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

December 15, 1994

NRC INFORMATION NOTICE 94-40, SUPPLEMENT 1: FAILURE OF A ROD CONTROL CLUSTER ASSEMBLY TO FULLY INSERT FOLLOWING A REACTOR TRIP AT BRAIDWOOD UNIT 2

Addressees

All holders of operating licenses or construction permits for nuclear power reactors.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this supplemental information notice to alert addressees to new events involving detached guide funnels underneath the reactor head. 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

The original information notice, dated May 26, 1994, described an event at Braidwood Station, Unit 2, on April 5. After receiving a valid reactor trip signal, the control rod located in core position K-2 inserted only to step 210 because a loose part prevented complete insertion. The loose part was a mechanical pin detached from a threaded connection joining a funnel and thermal sleeve for a thermocouple column penetration of the reactor head. The funnel guides the thermocouple column in aligning with connections below the reactor head, the pin prevents the threaded parts from rotating, and the cap weld keeps the pin in place. Subsequently, the licensee recovered a loosened but not detached pin from its position adjacent to the original position of the loose pin and a second loose pin from another funnel. The results of a metallurgical evaluation of these three failed pins are provided in the discussion section of this supplement. Also described below are events that involve similar funnels used to align control rod drive shafts instead of thermocouple columns.

Description of Circumstances

Byron Station, Unit 2

On October 8, 1993, the licensee, the Commonwealth Edison Company, discovered during a refueling outage that the control rod drive shaft funnel at position B-8 was uncoupled and resting on the upper internal structure. The licensee determined that the funnel had not been welded during original construction.

The licensee welded the funnel to the thermal sleeve using a plug weld according to design, inspected all remaining control rod drive shaft funnels, and found them secure.

Sequoyah Nuclear Plant, Unit 2

On July 22, 1994, the licensee, the Tennessee Valley Authority, observed during a refueling outage, while placing the reactor head onto the reactor vessel, that the control rod drive shaft at core position H-4 failed to align into the thermal sleeve guide tube and was severely damaged as the head continued to be lowered. The licensee stopped lowering the reactor head, inspected, and found that the H-4 drive shaft was misaligned and bent into an "S" shape. The associated funnel was detached from its thermal sleeve and was resting around the drive shaft on the upper internal structure. The licensee machined the replacement funnel to remove the internal threads and welded the funnel to the thermal sleeve.

The licensee sent the H-4 guide funnel to a hot cell facility for a failure analysis. The licensee concluded that the funnel had become detached as a result of wear of the retainer pin due to flow-induced vibration and subsequent loss of preload on the funnel.

The Sequoyah licensee used a remotely controlled device to inspect all the component guide funnels underneath the reactor head and verified that the threads were engaged, the pins were intact, the thermal sleeves had not been drilled through, and the funnels had no lateral play. The results indicated that two control rod drive shaft funnels had slight lateral play of about 3.2-1.6 mm [1/8-1/16 inch]. The licensee concluded that portions of the pin for that funnel had likely been worn away because of flow-induced vibration, that all pieces of the failed H-4 pin were accounted for, and that the funnel could become unthreaded and detached if the funnel was not fastened properly with the pin.

Diablo Canyon Nuclear Power Plant, Unit 1

On September 29, 1994, the licensee, the Pacific Gas and Electric Company, found during an inservice inspection that the control rod drive shaft funnels at core positions N5, N9, H2, H6, C7, and B6 could move laterally as much as 4.8 mm [3/16 inch]. The licensee repaired each loose funnel, using two stitch welds spaced 180 degrees apart. The licensee believes the funnels were loosened by flow-induced fretting of the dowel pin-hole interface.

Braidwood Station, Unit 2

On October 14, 1994, the licensee, the Commonwealth Edison Company, discovered during a refueling outage that the control rod drive shaft funnel at position B-8 was uncoupled and resting on the upper internal structure. The licensee determined by visual inspection that the design plug weld on the uncoupled funnel was intact but that weld residue was on the thermal sleeve. The licensee observed no other loose funnels.

Donald C. Cook Nuclear Power Plant, Unit 2

On October 14, 1994, while inspecting the reactor vessel head, the licensee, the Indiana/Michigan Power Company, found that 42 control rod drive shaft funnels could move approximately 1.6 mm [1/16 inch] and that the thermocouple column funnel at core position R-11 did not have a hole and dowel pin as designed. The licensee repaired the control rod funnels using two stitch welds, spaced 180 degrees apart, and repaired the thermocouple column funnel using a pin-and-cap weld, according to design.

Discussion

On September 9, 1994, the Braidwood licensee received the results of the metallurgical examination of the three thermocouple column funnel anti-rotation locking pins that had failed at Braidwood, Unit 2, in April 1994 (the subject of the original information notice). The components were constructed of the following materials:

Locking pins	ASME SA-479, Type 304 stainless steel
Funnels	ASME SA-240, Type 304 stainless steel
Thermocouple columns	Inconel 600, nickel based alloy

The pins were 2.2 cm [0.88 inch] long by 0.95 cm [3/8 inch] in diameter with a 0.038-cm [0.015-inch] chamfer at each end.

Metallographic examination verified that all three pins had been plug-welded to the housing guide during original construction. The welds were applied in multiple passes and were not porous.

Energy dispersive x-ray analysis indicated that the field-welded pins loosened because of combined vibration-induced wear and fatigue cracking. All three pins were worn on the ends, which were smooth and polished in a manner typical of wear caused by vibration-induced movement. Further, the wear was predominantly along one side of the pins, indicating unidirectional loading. The licensee postulated that as pin wear increased, the vibration-induced movement increased, creating high stresses at the plug welds, which eventually caused the welds to crack. Cracking then continued to propagate through the welds between the pins and the guide to form a circumferential crack. The licensee attributed the cause of the weld failure to fatigue cracking because no secondary cracking or tearing was observed. The additional vibration-induced movement eventually wore away enough of the weld metal to allow the pins to back out of the funnels.

On January 28, 1994, in response to the 1993 Byron event, the nuclear steam supply system vendor, Westinghouse Corporation, issued a Nuclear Safety Advisory Letter, concluding that a separated control rod drive shaft funnel does not significantly increase the probability or consequences of a licensing basis accident or create any accidents or malfunctions that are not already addressed by the existing licensing basis analyses. However, the potential for foreign objects in the top of the reactor exists for both the plug-weld and pin-and-cap weld designs for funnel-thermal sleeve attachment pins. The former design is used at the Braidwood and Byron plants and the latter design

is used at the Cook, Diablo Canyon, and Sequoyah plants. Therefore, jamming of control rod(s) by loose pins, as happened at Braidwood, may still occur. This condition could be detected by rod drop testing, performed as required by technical specifications, at each startup. Westinghouse recommended that each of its nuclear steam supply system customers consider an inspection and recovery action program for these attachments as part of their next outage activity.

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LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
94-84	Air Entrainment in Terry Turbine Lubricating Oil System	12/02/94	All holders of OLs or CPs for nuclear power reactors.
89-25, Rev. 1	Unauthorized Transfer of Ownership or Control of Licensed Activities	12/07/94	All fuel cycle and material licensees.
94-83	Reactor Trip Followed by Unexpected Events	12/06/94	All holders of OLs or CPs for nuclear power reactors.
94-82	Concerns Regarding Essential Chiller Reliability during Periods of Low Cooling Water Temperature	12/05/94	All holders of OLs or CPs for nuclear power reactors.
94-81	Accuracy of Bioassay and Environmental Sampling Results	11/25/94	All U.S. Nuclear Regulatory Commission licensees.
94-80	Inadequate DC Ground Detection in Direct Current Current Distribution Systems	11/25/94	All holders of OLs or CPs for nuclear power reactors.
94-79	Microbiologically Influenced Corrosion of Emergency Diesel Generator Service Water Piping	11/23/94	All holders of OLs or CPs for nuclear power reactors.
94-78	Electrical Component Failure due to Degradation of Polyvinyl Chloride Wire Insulation	11/21/94	All holders of OLs or CPs for nuclear power reactors.

OL = Operating License
CP = Construction Permit

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Original signed by
B. D. Liaw

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On January 28, 1994, the nuclear steam supply system vendor, Westinghouse Corporation, issued a Nuclear Safety Advisory Letter, concluding that a separated control rod drive shaft funnel does not significantly increase the probability or consequences of a licensing basis accident or create any accidents or malfunctions that are not already addressed by the existing licensing basis analyses. However, the potential for foreign objects in the top of the reactor exists for both the plug-weld and pin-and-cap weld designs for funnel-thermal sleeve attachment pins. The former design is used at the Braidwood and Byron plants and the latter design is used at the Cook, Diablo Canyon, and Sequoyah plants. Therefore, jamming of control rod(s) by loose pins, as happened at Braidwood, may still occur. This condition could be detected by rod drop testing, performed as required by technical specifications, at each startup. Westinghouse recommended that each of its nuclear steam supply system customers consider an inspection and recovery action program for these attachments as part of their next outage activity.

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No problem per RI, SRI and on-time chiff for Diablo Canyon. 11/28/94

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11/08/94	11/8 /94	11/10/94	11/ /94	11/ /94	11/ /94

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had slight lateral play of about 0.32-0.16 cm [1/8-1/16 inch]. The licensee concluded that portions of the pin for that funnel had likely been worn away because of flow induced vibration, that no pieces of the failed H-4 pin were not accounted for, and that without the effectiveness of the pin fastening, the funnel could become unthreaded and detached.

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