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

March 22, 1995

NRC INFORMATION NOTICE 95-20: FAILURES IN ROSEMOUNT PRESSURE TRANSMITTERS DUE TO HYDROGEN PERMEATION INTO THE SENSOR CELL

Addressees

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

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to a potential failure mode in Rosemount Nuclear Instruments, Incorporated, Model 1152, 1153 and 1154 pressure transmitters due to hydrogen gas permeation through the isolating diaphragm exposed to process fluid. It is expected that recipients will review the information for applicability to their facilities. However, suggestions contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances

On November 22, 1994, St. Lucie Unit 1 was in a cold shutdown condition and in the process of filling and venting the reactor coolant system (RCS). With RCS pressure at 0.45 MPa [50 psig] and RCS temperature at approximately 38 °C [100 °F], a safety injection actuation was initiated when two of the four pressurizer pressure channels generated high pressure signals. When the output from the two transmitters exceeded 11.91 MPa [1712 psig], the manual safety injection block, which had been established during cooldown, cleared. With the safety injection block cleared, and the two properly functioning pressurizer pressure transmitters indicating 0.45 MPa [50 psig], the safety injection actuation logic was satisfied and a safety injection was initiated.

It was determined that the two pressurizer pressure channels indicated high pressure because of an erroneous high output from the pressure transmitters. These transmitters are Rosemount Model 1153 gauge pressure transmitters that had been sent back to Rosemount for refurbishment because they were susceptible to sensor cell oil leakage as discussed in NRC Information Notice 89-42, "Failure of Rosemount Models 1153 and 1154 Transmitters," NRC Bulletin 90-01 "Loss of Fill Oil in Transmitters Manufactured by Rosemount," and NRC Bulletin 90-01, Supplement 1. The failed transmitters had been in service at St. Lucie since April 1993 (about one cycle) with no apparent symptoms.

A review of recorded pressurizer pressure channel signals indicated that the failures involved a gradual increase in transmitter output over an approximate 5 minute period, culminating in an output plateau near the upper end of the transmitter range. The two failures occurred approximately 10 minutes apart. Transmitter outputs remained high following the event. Loop calibrations were subsequently performed, and both transmitters showed extremely slow response. The transmitters were subsequently replaced and preserved for analysis. A third pressure transmitter on the pressurizer that had been refurbished in the same manner and time frame did not fail.

Discussions between licensee and Rosemount personnel indicated that the failure mode encountered at St. Lucie was not typical of oil loss as discussed in the NRC generic communications cited above. A preliminary inspection of the transmitter sensing modules confirmed that no oil loss had occurred. However, the high pressure side isolating diaphragm of the sensor cell of each failed transmitter was bulged. Rosemount stated that the failure modes were indicative of gas entrapment in the sensor cell. A detailed discussion of the failure is given in a Part 21 notification by Rosemount dated March 21, 1995, (Accession No. 9503220185).

Discussion

The failed transmitters were sent to the Southwest Research Institute laboratory for analysis of gases trapped in the sensor cells. The laboratory extracted the gas from one transmitter sensor cell and determined that it was hydrogen. No corrosion, galvanic action, water leakage or oil breakdown was observable. Gamma back scatter examination was performed to determine the composition of the isolating diaphragm material. This examination indicated that the material of the diaphragms was Monel metal instead of the Type-316 stainless steel specified for safety-related Model 1152, 1153 and 1154 transmitters in this application. Monel metal is a corrosion-resistant alloy of primarily nickel and copper which may be used in transmitters of this type for some plant applications. Monel is known to be permeable to monatomic hydrogen.

Monatomic hydrogen may be generated by a galvanic cell reaction between Monel and stainless steel, and this may enhance the permeation of hydrogen from the system through the diaphragm. Rosemount has postulated that over a period of months at power, monatomic hydrogen permeated or diffused through the Monel isolating diaphragms where it went into solution in the sensor cell fill oil. As some of the hydrogen recombined into diatomic hydrogen (chemical symbol "H_2" - the usual form of hydrogen gas), it became trapped because the isolating diaphragm, being relatively impermeable to H_2, retained it. Rosemount postulated that during constant pressure operation, a sensor with H_2 under the isolator diaphragm may not exhibit symptoms or erroneous output as the H_2 may be completely dissolved in the silicone oil.

This was apparently the case with the two confirmed failures on November 22, 1994, described above at St. Lucie Unit 1. The transmitters reportedly operated normally during the 16 month period prior to the plant outage. The monatomic hydrogen permeating the isolator during this time had no apparent affect on the transmitter operation. However, the precipitating sequence of events leading to the apparent sudden noticeable failure (as opposed to gradual, but detectable, degradation) involved (1) plant depressurization which allowed the entrapped H_2 to come out of solution and form a partial pressure within the sensor cell oil volume which may have caused some deformation of the relatively flexible isolating diaphragms, followed by (2) a partial re-pressurization. The repressurization may have caused the fill oil, which is the capacitor dielectric within the sensor, to be replaced partially with hydrogen gas. This would lead to an increase in the output signal. In addition, repressurization may have caused a deflection of the center diaphragm within the sensor, also contributing to the increase in output.

Based on the St. Lucie Unit 1 experience, conditions most likely to result in adverse transmitter failure consequences would be those involving a primary system depressurization followed by a partial or full repressurization. Such sequences would include steam line relief valve openings or breaks, loss-of-coolant accidents, and steam generator overfeeding events. In these cases, the transmitter should function normally during the initial depressurization. For pressurized water reactors it is likely that a safety injection actuation signal would be generated if primary system pressure went below the low pressure actuation setpoint. During any subsequent repressurization, multiple transmitter failures could lead to erroneously high pressure signals which could disable interlocks, disable any automatic reinitiation of safety injection if required, and could lead to opening of power-operated relief valves. In addition, under these conditions the operator could be presented with conflicting information on the reactor coolant system pressure, including, for a loss of coolant accident, some information indicating the primary system was subcooled and other information indicating a saturated primary system.

For boiling water reactors, failed transmitters could result in opening of the primary system relief valves and result in system blowdown. Failure of the pressure transmitters could also block automatic injection. While pump start signals would not be affected (low level in the reactor pressure vessel or high pressure in the drywell) low pressure injection could be precluded by closed injection valves. This is because low pressure emergency core cooling system logic typically includes a permissive which requires indication of low reactor pressure prior to opening the injection valves. In such a case, operators would need to bypass the permissive and open the injection valves from the control room. A similar scenario was discussed in IN 93-89.

Rosemount has made a preliminary determination that about 270 Model 1152, 1153 and 1154 safety-related transmitters constitute the suspect group. Rosemount has identified most of these by serial number and is in the process of informing affected utilities (see Attachment 1). The suspect lot is believed at this time to be limited to those units manufactured (or refurbished)

by Rosemount after September 1989 and is also limited to the higher pressure transmitters of pressure range codes 6, 7, 8, 9, and 0. The failures at St. Lucie occurred in range code 9 transmitters. Differential pressure transmitters, as well as both absolute and gauge-type pressure transmitters could be affected.

Measures such as alerting and briefing operators, conducting special training sessions and running event scenarios on simulators may help in responding to a pressure transmitter failure.

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.

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

Technical contacts: S.V. Athavale, NRR
(301)415-2974

Mark S. Miller, RII
(407) 464-7822

Stephen Alexander, NRR
(301) 415-2995

Jerry L. Mauck, NRR
(301) 415-3248

Attachments:
1. List of Rosemount Transmitters with Monel instead of Type 316 stainless steel diaphragms.
2. List of Recently Issued NRC Information Notices

Attachments Filed in Jacket

ORGANIZATIONS IN THE U.S. TO WHOM ROSEMOUNT REPORTED SENDING TRANSMITTERS OR SENSOR MODULES WITH MONEL ISOLATORS

Customer

Arizona Public Service
Baltimore Gas & Electric
Bechtel
Boston Edison
Carolina Power & Light
Commonwealth Edison
Consumers Power
Duke Power
Duquesne Light Company
Ellis & Watts
Florida Power Corp.
Florida Power & Light
Georgia Power
GPU
Gulf States Utilities
Houston Lighting & Power
Illinois Power
Maine Yankee Atomic Power Company
New Hampshire Yankee, Inc.
New York Power Authority
Niagara Mohawk Power Corp.
Northern States Power
Omaha Public Power District
Pacific Gas & Electric
Pennsylvania Power & Light
Philadelphia Electric Company
Portland GE
Public Service Electric & Gas
South Carolina Electric & Gas
Southern Cal. Edison
Systems Energy
Toledo Edison
TU Electric
TVA
Vermont Yankee
Virginia Power
Washington Public Power Supply System
Westinghouse
Wolf Creek NOC
Yankee Atomic

LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
95-19	Failure of Reactor Trip Breaker to Open Because of Cutoff Switch Material Lodged in the Trip Latch Mechanism	03/22/95	All holders of OLs or CPs for nuclear power reactors.
95-18	Potential Pressure-Locking of Safety-Related Power-Operated Gate Valves	03/15/95	All holders of OLs or CPs for nuclear power reactors.
95-17	Reactor Vessel Top Guide and Core Plate Cracking	03/10/95	All holders of OLs or CPs
95-16	Vibration Caused by Increased Recirculation Flow in a Boiling Water Reactor	03/09/95	All holders of OLs or CPs for boiling water reactors.
95-15	Inadequate Logic Testing of Safety-Related Circuits	03/07/95	All holders of OLs or CPs for nuclear power reactors.
95-14	Susceptibility of Containment Sump Recirculation Gate Valves to Pressure Locking	02/28/95	All holders of OLs or CPs for nuclear power reactors.
95-13	Potential for Data Collection Equipment to Affect Protection System Performance	02/24/95	All holders of OLs or CPs for nuclear power reactors.
95-12	Potentially Nonconforming Fasteners Supplied by A&G Engineering II, Inc.	02/21/95	All holders of OLs or CPs for nuclear power reactors.
95-11	Failure of Condensate Piping Because of Erosion/ Corrosion at a Flow-Straightening Device	02/24/95	All holders of OLs or CPs for nuclear power reactors.

OL = Operating License
CP = Construction Permit

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Measures such as alerting and briefing operators, conducting special training sessions and running event scenarios on simulators may help in responding to a pressure transmitter failure.

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Attachments:
1. List of Rosemount Transmitters with Monel instead of Type 316 stainless steel diaphragms.
2. List of Recently Issued NRC Information Notices

DOCUMENT NAME: 95-20.IN
*See previous concurrence.
C/HCIB:NRR
JMauck*
03/22/95

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NAME	SVAthavale*		SAlexander*		RMGallo*		RCJones*		JSWermiel*	
DATE	03/22/95		03/22/95		03/22/95		03/22/95		03/22/95	

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DATE	03/22/95		03/22/95		03/22/95		03/22/95		03/22/95	

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Measures such as alerting and briefing operators, conducting special training sessions and running event scenarios on simulators may help in identifying the existence of the above described pressure transmitter failure mode.

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DOCUMENT NAME: 95-20.IN

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NAME	SVAthavale		SAlexander		RMGallo		RCJones		SJShermel	
DATE	03/22/95		03/ /95		03/ /95		03/ /95		03/ /95	

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via eMail

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

Technical Contact: Hans Ashar, NRR
(301) 415-2851

Attachment:
List of Recently Issued NRC Information Notices

*See previous concurrence DOCUMENT NAME: G:\ASHAR\TLGINFON.HGA
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DATE	02/27/95*		03/03/95*		03/07/95*		03/13/95*		03/15/95*		/ /95	

TECH ED	OECB/DOPS		OECB/DOPS		OECB/DOPS		C:OECB/DOPS		D:DOPS/NRR	
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(7)

From: Robert C Jones (RCJ)
To: WN4:DCK1
Date: Wednesday, March 22, 1995 7:23 am
Subject: ROSEMONT PRESSURE TRANSMITTER FAILURE IN

The revised IN is acceptable to SRXB. You can use this E-Mail as a record of my concurrence.

From: Bruce A Boger (BAB2)
To: WN4:DCK1
Date: Wednesday, March 22, 1995 7:23 am
Subject: ROSEMONT PRESSURE TRANSMITTER FAILURE IN

You have my concurrence on the IN.

From: Robert M. Gallo (RMG)
To: WN4:DCK1
Date: Wednesday, March 22, 1995 8:18 am
Subject: ROSEMONT PRESSURE TRANSMITTER FAILURE IN

GALLO CONCURS, NOTING THE COMMENT FROM STEVE ALEXANDER ABOUT 95-21 VICE 95-20 ON PAGE 2 OF THE IN.

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