

PHÉNIX REACTOR – END OF LIFE EXPERIMENTS

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2009 is a key step for the French sodium cooled fast neutrons reactor Phénix: after 35 years of electricity production, fuel and material testing, a large scale campaign of experiments has been launched. Lead by the CEA, Areva and EDF consortium, these numerous experiments are thoroughly dedicated to the Fourth Generation of nuclear reactors and the codes validation needed to their design.

A CHALLENGING EXPERIENCE 7 MONTHS, 5 SENSITIVE TESTS

After having adjudicated the relevance of such a program and suggested a complementary test, IRSN had been asked by the French nuclear safety authority to evaluate the safety of each test.

The safety assessments achieved in 2009 relatively to these tests are massively based on the defense in depth principles, the emphasis being put on a specific level, as regards to the nature of the studied test. By and large, the global approach set up by IRSN in these circumstances could be described as followed:

- a standard risk analysis, its objective consisting in having an exhaustive list physical phenomenon affecting the safety functions,
- a systematic analysis of the surveillance systems dedicated to the risks evaluated previously, whether it is constituted by standard (formerly used on the reactor) equipment or specific systems fitted to the tests,
- a specific analysis of operating rules during the test and people training.

Two of these safety assessments are detailed below, as they present a specific interest relatively to the methodology used or to the results it produces.

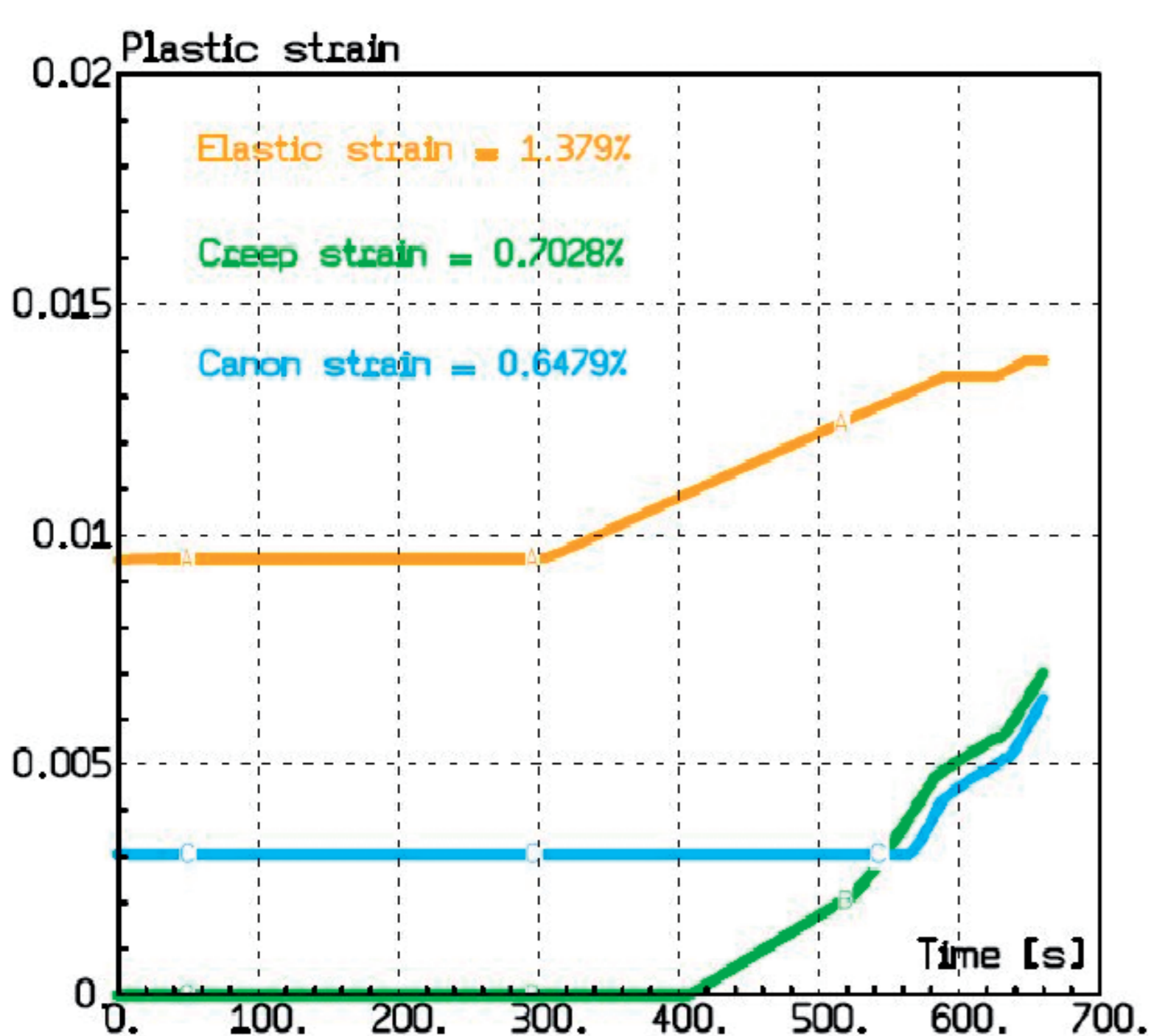
FUEL MELTING TEST SAFETY ASSESSMENT

This experiment was aimed to melt a fraction of an experimental (in its composition) fuel inserted in the reactor core by submitting it to a ten minute overpower transient.

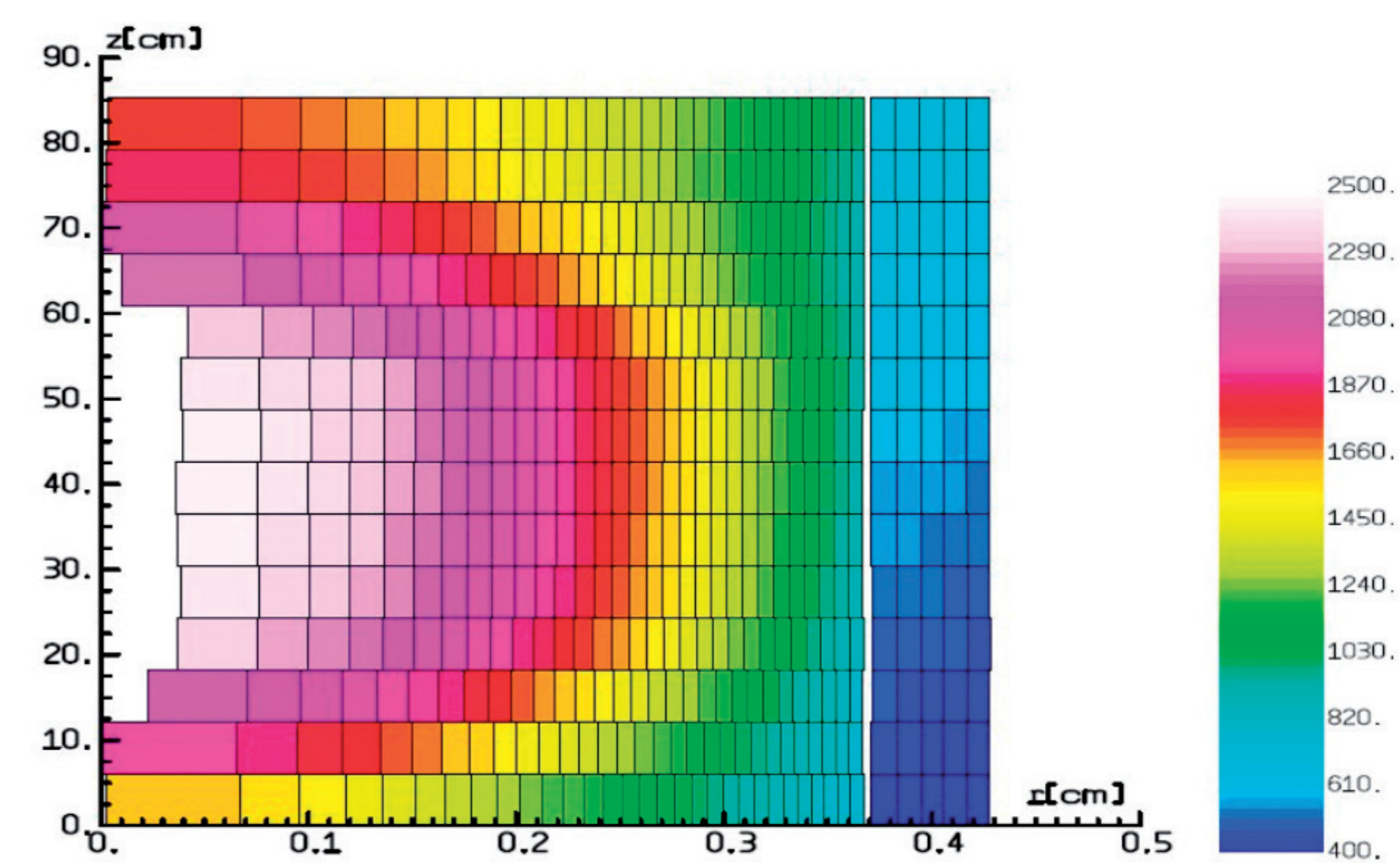
As the risk analysis carried out demonstrated that this test could lead to an energetic sodium-melt fuel interaction, IRSN launched a large scale campaign of thermo-mechanical numerical simulations on this fuel which aims were:

- to identify the key parameters leading to a risk of clad failure,
- to evaluate the robustness of the operator's demonstration relatively to this specific risk.

This study, partially founded on the IRSN proprietary code SCANAIR, concluded that the clad strain induced by the transient could be significant and lead to its failure. In such conditions, a complex though challenging dialogue with the Phénix operator and its technical supports, during which heavy arguments were brought on the table lead the operator to postpone the test. The experimental feedback (1980s CABRI experiments) raised up gave finally IRSN confidence that, if a clad failure could happen, though with a weak occurrence probability, it would not eject melted fuel, the melted fuel fraction being small enough to be contained in the fuel pellet center.



Temporal evolution of circumferential plastic strain at max. flux plan - inner side of the clad.



GLOBALIZED NATURAL CONVECTION TEST SAFETY ASSESSMENT

This experiment, constituted by a generation of significant residual power followed by a progressive shut down of the primary and secondary pumps could provide designers and TSOs a precious set of data regarding the capability of removing the decay heat with natural convection for future reactors safety analysis.

While the experimental feedback was large enough to provide IRSN the confidence that the primary circuit could perform in natural convection, the approach regarding the secondary loops was based on the surveillance equipment, specifically designed

for such an experiment and related to the risks induced by this test: thermal pipe stratification and sodium frost potentially causing pipe strains. IRSN considered that the thermometric measures available in the control room associated to clearly defined operating rules could provide a sufficient enough guaranty that the test could not lead to a sodium leak.

Nevertheless and in conformity with mechanical conception rules, IRSN asked that a visual inspection was performed before any re-utilization of the sodium loop for incoming test.