Mr. Garry L. Randolph Vice President and Chief Nuclear Officer Union Electric Company Post Office Box 620 Fulton, Missouri 65251

SUBJECT: REQUEST FOR A TECHNICAL REVIEW OF A DRAFT INFORMATION NOTICE REGARDING THE EFFECTS OF CRUD BUILDUP ON POWER DISTRIBUTION AND SHUTDOWN MARGIN

Dear Mr. Randolph:

The U.S. Nuclear Regulatory Commission is planning to issue an information notice (IN) discussing the recent axial offset anomaly at Callaway. We ask that you review the enclosed draft of that IN to ensure the technical information regarding the event is accurate. Your cooperation in this matter is appreciated. Please return any comments you may have by close of business on November 21, 1997. A copy of this request and your response will be placed in the Public Document Room for review by the public. Your response should be mailed to:

> U.S. Nuclear Regulatory Commission ATTN: William Burton MAIL STOP: 0-11E4 Washington, D.C. 20555-0001

Please address any questions you may have on this matter to William Burton of my staff. Mr. Bur on can be reached at 301-415-2853. If no comments are received by the close of business on November 28, 1997, we will assume the technical information in the notice is correct.

> Sincerely, [Original signed by] Robert L. Dennig, Section Chief Events Assessment, Generic Communications, and Special Inspections Branch **Division of Reactor Program Management** Office of Nuclear Reacto, Regulation

Docket No. 50-483

Enclosure: Draft Information Notice

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# Mr. Garry L. Randolph

cc w/encls: Professional Nuclear Consulting, Inc. 19041 Raines Drive Derwood, Maryland 20855

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Mr. H. D. Bono Supervising Engineer Quality Assurance Regulatory Support Union Electric Company Post Office Box 620 Fu'ton, Missouri 65251

U.S. Nuclear Regulatory Commission Resident Inspector Office 8201 NRC Road Steedman, Missouri 65077-1302

Mr. J. V. Laux, Manager Quality Assurance Union Electric Company Post Office Box 620 Fulton, Missouri 65251

Manager - Electric Department Missouri Public Service Commission 301 W. High Post Office Box 360 Jefferson City, Missouri 65102

Rogional Administrator, Region IV U.S. Nuclear Regulatory Commission Harris Tower & Pavilion 611 Ryan Plaza Driv:, Suite 400 Arlington, Texas 76011-8064

Mr. Ronald A. Kucera, Deputy Director Department of Natural Resources P.O. Box 176 Jefferson City, Missouri 65102 Mr. Otto L. Maynard President and Chief Executive Officer Wolf Creek Nuclear Operating Corporation P.O. Box 411 Burlington, Kansas 66839

Mr. Dan I. Bolef, President Kay Drey, Representative Board of Directors Coalition for the Environment 6267 Delmar Boulevard University City, Missouri 63130

Mr. Lee Fritz Presiding Commissioner Callaway County Court House 10 East Fifth Street Fulton, Missouri 65151

Mr. Alan C. Passwater, Manager Licensing and Fuels Union Electric Company Post Office Box 66149 St. Louis, Missouri 63166-6149

# UNITED STATES NUCLEAR REGULATORY COMMISSION OFFICE OF NUCLEAR REACTOR REGULATION WASHINGTON, D.C. 20555-0001

November, 1997

## NRC INFORMATION NOTICE 97-XX:

# EF, ECTS OF CRUD BUILDUP AND BORON DEPOSITION ON POWER DISTRIBUTION AND SHUTDOWN MARGIN

### Addressees

All holders of operating lightness for pressurized-water reactors (PWRs), except those licensees who have permanently ceased operations and have certified that the fuel has been permanently removed from the reactor vessel.

### Purcose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to a potentially significant problem pertaining to a malous behavior of the core axial power distribution and erosion of shutdown margin (SDM) attributed to crud buildup on the nuclear fuel and subsequent boron deposition in the crud layer. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. Sowever, suggestions contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

#### Background

The Callaway Plant is a PWR with a Westinghouse nuclear steam supply system, owned and operated by 'Jnion Electric Company (UE). The core contains 193 fuel assemblies and is currently in its ninth cycle of operation. The plant is licensed to operate at 3565 MWt.

Beginning with operating cycle 4, UE observed unexpected behavior in the power distribution at the plant. This anomaly was characterized by a gradual unexpected power shift toward the bottom of the core and was first detected at a core average burnup of approximately 7000 MWD/MTU in cycle 4. The power shift continued until burnup effects became dominant and caused power to shift back to the top of the core near the end of the cycle. In addition to the anomalous power distribution, deviations were observed in the estimated critical position (ECP) of the control rods. Although ECPs for plant restarts that occurred early in each cycle agreed well with measured critical positions, this agreement disappeared for restarts that occurred later in core life. During cycles 4 and 5, ECP deviations increased to over 0.5%  $\Delta k/k$ .

After analyzing relevant data, performing scoping calculations, and reviewing industry experience, UE and Westinghouse concluded that the power distribution anomaly was most likely initiated by subcooled nucleate boiling. The ECP deviations were another effect of this anomaly.

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Incore detector indications of flux depressions between fuel grids, as well as visual examinations showing crud deposits on fuel pins, supported these conclusions.

### Discussion

Axial offset (AO) is a measure of the difference between power in the upper and lower portions of the core. This difference must remain vithin limits established in the technical specifications to ensure that both SDM and clad local peaking factors are not exceeded. Exceeding these limits could result in the reactor fuel exceeding 10 CFR 50.46 limits on fuel clad temperature (2200 °F). If the reactor approaches these limits, compensatory measures, including a power reduction, must be taken to maintain the reactor within its operational limits.

On the basis of investigations by UE and Westinghouse, the cause of the axial offset anomaly (AOA) at Callaway is most likely crud buildup on fuel assemblies in the upper portion of the reactor core. This crud buildup is especially pronounced in high-power cores. High core power results in increased subcooled nucleate boiling in the upper core, which, in turn, causes greater crud accumulation on the fuel assemblies. Lithium borate is absorbed in the crud layer, reducing the fission rate in the upper portion of the core. The visual indications of crud buildup and flux depression at the grid straps support these conclusions. As a result of the reduced fissioning in the upper core, the power distribution shifts towards the bottom of the core. This resulting power shift causes a reduction in SDM and an increase in local peaking factors. Near the end of cycle, excess burnup in the bottom of the core causes the power distribution to shift back towards the upper portion of the core, partially restoring the power balance.

A number of Westinghouse plants have experienced AOAs ranging from -3 percent to -15 percent. These plants include Callaway, Catawba 1, Comanche Peak 2, Millstone 3, Seabrook, Vogtle 1 and 2, and Wolf Creek.

The -15 percent AO at Callaway is the largest to date. In response to the anomaly and continued erosion of SDM the licensee for Callaway reduced reactor power to 95 percent on July 15, 1997, and to 70 percent in mid-August 1997. On September 6, 1997, with the unit at 70 percent power and with AO at approximately 0 percent, the licensee, in consultation with Westinghouse, reduced reactor power to 30 percent in the hope of bringing about 75 percent of the lithium borate out of the crud, thereby creating a more positive AO when power was returned to 70 percent. Similar results had been seen in a previous cycle following a downpower event at Callaway. The results of this maneuver were not as predicted. After 24 hours at 30 percent power, only 25 percent of the lithium borate had come out of the crud. When power was increased to 70 percent, approximately 70 percent of the lithium borate that had been released during the power reduction was reabsorbed into the crud. The AO at the conclusion of the maneuver). Westinghouse and the licensee surmised that the cause of the worsening AO was the release of depleted boron during the power reduction, followed by the crud's reabsorbing fresh boron during the return to 70 percent power.

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SDM is decreasing at the rate of 3-4 percent-millirho (pcm) per day. As SDM has decreased (the technical specification limit is 1300 pcm), UE has taken several actions to restore it. These actions include reducing operational flexibility by modifying the rod insertion limits and relaxing the rod worth uncertainties in the SDM calculations (based on an approved Westinghouse topical report).

By reducing power and introducing operational restrictions, the licensee has continued to operate Callaway within the limits of the safety analysis for the plant. UE and Westinghouse are continuing their investigation into this phenomenon.

This information notice requires no specific action or written response. However, recipients are reminded that they are required by 10 CFR 50.55 to take industry-wide operating experience (including information presented in NRC information notices) into consideration, where practical, when setting goals and performing periodic evaluations. 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.

Jack W. Roe, Acting Director Division of Reactor Program Management Office of Nuclear Reactor Regulation

Technical Contacts: Margaret S. Chatterton, NRR 301-415-2889 E-mail: msc1@nrc.gov

Edward D. Kendrick, NRR 301-415-2891 E-mail: edk@nrc.gov

William F. Burton, NRR 301-415-2853 E-mail: wfb@nrc.gov

Attachment: List of Recently Issued NRC Information Notices.