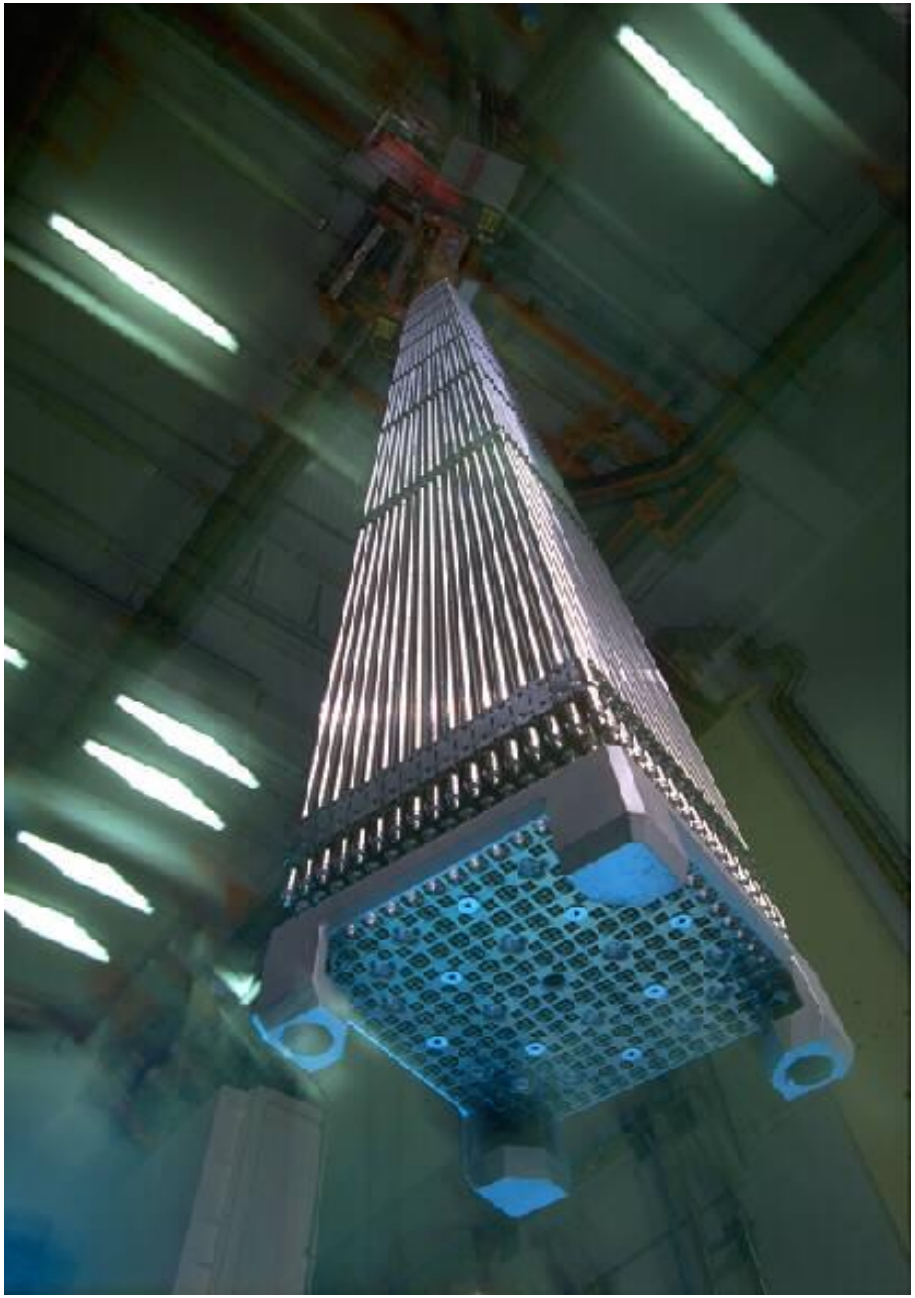


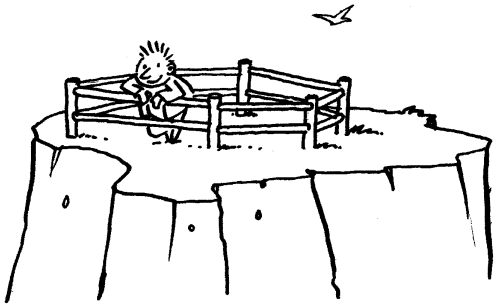
EGATF-L MARCH 3-5, 2015
PARIS

EDF pre-requisites for an irradiation of a limited number of ATF Experimental Fuel Rods in a commercial reactor

Developing an ATF

- For EDF, ATFs (when available) should improve public acceptance of commercial nuclear production in Europe
  - might be a strategic issue in a couple of decades
- Licensing a new fuel is a long and costly process
- Consensus about the objectives
  1. ATF should be as good as current fuels (and possibly better) during Normal Operation and DBA transients
  2. ATF should exhibit higher performance during severe accident
- Irradiation of a limited number of **ATF Lead Test Fuel Rods (LTFR)** in a commercial LWR is the best way to collect relevant in-reactor experience

Question: How to convince a plant operator (he is not going to put his plant at risk) ?

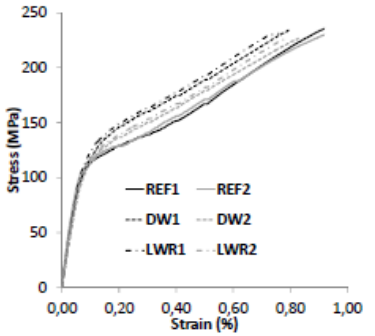


ATF Lead Tests Fuel Rods qualification path

- For normal operation and DBA transients, the qualification process of ATF LTFRs is similar to the one used for an advanced fuel

Characterization → modeling → limits→ justification

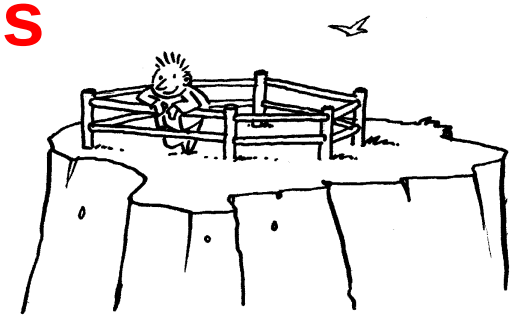
- Detailed characterization of the fuel rods (out-of-pile and in-pile tests) to develop/validate models and anticipate in-reactor behavior
  - Physical properties of the cladding material (thermal-mechanical properties, neutronic penalty),
  - Fuel rod behavior (corrosion, hydriding, irradiation damage, **creep, growth**, **fretting / erosion resistance**, PCI resistance, etc..)
  - Special attention should be given to multilayers concepts : individual layers + multilayered cladding need to be characterized



ATF Lead Tests Fuel Rods qualification path

- Fuel rods design limits
  - » Use standard Zr based alloys design limits (if relevant)
  - » Determine new design limits (if needed)
- Justify the overall behavior with respect to Safety Analysis Design Limits
  - » EOL rod internal pressure,
  - » **Fuel rod growth,**
  - » SCC-PCI,
  - » Max cladding strain
  - » …

What if the ~~novel~~ new fuel concept is (too) different from the current designs?



- Need to confirm ATF doesn't exhibit specific behavior or damage mechanisms that may require specific justification / design limits
- Examples of issues to address :
  - Is the **1% cladding strain** limit still relevant for multi-layers SiC claddings?
  - Does a **damage index** limit for multilayers or fibers cladding need to be used ?
  - Should the **design limits of the coating** and bulk be different?
  - Are the ATF claddings (multilayers and SiC for instance) compatible with the current **CHF correlation**?
  - Is the **FA pressure drop** affected by the cladding surface ?
  - Is the cladding sufficiently leak tight to **Tritium**?
  - Can the new fuel be **reprocessed**?
  - Etc...

Specific requirements to irradiate a few LTFR in a commercial NPP

1. If the LTFR is a simple evolution of a current fuel rod concept
   - Introducing a few LTF rods in a power plant doesn't require a comprehensive safety analysis
   - No core wide accidental analysis (LOCA, RIA, etc..) - limited impact in case of failure of a few LTR

2. If the LTFR is a breakthrough concept
   - The operator will require additional investigations to avoid any bad surprise
   - A bad surprise could be an **excessive fuel rod bow** or a loss of leaktightness (always possible) leading to a **complete degradation of the first barrier**
   - May lead to a premature NPP shutdown → **$$$** !
   - **Tritium permeation, coating adhesion, reprocessing viability... may be « killers »**

In summary

- To accept ATF Lead Test Fuel Rods in a commercial NPP, licensees will require some guarantees
- On top of the usual approach

Characterization → modeling → limits→ justification

The fuel supplier will be asked to demonstrate

- No unexpected fuel rod growth
- No in-reactor detrimental cladding coolant interactions (pollution of the primary circuit))
- No in-reactor detrimental behavior of the leakers