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

March 12, 1991

NRC INFORMATION NOTICE NO. 91-18: HIGH-ENERGY PIPING FAILURES CAUSED BY WALL THINNING

Addressees:

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

Purpose:

This information notice is intended to alert addressees to continuing erosion/corrosion problems affecting the integrity of high-energy piping systems and apparently inadequate monitoring programs. The piping failures at domestic plants indicate that, despite implementation of long-term monitoring programs pursuant to Generic Letter 89-08, "Erosion/Corrosion-Induced Pipe Wall Thinning," piping failures caused by wall thinning continue to occur in operating plants. 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:

On December 31, 1990, while Unit 3 of the Millstone Nuclear Power Station was operating at 86-percent power, two 6-inch, schedule 40 pipes, in the moisture separator drain (MSD) system, ruptured. The high-energy water (approximately 360 degrees F, 600 psi) flashed to steam and actuated portions of the turbine building fire protection deluge system. Two 480-volt motor control centers and one non-vital 120-volt inverter were rendered inoperable by the flooding, resulting in the loss of the plant process computer and the isolation of the instrument air to the containment building.

On July 2, 1990, while Unit 2 of the San Onofre Nuclear Generating Station was operating at full power, the licensee discovered a steam leak in one of the feedwater regulating valve (FRV) bypass lines. The licensee shut down the reactor to depressurize the line for inspection and repair. Ultrasonic testing (UT) revealed wall thinning in an area immediately downstream of the weld attaching the 6-inch bypass line to the 20-inch feedwater piping.



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On March 23, 1990, at Unit 1 of the Surry Power Station, a straight section of piping, downstream of a level control valve in the low pressure heater drain (LPHD) system, ruptured. Measurement of the piping revealed that it had thinned to 0.009 inch at the rupture.

On May 28, 1990, at Loviisa, Unit 1, a foreign plant, a flow-measuring orifice flange in the main feedwater system ruptured. The rupture occurred after one of the five main feedwater pumps tripped causing a check valve in the line to slam shut, creating a pressure spike. The utility inspected the flange and found that the flange had thinned to approximately 0.039 inch. After inspecting the other flow-orifice flanges in Units 1 and 2, the utility determined that 9 of 10 flanges had been thinned to below minimum wall requirements.

Discussion:

For all of these events, system temperature was in the range of 280 to 445 degrees F, system pressure was 500 to 1080 psi, flow was 9 to 29 feet per second and the piping material was carbon steel. Also, in each event, flow turbulence was present.

The licensee for Millstone Unit 3 had noted a through-wall leak approximately two inches from the level control valve in train A of the MSD system and was preparing to isolate the line for repair. However, when MSD pump A was secured, a pressure transient resulted, causing MSD trains A and B to rupture. Information obtained from the licensee indicates that in both trains, the ruptured piping had thinned to approximately 20 mils near the level control valve. Although the licensee had identified the MSD system as one of the systems to be analyzed for erosion/corrosion susceptibility, that analysis was not performed because of a communication error. The spool piece numbers for the MSD system were incorrectly listed under the moisture separator reheater drain system which was exempted from analysis because of temperature. The licensee has analyzed the MSD system using the Electric Power Research Institute computer code CHEC and determined that the MSD system is highly susceptible to erosion/corrosion and should have been inspected.

At San Onofre Unit 2, the licensee's erosion/corrosion monitoring program had excluded the FRV bypass lines from inspection for wall thinning based on the system temperature (445 degrees F) exceeding a criterion established by the licensee. However, the thinning of the FRV bypass lines demonstrates that erosion/corrosion is a multi-variable phenomena and that exclusion based on one variable may not be appropriate. The variables of piping material, configuration, flow rate, water temperature, water chemistry (pH, pH control agent, dissolved oxygen), and steam quality for steam/water systems are important when evaluating piping systems for erosion/corrosion susceptibility.

At Surry Unit 1, the pipe failure occurred in a straight section of pipe located just downstream of a level control valve in the 2B low pressure heater drain (LPHD) system. The licensee's erosion/corrosion monitoring program included the LPHD system and provided for inspecting the wall thickness of the pipe elbow located immediately downstream of the failed piping. However, the program did not provide an inspection for the short section of piping between

the elbow and the level control valve. After the pipe rupture occurred in train B, the licensee performed UT inspections of the same section in train A of the LPHD system and found that it had thinned to approximately 0.052 inch. The design requirement for minimum wall thickness in that pipe is 0.117 inch. The licensee replaced the damaged pipe with A106 grade B material and intends to replace that material with A335-P22 erosion resistant material during the next outage.

The licensee performed an analysis and found that the erosion/corrosion of the failed piping was caused by a combination of high velocity flow, a pH level of 9.0 or less in the heater drain system, and flow turbulence caused by valve throttling.

The feedwater pipe rupture at Loviisa Unit 1 occurred in the flange of the flow-measuring orifice (Figure 1). The 360-degree thinning of the interior wall of the flange started near the orifice plate and increased to the point of the rupture. In the area of the rupture, the flange wall had thinned to 0.039 inch. A 20 inch long pipe section attached to the downstream end of the flange had circumferential wall thinning from an initial wall thickness of 0.7 inch to a residual wall thickness of 0.195 - 0.390 inch. Neither this section of pipe nor the flange contained significant amounts of alloying elements. However, the piping downstream of the 20 inch pipe, which contained 0.20 percent chromium, 0.30 percent nickel and 0.30 percent copper, did not exhibit wall thinning.

The utility conducted an investigation and determined that the thinning was caused by erosion/corrosion. In 1982, the utility established a pipe inspection program for two phase (steam/water) systems and, in 1986, augmented the program to include single phase systems; however, the program concentrated on pipe elbows and tee fittings. To check for other degraded flanges, the utility inspected the flow-orifice flanges at Units 1 and 2 and found that 9 of 10 flanges were below minimum wall requirements. The utility replaced the flanges with the same material as the original flanges but is considering changing to a more erosion/corrosion resistant material as a final repair.

The NRC has issued the following related generic communications:

NRC Information Notice 86-106, "Feedwater Line Break," December 16, 1986, and supplements 1, 2, and 3.

NRC Information Notice 87-36, "Significant Unexpected Erosion of Feedwater Lines," August 4, 1987.

NRC Information Notice 88-17, "Summary of Responses to NRC Bulletin 87-01, 'Thinning of Pipe Walls in Nuclear Power Plants'," April 22, 1988.

NRC Bulletin 87-01, "Thinning of Pipe Walls in Nuclear Power Plants," July 9, 1987.

NRC Generic Letter 89-08, "Erosion/Corrosion-Induced Pipe Wall Thinning," May 4, 1989.

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

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Office of Nuclear Reactor Regulation

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(301) 492-0726

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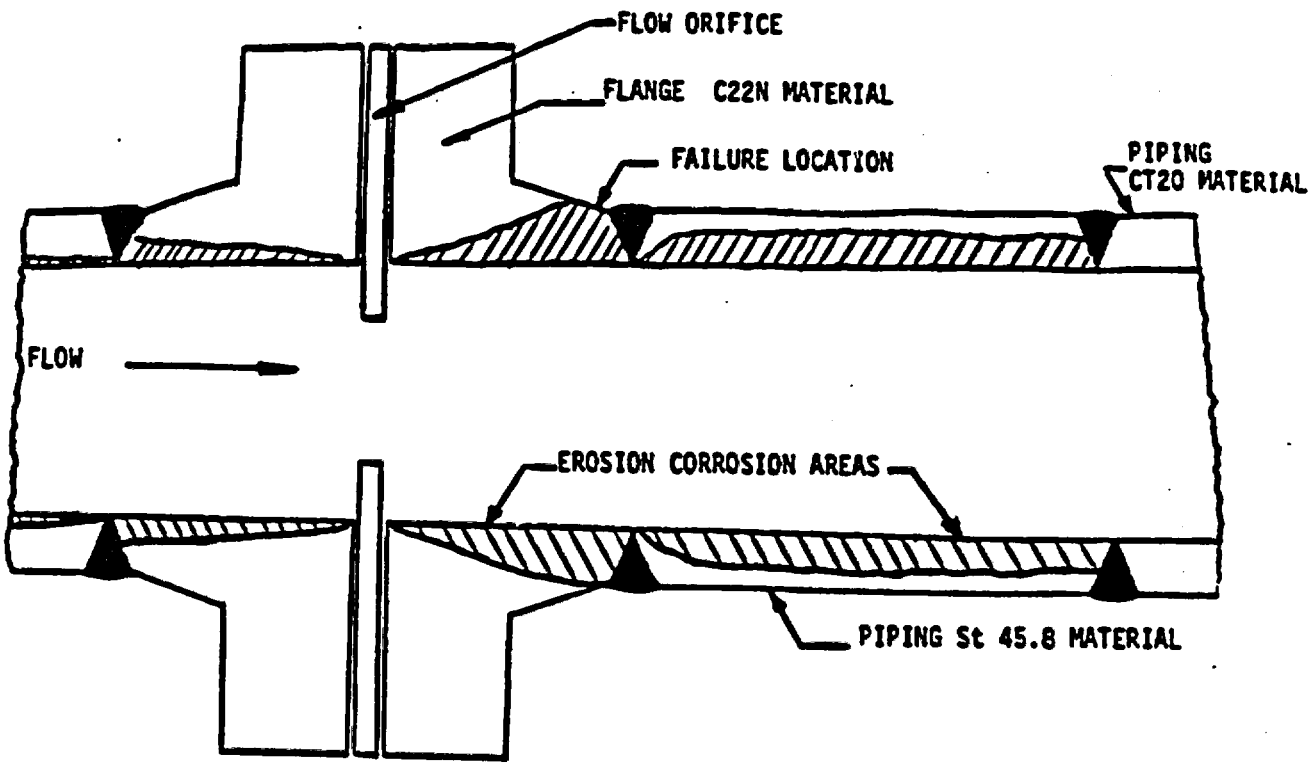
(301) 492-1152

Attachments:
1. Figure 1. Loviisa Unit-1 Erosion/Corrosion Areas
2. List of Recently Issued NRC Information Notices

FIGURE 1. LOVIISA UNIT-1 EROSION/CORROSION AREAS




| MATERIAL TYPE | MATERIAL COMPOSITION | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | C % | Mn % | Si % | S % | P % | Cr % | Ni % | Cu % |
| C 22 N | 0.18 | 0.50 | 0.32 | 0.022 | 0.012 | --- | --- | --- |
| St 45.8 | 0.20 | 0.89 | 0.26 | 0.018 | 0.029 | --- | --- | --- |
| CT 20 | 0.19 | 0.57 | 0.25 | 0.019 | 0.026 | 0.20 | 0.30 | 0.30 |

# LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

| Information Notice No. | Subject | Date of Issuance | Issued to |
|---|---|---|---|
| 90-25, Supp. 1 | Loss of Vital AC Power with Subsequent Reactor Coolant System Heat-Up | 03/11/91 | All holders of OLs or CPs for nuclear power reactors. |
| 91-17 | Fire Safety of Temporary Installations or Services | 03/11/91 | All holders of OLs or CPs for nuclear power reactors. |
| 91-16 | Unmonitored Release Pathways from Slightly Contaminated Recycle and Recirculation Water Systems at A Fuel Facility | 03/06/91 | All fuel cycle facilities. |
| 91-15 | Incorrect Configuration of Breaker Operating Springs in General Electric AK-Series Metal-Clad Circuit Breakers | 03/06/91 | All holders of OLs or CPs for nuclear power reactors. |
| 91-14 | Recent Safety-Related Incidents at Large Irradiators | 03/05/91 | All Nuclear Regulatory Commission (NRC) licensees authorized to possess and use sealed sources at large irradiators. |
| 91-13 | Inadequate Testing of Emergency Diesel Generators (EDGs) | 03/04/91 | All holders of OLs or CPs for nuclear power reactors. |
| 91-12 | Potential Loss of Net Positive Suction Head (NPSH) of Standby Liquid Control System Pumps | 02/15/91 | All holders of OLs or CPs for boiling water reactors (BWRs). |
| 91-11 | Inadequate Physical Separation and Electrical Isolation of Non-safety-related Circuits from Reactor Protection System Circuits | 02/20/91 | All holders of OLs or CPs for W-designed nuclear power reactors. |

OL = Operating License
CP = Construction Permit

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Original Signed by
Charles E. Rossi

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*SEE PREVIOUS CONCURRENCES

| | | | | |
|---|---|---|---|---|
| *AD/GPA:IP | D/DOEA:NRR | *C/OGCB:DOEA:NRR | *RPB:ADM | *C/OEAB:DOEA:NRR |
| HJFaulkner | CERossi | CHBerlinger | TechEd | AChaffee |
| 03/01/91 | 03/8/91 | 02/28/91 | 02/12/91 | 02/28/91 |
| *OGCB:DOEA:NRR | *EMCB:DET:NRR | *C/EMCB:DET:NRR | *D/DET:NRR | *OEAB:DOEA:NRR |
| JLBirmingham | SKoscielny | CYCheng | JRichardson | RWWoodruff |
| 02/12/91 | 02/26/91 | 02/27/91 | 02/25/91 | 02/13/91 |

DOCUMENT NAME: IN 91-18

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| 02///91 | 02/ /91 | 02/ /91 | 02/ /91 | 02/ /91 |