

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

Jim McKnight
P1-39

May 24, 1994

NRC INFORMATION NOTICE 94-36: UNDETECTED ACCUMULATION OF GAS IN REACTOR COOLANT SYSTEM

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 problems that could result from unrecognized evolution and accumulation of gas in reactor coolant system high points. It is expected that recipients will review this 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

Sequoyah Unit 1 had been shut down in March 1993. In early September 1993, after the unit had been refueled, the reactor vessel was reassembled and the reactor coolant system was degassed, filled, and vented. The reactor coolant system was then depressurized to atmospheric pressure. One pressurizer power-operated relief valve (PORV) was open and the reactor coolant system average temperature was being maintained at approximately 49°C [120°F]. Nitrogen cover gas was being supplied to the volume control tank at approximately 239 kPa [20 psig] and reactor coolant was being circulated by the charging system and the residual heat removal (RHR) system. The reactor vessel level indication system (RVLIS) was functional for a significant portion of the event. Before this event, instrument maintenance stickers were placed on the RVLIS indicators for other maintenance work. Although the RVLIS information was available, the operators were not monitoring this information because it was not procedurally required to be used in shutdown modes of operation. Reactor coolant system inventory was being monitored using pressurizer cold calibration level indications.

On December 17, 1993, the operators began to pressurize the containment to 191 kPa [13 psig] in order to perform a containment integrated leak rate test. As containment pressure increased, the operators noticed a decrease in pressurizer water level and, over a period of time, added approximately 31,400 liters [8,300 gallons] of water to maintain the pressurizer level. Licensee personnel evaluated this situation and recognized that gas was accumulating in the reactor coolant system. However, they failed to recognize the magnitude

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or cause of the problem. Three days later, as the containment was being depressurized upon completion of the containment leak test, the operators noted that approximately the same amount of water had to be removed from the reactor coolant system to maintain the level. On December 21, 1993, on the basis of operators' observations of the changing coolant system inventory during the containment leak test, the reactor vessel head was vented. It was subsequently vented several times to maintain appropriate reactor vessel inventory based on RVLIS information. The reactor vessel gas voiding conditions went undetected from early September 1993, when the reactor coolant system was verified to be filled, until December 21, 1993, when the reactor head was vented.

The gas evolution resulted from the temperature in the volume control tank being much lower than that normally expected. (This lower temperature was due to unusually low component cooling water temperatures and to a maintenance problem with a cooling water valve that resulted in the reduction of the heat sink temperature in the letdown heat exchanger.) The lower temperatures increased the solubility of gas in the volume control tank water so that more gas was dissolved in the water. This gas evolved when the water was transferred to the reactor coolant system by the charging system and heated up in the reactor vessel.

Further details concerning this event are in NRC Inspection Report No. 50-327; 50-328/94-04.

Discussion

The licensee completed a final evaluation in January 1994 and determined that during this event the reactor vessel water level had decreased to slightly below the top of the hot leg, and that the steam generator tubes were nearly empty. The reactor coolant system inventory was being monitored solely on the basis of pressurizer level, which was not indicative of the reactor vessel and steam generator levels. Calculations by the licensee indicated that an equilibrium had been reached during the event so that the water level was approximately 1.6 meters [5.25 feet] above the top of the core. Any additional gas evolved in the reactor vessel would be expected to be vented through the hot leg and surge line to the pressurizer and out through the open pressurizer PORV.

The reactor water level at which equilibrium was established at Sequoyah was sufficiently high so as not to interfere with reactor coolant flow through the RHR cooling system. However, at other plants, the equilibrium level, which is related to pressurizer surge line geometry and RHR suction line location, might be such that a similar event could interfere with shutdown cooling.

Another potential safety concern is related to the capability of the steam generators to transfer heat from the reactor coolant to secondary coolant. In the equilibrium condition at Sequoyah, the steam generator tubes were almost empty during at least a portion of the duration of this event. During this

period, the steam generators were assumed to be available as an alternate means for shutdown cooling. It is not clear that cooling through the steam generators could have been established, if needed, especially because the plant operators were unaware that the tubes were empty.

Several factors involving licensee performance contributed to the delay in the identification and evaluation of this event. They included (1) lack of consideration on the part of licensee personnel with respect to compression of gas in the system caused by containment pressure transmitted to the reactor coolant system water through the open pressurizer PORV; (2) misunderstanding by the operators about the operability of RVLIS; (3) failure to stop the containment leak test when water level changes were first noted so that the situation could have been adequately evaluated; (4) an apparent lack of thorough evaluation of previously published information on similar events.

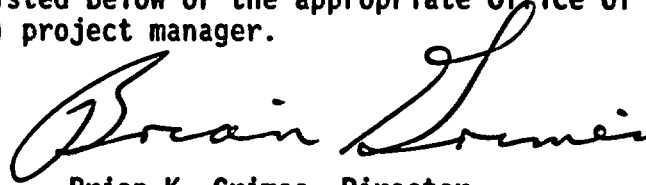
The event discussed in this information notice highlights the potential for gas evolution and accumulation in the reactor coolant system in locations and quantities that may not be evident to operators. Changes in temperature and pressure can have significant effects on the solubility of gas in water, especially at or near atmospheric pressure conditions. During cold shutdown, this phenomenon can permit significant quantities of cover gas to be dissolved in lower-temperature, higher-pressure volumes such as the volume control tank and to evolve into a large gas bubble in the reactor vessel (a lower-pressure, higher-temperature area). This phenomenon can occur without a sudden change in pressurizer level, which is the indicator normally used by the operators to monitor water inventory. Use of available instrumentation in shutdown modes to monitor reactor vessel water level can provide detection of unexpected system conditions when reduced vessel inventory is not planned as well as in reduced inventory evolutions.

On April 12, 1994, a similar gas accumulation event was identified at the Salem Generating Station (Unit 1) shortly after it entered Mode 5 (cold shutdown) operation. Although this occurrence did not involve amounts of gas accumulation as large as in the Sequoyah event, many similarities existed regarding both the process of gas formation and the lack of operator awareness of the abnormal condition. In both events, reactor vessel level information was or could have been made available for prompt identification of the problem.

Related Generic Communications

- NRC Information Notice 93-12, "Off-Gassing in Auxiliary Feedwater System Raw Water Sources," discusses similar solubility considerations related to air pockets in piping at the McGuire Nuclear Station.
- NRC Information Notice 87-46, "Undetected Loss of Reactor Coolant," discusses undetected loss of reactor coolant inventory at North Anna Unit 1 resulting from inadequate use of available indications and failure to perform mass inventory balances.

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 Operating Reactor Support
Office of Nuclear Reactor Regulation

Technical contacts: R. Benedict, NRR
(301) 504-1157

S. M. Shaeffer, RII
(615) 842-8001

Attachment:
List of Recently Issued NRC Information Notices

LIST OF RECENTLY ISSUED
 NRC INFORMATION NOTICES

| Information Notice No. | Subject | Date of Issuance | Issued to |
|------------------------|--|------------------|---|
| 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. |
| 94-35 | NIOSH Respirator User Notices, "Inadvertent Separation of the Mask-Mounted Regulator (MMR) from the Facepiece on the Mine Safety Appliances (MSA) Company MMR Self-Contained Breathing Apparatus (SCBA) and Status Update" | 05/16/94 | All holders of OLs or CPs for nuclear power reactors, and all licensed fuel facilities. |
| 94-34 | Thermo-Lag 330-660 Flexi-Blanket Ampacity Derating Concerns | 05/13/94 | All holders of OLs or CPs for nuclear power reactors. |
| 94-33 | Capacitor Failures in Westinghouse Eagle 21 Plant Protection Systems | 05/09/94 | All holders of OLs or CPs for nuclear power reactors. |
| 93-53, Supp. 1 | Effect of Hurricane Andrew on Turkey Point Nuclear Generating Station and Lessons Learned | 04/29/94 | All holders of OLs or CPs for nuclear power reactors. |
| 94-32 | Revised Seismic Hazard Estimates | 04/29/94 | All holders of OLs or CPs for nuclear power reactors. |
| 94-31 | Potential Failure of Wilco, Lexan-Type HN-4-L Fire Hose Nozzles | 04/14/94 | All holders of OLs or CPs for nuclear power reactors. |
| 90-68, Supp. 1 | Stress Corrosion Cracking of Reactor Coolant Pump Bolts | 04/14/94 | All holders of OL or CPs for pressurized water reactors. |
| 94-30 | Leaking Shutdown Cooling Isolation Valves at Cooper Nuclear Station | 04/12/94 | All holders of OLs or CPs for nuclear power reactors. |

OL = Operating License
 CP = Construction Permit

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| OFFICE | *OEAB:DORS | *DRP:RII | *OGCB:DORS | *SC/DRP:RII | *TECH ED |
| NAME | RBenedict | SMShaeffer | PCWen | MLesser | MFMejac |
| DATE | 05/04/94 | 05/05/94 | 05/05/94 | 05/05/94 | 05/05/94 |

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|---------------|-----------|--------------|---------------|--------------------|
| *AC/SRXB:DSSA | *AD/DSSA | *C/OEAB:DORS | *AC/OGCB:DORS | D/DORS |
| TECollins | MVirgilio | AChaffee | AJKugler | BKGrimes <i>gl</i> |
| 05/06/94 | 05/09/94 | 05/09/94 | 05/12/94 | / /94 |

DOCUMENT NAME: SEQGASIN.RV1

NOTE: The PMs for Sequoyah (D. LaBarge) and Salem (J. Stone) have been informed of the development of this information notice and they have reviewed the draft information notice.

Peter Wen, 5/10/94

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|------------------------|-------------------------|--------------|---------------|----------|
| TECollins <i>BE 21</i> | MVirgilio <i>BE 33?</i> | AChaffee | AJKugler | BKGrimes |
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| NAME | RBenedict | for SMShaeffer | PCWen | for MLesser | for MFMejac |
| DATE | 5/4/94 | 5/5/94 | 5/5/94 | 5/5/94 | 5/5/94 |
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| TECollins | MVirgilio | ACGrimes | AJKugler | BKGrimes | |
| 5/4/94 | 5/9/94 | 5/9/94 | 1/94 | 1/94 | |

DOCUMENT NAME: SEQGASIN.RV1
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NOTE: THE PMS FOR SEQUOYAH (D. LABARGE) AND SALEM (J. ^{STONE} ~~ZIMMERMAN~~)
 HAVE BEEN INFORMED OF THE DEVELOPMENT OF THIS INFO. NOTICE AND
 THEY HAVE REVIEWED THE DRAFT INFO NOTICE.

Peter Wen 5/10/94.

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orig /s/'d by BKGrimes

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| 05/06/94 | 05/09/94 | 05/09/94 | 05/12/94 | 05/19/94 |

DOCUMENT NAME: 94-36.IN

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