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

August 30, 1994

NRC INFORMATION NOTICE 94-62: OPERATIONAL EXPERIENCE ON STEAM GENERATOR TUBE LEAKS AND TUBE RUPTURES

Addressees

All holders of operating licenses or construction permits for pressurized water reactors.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to inform addressees of recent operational experience with steam generator tube leaks and tube ruptures. 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.

Background

The NRC staff reviewed events at pressurized-water reactors that involve tube leaks or tube ruptures and determined that those events provide significant operational experience regarding the handling of such events. A summary of the more significant events and the licensee actions taken in response to those events follows.

Description of Circumstances

Braidwood Unit 1

On October 23, 1993, at 5:45 a.m., operators at Braidwood Nuclear Station Unit 1, received indications of a primary-to-secondary coolant leak in the 1C steam generator. The indications included: (1) a 1C main steamline area radiation monitor alert alarm and (2) increases in other secondary-side radiation monitors such as the steam generator blowdown and the steam jet air ejector exhaust radiation monitors. At 6:45 a.m., chemistry samples also showed increases in secondary-side radionuclide activity levels. About 10:30 a.m., the leak rate was estimated to be about 863 liters [228 gallons] per day. At this time, the operations manager imposed an administrative leak rate limit of 1136 liters [300 gallons] per day. About 3:00 p.m., the leak rate was determined to be between 1060 and 1211 liters [280 and 320 gallons] per day and the licensee decided to shut down the reactor.

At 4:00 p.m., the licensee began shutting down the reactor at 5 percent per hour, 1 megawatt per minute. The main generator was taken off line at 10:52 a.m. the next day. A subsequent inspection found that the leak was

from a 3.3 centimeter [1.3 inch] long crack in a single tube located above the top tube support plate near an anti-vibration bar.

Palo Verde Unit 2

On March 14, 1993, at Palo Verde Nuclear Generating Station Unit 2, a tube in the No. 2 steam generator ruptured causing a primary-to-secondary leak of approximately 900 liters [240 gallons] per minute. Plant operators used the emergency operating procedures to diagnose and mitigate the event but twice failed to diagnose a tube rupture because the radiation monitors that would have led to that diagnosis were not in an alarm status when the applicable step in the procedure was reached. As a consequence, the operators did not isolate the affected steam generator until almost 3 hours after the rupture occurred. After the event, the licensee revised the procedures for diagnosing a tube rupture and reviewed the circumstances preceding the tube rupture.

Prior to the March 14, 1993, event, the licensee used several methods to estimate primary-to-secondary leakage. The most commonly used method was based on radionuclide activity in samples from the steam generator blowdown lines. On December 10, 1992, the manufacturer of the steam generators had informed the licensee that, because of feedwater "spillover" in the steam generator, the blowdown samples may be diluted by a factor of 5 to 10. However, the licensee did not change the primary-to-secondary leak rate procedures to reflect this information at that time. After the tube rupture, the licensee analyzed data from other radiation monitors and from chemistry samples to better determine the actual leak rates that preceded the rupture. Based on data from the condenser vacuum exhaust radiation monitor and a xenon-133 gas grab sample, the licensee determined that the leak rate for the faulted steam generator had spiked to approximately 400 liters [105 gallons] per day on March 4, gradually decreased, and stabilized at approximately 76 liters [20 gallons] per day two days later. The NRC staff reviewed the data and concluded that, by estimating the leak rate based on samples from the blowdown line, the licensee had significantly underestimated the leakage that occurred before the tube rupture (see NRC IN 93-56 and 94-43).

Arkansas Unit 2

On March 9, 1992, at 12:30 p.m., operators at Arkansas Nuclear One Unit 2 received an alarm from the condenser pump vacuum discharge radiation monitor indicating a primary-to-secondary leak. The leak was estimated to be about 1360 liters [360 gallons] per day; approximately half the limit in the technical specifications. The estimated leak rate was confirmed by three methods, argon and tritium sampling and the reactor coolant system inventory. At 7:00 p.m., about 6 hours after the leak was initially detected, the operators began to shut down the reactor and, at 8:21 p.m., the unit was taken offline [see NRC IN 92-80 and Licensee Event Report (LER) 92-002].

On the morning of January 16, 1992, operators at the McGuire Nuclear Station Unit 1 (McGuire) determined that the primary-to-secondary leak rate in steam generator 1D was 83 liters [22 gallons] per day. At approximately 4:00 p.m., the condenser air ejector and the steam generator blowdown radiation monitors indicated that a Trip 2 setpoint had been reached. That setpoint caused the

operators to take actions regarding the leakage and to increase the sampling frequency of the secondary coolant. Samples taken at 5:47 p.m. and 6:35 p.m. indicated that the leakage had increased to about 890 liters [235 gallons] per day. At 7:12 p.m., the licensee began a controlled shutdown of the reactor and Unit 1 was taken off line at 6:49 a.m. January 17, 1992. The licensee found that the leakage in steam generator 1D was coming primarily from a 2.5 centimeter [1 inch] axial crack in tube 47-46 with a lesser amount from a leaking sleeve-to-tube joint on tube 36-30. The leakage from these sources had increased from 83 liters [22 gallons] per day to about 890 liters [235 gallons] per day in less than 19 hours. McGuire Unit 1 has had additional sleeve-to-tube joint leaks since the above event (see NRC IN 94-05 and LER 92-01).

Indian Point Unit 3

On October 19, 1988, at Indian Point Unit 3, the primary-to-secondary leak rate increased rapidly from no indication of leakage to 7.6 liters [2 gallons] per minute in 2½ hours. This amount of leakage was about 7 times greater than the technical specification limit. The leakage was attributed to a crack found just above the uppermost tube support plate which extended about 250° around the tube circumference. After this event, the licensee made several improvements to the radiation monitoring equipment and the leak rate monitoring procedures (see NRC IN 88-99).

North Anna Unit 1

On July 15, 1987, at North Anna Power Station Unit 1, a tube in the C steam generator ruptured as a result of high cycle fatigue. Denting of the tube at the uppermost tube support plate was determined to be a contributing cause of the tube failure. Earlier, on July 14, the licensee had declared the steam jet air ejector exhaust radiation monitor to be inoperable because of erratic activity readings and had begun taking chemistry grab samples every 8 to 12 hours as required by the technical specifications. Therefore, the operators had no indication from the instrumentation normally used to quantify primary-to-secondary leakage. There were indications of increasing leakage from other radiation monitors but these were not used to quantify leakage and were set to alarm so as to ensure that technical specification release limits would not be exceeded. Consequently, the licensee was not fully aware of the increasing leakage until minutes before the tube ruptured.

A subsequent review by the licensee of data from the air ejector radiation monitor and from the chemistry grab samples showed that primary-to-secondary leakage was present and increasing for a significant period of time prior to the tube rupture. The licensee calculated that the mean estimated leak rate exceeded 380 liters [100 gallons] per day about 19 hours before the tube rupture and was greater than 1900 liters [500 gallons] per day about 6 hours before the tube rupture. The licensee took several actions to ensure that, in the future, similar precursor leakage would be detected and monitored so that the plant could be shut down before a gross tube rupture could occur. These actions included: (1) setting the air ejector monitor to alarm if a large step increase in estimated leakage occurs, (2) increasing the frequency of estimating primary-to-secondary leakage, and (3) installing N-16 radiation

monitors to alarm consistent with the air ejector monitor and also at two lower administrative levels to detect any initial crack propagation (see NRC Bulletin 88-02).

Discussion

For some of these events, the response of the operators to shut down the reactor and isolate the affected steam generator limited the contamination of the secondary coolant and may have avoided actual tube ruptures. In other events, delays in detecting excessive tube leakage or in shutting down the reactor and isolating the steam generator allowed increased contamination of secondary coolant and increased the potential for the tube leak to become a tube rupture. Other events show how quickly very low leak rates can increase well beyond technical specification limits.

Leak rate monitoring programs are important to minimizing the frequency of steam generator tube ruptures. The effectiveness of these programs depends, in part, on their ability to detect, quantify, trend, and respond to the primary-to-secondary leakage under various operating conditions. Leak rate monitoring programs are most effective when they provide, as close as possible, real time information on leak rates and changes in leak rates. At some sites, data from the air ejector radiation monitors is continuously displayed in the control room. At other sites, main steamline radiation monitors promptly detect increases in nitrogen-16 activity. When combined with appropriate alarm setpoints and operational limits, this information can quickly alert operators to implement response procedures to monitor increases in leak rates or to shut down the reactor and isolate the affected steam generator. Response procedures that provide clear guidance to operators regarding rapidly increasing leak rates and leakage limits are important in minimizing the potential for tube leaks to become tube ruptures. The NRC has issued several generic communications on primary-to-secondary leakage monitoring.

Related Generic Communications

- NRC Information Notice 94-43, "Determination of Primary-to-Secondary Steam Generator Leak Rate," June 10, 1994.
- NRC Information Notice 94-05, "Potential Failure of Steam Generator Tubes Sleeved With Kinetically Welded Sleeves," January 19, 1994.
- NRC Information Notice 93-56, "Weakness in Emergency Operating Procedures Found as Result of Steam Generator Tube Rupture," July 22, 1993.
- NRC Information Notice 93-52, "Draft NUREG-1477, 'Voltage-Based Interim Plugging Criteria for Steam Generator Tubes'," July 14, 1993.
- NRC Information Notice 92-80, "Operation With Steam Generator Tubes Seriously Degraded," December 7, 1992.

- NRC Information Notice 91-43, "Recent Incidents Involving Rapid Increases in Primary-to-Secondary Leak Rate," July 5, 1991.
- NRC Information Notice 90-49, "Stress Corrosion Cracking in PWR Steam Generator Tubes," August 6, 1990.
- NRC Information Notice 88-99, "Detection and Monitoring of Sudden and/or Rapidly Increasing Primary-to-Secondary Leakage," December 20, 1988.
- NRC Bulletin 88-02, "Rapidly Propagating Cracks In Steam Generator Tubes," February 5, 1988.

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.

C I Grimes

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

Technical contacts: Ted Sullivan, NRR
(301) 504-3266

Joseph Birmingham, NRR
(301) 504-2829

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List of Recently Issued NRC Information Notices

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LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
94-61	Corrosion of William Powell Gate Valve Disc Holders	08/25/94	All holders of OLs or CPs for nuclear power reactors.
94-60	Potential Overpressurization of Main Steam System	08/22/94	All holders of OLs or CPs for pressurized-water reactors.
94-30, Supp. 1	Leaking Shutdown Cooling Isolation Valves at Cooper Nuclear Station	08/19/94	All holders of OLs or CPs for nuclear power reactors.
94-59	Accelerated Dealloying of Cast Aluminum-Bronze Valves Caused by Microbiologically Induced Corrosion	08/17/94	All holders of OLs or CPs for nuclear power reactors.
94-58	Reactor Coolant Pump Lube Oil Fire	08/16/94	All holders of OLs or CPs for pressurized water reactors.
94-57	Debris in Containment and the Residual Heat Removal System	08/12/94	All holders of OLs or CPs for nuclear power reactors.
94-56	Inaccuracy of Safety Valve Set Pressure Determinations Using Assist Devices	08/11/94	All holders of OLs or CPs for nuclear power reactors.
94-55	Problems with Copes-Vulcan Pressurizer Power-Operated Relief Valves	08/04/94	All holders of OLs or CPs for nuclear power reactors.
91-79, Supp. 1	Deficiencies Found in Thermo-Lag Fire Barrier Installation	08/04/94	All holders of OLs or CPs for nuclear power reactors.

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OL = Operating License
CP = Construction Permit

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DATE	07/11/94	07/11/94	07/11/94	08/ /94

OFFICE	RPB:ADM	OGCB:DORS:NRR	AC/OGCB:DORS:NRR	D/DORS:NRR
NAME	RSanders*	JBirmingham*	ELDoolittle*	BKGrimes
DATE	01/31/94	08/11/94	08/15/94	08/ /94

OFFICIAL DOCUMENT NAME: 94-62.IN
A draft of this information notice was sent to the applicable Project Managers for their comment.

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