

IRSN ASSESSMENT OF FUEL RODS FAILURES DUE TO FRETTING PHENOMENON CYCLE 8 OF CATTENOM 3 UNIT

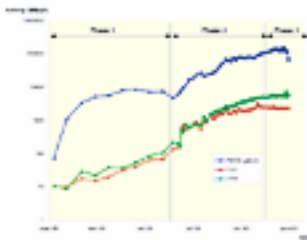
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> Introduction

The fretting phenomenon identified in unit 3 of Cattenom plant caused failures in a large number of fuel rods. After the same phenomenon was observed, though to a lesser extent, at Cattenom 1 and 4 units, the fretting phenomenon was declared by the operator to be a generic problem at least on the 1300 MWe plant series, which the Cattenom plants belong.

> Changes in reactor coolant activity during the cycle

- Phase 1 :**
- > the operator estimated that one or two rods of the third batch of assembly have failed
 - > the measured activity of noble gases and iodine increased slowly
- Phase 2 :**
- > a rapid increase of nobles gases and iodine activity occurred, particularly ^{134I} activity (indicative of the quantity of disseminated fuel material)
 - > the operator estimated that two additional second cycle fuel rods failures occurred
 - > a significant activity increase, indicative of high burnup fuel material dissemination, was observed
- Phase 3 :**
- > from the end of November 2000 until the end of cycle (February 2001), noble gases and iodine activities reached the first radio chemistry technical specification threshold, which led to stop the load follow operations
 - > the operator estimated that 6 to 11 fuels rods failed
 - > a dissemination of 70 to 94 grams of fuel material in the primary cooling system was evaluated



> Understanding of failure mechanism

primary fuel rod cladding failures at the first grid level and, in some cases, secondary failures in the upper part of the fuel rod (hydriding)

- > **primary failure :** rod vibration in grid cell, inducing fretting wear and then, cladding rupture
- > **secondary failure :** water entry into the fuel rod leading to cladding fuel hydriding due to the hydrogen produced by water radiolysis

> Safety problems

IRSN asked for complementary demonstration of :

- > behaviour of failed rods or rods with fretting wear in normal conditions (surveillance program based on depth measurement), incident and accident conditions (category 2 transients : risk of rod failure by pellet-clad mechanical interaction ; category 4 transients : loss of coolant accident and reactivity insertion accident)
- > impact of fuel material in the primary coolant system on radiological consequences, notably in case of a steam generator tube rupture
- > impact of fuel material in the primary cooling system on releases and radiation protection of workers during normal operation

> Lessons learned

Radio chemistry technical specifications

- > IRSN asked for implementation of more restrictive radio chemistry technical specifications for plants affected by fretting phenomenon
- > in the longer run, redefinition of these technical specifications

Possible remedy suggested by the operator for the fretting phenomenon in 1300 MWe plants

- > assembly design evolution based on a strengthening of assembly frame in the bottom (additional grid at first grid level)

> Observations made during unloading



- > 28 failed assemblies (26 second cycle and 2 third cycle fuel assemblies)
- > 56 to 92 failed fuel rods instead of 11 expected → **difficulty in estimating the number of fuel rods failures based on primary coolant activity**
- > all failed assemblies located in an intermediate core ring
- > types of failures : circumferential break (see picture), longitudinal crack, and "sunburst" blister

> Understanding of the potential fretting roots

- > **actual hypothesis put forward by the operator :** fuel rod vibration induced by hydraulic excitation at bases of assemblies, associated with inadequate spring force for certain rods, probably due to radiation-induced stress relaxation and manufacturing scatter
- > mixed cores induce an unfavourable thermal hydraulic core behaviour, that could in many cases be the starting point of the fuel rods failures

