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

September 29, 1989

NRC INFORMATION NOTICE NO. 89-69: LOSS OF THERMAL MARGIN CAUSED BY CHANNEL BOX BOW

Addressees:

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

Purpose:

This information notice is intended to alert addressees to potential problems involving loss of thermal margin caused by excessive bowing of BWR fuel channel boxes. 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 do not constitute NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances:

During a refueling outage in August 1988, four failed fuel rods in separate assemblies were identified at a foreign BWR facility. Subsequent evaluation of sipping, visual inspection, gamma scan, and hot-cell data led to the conclusion that these rods failed because the rods were operated under dryout conditions during steady-state operation for an extended period of time (between 2 and 7 days).

The failed fuel rods were located symmetrically in the core. The fuel assemblies containing the rods that had failed were located adjacent to once-burned fuel assemblies with highly exposed fuel channels (see Figure 1). These fuel channels were in their second bundle lifetime and had excessive channel bowing. In each assembly with failed fuel, the corner rod facing the adjacent control rod was heavily oxidized and the cladding was penetrated just below the top spacer grid. In addition, each of the four failed rods had typical secondary internal hydriding damage near the bottom of the fuel rods, resulting in loss of fuel material.

Discussion:

Dryout of the fuel rods in this foreign facility occurred because of modeling errors in the plant process computer, which resulted in nonconservative calculated values of the minimum critical power ratio (MCPR) of the core. These

IDR-11C

modeling errors were caused by neglecting the effects of channel bowing and the geometric variation between the reloaded and once-burned fuel assemblies. These effects substantially increased the widths of the control rod water gaps for the assemblies that contained these four fuel rods beyond that assumed in the plant process computer calculations. The increased neutron moderation associated with the increased water gap widths led to very high localized power peaking at these four fuel rods. However, these effects were not properly accounted for in the MCPR calculations. For some time, the plant operators were misled by these erroneous MCPR calculations and were operating the plant in steady-state beyond the MCPR safety limit.

The modeling error of generic concern to all BWRs, regardless of the fuel supplier, relates only to the greater-than-expected bowing of fuel channel boxes, which contributed about 15 percent error in the calculated MCPR value for this foreign facility. Channel bowing is a manifestation of differences in the channel growth of opposite sides of the channel box and is proportional to channel growth. The information obtained by the NRC indicates that the channel growth shows an accelerated trend at higher burnup exposure, especially when the fuel channels are being reused in their second bundle lifetime. The effect on core operating MCPR is magnified when fresh fuel is located adjacent to the bowed fuel channels. Core operating limits imposed by technical specifications may be exceeded if the reduction in margin caused by fuel channel bowing is not properly accounted for in the plant process computer for thermal limits monitoring. Based on a preliminary evaluation by BWR fuel vendors of U.S. reactors, the impact of the new data on actual versus calculated MCPR values is expected to range from 0.0 to 0.03 CPR units. However, the impact could be much greater (about 15 percent) for any reactors operating with fuel channels being reused in their second bundle lifetime.

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 NRR project manager.

Charles E. Rossi

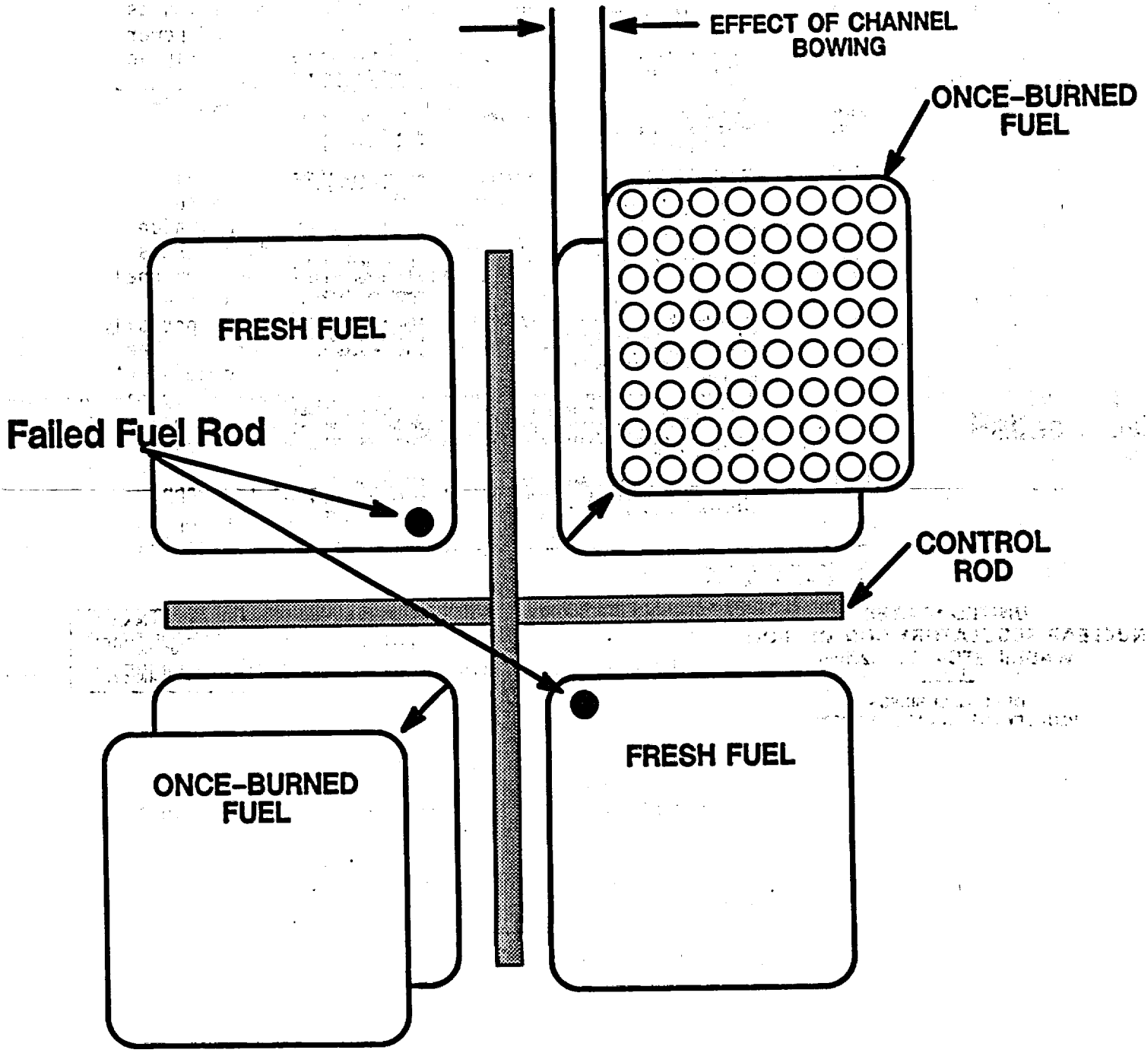
Charles E. Rossi, Director
Division of Operational Events Assessment
Office of Nuclear Reactor Regulation

Technical Contacts: Peter C. Wen, NRR
(301) 492-1172

Daniel B. Fieno, NRR
(301) 492-3236

Attachments:
1. Figure 1, "Channel Bow"
2. List of Recently Issued NRC Information Notices

Figure 1
Channel Bow



LIST OF RECENTLY ISSUED
NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
89-68	Evaluation of Instrument Setpoints During Modifications	9/25/89	All holders of OLs or CPs for nuclear power reactors.
89-67	Loss of Residual Heat Removal Caused by Accumulator Nitrogen Injection	9/13/89	All holders of OLs or CPs for PWRs.
89-66	Qualification Life of Solenoid Valves	9/11/89	All holders of OLs or CPs for nuclear power reactors.
88-46, Supp. 4	Licensee Report of Defective Refurbished Circuit Breakers	9/11/89	All holders of OLs or CPs for nuclear power reactors.
89-65	Potential for Stress Corrosion Cracking in Steam Generator Tube Plugs Supplied by Babcock and Wilcox	9/8/89	All holders of OLs or CPs for PWRs.
89-64	Electrical Bus Bar Failures	9/7/89	All holders of OLs or CPs for nuclear power reactors.
89-63	Possible Submergence of Electrical Circuits Located Above the Flood Level Because of Water Intrusion and Lack of Drainage	9/5/89	All holders of OLs or CPs for nuclear power reactors.
89-62	Malfunction of Borg-Warner Pressure Seal Bonnet Check Valves Caused By Vertical Misalignment of Disk	8/31/89	All holders of OLs or CPs for nuclear power reactors.
89-61	Failure of Borg-Warner Gate Valves to Close Against Differential Pressure	8/30/89	All holders of OLs or CPs for nuclear power reactors.

OL = Operating License
CP = Construction Permit

modeling errors were caused by neglecting the effects of channel bowing and the geometric variation between the reloaded and once-burned fuel assemblies. These effects substantially increased the widths of the control rod water gaps for the assemblies that contained these four fuel rods beyond that assumed in the plant process computer calculations. The increased neutron moderation associated with the increased water gap widths led to very high localized power peaking at these four fuel rods. However, these effects were not properly accounted for in the MCPR calculations. For some time, the plant operators were misled by these erroneous MCPR calculations and were operating the plant in steady-state beyond the MCPR safety limit.

The modeling error of generic concern to all BWRs, regardless of the fuel supplier, relates only to the greater-than-expected bowing of fuel channel boxes, which contributed about 15 percent error in the calculated MCPR value for this foreign facility. Channel bowing is a manifestation of differences in the channel growth of opposite sides of the channel box and is proportional to channel growth. The information obtained by the NRC indicates that the channel growth shows an accelerated trend at higher burnup exposure, especially when the fuel channels are being reused in their second bundle lifetime. The effect on core operating MCPR is magnified when fresh fuel is located adjacent to the bowed fuel channels. Core operating limits imposed by technical specifications may be exceeded if the reduction in margin caused by fuel channel bowing is not properly accounted for in the plant process computer for thermal limits monitoring. Based on a preliminary evaluation by BWR fuel vendors of U.S. reactors, the impact of the new data on actual versus calculated MCPR values is expected to range from 0.0 to 0.03 CPR units. However, the impact could be much greater (about 15 percent) for any reactors operating with fuel channels being reused in their second bundle lifetime.

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 NRR project manager.

Charles E. Rossi, Director
Division of Operational Events Assessment
Office of Nuclear Reactor Regulation

Technical Contacts: Peter C. Wen, NRR
(301) 492-1172

Daniel B. Fieno, NRR
(301) 492-3236

Attachments:
1. Figure 1, "Channel Bow"
2. List of Recently Issued NRC Information Notices

*SEE PREVIOUS PAGE FOR CONCURRENCE

	D/DOEA:NRR	*C/OGCB:DOEA:NRR	*GPA:IP	
	CERossi	CHBerlinger	RHauber	
	09/25/89	09/22/89	09/22/89	
*OGCB:DOEA:NRR	*SRXB:DEST:NRR	*SRXB:DEST:NRR	*C/SRXB:DEST:NRR	*RPB:ARM
PCWen	DBFieno	LEPhillips	MWHodges	TechEd
09/21/89	09/21/89	09/21/89	09/22/89	09/21/89

computer associated errors were caused by neglecting the effects of channel bowing and the geometric variation between the reloaded and once-burned fuel assemblies. These effects substantially increased the widths of the control rod water gaps for the assemblies that contained these four fuel rods beyond that assumed in the plant process computer calculations. The increased neutron moderation associated with the increased water gap widths led to very high localized power peaking at these four fuel rods. However, all these effects were not properly accounted for in the MCPR calculations. For some time, the plant operators were misled by these erroneous MCPR calculations and were operating the plant in steady-state beyond the MCPR safety limit.

The modeling error of generic concern to all BWRs, regardless of the fuel supplier, relates only to the greater-than-expected bowing of fuel channel boxes, which contributed about 15 percent error in the calculated MCPR value for this foreign facility. Channel bowing is a manifestation of differences in the channel growth of opposite sides of the channel box and is proportional to channel growth. The information obtained by the NRC indicates that the channel growth shows an accelerated trend at higher burnup exposure, especially when the fuel channels are being reused in their second bundle lifetime. The effect on core operating MCPR is magnified when fresh fuel is located adjacent to the bowed fuel channels. Core operating limits imposed by technical specifications may be exceeded if the reduction in margin caused by fuel channel bowing is not properly accounted for in the plant process computer for the thermal limits monitoring. Based on a preliminary evaluation by BWR fuel vendors of U.S. reactors, the impact of the new data on actual versus measured MCPR values is expected to range from 0.0 to 0.03 CPR units. However, the impact could be much greater (about 15 percent) for any reactors operating with fuel channels being reused in their second bundle lifetime.

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 NRR project manager.

Charles E. Rossi, Director
Division of Operational Events Assessment
Office of Nuclear Reactor Regulation

Technical Contacts: Peter C. Wen, NRR
(301) 492-1172

Daniel B. Fieno, NRR
(301) 492-3236

Attachments:
1. Figure 1, "Channel Bow"
2. List of Recently Issued NRC Information Notices

		D/DOEA:NRR	C/OGCB:DOEA:NRR	GPA:IP
		CERossi	CHBerlinger	RHauber
		09/ /89	09/11/89	09/22/89
*OGCB:DOEA:NRR	*SRXB:DEST:NRR	*SRXB:DEST:NRR	*C/SRXB:DEST:NRR	*RPB:ARM
PCWen	DBFieno	LEPhillips	MWHodges	TechEd
09/21/89	09/21/89	09/21/89	09/22/89	09/21/89

computer associated errors were caused by neglecting the effects of channel bowing and the geometric variation between the reloaded and once-burned fuel assemblies. These effects substantially increased the widths of the control rod water gaps for the assemblies that contained these four fuel rods beyond that assumed in the plant process computer calculations. The increased neutron moderation associated with the increased water gap widths led to very high localized power peaking at these four fuel rods. However, all these effects were not properly accounted for in the MCPR calculations. For some time, the plant operators were misled by these erroneous MCPR calculations and were operating the plant in steady-state beyond the MCPR safety limit.

The modeling error of generic concern to all BWRs relates only to the greater-than-expected bowing of fuel channel boxes, which contributed about 15 percent of the error in calculated MCPR value for this foreign facility. Channel bowing is a manifestation of differences in the channel growth of opposite sides and is proportional to channel growth. The information obtained by the NRC indicates that the channel growth shows an accelerated trend at higher burnup exposure, especially when the fuel channels are being reused in their second bundle lifetime. The effect on core operating MCPR is magnified when fresh fuel is located adjacent to the bowed fuel channels. Core operating limits imposed by technical specifications may be exceeded if the reduction in margin caused by fuel channel bowing is not properly accounted for in the plant process computer for the thermal limits monitoring. Based on a preliminary evaluation by BWR fuel vendors of U.S. reactors, the impact of the new data on actual versus measured MCPR values is expected to range from 0.0 to 0.03 CPR units. However, the impact could be much greater (about 15 percent) for any reactors operating with fuel channels being reused in their second bundle lifetime.

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 NRR project manager.

Charles E. Rossi, Director
Division of Operational Events Assessment
Office of Nuclear Reactor Regulation

Technical Contacts: Peter C. Wen, NRR
(301) 492-1172

Daniel B. Fieno, NRR
(301) 492-3236

Attachments:
1. Figure 1, "Channel Bow"
2. List of Recently Issued NRC Information Notices

GPA/IP
KDBarbe

			D/DOEA:NRR	C/OGCB:DOEA:NRR
			CERossi	CHBerlinger
			09/ /89	09/22/89
*OGCB:DOEA:NRR	*SRXB:DEST:NRR	*SRXB:DEST:NRR	C/SRXB:DEST:NRR	*RPB:ARM
PCWen	DBFieno	LEPhillips	MWHodges	TechEd
09/21/89	09/21/89	09/21/89	09/22/89	09/21/89

bowing and the geometric variation between the reloaded and once-burned fuel assemblies. These effects substantially increased the widths of the control rod water gaps for the assemblies that contained these four fuel rods beyond that assumed in the plant process computer calculations. The increased neutron moderation associated with the increased water gap widths led to very high localized power peaking at these four fuel rods. However, all these effects were not properly accounted for in the original MCPR calculations.

The modeling error of generic concern involves a nonconservative error of about 15 percent, which was primarily due to greater-than-expected bowing of fuel channel boxes. For some time, the plant operators were misled by these erroneous MCPR calculations and were operating the plant in steady-state beyond the MCPR safety limit.

Channel bowing is a manifestation of differences in the channel growth of opposite sides and is proportional to channel growth. The information obtained by the NRC indicates that the channel growth shows an accelerated trend at higher burnup exposure, especially when the fuel channels are being reused in their second bundle lifetime. The effect on core operating MCPR is magnified when fresh fuel is located adjacent to the bowed fuel channels. Core operating limits imposed by technical specifications may be exceeded if the reduction in margin caused by fuel channel bowing is not properly accounted for in the plant process computer for the thermal limits monitoring. Based on a preliminary evaluation by BWR fuel vendors of U.S. reactors, the impact of the new data on actual versus measured MCPR values is expected to range from 0.0 to 0.03 CPR units. However, the impact could be much greater (about 15 percent) for any reactors operating with fuel channels being reused in their second bundle lifetime.

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 NRR project manager.

Charles E. Rossi, Director
Division of Operational Events Assessment
Office of Nuclear Reactor Regulation

Technical Contacts: Peter C. Wen, NRR
(301) 492-1172

Daniel B. Fieno, NRR
(301) 492-3236

Attachments:
1. Figure 1, "Channel Bow"
2. List of Recently Issued NRC Information Notices

OGCB:DOEA:NRR	SRXB:DEST:NRR	SRXB:DEST:NRR	D/DOEA:NRR	C/OGCB:DOEA:NRR
PCWen	DBFieno	LEPhillips	CERossi	CHBerlinger
09/21/89	09/21/89	09/21/89	09/ /89	09/ /89

C/SRXB:DEST:NRR	RPB:ARM
MWHodges	TechEd for Mimi Mejac
09/ /89	09/21/89