Approach for the Fuel Element Failure Section of NEEP-423

- Very Comprehensive Treatment of pre-1977 period given in:

    "The Main Causes of Fuel Failure in Water-Cooled Power Reactors"

    by

    F. Garzaolli, R. von Jan, H. Stehle
    Atomic Energy Review, Vol. 17, No. 1, p. 31 (1979)

- Very Comprehensive review of the period in the 1980's and up to mid 1990's:

    "Proceedings of the 1997 International Topical Meeting on Light Water Reactor Fuel Performance"

    Portland, Oregon, March 2-6, 1997

Current Areas of R & D Focus

General

1.) **Fuel and Cladding Material Properties at High Burnup**

        (Concern here is for transient conditions)

- **Thermal diffusivity is different (lab vs in-reactor)**
- **Cladding ductility shows wide scatter due to H_2 concentration, sample preparation, and measurement techniques**
- **Must understand in-reactor behavior**

2.) **Failure Root cause Investigation**

        (To achieve zero defects, must understand causes)

- **Poolside inspections valuable for identification**
- **Expensive hotcell studies done only if poolside investigation does not work**

3.) **Updated Codes and Analytical Tools**

        (Especially important for high BU in PWR's)

- **Gadolinia absorbers, local boiling, effect of boiling on flow properties**
- **Integrated nuclear and thermal hydraulic codes**

Current Areas of R & D Focus (cont.)

4.) Transient Fuel Behavior

       (Controversy over reactor-initiated accidents [RIA])

    • All parties (regulators, utilities, and vendors) agree that simulated conditions are much more severe than reality
        • Particularly interested in post-LOCA and post-DNB conditions
        • Difficult to conduct meaningful experiments

5.) Next Generation Fuel

       (Concern here is to increase reliability and operational flexibility)

        • New fuel designs and materials
        • >60 GWd/T burnup, load following, extended cycle time
        • Water chemistry changes

Current Areas of R & D Focus (cont.)

PWR Specific

1.) Cladding Corrosion

       (Plant surveillance shows that cladding corrosion is limiting further BU extension)

2.) Water Chemistry Control

  • **Codes are now availible to predict corrosion rate as a function of:**

        heat flux
        coolant temperature
        neutron fluence
        cladding hydrogen content
        cladding intermetallic particles
        heat treatment
        coolant Li concentration

  • **Reccomendation is to raise pH and reduce source of crud**

      (requires 30% enriched ^{10}B to keep Li concentration<3 ppm)

Current Areas of R & D Focus (cont.)

BWR Specific

1.) Finding cladding barrier that is resistent to PCI failures

2.) Reduce "fuel washout" from failed fuel