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

April ??, 1988

NRC INFORMATION NOTICE NO. 88-17: SUMMARY OF RESPONSES TO NRC BULLETIN 87-01, "THINNING OF PIPE WALLS IN NUCLEAR POWER PLANTS"

Addressees:

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

Purpose:

This information notice is being provided to inform addressees of the results of the NRC staff review of responses to NRC Bulletin 87-01, "Thinning of Pipe Walls in Nuclear Power Plants." It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to prevent erosion/corrosion-induced piping degradation. However, suggestions contained in this notice do not constitute NRC requirements; therefore, no specific action or written response is required.

Background:

On December 9, 1986, Unit 2 at the Surry Power Station experienced a catastrophic failure of a main feedwater pipe, which resulted in fatal injuries to four workers. During the 1987 refueling outage at the Trojan plant, it was discovered that at least two areas of the straight sections of the main feedwater piping system had experienced wall thinning to an extent that the pipe wall thickness would have reached the minimum thickness required by the design code (American National Standards Institute (ANSI) Standard B31.7, "Nuclear Power Piping") during the next refueling cycle. These two straight-section areas are in safety-related portions of the Class 2 piping inside containment. In addition, numerous elbows and piping sections in the non-safety-related portion of the feedwater lines were replaced because of wall-thinning problems.

Because of the immediate concern about high-energy carbon steel systems in operating nuclear power plants, NRC Bulletin 87-01 was issued on July 9, 1987. The staff requested all licensees to provide the following information within 60 days of receiving the bulletin:

- the code or standard to which the high-energy, carbon steel piping was designed and fabricated

- the scope, extent, and sampling criteria of inspection programs to monitor pipe wall thinning of safety-related and non-safety-related high-energy, carbon steel piping systems

- the results of all inspections that have been performed to identify pipe wall thinning

- plans for revising existing pipe monitoring procedures or developing new or additional inspection programs

Discussion:

The staff review of licensee responses to the bulletin showed that before the rules for piping, pumps, and valves in Section III of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) were revised in 1971, the secondary coolant systems in nuclear power plants were designed and fabricated in accordance with ANSI B31.1. Fifty-seven percent of the licensed units belong to this category. After 1971, safety-related portions of the secondary coolant systems were designed and fabricated in accordance with ASME Code Section III, while non-safety-related portions of the secondary coolant systems continued to be designed and fabricated in accordance with ANSI B31.1. Forty-three percent of the licensed units belong to this category.

For two-phase, high-energy carbon steel piping systems, the responses to the bulletin indicated that programs for inspecting pipe wall thinning exist at all plants. Inspection locations are generally established in accordance with the 1985 guidelines in Electric Power Research Institute (EPRI) Document NP-3944, "Erosion/Corrosion in Nuclear Plant Steam Piping: Causes and Inspection Program Guidelines." However, because implementation of these guidelines is not required, the scope and the extent of the programs vary significantly from plant to plant.

Responses to the bulletin indicated that limited inspections of the single-phase feedwater-condensate systems were conducted in most plants after the Surry Unit 2 incident. Most plants developed their single-phase pipe wall thinning monitoring programs because of the events at Surry Unit 2 and at the Trojan plant. Some plants developed programs after NRC Bulletin 87-01 was issued. The responses to NRC Bulletin 87-01 show that 23 units, of a total of 110, still have not established an inspection program for monitoring pipe wall thinning in single-phase lines. Of these 23 units, 17 are operating and 6 are under construction.

The inspection frequency for pipe wall thickness measurements and replacement/repair decisions is based on a combination of predicted and measured erosion/corrosion rates. In general, the pipe wall thickness acceptance criteria use measured wall thicknesses and an erosion/corrosion damage rate to predict when the pipe wall thickness will approach its Code-allowable minimum wall thickness. The acceptance criteria provide guidance for determining if a piping component needs to be replaced or repaired immediately or for projecting when a piping component should be replaced.

The primary method of inspection reported was ultrasonic testing, supplemented by visual examination and, in a few cases, by radiography. Measurements of pipe wall thickness were either made by or verified by certified level 2 or level 3 inspectors. The NRC staff considers this an adequate inspection technique.

The systems and components reported as experiencing pipe wall thinning in the responses to Bulletin 87-01 are listed in Attachment 1. Pipe wall thinning problems in single-phase piping occurred primarily in the feedwater-condensate system; the problems in two-phase piping, although varied in extent, have been reported in a variety of systems in virtually all operating plants. Plants that were reported to have pipe wall thinning in feedwater-condensate systems are listed in Attachment 2. Although inspection of single-phase lines is not scheduled until the next refueling outage for a number of plants, the available results from plants already inspected indicate a widespread problem.

The staff's review also showed that wall thinning in feedwater-condensate systems is more prevalent in pressurized-water reactors (PWRs) than boiling-water reactors (BWRs). At the present time, licensees of 27 PWRs and 6 BWRs have identified various degrees of wall thinning in feedwater piping and fittings.

The staff's review further indicated that of the feedwater-condensate systems, the recirculation-to-condenser line (minimum-flow line) has experienced wall thinning degradation most frequently. The line is used to protect the pump during low-power operation and is isolated by a minimum-flow valve during high-power operation. Specific information regarding a minimum-flow line degradation incident at the LaSalle County Station is provided for recipients to review for applicability to their facilities and consider actions, if appropriate, to preclude similar problems occurring at their facilities.

Description of Circumstances of a Recent Event:

On December 10, 1987, at LaSalle County Station Unit 1, when the unit was at approximately 100 percent power, an increased floor drain input from the heater bay was observed. This prompted a search of that area by the plant Operating Department. Feedwater leakage was found immediately downstream of the 1B turbine-driven reactor feedwater pump (TDRFP) minimum-flow line control valve (1FW011B). This valve discharges immediately into a 45-degree elbow that is welded to an 8-inch by 14-inch expander, which is connected to piping that feeds directly to the main condenser. The 45-degree elbow (schedule 160, 5% chrome, 1/2% molybdenum alloy steel) was found to have through-wall pinhole leaks in it. Further investigation identified the cause of the leakage to be internal piping erosion.

A visual inspection and ultrasonic testing of the other feedwater pump minimum-flow lines at both Unit 1 and Unit 2 revealed the following:

(1) The 2A TDRFP had wall thinning in the 8-inch by 14-inch expander (schedule 80, 5% chrome, 1/2% molybdenum steel), and a 1/4-inch diameter hole in the expander was located 1 inch downstream from the elbow/reducer weld.

(2) The 1A and 2B TDRFPs had localized wall thinning in the elbow downstream of the flow control valve similar to that found on the 1B minimum-flow line. This metal loss did not result in a through-wall leak.

(3) The 1C and 2C feedwater pumps are motor-driven pumps with smaller minimum-flow lines (10 inches rather than 14 inches), and no degradation of the wall thickness downstream of the flow control valves was noted.

The erosion pattern was thought to be caused by the design of the minimum-flow control valves and the geometry of the downstream piping. The valves were manufactured by Control Components, Inc., and were pressure breakdown "drag" valves. The valves have a cone-shaped disk and are not designed to be leak tight. Any feedwater leaking past the seat flashes to steam because of a vacuum pulling on the water from the condenser. With a cone-shaped disk, the steam is then directed, like a jet, immediately onto the opposing wall of the elbow or reducer, causing the erosion (see Attachment 3).

The feedpump minimum-flow lines are not considered to have a safety-related function and, therefore, this failure did not affect the ability to achieve a safe shutdown. However, this could present a plant personnel safety concern in the event of a catastrophic failure. The licensee did a weld overlay repair of the wall thinning areas of all four minimum-flow lines. The lines will be replaced during the next refueling outage. The licensee is evaluating a modification to the control valve disk to prevent flow or leakage through the line from being focused onto the downstream piping because of the conical shape of the disk.

Past Related Generic Communications:

IE Information Notice 82-22, "Failure in Turbine Exhaust Lines," dated July 9, 1982, provides additional information on erosion/corrosion in wet steam piping. Other erosion/corrosion events pertaining specifically to the feedwater system (including emergency and auxiliary feedwater) have occurred in feedwater pump minimum-flow lines, J-tubes in steam generator feedwater rings, and emergency supplies to a helium circulator.

IE Information Notice 86-106, "Feedwater Line Break," was issued on December 16, 1986. It described the then-known details of the December 9, 1986, failure of the suction line to a main feedwater pump at Surry Power Station Unit 2. Supplement 1 to this information notice, which was issued on February 13, 1987, provided additional detail on the failure mechanism. Supplement 2, which was issued on March 10, 1987, discussed the effects of the system interactions that resulted from the line break.

NRC Bulletin 87-01, "Thinning of Pipe Walls in Nuclear Power Plants," issued on July 9, 1987, requested that licensees submit information concerning their programs for monitoring the thickness of pipe walls in high-energy single-phase and two-phase carbon steel piping systems.

NRC Information Notice 87-36, "Significant Unexpected Erosion of Feedwater Lines," was issued August 4, 1987. It described a potentially generic problem pertaining to significant unexpected erosion that resulted in pipe wall thinning in the safety-related portions of feedwater lines and other related problems discovered at the Trojan Plant.

No specific action or written response is required by this information notice. If you have any questions about this matter, please contact 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: Paul C. Wu, NRR
(301) 492-0826

Michael Jordan, RIII
(312) 790-5552

Attachments:
1. Systems/Components Experiencing Pipe Wall Thinning
2. Plants Experiencing Pipe Wall Thinning in Feedwater-Condensate System
3. LaSalle Minimum-Flow Control Valve
4. List of Recently Issued NRC Information Notices

SYSTEMS/COMPONENTS EXPERIENCING PIPE WALL THINNING

Single-Phase Line

- main feedwater lines, straight runs, fittings
- main feedwater recirculation to condenser, straight runs, fittings
- feedwater pump suction lines, straight runs, fittings
- feedwater pump discharge lines, straight runs, fittings
- condensate booster pump recirculation line fittings
- steam generator letdown lines, straight runs, fittings

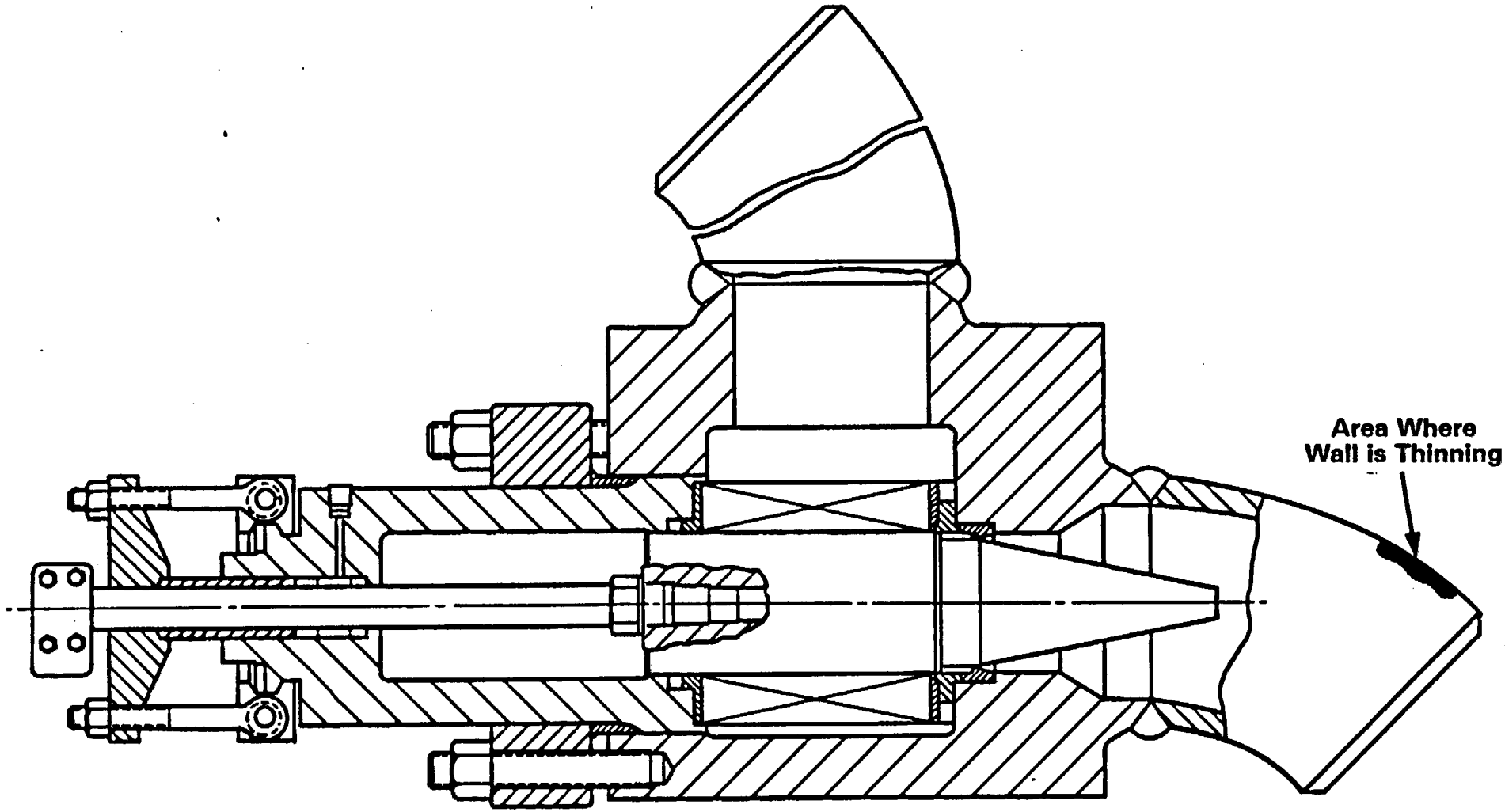
Two-Phase Line

- main steamlines
- turbine cross-over piping
- turbine cross-under piping
- extraction steamlines
- moisture separator reheater
- feedwater heater drain piping

PLANTS EXPERIENCING PIPE WALL THINNING IN FEEDWATER-CONDENSATE SYSTEM

Plant	Unit	Type of Reactor	Commercial Operation	Degraded Component Fittings or Straight Runs
Dresden	2	BWR	January 1970	elbows
Duane Arnold		BWR	March 1974	elbows, reducers, straight runs
Pilgrim	1	BWR	June 1972	elbows
Oyster Creek		BWR	May 1969	elbows
River Bend	1	BWR	October 1985	recirculation line
Perry		BWR	June 1986	straight runs
Arkansas	1	PWR	August 1974	elbows, drain pump discharge piping
Arkansas	2	PWR	December 1978	undefined
Calvert Cliffs	1	PWR	October 1974	elbows, reducers, straight runs
Calvert Cliffs	2	PWR	November 1976	elbows, reducers, straight runs
Callaway		PWR	October 1984	recirculation line elbows
Diablo Canyon	1	PWR	April 1984	elbows, straight runs
Diablo Canyon	2	PWR	August 1985	elbows, and Y
Donald Cook	2	PWR	March 1978	elbows
Ft. Calhoun		PWR	August 1973	elbows, straight run
Haddam Neck		PWR	July 1967	recirculation line
Millstone	2	PWR	October 1975	elbows, heater vent piping
North Anna	1	PWR	April 1978	elbows, straight runs
North Anna	2	PWR	June 1980	elbows, straight runs
H. B. Robinson	2	PWR	September 1970	recirculation lines
San Onofre	1	PWR	June 1967	reducers, heater drain piping
San Onofre	2	PWR	July 1982	heater drain piping
San Onofre	3	PWR	August 1983	heater drain piping
Salem	1	PWR	December 1976	recirculation line
Salem	2	PWR	August 1980	recirculation line
Shearon Harris		PWR	October 1986	recirculation line
Surry	1	PWR	July 1972	fittings
Surry	2	PWR	March 1973	fittings
Sequoyah	1	PWR	July 1980	elbows, straight runs
Sequoyah	2	PWR	November 1981	elbows
Trojan		PWR	December 1975	elbows, reducers, straight runs
Turkey Point	3	PWR	October 1972	feedwater pump suction line fittings
Fort St. Vrain		HGTR*	January 1974	straight run in emergency feedwater line
Rancho Seco		PWR	September 1974	straight runs downstream of MFW loop isolation valve or MFPs miniflow valves

* High Temperature Gas Reactor



LaSalle Minimum-Flow Control Valve

LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
88-16	Identifying Waste Generators in Shipments of Low-Level Waste to Land Disposal Facilities	4/22/88	Radioactive waste collection and service company licensees handling prepackaged waste, and licensees operating low-level waste disposal facilities.
88-15	Availability of U.S. Food and Drug Administration (FDA)-Approved Potassium Iodide for Use in Emergencies Involving Radioactive Iodine	4/18/88	Medical, Academic, and Commercial licensees who possess radioactive iodine.
88-14	Potential Problems with Electrical Relays	4/18/88	All holders of OLs or CPs for nuclear power reactors.
88-13	Water Hammer and Possible Piping Damage Caused by Misapplication of Kerotest Packless Metal Diaphragm Globe Valves	4/18/88	All holders of OLs or CPs for nuclear power reactors.
88-12	Overgreasing of Electric Motor Bearings	4/12/88	All holders of OLs or CPs for nuclear power reactors.
88-11	Potential Loss of Motor Control Center and/or Switchboard Function Due to Faulty Tie Bolts	4/7/88	All holders of OLs or CPs for nuclear power reactors.
88-10	Materials Licensees: Lack of Management Controls Over Licensed Programs	3/28/88	All NRC licensees authorized to use byproduct material.
87-44, Supp. 1	Thimble Tube Thinning in Westinghouse Reactors	3/28/88	All holders of OLs or CPs for nuclear power reactors that employ a Westinghouse NSSS.

OL = Operating License
CP = Construction Permit

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*Tranmitted by memorandum to C. E. Rossi from L. C. Shao dated March 31, 1988

D/DOEA:NRR	*C/OGCB:DOEA:NRR	*PPMB:ARM	*RIII	*RIII
CERossi	CHBerlinger	TechEd	MJordan	EGreenman
04/19/88	04/14/88	04/6/88	04/7/88	04/7/88
*OGCB:DOEA:NRR	*ECEB:DEST:NRR	*C/ECEB:DEST:NRR	*EAD/DEST:NRR	*D/DEST:NRR
RJKiessel	PCWu	CEMcCracken	JRichardson	LCShao
04/6/88	04/ /88	04/ /88	04/ /88	04/ /88

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D/DOEA:NRR	C/OGCB:DOEA:NRR	PPMB:ARM for	RIII by phone	RIII by phone
CERossi	CHBerlinger	TechEd	MJordan	EGreenman
04/ /88	04/14/88	04/6 /88	04/7/88	04/7/88
OGCB:DOEA:NRR	*ECEB:DEST:NRR	*C/ECEB:DEST:NRR	*EAD/DEST:NRR	*D/DEST:NRR
RJKiessel	PCWu	CEMcCracken	JRichardson	LCShao
04/6 /88	04/ /88	04/ /88	04/ /88	04/ /88