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
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.
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

Fuel placed in pit storage in CASCAD

Transport from STAR -> CASCAD
Types of containers to repack
### Types of containers to repackate

#### PEGASE

<table>
<thead>
<tr>
<th>Type of container</th>
<th>Length (mm)</th>
<th>Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA308</td>
<td>1658</td>
<td>100</td>
</tr>
<tr>
<td>AA194</td>
<td>1885</td>
<td>100</td>
</tr>
<tr>
<td>AA241</td>
<td>840</td>
<td>145</td>
</tr>
</tbody>
</table>

#### Characteristics of the STAR facility

<table>
<thead>
<tr>
<th>Type of container</th>
<th>Length</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>N2 (primary casing)</td>
<td>628</td>
<td>126</td>
</tr>
<tr>
<td>C2 (primary casing)</td>
<td>744</td>
<td>336</td>
</tr>
<tr>
<td>AA194 (primary casing)</td>
<td>1885</td>
<td>100</td>
</tr>
<tr>
<td>C194 (secondary casing)</td>
<td>2076</td>
<td>118</td>
</tr>
</tbody>
</table>
Types of containers to repackage

Different photos of casings

\[ \text{C2 Containers} \]

336 mm

744 mm

\[ \text{Inside C2} \]

\[ 3 \times \text{N2} \]

\[ \text{C194 Containers} \]

2076 mm
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

Oxygen in air

Containment

Gas mixtures

Lower explosive limit (LEL): 4%
Upper explosive limit (UEL): 77%

Hydrogen

Source of heat: perforating drill bit
Risk of radiolysis

Eliminating the risk of explosion

- Hot cell in a neutral gas atmosphere
- Hydrogen
- Sweeping the container with neutral gas
- Pressure relief valve
- Hydrogen diluted to < 4%
- Drill bit cooled with nitrogen
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

HOTLAB 2017 MITO, Japan
16-23 September 2017
Repackaging process in the STAR facility

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
- 1 fuel 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

CONCLUSION
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
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
I look forward to answering any questions you may have!