NUCLEAR FUEL PERFORMANCE

Office of Nuclear Regulatory Research
Office of Nuclear Reactor Regulation

February 24, 2005

ACRONYMS

- ALARA — As low as reasonably achievable
- BWR — Boiling-water reactor
- CFR — Code of Federal Regulations
- GDC — 10 CFR Part 50, Appendix A General Design Criterion
- ISG — Interim Staff Guidance
- LTA — Lead Test Assembly
- LOCA — Loss-of-Coolant Accident
- PWR — Pressurized-water reactor
- RCS — Reactor Coolant System
- RIA — Reactivity Initiated Accident
- SRP — Standard Review Plan (NUREG-0800)
- UFSAR — Updated Final Safety Analysis Report

AGENDA

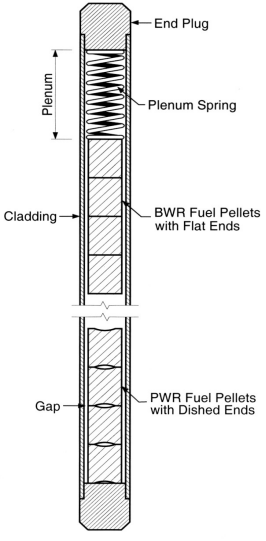
- Activities on Fuel Behavior, Office of Nuclear Regulatory Research (RES)
  - Dr. Farouk Eltawila
- Oversight and Guidance, Office of Nuclear Reactor Regulation (NRR)
  - Frank Akstulewicz

ACTIVITIES ON FUEL BEHAVIOR

Dr. Farouk Eltawila

Office of Nuclear Regulatory Research

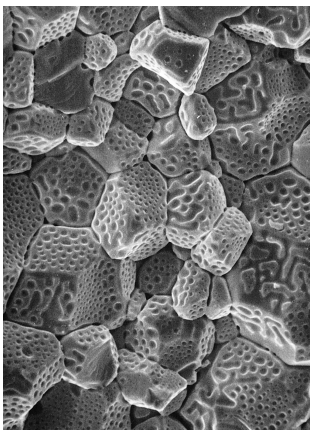
FUNCTIONS OF FUEL ROD CLADDING



Often considered to be the first barrier for retention of fission products

Provides structural integrity to ensure coolable core geometry

FUEL PELLETS RETAIN MOST FISSION PRODUCTS ATOPERATING TEMPERATURES



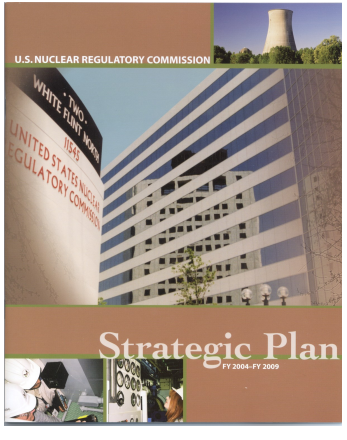
UO_2 fuel pellets consist of crystalline grains with porosity

Fission products can be trapped in the pores and within the grains.

Only a few percent of the volatile fission products are released from the pellets during normal operation.

Temperatures near core melt are needed to get large releases of fission products trapped in the UO_2 pellets.

RESEARCH FOCUSED ON POTENTIALLY RISK-SIGNIFICANT REACTOR EVENTS



Significant fission products occur only when temperature approaches fuel melting.

Only two ways to melt fuel:

1. Too much power: Reactivity Insertion Accident (RIA)
2. Not enough cooling: Loss of coolant accident (LOCA)

REGULATORY CRITERIA FOR REACTIVITY-INITIATED ACCIDENTS (RIAs)

Regulatory limit developed in 1974 with data on fresh and low-burnup fuel (Reg. Guide 1.77).

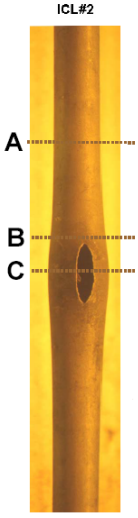
Tests in early 1990s (France and Japan) showed large effect of burnup from cladding corrosion.

Research Information Letter (No. 0401) provided an assessment of RIAs in operating reactors based on recent data for high-burnup fuel.

RES currently assisting NRR with review of industry submittal on this subject.

Regulatory Guide 1.77 to be revised.

REGULATORY CRITERIA FOR LOSS-OF-COOLANT ACCIDENTS (LOCAs)



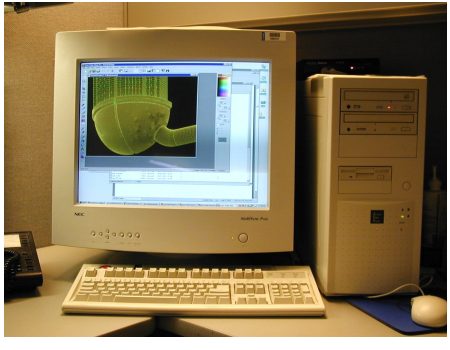
Regulatory limits (10 CFR 50.46(b)) on cladding temperature and oxidation developed in 1973 based on data from unirradiated Zircaloy tubes.

Burnup effects and alloy effects are expected based on current understanding.

Major research effort is underway at Argonne by NRC with industry cooperation. Laboratories in other countries are also investigating.

Technical basis for performance-based cladding criteria is targeted for September, 2005.

ANALYTICAL CAPABILITY FOR HIGH-BURNUP FUEL



Calculations needed for NRR reviews (fuel temperature, rod pressure, fission gas release, and vendor code audits).

Calculations needed to plan tests and understand results.

NRC's fuel rod computer codes, FRAPCON and FRAPTRAN, are updated for new cladding alloys, higher burnups, and other new conditions

OVERSIGHT AND GUIDANCE

Frank Akstulewicz
Office of Nuclear Reactor Regulation

REGULATORY REQUIREMENTS FOR DESIGN BASIS ACCIDENTS

- Technical Specifications limit coolant activity
  - Maintain design basis accident site boundary dose consequences per 10 CFR 50.67
  - Maintain design basis accident control room dose consequences per GDC19

REGULATORY REQUIREMENTS FOR PLANT OPERATION

- Radiation Protection Programs have been developed to achieve occupational and public doses as low as reasonable achievable (ALARA)
  - Licensees comply with occupational and public exposure limits per 10 CFR Part 20
  - Licensees perform offsite dose projections and control gaseous and liquid effluent systems to satisfy ALARA design objectives per 10 CFR Part 50 Appendix I

CURRENT FUEL RELIABILITY STATISTICS

Current Statistics	PWR	BWR
Number of Plants	68	35
Number of Fuel Rods with Defects	22	9
Number of Plants with Fuel Defects	14	8
% of Plants with Fuel Rod Failures	21%	23%
Estimated fuel rod defect rate (failed rods per million)	**6.7**	**4.3**

NRR OVERSIGHT AND GUIDANCE

- Meet periodically with fuel vendors
- Review and approve fuel design changes.
  - Establish limits on fuel duty, oxidation, and burnup
  - Encourage Lead Test Assemblies (LTAs)
  - Require mechanical and thermal/hydraulic testing

CONCLUSIONS

- Radioactive control programs ensure occupational and public exposure is maintained ALARA.
- Staff continues to monitor fuel performance
- Staff reviews fuel design changes
- Staff and industry oversight continue to maintain high fuel reliability
- Important role of defense-in-depth