





French Evaluation of ATF Concepts

Jeremy Bischoff, **AREVA NP**

Thierry Forgeron, Jean-Christophe Brachet, Christophe Lorrette, **CEA**

Marie Moatti, Nicolas Waeckel, Antoine Ambard, **EDF**

FUEL



French Three Parties Institute Context

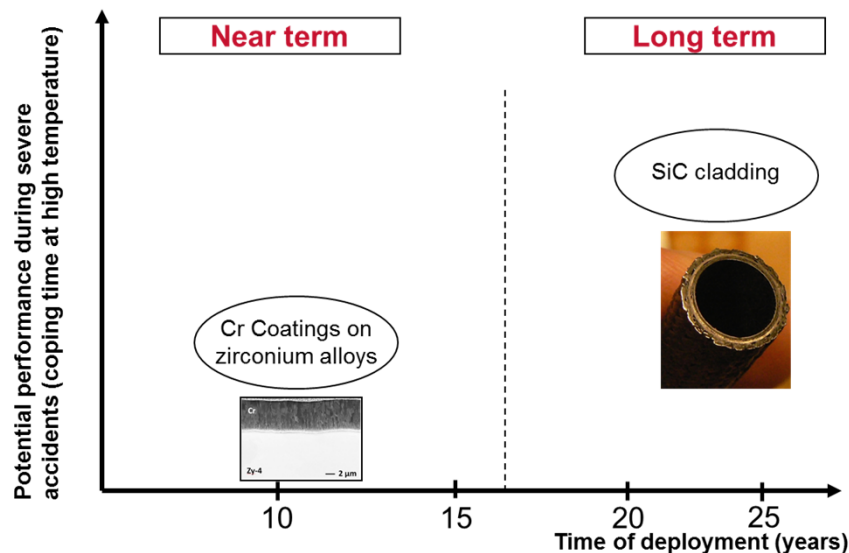
► French Nuclear Institute (consortium bringing together CEA-AREVA-EDF to do R&D on nuclear) on Innovative Fuel:

◆ Focus on two main solutions

- Near term: Cr coatings on Zr alloys → performance benefits in normal operation expected
- Long term: SiC/SiC composite sandwich cladding

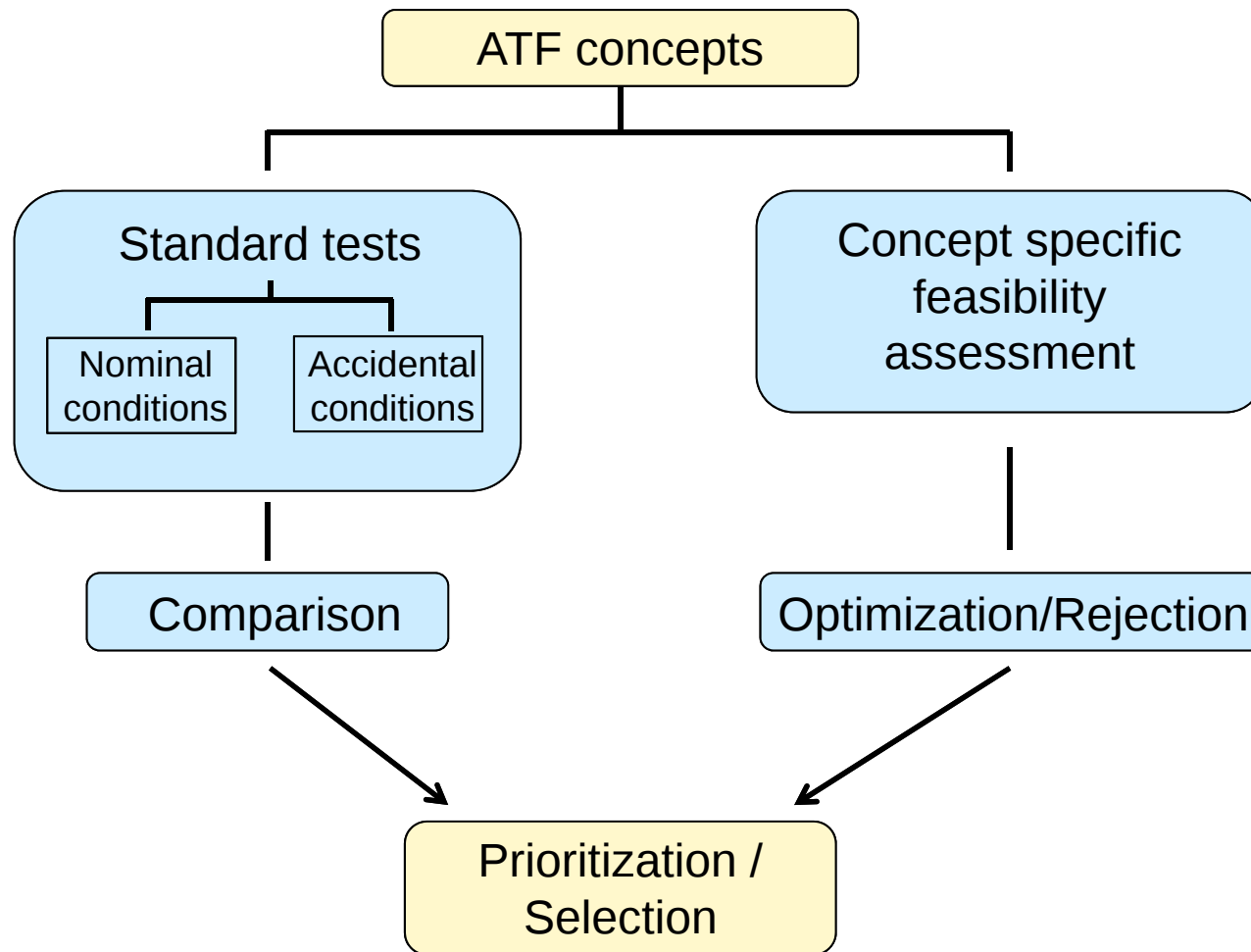
◆ Proposal of Zy-4 coated UO₂ fuel rodlets for irradiation in the Halden Reactor Program (White Paper submitted)

- Step 1 : Assessment of coating stability during in service condition (PCI design possible)
- Step 2 : Evaluation of Benefits in LOCA Transient of in-pile corroded Cr coated cladding



FUEL

2-step ATF Evaluation Process





Standard Test Evaluation



► Nominal conditions:

◆ Corrosion:

- ASTM G2 400°C steam for 3 days extended to 14 days
- PWR water chemistry 360°C long term autoclave test (up to 240 days)

◆ Mechanical properties:

- Internal pressure test with 1 and 2% deformation at 400°C (and 20°C)
- Tensile test at 400°C (and 20°C)
- Internal pressure creep test at 400°C (and 20°C)

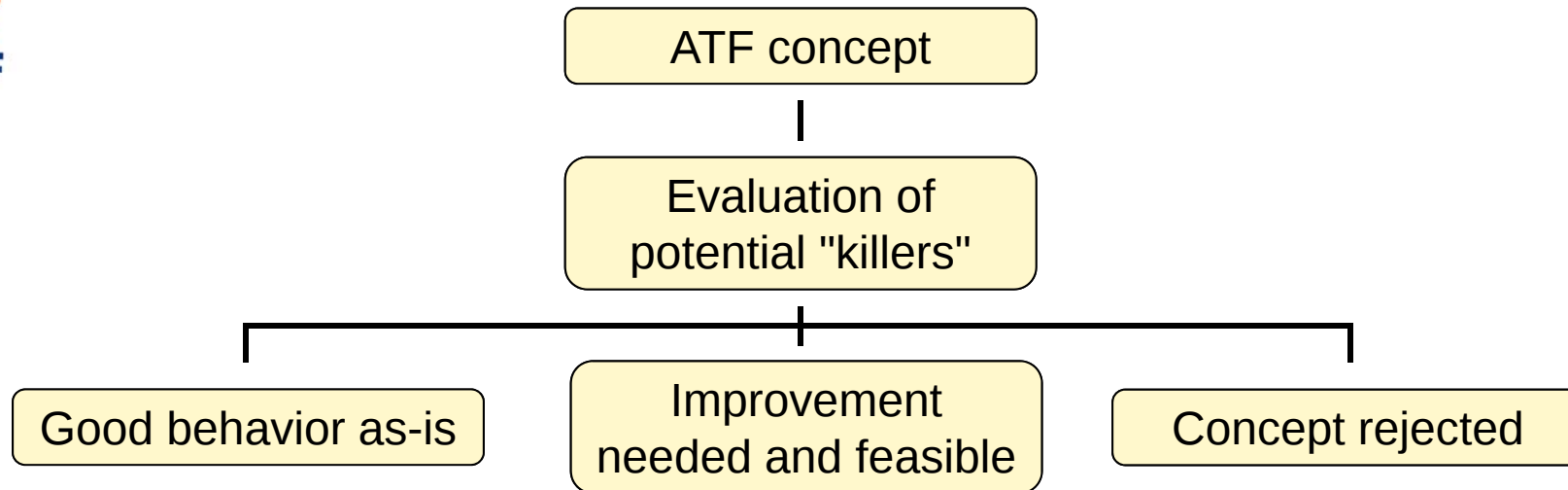
► Accidental conditions:

- ◆ High temperature one-sided steam oxidation at 1200° C for 600s (with post-quench mechanical evaluation by Ring Compression Test)
- ◆ Dynamic internal pressure high temperature ballooning and burst test

► Comparison of the results for each concept to determine its potential gains in nominal and accidental conditions

- ◆ Ranking of the investigated solutions

Concept-specific feasibility assessment



► Cr coatings:

- ◆ Coating adhesion / ductility → internal pressure deformation + EDGAR + scratch test
- ◆ Fabrication defects: impact on corrosion/adhesion and controllability

► SiC/SiC cladding:

- ◆ Coolant compatibility: PWR/BWR water corrosion (360° C)
- ◆ Thermal conductivity (especially under irradiation)
- ◆ Leak-tightness / seal
- ◆ Ductility / deformation



Conclusion



- ▶ **The French Nuclear Institute R&D on ATF focuses on two potential solutions:**
 - ◆ **Cr coatings on Zr alloys**
 - ◆ **SiC/SiC composite sandwich cladding**
- ▶ **Development of ATF concepts follows a 2-step evaluation process:**
 - ◆ **Standard test evaluation to compare concepts**
 - ◆ **Concept-specific feasibility assessment focusing on potential « killers » and leading to development as-is, improvement needs or rejection of concept**
- ▶ **To complement international evaluation of concepts through modeling, it seems important to move towards standardized empirical testing procedures**



“ Any reproduction, alteration, transmission to any third party or publication in whole or in part of this document and/or its content is prohibited unless AREVA NP has provided its prior and written consent. This document and any information it contains shall not be used for any other purpose than the one for which they were provided. Legal action may be taken against any infringer and/or any person breaching the aforementioned obligations.

”