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

November 10, 1992

NRC INFORMATION NOTICE 92-74: POWER OSCILLATIONS AT WASHINGTON NUCLEAR POWER UNIT 2

Addressees

All holders of operating licenses or construction permits for boiling-water reactors (BWRs).

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to a recent event involving power oscillations in an operating region where instability had not been specifically predicted. 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.

Background

On March 9, 1988, a thermal hydraulic instability event occurred at LaSalle Unit 2. The NRC discussed this event in Information Notice 88-39, "LaSalle Unit 2 Loss of Recirculation Pumps with Power Oscillation Event," and Bulletins 88-07 and 88-07, Supplement 1, "Power Oscillations in Boiling Water Reactors." In the first bulletin, the NRC requested licensees to establish procedures and give training to reactor operators to enable them to recognize oscillations and to take appropriate actions. In the supplement, the NRC requested licensees to implement the General Electric (GE) Interim Recommendations for Stability Actions, designated the Interim Corrective Actions (ICA). GE defined the exclusion regions on the power/flow map in which, with varying probability, instability might be expected. Three regions were defined in which operation was to be avoided (immediate exit if entered) or limited (e.g., when required during startup). These regions were based on operating or test experience for reactors with GE fuel. The exclusion regions for new fuel designs were to be reevaluated and justified based on any applicable operating experience, calculated changes in core decay ratio using NRC-approved methodology, and/or core decay ratio measurements. Since the LaSalle event in 1988, the NRC and the BWR Owners' Group (BWROG) have conducted extensive analyses and reviews of various aspects of stability while developing long-term solutions to augment or replace the ICA. On March 18, 1992, the BWROG sent a letter (BWROG-92030) to BWROG members

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transmitting "Implementation Guidance for Stability Interim Corrective Actions." In this letter, the BWROG emphasized the need for caution when operating near the exclusion regions. The BWROG also recommended reexamining procedures and training to reflect uncertainties in the definition of exclusion region boundaries.

Description of Circumstances

On August 15, 1992, Washington Nuclear Power Unit 2 (WNP-2) experienced power oscillations during startup. The event occurred early in cycle 8 operation. During cycle 8, the licensee had two previous startups without incident. The reactor core consisted primarily of Siemens fuel, with about 74 percent of this fuel in 8x8 fuel assemblies and about 25 percent in 9x9 fuel assemblies, and with the remainder of the core consisting of various lead test assemblies. The 9x9 fuel assembly used in WNP-2, designated 9x9-9x, has a higher flow resistance than the 8x8 fuel assembly with a difference of about 10 percent in pressure drop. These 9x9 fuel assemblies were loaded during cycles 7 and 8.

About 33 hours before the event, the licensee commenced a controlled power reduction from full power to 5-percent power to repair a valve packing leak in the drywell. After completing the repairs, the licensee began a return to full power. The licensee increased reactor power to about 34 percent and then held it at that level for 3 hours to perform turbine bypass valve tests and control rod drive system timing tests. The recirculation system was operated with flow control valves (FCVs) full open and pumps at slow speed.

After completing the tests, the operators continued the restart up the (approximately) 30-percent flow line to about 36-percent power (Figure 1). This is at a power above the recirculation pump cavitation region. The operators then began closing one of the two FCVs in preparation for shifting the associated recirculation pump to fast speed. During this change, in which power and flow decreased along the 76-percent rod line to a power/flow of about 34/27 percent, the operators observed power oscillations first on the average power range monitors (APRMs) and then by local power range monitors (LPRMs) downscale indications. Upon recognizing the power oscillations, the plant operators manually initiated a reactor scram. Post-event review indicated that the 2-second-period oscillations were in-phase (core-wide) and had grown to a peak-to-peak amplitude of about 25 percent of rated power. Most of the oscillation amplitude increase occurred in an interval of about 1 minute with the oscillations continuing at the limiting (maximum) amplitude for an additional minute before scram. The oscillations occurred while the reactor was operating at a power about 4 percent of rated power below the lower exclusion region boundary line (the nominal 80-percent rod line). During later review, the licensee found no indication that fuel had failed because of the event.

The NRC sent an Augmented Inspection Team (AIT) to the site to determine the possible causes and relevant facts of this event. The AIT concluded that the primary cause of the oscillations was very skewed radial and bottom peaked axial power distributions in the reactor (1.92 radial peaking factor and 1.62 core average axial peaking factor). These power distributions resulted from (1) the control rod pattern that the shift technical advisor selected for increasing the power and shifting the recirculation pump speed, and (2) the relationship of this control rod pattern to the specific WNP-2 cycle 8 core fuel loading configuration. These rod patterns were primarily directed towards achieving the target full power configuration and did not consider stability concerns.

The AIT also found, by analyses using the LAPUR code, that a contributor to the oscillations was the core loading, consisting of a mixed core with unbalanced flow characteristics between the new 9x9-9x fuel and the old 8x8 fuel. The analyses indicated that a full core of the 9x9-9x fuel would be significantly less stable than the old 8x8 fuel, and that the mixed core was less stable than a fully loaded core of either fuel type. The analyses also indicated that while the oscillations would be in-phase (core-wide), as observed in the event, the out-of-phase (regional) instability boundary would be very close to the in-phase boundary (Figure 1). The AIT found that small changes in operating conditions could have resulted in out-of-phase oscillations, which would have been more difficult for the APRM system to detect.

WNP-2 has a Siemens Advanced Neutron Noise Analysis (ANNA) monitor, a stability monitor required by technical specifications only if the licensee intends to enter the lower exclusion region. Since the licensee did not intend to enter the exclusion region during this startup, the ANNA monitor was not put into the observation mode, although it was gathering data which was used later to confirm stability calculations performed after the event.

The licensee successfully restarted the unit after implementing the following restrictions for maintaining the limits on rod withdrawal patterns and power distribution in the low flow regions of concern.

- The licensee analyzed the control rod patterns for stability before startup, and the operator could not change these patterns without analysis and review.

- The calculated maximum total peaking factor was less than 3.4.

- The calculated core average axial peaking factor was less than 1.45.
- The Minimum Critical Power Ratio was greater than 2.2.
- The licensee analyzed the conditions at FCV closure and found a decay ratio of less than 0.5. The recirculation pump was shifted to fast speed with the reactor power less than 33 percent and the feedwater temperature greater than 146.1 °C (295 °F).
- The licensee continuously used the ANNA monitor when the reactor was operating above 25 percent power and below 50 percent flow.

Further detailed description of the event can be found in the AIT Inspection Report No. 50-397/92-30.

Discussion

The WNP-2 power oscillation event indicates that the boundaries of the ICA regions, or modifications approved for various reactor technical specifications, do not necessarily encompass all stability limits. Instability may occur beyond these boundaries if the reactor is operated with configurations outside those used to define the boundaries. This event presented direct evidence that the following factors can be significant contributors to the possibility of unstable operation.

- Power distributions involving extremely skewed radial and axial peaking factors can induce unstable operation even in regions or with operating conditions not otherwise considered susceptible to oscillations.
- Core loading patterns involving a mixture of fuel types with differing flow resistances can contribute to instability.
- Reactors with two-speed recirculation pumps and FCVs can hinder stability because of the narrow range of operation between pump cavitation regions and possible instability regions.

The event also indicates the value of operating a stability monitor. The ANNA monitor could have given the operators information that instability was imminent, prompting them to alter operations to avoid the oscillations.

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 Office of Nuclear Reactor Regulation (NRR) project manager.

Brian K. Grimes, Director
Division of Operating Reactors Support
Office of Nuclear Reactor Regulation

Technical contacts: Howard Richings, NRR
(301) 504-2888

Peter C. Wen, NRR
(301) 504-2832

Attachments:
1. Figure 1. Best-Estimate Lines of Constant Decay Ratio=1.0 for Actual Conditions of WNP-2 8/15/1992 Event, Assuming Constant Power Distribution
2. List of Recently Issued NRC Information Notices

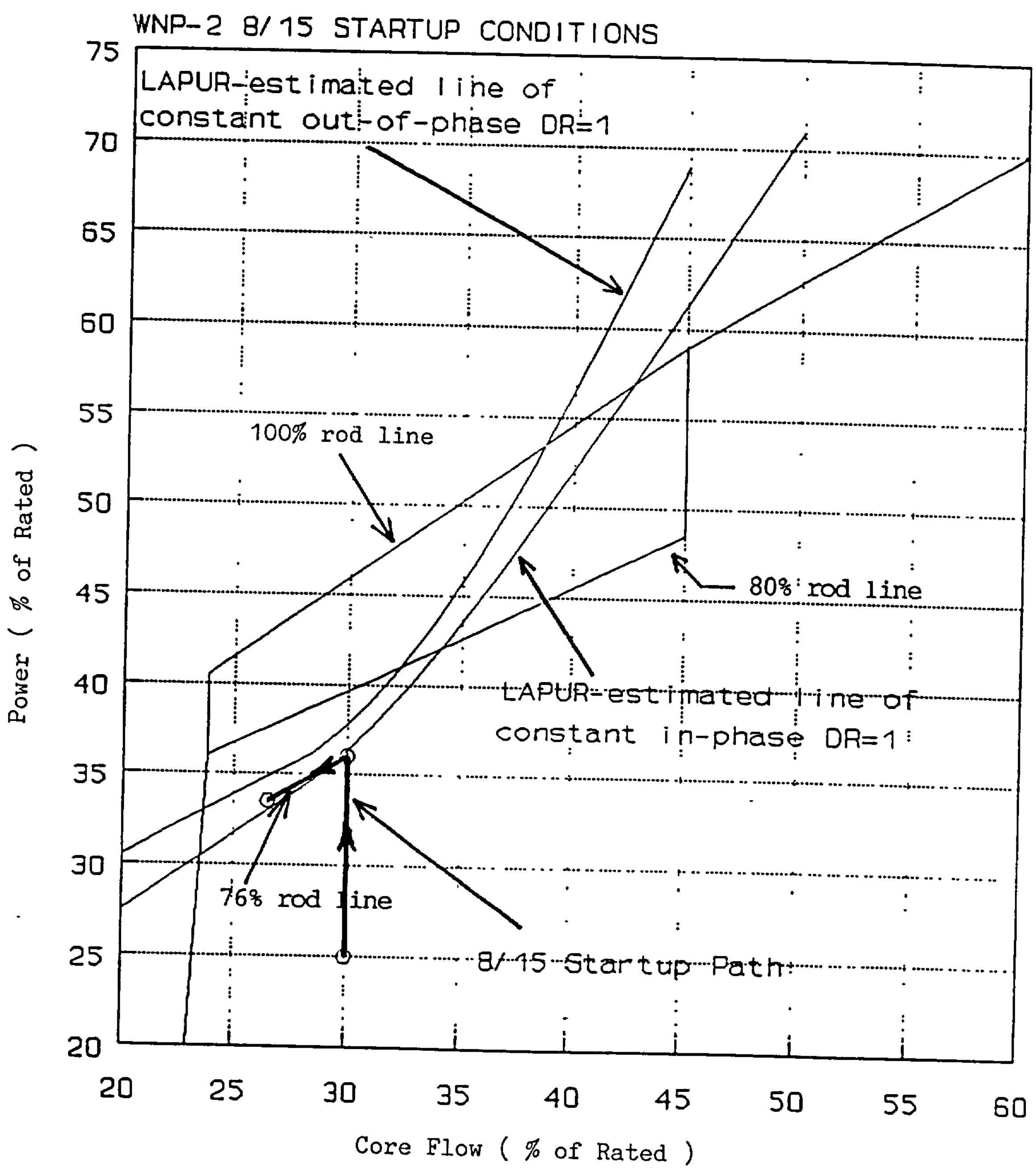

Figure 1 Best-estimate lines of constant decay ratio=1.0 for actual conditions of 8/15 event, assuming constant power distribution

LIST OF RECENTLY ISSUED
NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
92-61, Supp. 1	Loss of High Head Safety Injection	11/06/92	All holders of OLs or CPs for nuclear power reactors.
92-73	Removal of A Fuel Element from A Research Reactor Core While Critical	11-04/92	All holders of OLs or CPs for nuclear power reactors.
92-59, Rev. 1	Horizontally-Installed Motor-Operated Gate Valves	11/04/92	All holders of OLs or CPs for nuclear power reactors.
92-72	Employee Training and Shipper Registration Requirements for Transporting Radioactive Materials	10/28/92	All U.S. Nuclear Regulatory Commission Licensees.
91-64, Supp. 1	Site Area Emergency Resulting from A Loss of Non-Class 1E Uninterruptible Power Supplies	10/07/92	All holders of OLs or CPs for nuclear power reactors.
92-71	Partial Plugging of Suppression Pool Strainers At A Foreign BWR	09/30/92	All holders of OLs or CPs for nuclear power reactors.
92-70	Westinghouse Motor-Operated Valve Performance Data Supplied to Nuclear Power Plant Licensees	09/25/92	All holders of OLs or CPs for nuclear power reactors.
92-69	Water Leakage from Yard Area Through Conduits Into Buildings	09/22/92	All holders of OLs or CPs for nuclear power reactors.
91-29, Supp. 1	Deficiencies Identified During Electrical Distribution System Functional Inspections	09/14/92	All holders of OLs or CPs for nuclear power reactors.

OL = Operating License
CP = Construction Permit

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Original signed by
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