UNITED STATES
NUCLEAR REGULATORY COMMUNICATION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555

October 12, 1993

NRC INFORMATION NOTICE 93-82: RECENT FUEL AND CORE PERFORMANCE PROBLEMS IN OPERATING REACTORS

Addressees

All holders of operating licenses or construction permits for nuclear power reactors and all NRC-approved fuel suppliers.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees of recent fuel and core performance problems in operating reactors resulting from deficiencies and oversights in evaluating the impact of fuel design changes and mixed core behavior in the fuel and reload core design process. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances

Salem Unit 2 and Beaver Valley Unit 1

During shutdown inspection activities after Cycle 7 at Salem Unit 2 and Cycle 9 at Beaver Valley Unit 1, the licensees at both plants discovered numerous fuel rods that had developed fretting wear and perforation. The fuel vendor attributed the degradation to grid-to-rod fretting resulting from flow-induced vibration of the fuel bundles. All but one of the affected fuel assemblies were Westinghouse twice-burned VANTAGE 5H fuel located next to the core baffle or with a history of previous operation at a peripheral location. The fretting wear occurred at the zircaloy mid-grid spacers rather than at lower grid locations where debris-induced fretting wear typically occurs. In some of the affected assemblies, secondary hydriding also was evident.

Wolf Creek

During the Cycle 5 shutdown at Wolf Creek, the licensee discovered 44 failed fuel rods in three Westinghouse Batch F (standard) fuel assemblies that had completed two cycles of operation with accrued assembly average burnups of 24,000 MWd/MTU. The most severely degraded fuel rod fragmented into three segments during fuel handling operations while offloading the core.

Inspection of the failed fuel rods revealed the failures to be grid-to-rod fretting wear at the lower three grid locations on in-core interior fuel assemblies. During Cycle 6 operation, additional fuel failures occurred in three Batch F assemblies in their third cycle of operation with assembly average burnups of 38,500 MWd/MTU. The occurrence was a virtual repeat of the Cycle 5 experience, including the discovery of a broken fuel rod during core offloading. These fuel failures have been attributed to high cross flows, caused, in part, from mixed fuel designs which induced fuel rod vibration with fretting wear at the lower grids. The mixture of standard and VANTAGE 5H fuel (with debris filter bottom nozzles) resulted in axial mismatches between the bottom nozzles and the grid spacers of the two fuel types. The failed assemblies were all standard fuel and had been subjected to high cross flow. The transition to VANTAGE 5H fuel had commenced with Cycle 5.

Palisades

Before Cycle 11 startup at Palisades, three separate segments of a damaged fuel rod were discovered in the tilt pit area of the reactor cavity and a 0.15 m [6 in] segment containing the upper end cap was found in the fuel assembly upper grid spacer. The upper 1.68 m [5.5 ft] segment in the tilt pit was split with the plenum spring exposed and about 1/3 of the full fuel rod inventory of fuel pellets was missing. The second segment (1.37 m [4.5 ft] in length) and the third segment (0.46 m [1.5 ft] long with the lower end plug) appeared to have fuel pellets intact. The fuel rod was from a corner rod location in a peripheral fuel assembly which had been located in the corner of the core adjacent to the core baffle during Cycle 10 operation.

The defective fuel assembly was one of a batch of 16 fuel assemblies, fabricated by Siemens Nuclear Power Co. (SNP), located on the core periphery since Cycle 9 that had 8-rod hafnium absorber clusters inserted for vessel fluence reduction. Inspection of this fuel assembly and others from the batch of 16 fuel assemblies revealed that the spacer springs had relaxed and there was up to 90-percent through-wall fretting wear at mid-grid locations, predominantly on the corner rods of affected fuel assemblies. Although the typical exposure for these fuel assemblies was only 80 percent of the design life, they had been subjected to the reactor environment and fast flux exposure during five cycles of operation. Tests by SNP confirmed that the lengthy service life was a contributory cause to the spring relaxation.

During Cycle 10, the licensee operated the plant with two batches of the SNP fuel assemblies with high thermal performance flow mixing spacers. Flow mixing spacers in neighboring fuel assembly locations and the low power of the peripheral fuel assemblies adjacent to the core baffle produced a hydraulic mismatch that caused cross flow into the peripheral fuel assemblies. In addition, the flow forces had increased when primary coolant flow increased 7 percent after the replacement of steam generator tube bundles before Cycle 9 startup. Limited inspection by the licensee indicated that corner fuel rods closest to the baffle were the most severely worn. The licensee also found corresponding wear locations between the most severely damaged fuel assembly and the core baffle, indicating that the fuel assembly had rubbed against the baffle, resulting in severe spacer damage.

Hatch Unit 2, Peach Bottom Unit 3, and Perry

Recent fuel failures found at Hatch Unit 2 and Peach Bottom Unit 3 in General Electric (GE) zirconium-barrier fuel have been attributed to debris fretting or to undetected manufacturing defects. At Perry, leaking fuel rods in two bundles during Cycle 1, one bundle during Cycle 2, and two bundles during Cycle 3 are believed to have been the result of bad end cap welds. However, during the recently completed Cycle 4, one severely damaged fuel rod (with a 50.8 cm [20 inch] long large axial crack as a result of secondary hydriding) and possible leaking fuel rods in several other bundles were noted. These fuel bundles were fabricated to avoid repetition of the end cap problem. GE believes that the root cause of the failures is undetected manufacturing defects, possibly exacerbated by the Perry operating practice of using control rod movement rather than flow control for minor power adjustments.

DISCUSSION

Recent operating experience of pressurized-water reactors has identified debris-induced fretting as a leading cause of fuel failure. However, current experience also indicates that a new type of vibrational fretting is emerging. During ultrasonic examination of VANTAGE 5H failed fuel assemblies at Salem and Beaver Valley, Westinghouse confirmed grid-to-rod fretting at the zircaloy low-pressure drop mid-grids. Most of the failures occurred near the core baffle or in fuel that had resided near the core baffle in a preceding cycle. Through several tests, Westinghouse determined that the occurrence of flow-induced vibrational fretting was likely. This vibrational fretting involves the natural frequency and flow condition for fuel assemblies adjacent to the core baffle. To avoid this type of fretting wear, Westinghouse proposed corrective actions for existing fuel assemblies adjacent to the core baffle to dampen the vibrations. The long-term corrective actions will include design modifications and more extensive vibration testing to ensure that the natural frequency of the fuel assembly does not correspond to flow conditions that may exist in the reactor.

For Wolf Creek, the fretting wear involved a mixed core of standard fuel and VANTAGE 5H fuel with inclusion of intermediate flow mixer grids and debris filter bottom nozzles. The failures were located at the lower grids, especially near debris filter bottom nozzles. Westinghouse performed a sensitivity study to analyze the flow condition near the debris filter bottom nozzle region for mixed cores. The analysis indicated that excessive vibration of the fuel rods of the standard fuel assembly may have been caused by cross flow from VANTAGE 5H fuel to the standard fuel and that the mixed core of different bottom nozzle designs may have contributed to such a cross flow phenomenon.

An issue involving the compatibility of mixed cores in a boiling-water reactor was identified during the NRC evaluation of the Washington Nuclear Power Unit 2 (WNP-2) instability event of August 15, 1992. At that time, it was noted that an abnormally large mismatch in flow and pressure drop between neighboring fuel assemblies in a mixed core was further exaggerated by the core reload operating scheme and may have contributed to thermal-hydraulic instability of the core. Similarly, it now appears that core designs comprised of mixed-fuel types sometimes result in physical mismatches of neighboring fuel assemblies that may be contributing to flow-induced fretting wear failure of fuel rods in pressurized-water reactors. The mixing of fuel of different types is further complicated by design variations introduced by fuel reconstitution and by the purchase options offered by at least one fuel vendor (Westinghouse) to include design features such as intermediate flow mixer grids and debris filter bottom nozzles with the fuel type of customer choice. This has resulted in one known instance (at Turkey Point Unit 3) of an axial offset in power distribution as a result of a small axial mismatch between burnable poison rods and the active core. The mismatch occurred when debris filter bottom nozzles were included with the fuel type chosen by the licensee, but a corresponding revision of burnable poison rod specifications was overlooked.

The above problems raise questions about the effectiveness of design quality assurance, as implemented by some licensees and vendors to ensure that the reactor core continues to conform to its design bases when new and modified fuel designs are introduced during core reload. The degree of core design responsibility exercised by the fuel supplier varies significantly depending to a large extent on the wishes of each individual licensee. Defining reload core design safety evaluation and quality assurance responsibilities, especially the interaction with fuel suppliers, can help assure that licensee and vendor design responsibilities are properly implemented.

No specific action or written response is required by this information notice. If you have any questions regarding this matter, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

Alfred E Chaffee for

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Attachment: List of Recently Issued NRC Information Notices

LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
93-81	Implementation of Engineering Expertise on Shift	10/12/93	All holders of OLs or CPs for nuclear power reactors
93-80	Implementation of the Revised 10 CFR Part 20	10/08/93	All byproduct, source, and special nuclear material licensees
93-79	Core Shroud Cracking at Beltline Region Welds in Boiling-Water Reactors	09/30/93	All holders of operating licenses or construction permits for boiling-water reactors (BWRs).
93-78	Inoperable Safety Systems At A Non-Power Reactor	10/04/93	All holders of OLs or CPs for test and research reactors.
93-77	Human Errors that Result in Inadvertent Transfers of Special Nuclear Material at Fuel Cycle Facilities	10/04/93	All nuclear fuel cycle licensees.
93-76	Inadequate Control of Paint and Cleaners for Safety-Related Equipment	09/21/93	All holders of OLs or CPs for nuclear power reactors.
93-75	Spurious Tripping of Low-Voltage Power Circuit Breakers with GE RMS-9 Digital Trip Units	09/17/93	All holders of OLs or CPs for nuclear power reactors.
93-74	High Temperatures Reduce Limitorque AC Motor Operator Torque	09/16/93	All holders of OLs or CPs for nuclear power reactors.
93-73	Criminal Prosecution of Nuclear Suppliers for Wrongdoing	09/15/93	All NRC licensees.

OL = Operating License
CP = Construction Permit

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OFFICE	*OGCB	*SRXB	*TECH ED.	*SC:SRXB	*C:SRXB
NAME	PCWen/vsb	SLWu	DGable	LEPhillips	RCJones
DATE	09/08/93	09/08/93	09/08/93	09/09/93	09/10/93

*D:DSSA:NRR	C:OGCB:DORS:NRR	D:DORS:NRR
ACThadani	GHMarcus*	BKGrimes
09/16/93	09/23/93	10/8/93

DOCUMENT NAME: 93-82.IN

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09/16/93	09/23/93 for	09/ /93

DOCUMENT NAME: FUELFRET.WEN

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