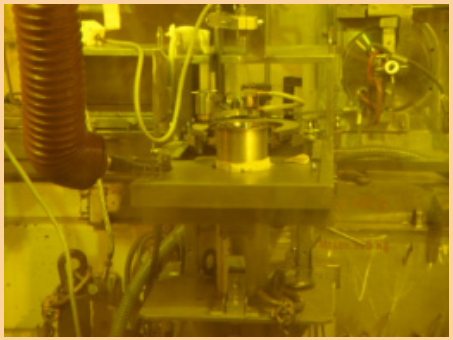


Repackaging in new AA194 or N2 casings

Repackaging process in the STAR facility



Welding the primary casing



Packaging in C194 or C2 secondary casings

Transfer to CASCAD

To operate the hot cells:

- Work shifts from Monday 6:00 am to Friday 7:00 pm
- 4 teams comprising 4 technicians to operate the hot cells
- 1fuel engineer

Project management and support services: transport, nuclear material, waste, criticality, radiation protection, facility and process maintenance, etc.

Drying and dryness test

The CASCAD facility provides interim storage for **dry fuel**

Fuel containing water is delivered to STAR

↓

The casing is perforated

- In the case of entire fuel rods → The fuel is drained and dried by creating a vacuum
- In the case of fuel rod sections → The fuel is dried in a furnace

Dryness test by vacuum

Results of the repackaging project

Results of the repackaging project

Time: 4 years

136 containers repackaged

Several dozen kilos of fissile material removed

Criticality risk managed

Management of nuclear material transport and accountancy

Design of innovative safe equipment

Results of the repackaging project

The experience gained over these 4 years during which more than 136 fuel casings were repackaged makes the CEA CADARACHE centre a key player in this field and confirms its ability to meet the requirements of different programmes.

Thank you for listening

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I look forward to answering any questions you may have!

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