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

July 22, 1993

NRC INFORMATION NOTICE 93-56: WEAKNESS IN EMERGENCY OPERATING PROCEDURES FOUND AS RESULT OF STEAM GENERATOR TUBE RUPTURE

Addressees

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

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to a weakness in emergency operating procedures (EOPs) found as a result of a steam generator tube rupture event. 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 March 14, 1993, Palo Verde Unit 2, was at 98 percent power and near the end of the operating cycle. Unit 2 is a two loop PWR designed by Combustion Engineering and has process radiation monitors located on the main steam lines, the steam generator blowdown lines and the condenser vacuum exhaust. At approximately 4:34 a.m., a tube in the No. 2 steam generator ruptured and began to release approximately 910 liters [240 gallons] per minute of primary coolant to the secondary side of the steam generator. About 10 minutes later, the operators manually tripped the reactor because of decreasing pressurizer level and pressure. The safety injection actuation system and the containment isolation actuation system automatically initiated. The indicated level for the pressurizer fell below zero percent but returned to approximately 4 percent as coolant was added by the charging pumps and the high pressure safety injection (HPSI) system. The shutoff head for the HPSI pumps is below normal operating pressure and indication of HPSI flow ceased when the reactor coolant system (RCS) pressure increased to approximately 12.96 MPa [1880 psia]. All safety systems functioned as required and all plant equipment needed to diagnose or mitigate the event was in service. Plant personnel later determined that the condenser exhaust radiation monitor was not within calibration tolerances.

Before the reactor trip, several conditions caused the control room operators to suspect that a tube rupture was in progress. One of these conditions was

an alarm for the radiation monitor on the main steam line for the No. 2 steam generator. The monitor was in alarm status from a time near the beginning of the event until shortly after the reactor was tripped. Apparently, the alarm was caused by nitrogen-16 in the primary coolant which had entered the steam generator. The alarm cleared a short time after the reactor trip because of the short half-life and decreased production of nitrogen-16.

After the reactor trip, the operators used the EOP diagnostic logic tree to diagnose and mitigate the event. However, the operators twice failed to diagnose a tube rupture because the radiation monitors that would have led to that diagnosis were not in alarm status when the applicable step in the logic tree was reached. As a result, the logic tree directed the operators to use the procedure for a reactor trip without complications to begin recovery actions. The operators could not enter that procedure because the pressurizer level was below 10 percent. Therefore, at 5:02 a.m., the control room supervisor directed the operators to begin the functional recovery procedure.

The first EOP steps to mitigate the event were taken when the long-term actions in the functional recovery procedure directed the operators to begin plant cooldown and depressurization. Reducing RCS pressure below the HPSI shutoff head allowed pressurizer level to be restored. With the pressurizer level above 33 percent, all of the functional recovery procedure exit conditions were met and the procedure was exited at 6:24 a.m. The control room supervisor then directed the operators to reperform the steps in the diagnostic logic tree. The logic tree now directed that the optimal recovery procedure for a tube rupture should be used because the steam generator blowdown and condenser exhaust process radiation monitors were in alarm status. Following this procedure, the operators isolated the steam generator with the tube rupture at 7:28 a.m. (2 hours and 53 minutes after the rupture had occurred). The operators then took the plant to cold shutdown.

Discussion

Licensee review of the EOPs and the process radiation monitor setpoints found that the logic tree would not identify a tube rupture unless activity in the RCS was very high. Three aspects of the EOPs contributed to this problem (1) the logic tree used alarms from the process radiation monitors to identify a tube rupture, (2) the logic tree decision points were made using a "snapshot" of plant conditions that existed as each step was read (parameter trending and past abnormal conditions were not considered), and (3) the steps that evaluated radiation monitor status were not continuously applicable. The process radiation monitors used in the logic tree for identifying a tube rupture were:

- Steam Generator Blowdown Radiation Monitors The alarm for these monitors was set based on the activity level in the steam generators and should have detected a tube rupture within several minutes. However, these monitors had been isolated by the containment isolation signal when the applicable step in the logic tree was read. Apparently, the blowdown monitor for the steam generator with the tube rupture did not alarm before the reactor trip because the tube rupture occurred at a high

location in the steam generator. However, even if this monitor had alarmed before the reactor trip, the alarm may not have been considered because of the "snapshot" method used to perform the EOPs.

- Main Steam Line Radiation Monitors. The alarm point for these monitors was set at approximately three times background activity. Although the monitor for steam generator No. 2 did alarm before the reactor trip, the alarm cleared shortly after the reactor was tripped and the monitor was not in alarm status when the applicable step was read. The alarm that occurred before the reactor trip was not considered because of the "snapshot" method used to perform the EOPs.

- Condenser Exhaust Radiation Monitor The alarm point for this monitor was set at a projected site boundary dose rate of 5.0 milliSievert (mSv) [500 millirem] per hour rather than on the activity levels in the primary and secondary coolant. Because of this setting, the monitor would not have provided reliable and timely indication of a tube rupture. This monitor did not alarm until about 1 hour after the rupture occurred. Later, the licensee found that this monitor was not within calibration tolerances and was reading 1/4 to 1/6 of actual condenser exhaust activity. The licensee calculated that if the monitor had been in calibration it would have alarmed about 20 minutes after the rupture occurred.

An NRC Augmented Inspection Team (AIT) reviewed the event and determined that the lack of a continuous action step in the EOPs to evaluate whether a process radiation monitor had alarmed was a significant contributor to the delay in isolating the faulted steam generator. When the operators performed the step in the functional recovery procedure that would have led them to diagnose a tube rupture, the process radiation monitors were not in alarm. This occurred because (1) the radiation monitors on the steam generator blowdown lines were isolated by the containment isolation signal, (2) the radiation monitor on the steam line for steam generator No. 2 was no longer in alarm, and (3) the radiation monitor on the condenser exhaust was not in alarm because, in part, it was set to alarm based on a projected site boundary dose rate rather than on the activity levels in the primary and secondary coolant. Therefore, the procedure did not direct the operators to follow the guidance in that procedure to mitigate a tube rupture.

Approximately 5 minutes after the operators performed the step in the procedure that assessed the status of process radiation monitor alarms, two independent monitors alarmed. Those alarms would have led the operators to implement the tube rupture recovery guidance in the procedure but the EOPs did not allow the operators to repeat steps in the procedure after the steps had been completed. The training that the operators received for implementing the EOPs promoted strict procedural compliance and reinforced their decision not to repeat the step that evaluated for a tube rupture because it was not continuously applicable. Also, the EOPs did not allow the operators to rediagnose an event after the operators had entered a functional recovery procedure until all of the exit conditions for that procedure were met.

The AIT reviewed the operator training for implementing the EOPs relative to a tube rupture and, in general, found the training to be adequate. However, the AIT found that the simulator scenarios for a tube rupture have at least one radiation monitor in alarm status as indication of a tube rupture. The AIT considered that the operators had learned to expect a radiation monitor to alarm to indicate a tube rupture.

In summary, the diagnostic logic tree was based on the incorrect assumption that a tube rupture would always result in one or more process radiation monitors alarming. This assumption may be applicable as well to the detection of small-break or inter-system loss-of-coolant accidents because the logic tree uses process radiation monitor alarms as the basis to diagnose those occurrences. The licensee is evaluating whether this logic is used in the diagnostic logic tree for diagnosing other events.

The AIT reviewed the licensee EOP development process and found another contributor to the failure of the EOPs to identify a tube rupture in a timely manner. The owners group generic emergency procedure guidelines (EPGs) states that "activity in the steam plant" should be used as a basis for diagnosing a tube rupture. The licensee implemented this guidance and based the EOPs for diagnosing a tube rupture on process radiation monitor alarms in the steam plant but did not fully evaluate the bases of the alarm setpoints. The licensee documented that this implementation did not deviate from the EPGs. When the reactor vendor reviewed the licensee EOP to EPG deviation documentation, the vendor also did not identify this as a deviation. Regarding the use of radiation monitor alarms to diagnose a tube rupture, the licensee has revised the "snapshot" methodology and is considering changes to procedures and hardware to correct problems in implementing the EOPs.

NRC Information Notice (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," specifically discussed the use of radiation monitors to detect abnormal plant events. In these information notices the NRC discussed several incidents, both foreign and domestic, of rapid increases in primary-to-secondary leak rates. The NRC also discussed the fact that data from air ejection radiation monitors and nitrogen-16 monitors can aid in the early detection and response for such increases and help minimize the number of actual steam generator tube ruptures.

This information notice requires no specific action or written response. 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.

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

Technical contact: Dennis Kirsch, RV
(510) 975-0290

Attachment:
List of Recently Issued NRC Information Notices

LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
93-55	Potential Problem with Main Steamline Break Analysis for Main Steam Vaults/Tunnels	07/21/93	All holders of OLs or CPs for pressurized water reactors.
93-54	Motor-Operated Valve Actuator Thrust Variations Measured with A Torque Thrust Cell and A Strain Gage	07/20/93	All holders of OLs or CPs for nuclear power reactors.
93-53	Effect of Hurricane Andrew on Turkey Point Nuclear Generating Station and Lessons Learned	07/20/93	All holders of OLs or CPs for nuclear power reactors.
93-52	Draft NUREG-1477, "Voltage-Based Interim Plugging Criteria for Steam Generator Tubes"	07/14/93	All holders of OLs or CPs for pressurized water reactor (PWRs).
93-51	Repetitive Overspeed Tripping of Turbine-Driven Auxiliary Feed-water Pumps	07/09/93	All holders of OLs or CPs for nuclear power reactors.
93-50	Extended Storage of Sealed Sources	07/08/93	All licensees authorized to possess sealed sources.
93-49	Improper Integration of Software into Operating Practices	07/08/93	All holders of OLs or CPs for nuclear power reactors.
93-48	Failure of Turbine-Driven Main Feedwater Pump to Trip Because of Contaminated Oil	7/6/93	All holders of OLs or CPs for nuclear power reactors.

OL = Operating License
CP = Construction Permit

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05/13/93	06/10/93	06/14/93	06/17/93	07/16/93

DRSP:RV	C/RPB:RV
HWong*	CVanDenburgh*
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DOC NAME: 93-56.IN

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G. Galletti

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