Enclosure

SAFETY EVALUATION OF INTERIM ACTIONS TAKEN
TO ELIMINATE FEEDWATER PIPING CRACKS

On May 20, 1979, Indiana and Michigan Power Company notified the NRC of cracking in two feedwater lines at their D. C. Cook Unit 2 facility. The cracking was discovered following a shutdown on May 19 to investigate leakage inside containment. Leaking circumferential cracks were identified in the 16-inch diameter feedwater elbows adjacent to two steam generator nozzle to elbow welds. Subsequent radiographic examinations revealed cracks in all eight steam generator feedwater lines at this location on both units 1 and 2.

On May 25, 1979, a letter was sent to all PWR licensees by the Office of Nuclear Reactor Regulation which informed licensees of the D. C. Cook failures and requested specific information on feedwater system design, fabrication, inspection and operating histories. To further explore the generic nature of the cracking problem, the Office of Inspection and Enforcement requested licensees of PWR plants in current outages to immediately conduct volumetric examination of certain feedwater piping welds. As a result of these actions several other licensees reported cracking in the steam generator feedwater nozzle-to-piping weld vicinity. On June 25, 1979, IE Bulletin 79-13 was issued. The Bulletin required inspection of the steam generator nozzle-to-pipe welds and adjacent areas within 90 days. If flaws were found in these welds, the feedwater piping welds to the first support, the feedwater piping to containment penetration and the auxiliary feedwater to main feedwater piping connection were required to be inspected.

In conformance with the Bulletin, the facilities who have observed crack indications (Table 1) have completed the radiographic examinations and have found cracking in their feedwater piping systems.

Meetings and/or telephone conference calls were held with the respective licensees to discuss the following items regarding the feedwater piping cracks at their facilities:

1. Nature and extent of the cracking.
2. Metallurgical evaluation of the cracking including identification of the mode of failure.
3. Stress analyses
4. Operating history
5. Feedwater chemistry
6. Corrective actions
7. Safety Implications

The licensees' interim reports containing the information above were submitted and reviewed by the staff prior to the units returning to power. The extent of the cracking at the facilities is summarized in Table 1. The mode of failure at all the facilities including Millstone, Unit No. 2, with the exception of Yankee Rowe was identified as fatigue assisted by corrosion. The Yankee Rowe facility had gross fabrication defects in its feedwater piping. No anomolies were found in the Code required stress analyses at the facilities.

From the results of instrumentation installed at several plants which have experienced feedwater piping cracks and other modeling and analyses by a utility sponsored Owners Group, significant cyclic stresses have been identified that occur in the feedwater piping in the vicinity of the steam generator nozzle from mixing and stratification of cold auxiliary feedwater with hot water from the steam generator during low flow conditions. The Owners Group is expected to complete their investigations and make recommendations for changes in design and operating procedures in early 1980.

The licensees have repaired and/or replaced the affected piping in most cases with improved designs to minimize stress risers. In addition, the licensees have committed to reinspect the steam generator to feedwater piping weld vicinities at the subsequent refueling outage.

Although the piping has been repaired at the facilities listed in Table 1, the staff feels that cracking could re-occur in the future at these facilities. The staff and Owners Group both have performed independent analyses and have determined that flawed feedwater piping could withstand challenges from operating and faulted loads including seismic and limited water loads without loss of piping integrity. Pipe breaks have occurred in the past in feedwater piping as the result of water hammer loads. However, design changes such as "J" tubes have been made and operational changes have occurred to minimize the possibility of water hammer. In the unlikely event of a feedwater pipe break from a severe water hammer, the consequences have been analyzed as a design base accident and measures have established to deal with the event.

The NRC has instituted a Pipe Crack Study Group to review this and other pipe cracking problems in PWR's. It is anticipated that the Pipe Crack Study Group will complete its work by June 1980 and provide recommendations for review and implementation by the staff as new criteria for operating plants.

We conclude that repairs to the feedwater piping, the nondestructive inspections performed and scheduled, and the analyses performed for flawed piping ensure that the piping integrity will be maintained until the recommendations of the Owners Group and the Pipe Crack Study Group have been evaluated. Should the staff determine that further actions are required after evaluation of the Owners Group and Pipe Crack Study Group recommendations, the licensees will be notified at that time.

Table 1 - Summary of PWR Feedwater Piping Cracks

PLANT	EXTENT OF CRACKING (NOZZLE VICINITY) Max. Depth	Location max. Depth Crack	No. of Lines Cracked	PIPING COMPONENT	PROBABLE CAUSE	COMMENTS
Westinghouse						
D. C. Cook 1/2	Thru wall	TOP	8 of 8	elbow	Corrosion Assisted Fatigue	2 cracks thru wall
Beaver Valley	0.400"	9 O'clock	3 of 3	elbow	Corrosion Assisted Fatigue	13 additional fab. related indications repaired
Kawaunee	0.050"	7 O'clock	2 of 2	pipe	Corrosion Assistd Fatigue	3" dia. aux. feed near SG inlet
Pt. Beach 1/2	0.047"	3 O'clock	2 of 2	reducer	Corrosion Assisted Fatigue	3" dia. aux. feed near SG inlet
H.B.Robinson 2	0.750"	9 O'clock	3 of 3	reducer	Corrosion Assisted Fatigue	Shallow cracking in nozzle under thermal sleeve
Salem 1	0.235"		4 of 4	elbow reducer	Corrosion Assisted Fatigue	
San Onofre 1	0.100"	lower half of reducer	3 of 3	reducer	Stress Assisted Corrosion	Multiple branched cracks evidence of some fatigue
Surry 1/2	0.080"	2 and 5 O'clock	6 of 6	reducer	Corrosion Assisted Fatigue	
Ginna	0.107"	8:30 O'clock	2 of 2	elbow	Stress Assisted Corrosion/Corrosion Fatigue	Cracks also at deep machining marks
Zion 1/2	0.088"	4 O'clock	8 of 8	elbow pipe	Corrosion Assisted Fatigue	

Table 1 - Summary of PWR Feedwater Piping Cracks

PLANT	EXTENT OF CRACKING (NOZZLE VICINITY)			PIPING COMPONENT	PROBABLE CAUSE	COMMENTS
	Max. Depth	Location max. Depth Crack	No. of Lines Cracked			
Combustion Engineering						
Millstone 2	0.250"	12 O'clock	2 of 2	pipe	Not analyzed	
Palisades	0.170"	3 and 9 O'clock	2 of 2	pipe	Corrosion Assisted Fatigue	Cracks found also at weld vicinity of horizontal piping