UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION &
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS
WASHINGTON, D.C. 20555

August 31, 1994

NRC INFORMATION NOTICE 94-64: REACTIVITY INSERTION TRANSIENT AND ACCIDENT LIMITS FOR HIGH BURNUP FUEL

Addressees

All holders of operating licenses or construction permits for nuclear power reactors and all fuel fabrication licensees.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to recent information on high burnup fuel performance that could affect previously approved fuel burnup limits and enthalpy limits of highly exposed fuel. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to minimize adverse effect on design and operation of reload cores and to properly evaluate their 10 CFR Part 21 reporting responsibilities if continuing evaluation indicates limits should be reduced. However, suggestions contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances

Recent experimental data have suggested that high burnup fuel may be more prone to failure during design-basis transients and reactivity insertion accidents (RIAs) than previously thought. Recent data on the relationship between fuel failure enthalpy and burnup for pressurized water reactor fuel rods tested in foreign experimental facilities indicate lower failure initiation enthalpy thresholds (measured in differential cal/gm) than was considered in the evaluation of currently approved fuel burnup limits. The NRC is closely following work to confirm the validity of the preliminary results by verifying the conditions of the experimental tests. The NRC is also reviewing data reduction, data interpretation, and the implications of the observed failure results at low enthalpy rise levels on the safety evaluation of LWR design-basis transients and accidents. The NRC is scheduled to complete its review of the high burnup fuel data by the summer of 1995. The results of this study may invalidate the basis for the previous staff approvals of fuel design topical reports and fuel failure and fuel burnup limits.

Discussion

Recent information suggests that fuel rod damage during reactivity transients can increase with high burnup. Various investigators have reported a "rim" effect, consisting of a high burnup peripheral region of the fuel pellet, in which the solid fuel matrix has a small grain size and is surrounded by fission gas bubbles (Ref. 1). This porous microstructure could enable fuel to disperse in powder form during transients that heat and expand the fission gas bubbles.

A recent study for the Electric Power Research Institute (EPRI) was conducted on fuel irradiated up to burnups of 60 GWD/MTU (Ref. 2). The objective was to evaluate the degradation of mechanical properties in cladding and assembly structural components caused by oxidation, hydriding, and radiation embrittlement. While strength increases, ductility was found to be very low and dependent on hydrogen content and fluence, both of which increase with burnup. This appears to contradict a previous belief that metal annealing at operating temperatures would prevent radiation damage from accumulating after some initial period.

Recent integral tests with high burnup fuel under reactivity transient conditions have indicated that the bounding peak fuel enthalpy that may cause fuel cladding failure decreases significantly with increasing fuel exposure. Of the fuel rods tested, the one with the highest burnup (approximately 65 GWD/MTU) failed at an enthalpy level of only 30 cal/gm with a reactivity insertion corresponding to less than 15 cal/gm; some fuel dispersal may be associated with this failure. An earlier integral test at the intermediate burnup level of 32 GWD/MTU showed cladding failure at about 85 cal/gm (Ref. 3). If the scatter of data points for high burnup failure is similar to that observed in lower burnup failure data, the recent cited data are not conclusive regarding the enthalpy failure limit for a specific fuel rod. However, the transient data, the declining cladding ductility with increasing burnup, and the fuel pellet "rim" effect, when considered together, suggest that the trend of these results may be real.

LWR fuel suppliers and reactor operators (licensees) may wish to consider this preliminary information in planning for fuel cycle designs, particularly those fuel design changes and longer core operating cycles which may approach or exceed approved fuel burnup limits. A higher burnup fuel may be required to meet more restrictive enthalpy limits for fuel failure, fragmentation, and dispersal than those permitted by the acceptance criteria of the standard review plan (Ref. 4). The NRC review of pending and future requests to extend burnup beyond the limits previously approved for existing fuel designs (up to approximately 60 GWD/MTU, fuel rod average) will more carefully consider the adequacy of the reactivity insertion experimental data included or referenced by such requests, until the implications of these high burnup experimental data on licensing safety evaluations are resolved.

On October 26, 1994, the NRC will present additional technical information on this subject at the NRC 22nd Water Reactor Safety Information Meeting.

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate NRC project manager.

Robert F. Burnett, Director
Division of Fuel Cycle Safety
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Office of Nuclear Material Safety
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Brian K. Grimes, Director
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Office of Nuclear Reactor Regulation

Technical contacts: L. E. Phillips, NRR
(301) 504-3232

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J. Roth, NMSS
(301) 415-7257

Attachments:
1. References
2. List of Recently Issued NRC Information Notices
3. List of Recently Issued NMSS Information Notices

Enclosure Filed in Jackets

REFERENCES

1. M. E. Cunningham, *et al.*, "Development and Characteristics of the Rim Region in High-Burnup UO_2 Fuel Pellets," *Journal of Nuclear Materials*, Vol. 188, page 19, June 1992.

2. G. P. Smith, *et al.*, "Hot Cell Examination of Extended Burnup Fuel from Calvert Cliffs-1,' EPRI TR-103302, November 1993.

3. P. E. MacDonald, *et al.*, "Assessment of Light-Water-Reactor Fuel Damage During a Reactivity-Initiated Accident," *Nuclear Safety*, Vol. 21 No. 5, September-October 1980.

4. "NRC Standard Review Plan," NUREG-0800, Rev. 2, July 1981.

LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
94-63	Boric Acid Corrosion of Charging Pump Casing Caused by Cladding Cracks	08/30/94	All holders of OLs or CPs for pressurized water reactors.
94-62	Operational Experience on Steam Generator Tube Leaks and Tube Ruptures	08/30/94	All holders of OLs or CPs for pressurized water reactors.
94-61	Corrosion of William Powell Gate Valve Disc Holders	08/25/94	All holders of OLs or CPs for nuclear power reactors.
94-60	Potential Overpressurization of Main Steam System	08/22/94	All holders of OLs or CPs for pressurized-water reactors.
94-30, Supp. 1	Leaking Shutdown Cooling Isolation Valves at Cooper Nuclear Station	08/19/94	All holders of OLs or CPs for nuclear power reactors.
94-59	Accelerated Dealloying of Cast Aluminum-Bronze Valves Caused by Microbiologically Induced Corrosion	08/17/94	All holders of OLs or CPs for nuclear power reactors.
94-58	Reactor Coolant Pump Lube Oil Fire	08/16/94	All holders of OLs or CPs for pressurized water reactors.
94-57	Debris in Containment and the Residual Heat Removal System	08/12/94	All holders of OLs or CPs for nuclear power reactors.
94-56	Inaccuracy of Safety Valve Set Pressure Determinations Using Assist Devices	08/11/94	All holders of OLs or CPs for nuclear power reactors.

OL = Operating License
CP = Construction Permit

LIST OF RECENTLY ISSUED NMSS INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
94-47	Accuracy of Information Provided to NRC during the Licensing Process	06/21/94	All U.S. Nuclear Regulatory Commission Material Licensees.
94-39	Identified Problems in Gamma Stereotactic Radiosurgery	05/31/94	All U.S. Nuclear Regulatory Commission Teletherapy Medical Licensees.
94-38	Results of a Special NRC Inspection at Dresden Nuclear Power Station Unit 1 Following a Rupture of Service Water Inside Containment	05/27/94	All holders of OLs or CPs for NPRs and all fuel cycle and materials licensees authorized to possess spent fuel.
94-37	Misadministration Caused by a Bent Interstitial Needle during Brachy-therapy Procedure	05/27/94	All U.S. Nuclear Regulatory Commission Medical Licensees authorized to use brachy-therapy sources in high-, medium-, and pulsed-dose-rate remote afterloaders.
94-35	NIOSH Respirator User Notices, "Inadvertent Separation of the Mask-Mounted Regulator (MMR) from the Facepiece on the Mine Safety Appliances (MSA) Company MMR Self-Contained Breathing Apparatus (SCBA) and Status Update"	05/16/94	All holders of OLs or CPs for nuclear power reactors, and all licensed fuel facilities.
94-23	Guidance to Hazardous, Radioactive and Mixed Waste Generators on the Elements of A Waste Minimization Program	03/25/94	All NRC licensees.

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This information notice has been coordinated with MBCongdon of OIP.

*SEE PREVIOUS CONCURRENCE

OFFICE	*OGCB/DORS	*TECH ED	*SRXB/DSSA	*SRXB/DSSA	*C:SRXB/DSSA
NAME	CVHodge	JDMain	EDKendrick	LEPhillips	RCJones
DATE	08/11/94	08/09/94	08/11/94	08/12/94	08/12/94

*D:DSSA	*NMSS/IMNS	*NMSS/FCSS	*NMSS/FCSS	*AC:OGCB/DORS	D:DORS/NRR
GMHolahan	KMRamsey	JRoth	RFBurnett	ELDoolittle	BKGrimes
08/15/94	08/22/94	08/22/94	08/22/94	08/22/94	08/24/94

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