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

June 10, 1994

NRC INFORMATION NOTICE 94-43: DETERMINATION OF PRIMARY-TO-SECONDARY STEAM GENERATOR LEAK RATE

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 to alert licensees to problems that may exist in methods used to determine steam generator primary-to-secondary leak rates that could lead to the calculation of unconservative leak rates. 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

In July 1992, the licensee for Palo Verde Nuclear Generating Station Unit 2 (Palo Verde 2) noted a small steam generator tube leak by means of detectable levels of activity in the secondary system. By early February 1993, the licensee observed an increasing trend in steam generator blowdown radiation monitor activity.

On March 4, 1993, primary-to-secondary leakage in steam generator no. 2 increased rapidly. At the same time, there was a small increase of 275 to 345 kilopascal (kPa) [40 to 50 psi] in reactor coolant system pressure because of a charging pump surveillance test. Using samples of steam generator blowdown water analyzed for iodine-131 (I-131), the licensee estimated primary-to-secondary leak rates of approximately 38 liters per day (lpd) [10 gallons per day (gpd)]. Retrospective calculations based on readings from the condenser vacuum exhaust radiation monitor and a xenon-133 (Xe-133) gas grab sample, indicated that the leak rate had spiked to approximately 397 lpd (105 gpd), gradually decreased, and stabilized at approximately 76 lpd (20 gpd) two days later.

On March 14, 1993, while operating at 98-percent power, Palo Verde 2 experienced a steam generator tube rupture (SGTR) causing a primary-to-secondary leakage rate of approximately 908 liters per minute (lpm) [240 gallons per minute (gpm)]. Before the tube rupture event, the licensee had been measuring leak rates of approximately 15 to 38 lpd (4 to 10 gpd) in

Unit 2 steam generator no. 2 using samples from the blowdown line. An NRC augmented inspection team (AIT) was dispatched to the site to review the event. This event is further described in NRC Information Notice 93-56 dated July 22, 1993.

Before the SGTR event, the licensee had used several different methods to calculate primary-to-secondary leakage. The method the licensee used most often involved measuring radionuclide activity (usually I-131) in the steam generators using samples from the blowdown line. Station procedures did not specify which method to use or require a verification of the leak rate by performing a comparison.

On the basis of earlier tests, Combustion Engineering (CE) had concluded that the steam generator blowdown samples were diluted by a factor ranging from 5 to 10 by feedwater "spilling over" the center divider plate in the steam generator. CE sent this information to the licensee in a letter dated December 10, 1992. The CE letter stated that the downcomer samples were more representative of steam generator bulk water than the blowdown samples.

The NRC staff reviewed the accuracy of calculating primary-to-secondary leakage using samples from the blowdown line and concluded that this method was inaccurate and had caused the licensee to underestimate the actual leakage by as much as a factor of ten. The underestimation occurred because feedwater had diluted the steam generator blowdown samples.

Discussion

Failure to recognize the potential problems associated with the methods used to calculate primary-to-secondary leak rates can lead to unconservative estimates of the leak rate. Early indications of a primary-to-secondary leak can be obtained from several different locations, including the condenser off-gas radiation monitors, main steam line radiation monitors (particularly those sensitive to N-16), and chemistry samples from the secondary side of the steam generator. It is important to understand the limitations of any method used in order to take appropriate actions to mitigate the consequences of a tube leak or rupture.

The two most common methods for determining primary-to-secondary leak rates are (1) sampling the secondary side of the steam generator for iodine and (2) sampling feedwater for tritium. Limitations associated with these methods include hideout of the iodine within the steam generator, sample dilution by incoming feedwater, changes to blowdown rate, and unaccounted tritium losses in the secondary system. Hideout occurs when iodine from the primary coolant selectively concentrates in structures within the steam generator after the iodine transfers to the secondary coolant. In System 80 steam generators designed by CE, feedwater enters the steam generator on the cold-leg side and is prevented from contacting the hot-leg side by a center divider plate. However, the potential exists for feedwater to spill over the divider plate, enter the hot-leg blowdown line, and dilute the sample.

Using tritium to calculate primary-to-secondary leak rates involves a simple mass balance of tritium in the secondary plant. Difficulties arise when significant tritium loss mechanisms are either not accounted for or are not well understood. One of these mechanisms is the loss of tritium in water vapor through the condenser off-gas exhaust and leaking seals.

Additionally, methods of leak rate determination can lag significantly behind the actual leak rate or can vary during power transients due to hideout return. The lag time is due to the inherent time delay in the circulation of the water from the steam generator to the sample point.

Main steam line monitors designed for detecting N-16 are able to discriminate between N-16 and other radiation and respond relatively rapidly in real time to a steam generator tube leak. These monitors also have a continuous readout in the control room, making it possible to track and trend the monitor response.

Another method for detecting primary-to-secondary steam generator tube leakage is through the use of on-line condenser off-gas monitors. When such monitors are in service, they respond very rapidly to radiation from noble gases associated with primary-to-secondary steam generator leaks. The response of off-gas monitors can be continuously observed and their alarm setpoints can be set to quickly respond even for small leaks, allowing operators to respond to the alarm and take appropriate corrective actions. Samples of the condenser off-gas can be collected and subsequently analyzed to assist with leak rate calculations; krypton (Kr) and xenon (Xe) are generally used for this purpose. The common choice of isotope for this method is Xe-133. The accuracy of this method is generally unaffected by the limitations that affect the other methods.

On August 22, 1993, the operators at McGuire Nuclear Station Unit 1, shut down the unit based on the early indications of a primary-to-secondary leakage. While the plant was operating at full power, operators received radiation monitor alarms from steam line nitrogen-16 (N-16) detectors and the condenser air ejector radiation monitor. Chemistry samples confirmed primary-to-secondary leakage of 666 lpd (176 gpd) from steam generator A. Based on the licensee's administrative limit of 190 lpd (50 gpd) leakage in any steam generator, the licensee shut down the plant. Subsequent licensee testing revealed that there were eight tubes leaking with leak rates ranging from 7 lpd to 700 lpd (2 gpd to 185 gpd). The 700 lpd (185 gpd) leak was coming through the upper joint of a sleeved tube. This illustrates an appropriate use of indications from one method to detect and other methods to quantify a primary-to-secondary steam generator leak. NRC Information Notice (IN) 94-05, "Potential Failure of Steam Generator Tubes with Kinetically Welded Sleeves," provided further details on this event. IN 91-43, "Recent Incidents Involving Rapid Increases in Primary-to-Secondary Leak Rate," and IN 88-99, "Detection and Monitoring of Sudden and/or Rapidly Increasing Primary-to-Secondary Leakage," also discuss events where condenser air ejector monitors detected abnormal steam generator leakage.

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Information Notice No.	Subject	Date of Issuance	Issued to
94-42	Cracking in the Lower Region of the Core Shroud in Boiling-Water Reactors	06/07/94	All holders of OLs or CPs for boiling-water reactors (BWRs).
94-41	Problems with General Electric Type CR124 Overload Relay Ambient Compensation	06/07/94	All holders of OLs or CPs for nuclear power reactors.
94-40	Failure of a Rod Control Cluster Assembly to Fully Insert Following a Reactor Trip at Braidwood Unit 2	05/26/94	All holders of OLs or CPs for pressurized-water reactors (PWRs).
94-39	Identified Problems in Gamma Stereotactic Radiosurgery	05/31/94	All U.S. Nuclear Regulatory Commission Teletherapy Medical Licensees.
94-38	Results of a Special NRC Inspection at Dresden Nuclear Power Station Unit 1 Following a Rupture of Service Water Inside Containment	05/27/94	All holders of OLs or CPs for NPRs and all fuel cycle and materials licensees authorized to possess spent fuel.
94-37	Misadministration Caused by a Bent Interstitial Needle during Brachy-therapy Procedure	05/27/94	All U.S. Nuclear Regulatory Commission Medical Licensees authorized to use brachy-therapy sources in high-, medium-, and pulsed-dose-rate remote afterloaders.
94-36	Undetected Accumulation of Gas in Reactor Coolant System	05/24/94	All holders of OLs or CPs for nuclear power reactors.
91-81, Supp. 1	Switchyard Problems that Contribute to Loss of Offsite Power	05/19/94	All holders of OLs or CPs for nuclear power reactors.

OL = Operating License
CP = Construction Permit

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orig /s/'d by BKGrimes

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*SEE PREVIOUS CONCURRENCES

OFFICE	OEAB:DORS	SC:OEAB:DORS	PDIV-2:ADR4-5	PDII-4:ADR2	DRSS:RV
NAME	*TKoshy	*EGoodwin	*BHolian	*VNerses	*JReese
DATE	04/12/94	02/04/94	01/10/94	01/13/94	01/24/94

OGCB:DORS	PRPB:DRSS	C/OEAB:DORS	ADM/PUB	C/PRPB:DRSS	D/DRSS
*PCWen	*TEssig	*AChaffee	*Tech Ed	*LCunningham	*FCongel
02/04/94	01/13/94	02/10/94	02/24/94	03/15/94	03/22/94

AC/OGCB:DORS	C/EMCB:DE	D/DE	D/DORS
*AKugler	JStrosnider*	BSheron*	BKGrimes
04/14/94	05/14/94	05/24/94	06/7/94

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02/04/94	01/13/94	02/10/94	02/24/94	03/15/94	03/22/94

AC/OGCB:DORS	C/EMCB:DE	D/DE	D/DORS
*AKugler	JStrosnider	BSheron	BKGrimes
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OEAB:DORS *TKoshy 4/12/94	SC:OEAB:DORS *EGoodwin 02/04/94	PDIV-2:ADR4-5 *BHolian 01/10/94	PDII-4:ADR2 *VNerses 01/13/94	
DRSS:RV *JReese 01/24/94 Email	OGCB:DORS *PCWen 02/04/94	PRPB:DRSS *TEssig 01/13/94	C/OEAB:DORS *AChaffee 02/10/94	
ADM/PUB *Tech Ed 02/24/94	C/PRPB:DRSS *LCunningham 03/15/94	D/DRSS *FCongel 03/22/94	AC/OGCB:DORS AKugler 4/14/94	D/DORS BGrimes / /94

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OEAB:DORS *TKoshy 3/22/94	SC:OEAB:DORS *EGoodwin 02/04/94	PDIV-2:ADR4-5 *BHolian 01/10/94	PDII-4:ADR2 *VNerses 01/13/94	
DRSS:RV *JReese 01/24/94 Email	OGCB:DORS *PCWen 02/04/94	PRPB:DRSS *TEssig 01/13/94	C/OEAB:DORS *AChaffee 02/10/94	
ADM/PUB *Tech Ed 02/24/94	C/PRPB:DRSS *LCunningham 03/15/94	D/DRSS *FCongel 03/22/94	AC/OGCB:DORS AKugler / /94	D/DORS BGrimes / /94

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DRSS:RV *JReese 01/24/94 Email	OGCB:DORS *PCWen 02/04/94	PRPB:DRSS *TEssig 01/13/94	C/OEAB:DORS *AChaffee 02/10/94	
ADM/PUB *Tech Ed 02/24/94	C/PRPB:DRSS *LCunningham 3/15/94	D/DRSS *FCongel 3/22/94	AC/OGCB:DORS AKugler / /94	D/DORS BGrimes / /94

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OEAB:DORS *TKoshy 02/25/94	SC:OEAB:DORS EGoodwin 02/04/94	PDIV-2:ADR4-5 *BHolian 01/10/94	PDII-4:ADR2 *VNerses 01/13/94	
DRSS:RV *JReese 01/24/94 Email	OGCB:DORS *PCWen 02/04/94	PRPB:DRSS *TEssig 01/13/94	C/OEAB:DORS *AChaffee 02/10/94	
ADM/PUB *Tech Ed 02/24/94	C/PRPB:DRSS LCunningham 3/15/94	D/DRSS FCongel 3/22/94 3/17 #1	AC/OGCB:DORS AKugler / /94	D/DORS BGrimes / /94

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DRSS:RV *JReese 01/24/94 Email	OGCB:DORS *PCWen 02/04/94	PRPB:DRSS *TEssig 01/13/94	C/OEAB:DORS *AChaffee 02/10/94	
ADM/PUB Tech Ed RS 02/24/94	C/PRPB:DRSS LCunningham 02/ /94	D/DRSS FCongel 02/ /94	AC/OGCB:DORS AKugler 02/ /94	D/DORS BGrimes 02/ /94

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DRSS:RV *JReese 01/24/94 Email	OGCB:DORS *PCWen 02/04/94	PRPB:DRSS *TEssig 01/13/94	C/OEAB:DORS *AChaffee 02/10/94
AC/OGCB:DORS AKugler 02/ /94	D/DORS BGrimes 02/ /94		

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OEAB:DORS *TKoshy 02/7/94	SC:OEAB:DORS EGoodwin 02/04/94	PDIV-2:ADR4-5 *BHolian 01/10/94	PDII-4:ADR2 *VNerses 01/13/94
DRSS:RV *JReese 01/24/94 Email	OGCB:DORS *PCWen 02/ /94	PRPB:DRSS *TEssig 01/ /94	C/OEAB:DORS AChaffee 02/10/94
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OEAB:DORS	SC:OEAB:DORS	C:OEAB:DORS:NRR	C:OGCB:DORS	D:DORS:NRR
*TKoshy	FaEGoodwin	AChaffee	AKugler(Act.)	BGrimes
01/06/94	02/04/94	01/ /94	02/ /94	2/ /94
PDIV-2:NRR	PDII-4:NRR	Bc:DRSS:RV	OEAB:OGCB	PRPB:NRR
*BHolan	*VNerses	*JReese	PCWen PCW	*TEssig
01/10/94	01/13/94	01/24/94 Email	02/4/94	01/13/94

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A. Kugler (Acting)
Generic Comm

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*TKoshy	EGoodwin	AChaffee	BGrimes	
01/06/94	01/ /94	01/ /94	01/ /94	
PDIV-2:NRR	PDII-4:NRR	DRSS:RV	SRXB:NRR	PRPB:NRR
*BHolan	*VNerses	For JReese	RJones	TEssig
01/10/94	01/13/94	01/24/94 By E-Mail.	01/ /94	01/13/94

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TKoshy	EGoodwin	AChaffee	BGrimes	
1/6 /94	1/ /94	1/ /94	1/ /94	
PDIV-2:NRR	PDI-4:NRR	DRSS:RV	SRXB:NRR	PRPB:NRR
BHolian	VNerses	JReese	RJones	TEssig
1/10/94	1/13/94	1/ /94	1/ /94	1/ /94

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COMMENTS INCLUDED