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

March 24, 1993

NRC INFORMATION NOTICE 93-20: THERMAL FATIGUE CRACKING OF FEEDWATER PIPING TO STEAM GENERATORS

Addressees

All holders of operating licenses or construction permits for pressurized water reactors (PWRs) supplied by Westinghouse or Combustion Engineering.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to inform addressees of cracks found in the feedwater piping to steam generators at the Sequoyah Nuclear Power Plant, Units 1 and 2 and the Diablo Canyon Nuclear Power Plant, Unit 1. Recipients are expected to 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

In 1992, cracks were found in the feedwater lines at Diablo Canyon Unit 1. In addition, a through-wall crack and other cracks were found in the feedwater lines at Sequoyah. The cracks were attributed to thermal fatigue.

The NRC staff first learned of cracks in feedwater lines to steam generators which resulted from thermal fatigue in 1979 when the Indiana and Michigan Electric Company, the licensee for the Donald C. Cook Plant, reported leaks. In dealing with this problem, the NRC staff issued the following documents:

- a letter to PWR licensees pursuant to Paragraph 50.54(f) of Title 10 of the Code of Federal Regulations, May 25, 1979
- Office of Inspection and Enforcement (IE) Bulletin 79-13, "Cracking in Feedwater System Piping," June 25, 1979, Revision 1, August 30, 1979, and Revision 2, October 17, 1979
- NUREG/CR-5285, "Closeout of IE Bulletin 79-13," 1991

In Bulletin 79-13, the NRC requested that licensees perform radiographic and ultrasonic examinations of feedwater lines. As a result of these examinations, cracks were found at 18 of the 54 facilities inspected. The staff closed the bulletin on the basis of the results of the one-time inspection. The industry had taken the actions recommended in the bulletin

9303180065 PDR I&E Notice 93-020 930324

DF03
1/0

and instituted the augmented inservice inspection programs, which appeared to provide for reliable detection of cracks in feedwater piping.

Other technical evaluations were documented in the following reports:

- "Investigation of Feedwater Line Cracking in PWRs" (Westinghouse, 1980)
- NUREG-0691, "Investigation and Evaluation of Cracking Incidents in Piping in PWRs," (PWR pipe crack study group, 1980)

These studies showed that thermal fatigue was the main cause of the cracks. Modifications to minimize the effects of thermal stratification in feedwater lines and augmented licensee inservice inspections were recommended in the studies.

Recently, some licensees have again reported cracks in feedwater piping. The licensee for the Sequoyah units reported an actual leak despite augmented inservice inspections. The augmented inspections using ultrasonic techniques showed indications that might earlier have revealed the cracks, but the licensee misinterpreted these as resulting from the geometric configuration of the pipe. After finding the leak, the licensee performed radiography on all feedwater nozzles of both units and found cracks in five of the eight nozzles.

The licensee for Diablo Canyon Unit 1 reported indications with cracklike ultrasonic signal characteristics in feedwater piping to all four steam generators. The indications varied in length up to 20 cm [7-3/4 inches] in a circumferential direction, and many were intermittent. Some intermittent indications extended the full circumference with segments up to 5 cm [2 inches] long. The licensee tried to verify the indications by radiography but failed. Later, metallurgical analysis showed the indications to be cracks.

Only one nozzle at Diablo Canyon had been scheduled for an inspection. This inspection was performed in accordance with Section XI of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code). However, information on the leak at Sequoyah led the licensee for Diablo Canyon to use enhanced ultrasonic techniques to inspect all four lines. These techniques were considered more appropriate for finding small cracks from thermal fatigue than techniques specified by the ASME Code, which may not be adequate to detect these types of defects. Flaw sizing by ultrasonic techniques proved to be overly conservative at Diablo Canyon, however, presumably because inclusions in the material led to inaccurate results: cracks sized at 8.9 mm [0.35 inch] deep by ultrasonic inspection were shown by cross sectioning to be cracks 0.94 mm [0.037 inch] deep.

Discussion

Cracks from thermal fatigue in PWR feedwater lines have proved to be a recurring problem. The main cause of crack growth appears to be fatigue induced by stresses from thermal stratification during cold, low-flow, feedwater injections. Other factors that contribute to crack growth are a high oxygen content, counterbore weld preparation geometry, and thermal conditions during heatup, hot standby, and low-power operation. A favored solution has been to replace the degraded piping. However, replacing the degraded piping in kind without other corrective actions to eliminate or minimize the factors which cause the cracks can leave the piping susceptible to the same problem.

Inspection techniques specified in the ASME Code Section XI, do not appear adequate to find cracks of this type.

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 Grimes

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

Technical contacts: Lee Banic, NRR
(301) 504-2771

Robert A. Hermann, NRR
(301) 504-2768

Attachment: List of Recently Issued NRC Information Notices

LIST OF RECENTLY ISSUED
NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
93-19	Slab Hopper Bulging	03/17/92	All nuclear fuel cycle licensees.
93-18	Portable Moisture-Density Gauge User Responsibilities during Field Operations	03/10/93	All U.S. Nuclear Regulatory Commission licensees that possess moisture-density gauges.
93-17	Safety Systems Response to Loss of Coolant and Loss of Offsite Power	03/08/93	All holders of OLs or CPs for nuclear power reactors.
93-16	Failures of Nut-Locking Devices in Check Valves	02/19/93	All holders of OLs or CPs for nuclear power reactors.
93-15	Failure to Verify the Continuity of Shunt Trip Attachment Contacts in Manual Safety Injection and Reactor Trip Switches	02/18/93	All holders of OLs or CPs for nuclear power reactors.
93-14	Clarification of 10 CFR 40.22, Small Quantities of Source Material	02/18/93	All licensees who possess source material.
93-13	Undetected Modification of Flow Characteristics in the High Pressure Safety Injection System	02/16/93	All holders of OLs or CPs for nuclear power reactors.
93-12	Off-Gassing in Auxiliary Feedwater System Raw Water Sources	02/11/93	All holders of OLs or CPs for nuclear power reactors.
93-11	Single Failure Vulnerability of Engineered Safety Features Actuation Systems	02/04/93	All holders of OLs or CPs for nuclear power reactors.
93-10	Dose Calibrator Quality Control	02/02/93	All Nuclear Regulatory Commission medical licensees.

OL = Operating License
CP = Construction Permit

FIRST CLASS MAIL
POSTAGE AND FEES PAID
USNRC
PERMIT NO. G-67

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

conditions during heatup, hot standby, and low-power operation. A favored solution has been to replace the degraded piping. However, replacing the degraded piping in kind without other corrective actions to eliminate or minimize the factors which cause the cracks can leave the piping susceptible to the same problem.

Inspection techniques specified in the ASME Code Section XI, do not appear adequate to find cracks of this type.

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.

Original signed by
Brian K. Grimes

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

Technical contacts: Lee Banic, NRR
(301) 504-2771

Robert A. Hermann, NRR
(301) 504-2768

Attachment: List of Recently Issued NRC Information Notices

Filed in jacket

Document Name: 93-20.IN

*SEE PREVIOUS CONCURRENCES

		D/DORS:NRR	*C/OGCB:DORS:NRR	*RPB:ADM
		BKGrimes	GHMarcus	TechEd
		03/18/93	03/04/93	01/14/93
*OGCB:DORS:NRR	*EMCB:DE:NRR	*SC/EMCB:DE:NRR	*C/EMCB:DE:NRR	*D/DE:NRR
CVHodge	LBanic	RAHermann	JRStrosnider	JERichardson
01/25/93	01/26/93	01/26/93	01/27/93	02/01/93

IDR-11C

conditions during heatup, hot standby, and low-power operation. A favored solution has been to replace the degraded piping. However, replacing the degraded piping in kind without other corrective actions to eliminate or minimize the factors which cause the cracks would leave the piping susceptible to the same problem.

Inspection techniques specified in the ASME Code Section XI, do not appear adequate to finding cracks of this type.

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 Reactor Support
Office of Nuclear Reactor Regulation

Technical contacts: Lee Banic, NRR
(301) 504-2771

Robert A. Hermann, NRR
(301) 504-2768

Attachment: List of Recently Issued NRC Information Notices

Document Name: DIANINF.IN
*SEE PREVIOUS CONCURRENCES

		D/DORS:NRR	*C/OGCB:DORS:NRR	*RPB:ADM
		BKGrimes	GHMarcus	TechEd
		03/ /93	03/04/93	01/14/93
*OGCB:DORS:NRR	*EMCB:DE:NRR	*SC/EMCB:DE:NRR	*C/EMCB:DE:NRR	*D/DE:NRR
CVHodge	LBanic	RAHermann	JRStrosnider	JERichardson
01/25/93	01/26/93	01/26/93	01/27/93	02/01/93

replace the degraded piping. However, replacing the degraded piping in kind without other corrective actions to eliminate or minimize stratification will leave it susceptible to cracking again.

Inspection techniques specified in the ASME Code, Section XI, appear to be inadequate for finding the cracking.

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 Reactor Support
Office of Nuclear Reactor Regulation

Technical contacts: Lee Banic, NRR
(301) 504-2771

Robert A. Hermann, NRR
(301) 504-2768

Attachment: List of Recently Issued NRC Information Notices

Document Name: DIANINF.IN
*SEE PREVIOUS CONCURRENCES

		D/DORS:NRR	C/OGCB:DORS:NRR	*RPB:ADM
		BKGrimes mkw	GHMarcus GHM	TechEd
		03/ /93	03/4/93	01/14/93
*OGCB:DORS:NRR	*EMCB:DE:NRR	*SC/EMCB:DE:NRR	*C/EMCB:DE:NRR	*D/DE:NRR
CVHodge	LBanic	RAHermann	JRStrosnider	JERichardson
01/25/93	01/26/93	01/26/93	01/27/93	02/01/93

in the ASME Code, Section XI, appear to be inadequate for finding the cracking. A favored solution has been to replace the degraded piping. However, replacing the degraded piping in kind without other corrective actions to eliminate or minimize stratification will leave it susceptible to cracking again.

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 Reactor Support
Office of Nuclear Reactor Regulation

Technical contacts: Lee Banic, NRR
(301) 504-2771

Robert A. Hermann, NRR
(301) 504-2768

Attachment: List of Recently Issued NRC Information Notices

Document Name: DIANINF.IN
*SEE PREVIOUS CONCURRENCES

		D/DORS:NRR	C/OGCB:DORS:NRR	*RPB:ADM
		BKGrimes	GHMarcus	TechEd
		02/ /93	02/ /93	01/14/93
*OGCB:DORS:NRR	*EMCB:DE:NRR	*SC/EMCB:DE:NRR	*C/EMCB:DE:NRR	*D/DE:NRR
CVHodge	LBanic	RAHermann	JRStrosnider	JERichardson
01/25/93	01/26/93	01/26/93	01/27/93	02/01/93

in the ASME Code, Section XI, appear to be inadequate for finding the cracking. A favored solution has been to replace the degraded piping. However, replacing the degraded piping in kind without other corrective actions to eliminate or minimize stratification will leave it susceptible to cracking.

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 Reactor Support
Office of Nuclear Reactor Regulation

Technical contacts: Lee Banic, NRR
(301) 504-2771

Robert A. Hermann, NRR
(301) 504-2768

Attachment: List of Recently Issued NRC Information Notices

Document Name: DIANINF.IN
*SEE PREVIOUS CONCURRENCES

		D/DORS:NRR BKGrimes 01/ /93	C/OGCB:DORS:NRR GHMarcus 01/ /93	RPB:ADM TechEd* 01/14/93
OGCB:DORS:NRR CVHodge* 01/25/93	EMCB:DE:NRR LBanic* 01/26/93	SC/EMCB:DE:NRR RAHermann* 01/26/93	C/EMCB:DE:NRR JRStrosnider 01/27/93	D/DE:NRR JERichardson 01/ /93

#3 1/28
csp

Discussion

Cracking from thermal fatigue is a persistent problem. The main cause of crack growth is fatigue induced by stresses from thermal stratification during cold, low-flow, feedwater injections. Other factors are a high oxygen content, counterbore weld preparation geometry, and thermal conditions during heatup, hot standby, and low-power operation. Inspection techniques specified in the ASME Code, Section XI, appear to be inadequate for finding the cracking. A favored solution has been to replace the degraded piping. However, replacing the degraded piping in kind without other corrective actions to eliminate or minimize stratification will leave it susceptible to cracking.

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 Reactor Support
Office of Nuclear Reactor Regulation

Technical contacts: Lee Banic, NRR
(301) 504-2771

Robert A. Hermann, NRR
(301) 504-2768

Attachment: List of Recently Issued NRC Information Notices

Document Name: DIANINF.IN
*SEE PREVIOUS CONCURRENCES

		D/DORS:NRR	C/OGCB:DORS:NRR	*RPB:ADM
		BKGrimes	GHMarcus	TechEd
		01/ /93	01/ /93	01/14/93
OGCB:DORS:NRR	EMCB:DE:NRR	SC/EMCB:DE:NRR	C/EMCB:DE:NRR	D/DE:NRR
CVHodge	LBanic	RAHermann	JRStrosnider	JERichardson
01/25/93	01/26/93	01/26/93	01/ /93	01/ /93

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 Reactor Support
Office of Nuclear Reactor Regulation

Technical contacts: Lee Banic, NRR
(301) 504-2771

Robert A. Hermann, NRR
(301) 504-2768

Attachment: List of Recently Issued NRC Information Notices

Document Name: DIANINF.IN

		D/DORS:NRR	C/OGCB:DORS:NRR	RPB:ADM
		BKGrimes	GHMarcus	TechEd JMain JM
		01/ /93	01/ /93	01/14/93
OGCB:DORS:NRR	EMCB:DE:NRR	SC/EMCB:DE:NRR	C/EMCB:DE:NRR	D/DE:NRR
CVHodge	LBanic MB	RAHermann	JRStrosnider	JERichardson
01/ /93	01/06/93	01/ /93	01/ /93	01/ /93