UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555-0001

December 11, 1997

NRC INFORMATION NOTICE 97-84: RUPTURE IN EXTRACTION STEAM PIPING AS A RESULT OF FLOW-ACCELERATED CORROSION

Addressees

All holders of operating licenses for nuclear power reactors except those who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to potential generic problems related to the occurrence and prediction of flow-accelerated corrosion (FAC) in extraction steam systems. 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 are not NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances

On April 21, 1997, Omaha Public Power District's Fort Calhoun Station, while operating at 100-percent power, experienced an approximate 0.56 m^2 [6 ft^2] rupture of a 30.5-centimeter [12-inch]-diameter sweep elbow (radius equal to five times the pipe diameter) in the fourth-stage extraction steam piping. The operator, upon hearing steam noise and observing steam rising from the turbine deck, believed that a steam line had broken and manually scrammed the reactor. As a precaution, emergency boration was initiated. The main turbine tripped automatically as a result of the reactor trip. The turbine trip had the effect of isolating the rupture. Plant systems and related parameters responded as expected during the event.

The steam line rupture damaged a nonsafety-related electrical load center in the vicinity of the pipe break. Additionally, collateral damage was experienced in several cable trays and pipe hangers, and insulation containing asbestos was blown throughout the turbine building. Certain portions of the fire protection system actuated in response to fusible links in the sprinkler heads melting because of high temperature. Because there were no personnel in the immediate vicinity of the rupture, no one was injured.

The fourth-stage extraction steam system emanates from the outlet of the high-pressure turbine and preheats the feedwater heaters. The design operating conditions in the piping are 2068 kilopascal gauge [300 psig] and 218°C [425°F], with a steam quality of approximately 92 percent. The piping is fabricated of A-106B carbon steel and has a nominal wall thickness of 0.953 centimeter [0.375 inch]. The licensee's root cause assessment attributed the failure to FAC in the extraction steam piping. Initial indications of degradation in the extraction steam line at the Fort Calhoun facility were first discovered in 1985, when the furthest upstream long-radius elbow (radius equal to one and a half times the pipe diameter) was replaced because of a pinhole leak. At that time the next upstream sweep elbow was also replaced.

Discussion

The fourth-stage extraction steam system had been recognized as a system that was susceptible to erosion and/or corrosion. It was, therefore, being monitored by the licensee's erosion and corrosion control program. Part of the licensee program was utilizing the CHECWORKS computer code to identify high-wear-rate areas to be selected for inspection.

The CHECWORKS model for the fourth-stage extraction steam piping predicted that long-radius elbows would wear at a higher rate than the sweep elbows when exposed to similar conditions. Using CHECWORKS predictions, the licensee inspected and replaced all four long-radius elbows, but the failed sweep elbow was never inspected.

Part of the licensee's corrective actions following the rupture included inspecting all sweep elbows that had not been previously inspected. The measured wall thickness (0.112 centimeter [0.044 inch]) of the furthest downstream sweep elbow in the fourth-stage extraction piping was also significantly below the minimum wall thickness (0.272 centimeter [0.107 inch]) specified by code requirements and had to be replaced. Additionally, another sweep elbow in the fourth-stage extraction piping was also replaced because the wear (measured wall thickness of 0.394 centimeter [0.155 inch]) was considered excessive, even though it was not below the minimum allowable thickness.

The CHECWORKS predictions of the wear in the fourth-stage extraction steam system were not consistent with the actual observed wear rates as measured on the components, that is, sweep elbows showed substantially greater wear than predicted.

Subsequent investigations by the licensee determined that the inconsistencies between predicted and actual wear were due to two factors. First, the "line correction factor" calculated by CHECWORKS for the fourth-stage extraction steamline was not within the acceptable range specified in the CHECWORKS users' manual. The line correction factor in CHECWORKS is used to adjust wear rate predictions in a given line to account for plant operating conditions that may vary with time. It is determined by comparing predicted wear to measured wear at locations in the line which have been inspected.

In order for the CHECWORKS predicted wear rate for a location to be valid, the line correction factor must be between 0.5 and 2.5. For the line containing the sweep elbow that failed, the wear rates calculated by CHECWORKS used a line correction factor that was outside this range. Therefore, as specified in the CHECWORKS users' manual, the predicted wear rates for this line were not valid.

Second, the line correction factor was biased and thus underpredicted the wear rates. In 1987, the licensee updated the parameters used by CHECWORKS to include the wear measured in a long-radius elbow. One of the inputs in CHECWORKS is the length of time the component has been in service. The licensee assumed that this elbow had been in service since initial operation of the plant in 1973; however, the elbow had been replaced in 1985. Therefore, the actual wear occurred over 2 years rather than the presumed 14 years. Thus, the period of time that was assumed for the wear to have occurred caused CHECWORKS to calculate a line correction factor that underestimated the wear rates for sites in the line.

This event revealed the importance of understanding the limitation of methodologies used in computer programs and of incorporating accurate plant-specific data from nondestructive examination programs.

Related Generic Communications

In NRC Bulletin 87-01, "Thinning of Pipe Walls in Nuclear Power Plants," July 9, 1987, the staff asked licensees and applicants to inform the NRC about their programs for monitoring the wall thickness of carbon steel piping (Accession No. 8707020018).

In NRC Generic Letter 89-08, "Erosion/Corrosion Induced Pipe Wall Thinning," May 2, 1989, the staff asked licensees and applicants to implement long-term erosion/corrosion monitoring programs (Accession No. 8905040276).

Additionally, the following NRC information notices (INs) provide information about similar events related to FAC:

IN 82-22, "Failures in Turbine Exhaust Lines," July 9, 1982 (Accession No. 8204210392).

IN 86-106, "Feedwater Line Break," December 16, 1986 (Accession No. 8612160250).

IN 87-36, "Significant Unexpected Erosion of Feedwater Lines," August 4, 1987 (Accession No. 8707290264).

IN 88-17, "Summary of Responses to NRC Bulletin 87-01, `Thinning of Pipe Walls in Nuclear Power Plants,'" April 22, 1988 (Accession No. 8804180039).

IN 89-53, "Rupture of Extraction Steam Line on High Pressure Turbine," June 13, 1989 (Accession No. 8906070273).

IN 91-18, "High Energy Pipe Failures Caused by Wall Thinning," March 12, 1991 (Accession No. 9103060153).

IN 91-18, Supplement 1, "High Energy Pipe Failures Caused by Wall Thinning," December 18, 1991 (Accession No. 9112120218).

IN 93-21, "Summary of NRC Staff Observations Compiled During Engineering Audits or Inspections of Licensee Erosion/Corrosion Programs," March 25, 1993 (Accession No. 9303190051).

IN 95-11, "Failure of Condensate Piping Because of Erosion/Corrosion at a Flow-Straightening Device," February 24, 1995 (Accession No. 9502210050).

This information notice requires no specific action or written response. However, recipients are reminded that they are required to consider industry-wide operating experience (including NRC information notices) where practical, when setting goals and performing periodic evaluations under Section 50.65, "Requirement for monitoring the effectiveness of maintenance at nuclear power plants," to Part 50 of Title 10 of the Code of Federal Regulations. If you have any questions about the information in this notice, please contact the technical contact listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

Jack W. Roe, Acting Director
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Office of Nuclear Reactor Regulation

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(817) 860-8144
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LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
95-49, Sup. 1	Seismic Adequacy of Thermo-Lag Panels	12/10/97	All holders of OLs for nuclear power reactors
97-83	Recent Events Involving Reactor Coolant System Inventory Control During Shutdown	12/05/97	All holders of OLs for pressurized-water reactors, except those licensees who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel
97-82	Inadvertent Control Room Halon Actuation Due to a Camera Flash	11/28/97	All holders of OLs for nuclear power reactors
97-81	Deficiencies in Failure Modes and Effects Analyses for Instrumentation and Control Systems	11/24/97	All holders of OLs for nuclear power reactors except those who have ceased operations and have certified that fuel has been permanently removed from the vessel
97-80	Licensee Technical Specifications Interpretations	11/21/97	All holders of OLs for nuclear power reactors

OL = Operating License
CP = Construction Permit

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DATE	9/23/97	9/23/97	9/23/97	11/21/97

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NAME	S. Richards	J. Roe
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