

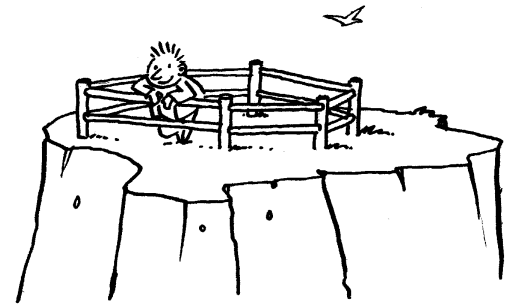


OECD/NEA Workshop on Accident Tolerant Fuels of LWRs

ATF in normal operation

What will require the operator to irradiate a few ATF Lead Test Rods in a commercial NPP ?

Developing an ATF



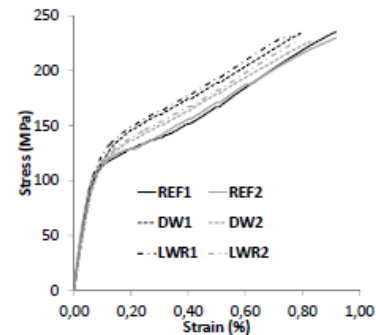
- Developing an ATF is going to be a long, stepwise /iterative, approach
 - Consensus about the objectives
 1. ATF should be as good as current fuels during Normal Operation and for DBA
 2. ATF should exhibit higher performance during severe accident
- To gather necessary experience feedback, the objective is to irradiate ASAP some **ATF Lead Test rods** in a commercial LWR
 - How to convince the plant operator ?

ATF Lead Tests Rods qualification path

- For normal operation and DBA, the qualification path should follow the usual regulatory requirements (as for an advanced fuel)

Characterization → modeling → limits → justification

- Detailed characterization of the fuel rods
 - Physical properties of the cladding material (thermal, mechanical and neutronic properties),
 - Fuel rod behavior (corrosion, hydriding, irradiation damage, creep, growth, **fretting resistance**, PCI resistance, etc..)
 - Special attention should be given to the multi layers concepts : each individual layers + the multilayered cladding need to be characterized
- Simulate the in reactor behavior of the fuel rods using relevant modeling
 - In pile instrumented separate effect tests to validate the simulation tools

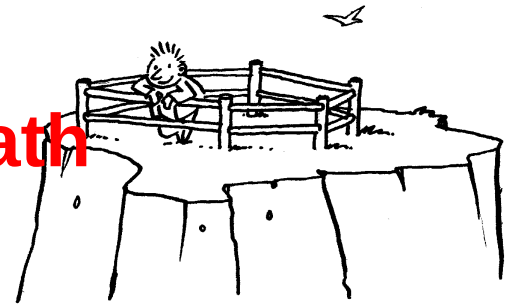


ATF Lead Tests Rods qualification path

- Simulate in-reactor behavior of the fuel rods with relevant modeling
 - » Instrumented separate effect tests in a MTR to validate the simulation tools
- Define the fuel rods design limits
 - » Use standard Zr based alloys design limits (if relevant)
 - » Determine new design limits (see later)
- Justify the overall behavior against the Safety Analysis Design Limits
 - » EOL rod internal pressure,
 - » Fuel rod growth,
 - » SCC-PCI,
 - » Max cladding strain
 - » ...



ATF Lead Tests Rods qualification path



- Design limits :

- » Justify that the current SAFDLs are still relevant in terms of values and in terms of related margins.
- » Confirm the ATF don't exhibit a specific behavior or damage mechanisms that may require specific justification (specific tests, specific SAFDL)
- » Examples :
 - Is the 1% cladding strain limit still relevant for multi-layers SiC claddings?
 - Do we need to introduce a damage index limit for multilayers or fibers cladding ?
 - How to define coating versus bulk design limits ?
 - Does the ATF claddings (multilayers and SiC for instance) compatible with the current CHF correlation?
 - Is the FA pressure drop affected by the cladding surface ?



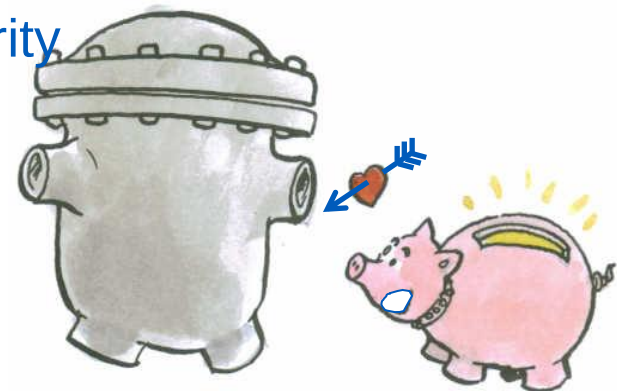
Specific requirement to irradiate ATF lead test rods in a commercial NPP

- Case 1 : The Lead Test Fuel rods are a simple evolution of the current fuel rods design
 - Introducing a few Lead Test Fuel rods in a power plant doesn't require a comprehensive safety analysis
 - No core wide accidental analysis (LOCA, RIA, etc..) thanks to the limited number of LTF rods (limited impact in case of failure)
- Case 2: The Lead Test Fuel rods are a breakthrough design
 - The operator will require additional investigations to avoid any bad surprise
 - A bad surprise is a leaking rod losing its integrity
 - May lead to a premature NPP shutdown

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Need to demonstrate the ATF rods exhibit no detrimental behavior in case of cladding failure

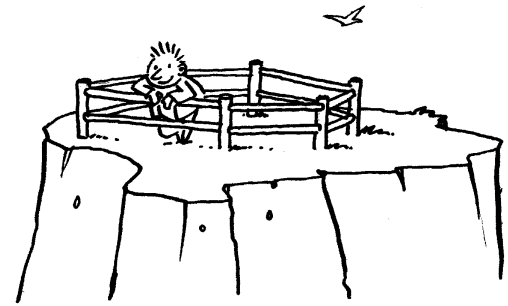
Operators need guarantees !



Specific requirement to irradiate lead test ATF rods in a commercial NPP

- Identify the various types of failure mechanisms
 - Grid to rod Fretting or debris
 - PCI
 - Cladding degradation (coating or layers delamination, ..)
 - Other?
- Demonstrate any cladding failures will not propagate under normal operation (including load following)
 - Well know for Zr based alloys but need to be checked for breakthrough cladding designs
 - How ? → Irradiate in a LWR loop some leaking ATF rodlets, in prototypical conditions (pressure, temperature, chemistry, LHR, power history, time, etc..)

Summary



- To accept to irradiate some ATF Lead Test Rods in a commercial NPP, the operator will ask for guarantees
- On top of the usual approach

Characterization → modeling → limits → justification

the fuel supplier will have to demonstrate that a failed ATF rod still behave properly

- no cladding degradation,
- fuel pellets remain confined within the cladding

**Thank you for
your attention !**



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your attention !**



TESTING

MODELING

Justification

Robust Fuel

