RAS 8249

Exhibit 3

NUCLEAR REGULATORY COMMISSION

Docket No. 50-413/414-OLA Official Exh. No. 3

In the matter of Duke Catawba

Staff _____ IDENTIFIED 7/14/04

Applicant ✓ RECEIVED 7/14/04

Intervenor _____ REJECTED _____

Cross-Examiner _____

Contractor _____ DATE _____

Other _____ Witness _____

Reporter _____

Template=SECY-028

SECY-02

Lambert, M., *et. al.*, "Synthesis of an EDF and FRAMATOME ANP Analysis on Fuel Relocation Impact in Large Break LOCA," NEA/CSNI/R(2001)18, Aix-en-Provence, March 2001

10. Synthesis of an EDF and FRAMATOME ANP Analysis on Fuel Relocation Impact in Large Break LOCA

Michel Lambert, Yann Le Hénaff, EDF/SEPTEN,
Jean-Luc Gandrille, Framatome ANP, France

Paper summary

During a Large Break (LB) LOCA, there is a rapid loss of coolant, inducing depressurization and loss of cooling of the fuel rods. Considering the hottest fuel pin, simulated with conservative assumptions, the following phenomena happen :

- *increase of the stress (depressurization),*
- *cladding strain and burst,*
- *violent gap depressurization of the broken fuel pins,*
- *and possible relocation of fragments of the pellets in the burst area.*

Locally (a few centimeters), geometry, and residual power are therefore potentially modified. Qualitative analysis shows that dominant parameters are:

- *the fill up ratio of the balloon by the fragments,*
- *the balloon diameter in the affected area of the pin,*
- *the thermal conductivity of the fragmented fuel material,*
- *and the heat transfer between fragments and cladding.*

Calculations are performed using the CATHARE LB version of the CATHARE code (this version is based on CATHARE 2 V1.3L_1 version with additional models specific to LB LOCA). The code has been approved by French Safety Authority for Large Break safety analysis.

The impact of relocation is estimated using conservative assumptions for the transient,

- *penalizing size and location of the break (stagnation point in the core),*
- *SERMA + 2 σ low for residual power,*
- *Penalizing maximum local power.*

but realistic approach for relocation models (mainly balloon size, filling rate and heat transfer models). In assembly creep experiment, an azimuthal hot spot is observed, so the Keusenhoff's azimuthal temperature difference model, qualified on REBEKA experiment, is used to calculate the balloon size.

Calculation results show a limited impact on the Peak Clad Temperature (PCT) (~30°C).
Therefore, it can be concluded that relocation phenomenon should not be taken into account in safety regulation, considering that:

- *the effect of relocation on cladding temperature is low, even for the more penalizing transient, simulated with conservative assumptions (except for relocation phenomenon which is simulated with more realism),*
- *overall conservatism in the LB safety analysis is higher than relocation penalty,*
- *the relocation phenomenon, if it exists, is limited to the burst area (a few centimeters), and to the hot rods.*

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Synthesis of an EDF and FRAMATOME ANP analysis on fuel relocation impact in Large Break LOCA

Michel Lambert (EDF/SEPTEN)
Yann Le Hénaff (EDF/SEPTEN)
Jean-Luc Gandrille (FRAMATOME ANP)

FRAMATOME ANP

Relocation in Large Break LOCA
Plan

- introduction
- description of the phenomenon
- conductivity model
- burst strain
- effect on cladding temperature
- conclusion

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Relocation in Large Break LOCA
Introduction

- During LB LOCA, with the conservative conditions of the Safety Reports :
  - fluid depressurisation
    - ⇒ stress
    - ⇒ cladding strain ⇒ cladding burst
    - ⇒violent gap depressurisation
    - ⇒ possible relocation of fragments of pellet in burst area
- Main question for the plant operator :
  - Is it necessary to consider the relocation phenomenon in safety studies ?

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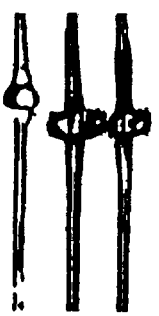
Relocation in Large Break LOCA
Description of the phenomenon



- main parameters :
  - fill up ratio
  - balloon diameter
  - Conductivity of the fragmented area
  - Exchange between fragments and cladding

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Relocation in Large Break LOCA
Conductivity of the fragmented area

- Many conductivity correlations describing an heterogenous area exist.
- The Imura-Yagi model (ICARE2 model) is the best one with regard to the temperature level and fragment size.

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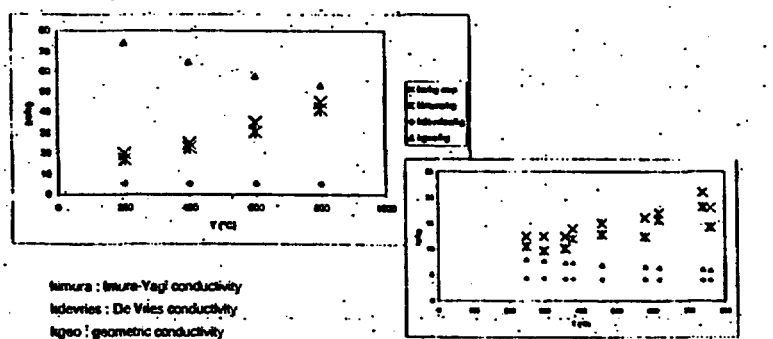
Relocation in Large Break LOCA
Conductivity of the fragmented area



kimura : Imura-Yagi conductivity
kdevries : De Vries conductivity
kgeo : geometric conductivity

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Relocation in Large Break LOCA
Burst strain

- Realistic approach :
  - In assembly creep experiment, existence of an azimuthal hot spot. (hot-side-straight effect)
    - FRAMATOME/CEA-Grenoble qualified an hot spot model (keusenhoff) on REBEKA experiment
  - In Keusenhoff model, the azimuthal hot spot temperature difference is governed by the eccentricity parameter.

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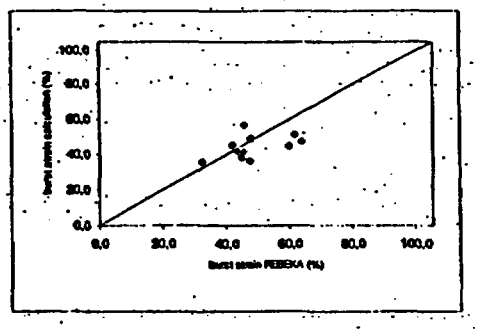
Relocation in Large Break LOCA
Burst strain



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Relocation in Large Break LOCA
Calculation

- To estimate the effect of relocation, CATHARE GB (LB) was used.
- CATHARE LB is approved by French safety authorities.
  - Based on CATHARE 2 V1.3L_1 version developped by CEA-Grenoble.
  - Specific models developed by FRAMATOME for LB LOCA (refill phase, cross-flow, fuel models ...).

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Relocation in Large Break LOCA
Calculation

- Relocation is not taken into account in the present safety regulation.
  ⇒ a realistic approach can be use
- With realistic LB LOCA transient : no relocation
  ⇒ Conservative transient to estimate relocation impact
- Description of the reference case (3 loops PWR) :
  - conservative transient
    - penalizing size break
    - residual power SERMA+2σ
    - penalizing maximum local power (FQmax)
  - relocation model : realistic approach

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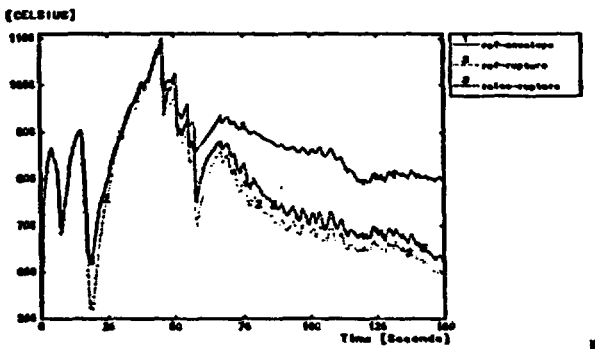
Relocation in Large Break LOCA
Calculation



cladding temperatures

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Relocation in Large Break LOCA
Conclusion

- EDF considers that relocation phenomenon should not be taken into account in safety regulation :
  - The effect of relocation on cladding temperature is weak even with conservative assumptions.
  - All the others conservatisms in the LB safety caculations are higher than relocation penalty.
  - Relocation phenomenon doesn't exist with realistic conditions.
  - The rupture node is not necessarily the hot spot node.
  - The relocation is limited to the burst area (a few centimeters) and to the hotest rods.