UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555-0001

December 11, 1996

NRC INFORMATION NOTICE 96-65: UNDETECTED ACCUMULATION OF GAS IN REACTOR COOLANT SYSTEM AND INACCURATE REACTOR WATER LEVEL INDICATION DURING SHUTDOWN

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 ongoing issues related to an undetected loss of reactor coolant inventory at Haddam Neck caused by an accumulation of nitrogen in the reactor coolant system. 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

Information Notice (IN) 94-36, "Undetected Accumulation of Gas in Reactor Coolant System," issued on May 24, 1994, discussed an event at the Sequoyah Nuclear Power Plant in September 1993 where gas accumulated in the reactor coolant system (RCS). The gas accumulated because the temperature in the volume control tank was much lower than normally expected. (This lower temperature resulted from unusually low component cooling water temperatures and from a maintenance problem with a cooling water valve that reduced 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 there was more dissolved gas in the water. When the water was transferred to the RCS by the charging system and heated up in the reactor vessel, the gas came out of solution and collected in the RCS. This information notice also discussed a similar issue which occurred at the Salem Nuclear Generating Station on April 12, 1994.

IN 96-37, "Inaccurate Reactor Water Level Indication and Inadvertent Draindown During Shutdown," issued on June 18, 1996, discussed an event which occurred on September 13, 1995, at Surry Unit 1. The plant was in cold shutdown and depressurized. Operators had closed the reactor head vent to install the reactor vessel cavity seal ring. After the seal ring was in place, the reactor head vent was not reopened. This resulted in a loss of function of the only reactor vessel water level indication. As pressurizer relief tank nitrogen pressure was gradually being reduced, an operator saw the standpipe indicated level increase as the

gas bubble trapped in the reactor vessel head expanded, forcing water out of the reactor and up the surge line and standpipe. Unaware of the closed head vent and believing the standpipe level indication, the operator increased letdown from the reactor coolant system cold leg piping to maintain indicated level. This effectively reduced the inventory in the RCS by approximately 17.0 cubic meters [4500 gallons] over a period of 5 hours.

Description of Circumstances

The reactor at Haddam Neck was in cold shutdown and decay heat was being removed by the residual heat removal (RHR) system using the "A" RHR pump. The RCS was depressurized and a temporary primary vent header was connected to the reactor vessel head. The volume control tank was being maintained at a pressure of 310 kPa [30 psig]. The RCS loop stop valves had been closed to isolate the reactor vessel from the steam generators. The Technical Specification required boration flow path was from the boric acid metering tank, through the chemical and volume control system metering pump, and into the RCS. The reactor vessel level indication system (RVLIS) and core exit thermocouples were disconnected in preparation for removal of the reactor vessel head. The operators were using pressurizer level indication and cavity level indication to monitor reactor vessel level (see Attachment 1).

On August 28, 1996, the metering pump was to be declared inoperable because of an upcoming surveillance test on the emergency power supply for the pump, requiring the alignment of a different boric acid flow path. During the alignment, the operator opened both valve BA-V-354 (blended makeup to the volume control tank) and BA-V-355 (blended makeup to the charging pump suction). It appears that following this operation the operator may have failed to fully seat one isolation valve (BA-V-355) between the top of the volume control tank (nitrogen gas space) and the RCS (see Attachment 2). Note: the procedure in use during the alignment did not allow valve BA-V-355 and BA-V-354 to be open at the same time. This allowed nitrogen from the volume control tank to leak from the volume control tank, through several closed, leaking valves in the chemical and volume control system, and into the reactor vessel. The installed vent system was unable to vent off nitrogen as fast as the nitrogen was being added to the reactor vessel and a nitrogen bubble accumulated in the vessel head region. As the nitrogen gas displaced water from the reactor vessel into the pressurizer, the water level in the reactor vessel decreased and the water level in the pressurizer increased.

The pressurizer level instrumentation erroneously indicated that the reactor vessel was full of water. Pressurizer level slowly increased because of the displacement of water from the reactor vessel by nitrogen gas. The operators believed that the level increase was caused by water leaking into the RCS through the loop stop valves. The operators tightened the valves to stop the leakage. Water continued to be displaced from the reactor vessel by the growing nitrogen bubble. However, this was masked by the operators removing RCS inventory to remove the reactor vessel conoseals. For approximately four days, control room operators were unaware that nitrogen gas was leaking into the reactor vessel and causing the level in the reactor vessel to decrease.

On September 1, 1996, the nitrogen gas supply to the volume control tank was isolated in an attempt to identify the source of the relatively high nitrogen usage. The isolation of the nitrogen gas stopped the nitrogen leakage into the RCS. The vent header system capacity now exceeded the rate of gas intrusion and the vent began to release the nitrogen which had accumulated in the reactor vessel. The volume of nitrogen being removed from the reactor vessel was replaced by the water in the pressurizer. The pressurizer level rapidly decreased until the level indication decreased off scale (low). Six additions of water to the RCS, totalling approximately 18.9 cubic meters [5000 gallons], were required to stabilize pressurizer level within the normal range.

Discussion

The event at Haddam Neck revealed a number of weaknesses. However, there are three issues which the NRC has determined warrant particular notice. These issues are: (1) Inaccurate reactor vessel level instrumentation; (2) Inadequate reactor coolant inventory balance; and (3) Non-condensible gas intrusion into the RCS. These issues are discussed below. An NRC augmented inspection team evaluated this event and reported its findings in NRC Inspection Report 50-213/96-80.

Inaccurate Reactor Vessel Level Instrumentation

Lack of accurate reactor vessel level instrumentation and lack of adequate inventory balances while shutdown are issues of generic concern. The NRC has issued several generic communications on the issue: these are listed in the "Related Generic Communications" section. These generic communications discuss numerous events where safety-related equipment operability was challenged because of inaccurate level instrumentation.

At Haddam Neck, the absence of direct reactor vessel monitoring instrumentation had an adverse affect on the operators' ability to monitor reactor vessel conditions. The available level instruments (pressurizer level and cavity level) did not provide a direct indication of reactor vessel level. The level instrumentation measured actual level in the pressurizer which the operators believed was representative of reactor vessel level because the pressurizer air space was vented to the same vent header as the reactor vessel head (see Attachment 1). During this event, pressurizer level indication and cavity level indication were not representative of actual reactor vessel level because of a difference in pressure between the reactor vessel head and the pressurizer air space. The difference in pressure was caused by the inability of the installed reactor vessel head vent system to remove nitrogen gas as fast as it was being introduced into the RCS.

RVLIS, which does provide a direct reactor vessel level indication, was disconnected in preparation for refueling maintenance activities. The core exit thermocouples are another direct indication of reactor vessel conditions. The core exit thermocouples were also disconnected during the duration of this event.

The RVLIS indicates reactor vessel level at discrete elevations. During this event, the RVLIS would have indicated abnormal reactor vessel level when the actual level dropped below the

reactor vessel flange. Following this event, local RVLIS readings were collected and a temporary jumper was purchased and installed to provide RVLIS indications in the control room. A second jumper was installed to provide core exit thermocouple indication in the control room.

Inadequate Reactor Coolant Inventory Balance

The licensee had not maintained an RCS inventory balance to account for the transfer of water into and out of the RCS. No detailed procedural guidance existed which required an inventory balance for draindown operations. The operators compensated for a lack of detailed procedural guidance by writing instructions in accordance with administrative control procedure 1.2-5.3, "Evaluation of Activities\Evolutions Not Controlled by Procedure." The instructions written in accordance with administrative control procedure 1.2-5.3 do not require the same level of review and approval that other plant procedures receive. The guidance written for the RCS draindown did not require RCS inventory balances or specify reference levels.

On August 29, 1996, plant management made the decision to suspend refueling activities over the weekend. The operators were directed to and did refill the RCS. However, where 5000 gallons had been removed from the RCS earlier, only 1000 gallons were added to the RCS to reach essentially the same indicated level. (The resulting 8-inch difference in P_{zr} level indication between before and after only represented 500 gallons of the inventory difference not the 4000 gallons which existed.)

The magnitude of the apparent RCS inventory discrepancy was not explained to operations management nor did the operators solicit engineering and technical support to assist in resolving this discrepancy. The licensee had experienced leakage of the loop stop valves during past outages, however, an inventory balance may have alerted the operators to the actual magnitude of the inventory discrepancy, and may have caused the operators to question their initial conclusion that the increase in pressurizer level was caused by leaking stop valves.

Non-Condensible Gas Intrusion into the RCS

Gas intrusion into the RCS and safety-related cooling system piping is an issue of generic concern. The NRC has issued several generic communications on the issue: these are listed in the "Related Generic Communications" section. These generic communications discuss numerous events where safety-related equipment was potentially rendered inoperable because of gas intrusion. The generic communications discuss the various processes by which non-condensible gases have accumulated unknown to the reactor operators in the RCS and safety-related cooling system piping. The event at Haddam Neck illustrates that gas intrusion events continue to occur in spite of the operational experience available to the industry.

At Haddam Neck, nitrogen intrusion into the RCS could potentially result in gas binding and common mode failure of the decay heat removal pumps and the charging pumps. In

addition, nitrogen present in the RCS could potentially interfere with the ability of the steam generators to remove heat from the RCS via natural circulation cooling. The significance of the loss of the charging pumps at Haddam Neck is that a method of injecting water into the reactor vessel would be lost and that the charging pumps are needed to fill the RCS before opening the loop stop valves. The loop stop valves would need to be opened to allow the RCS to communicate with the steam generators, a condition necessary for the steam generators to remove heat from the RCS via natural circulation. In addition, the volume of the RCS increases significantly with the loop stop valves open, thus providing a larger passive heat sink which would slow the heating of the RCS.

At Haddam Neck the overpressure in the volume control tank was purposely maintained by the licensee as an independent source of motive force to inject water into the RCS in the event of a loss of other injection methods. The potential hazard of this condition is that nitrogen may intrude into the RCS if valves relied upon to isolate the volume control tank from the RCS either leak or are not properly controlled.

During the event, the operators attempted to start the "B" RHR pump, however, it was found to be seized. The licensee believes that the seizure occurred at the end of the last surveillance test and was not related to the gas intrusion event. The operators were unaware that the "B" RHR had seized following its last operation on August 19, 1996. After the event, the licensee determined that the "B" RHR pump was inoperable throughout the event. The failure of the "B" RHR pump added to the significance of this event. If the "A" pump was damaged, the RHR system would not be available to remove decay heat. A mitigating condition at Haddam Neck is that two trains of the low pressure injection system were available.

The abnormal operating procedure for a loss of RHR requires that a cavitating RHR pump be secured and vented. However, the location of the RHR pump vents is not optimal and significant difficulty was encountered during venting the "B" RHR pump following maintenance to address its seizure. Therefore, an effective venting of a RHR pump may not have been easy to achieve during an event if a pump had become gas bound.

Related Generic Communications

Information Notice 88-23, "Potential for Gas Binding of High-Pressure Safety Injection Pumps During a Loss-of-Coolant Accident," May 12, 1988.

Information Notice 88-23, Supplement 1, "Potential for Gas Binding of High-Pressure Safety Injection Pumps During a Loss-of-Coolant Accident," January 5, 1989.

Information Notice 89-67, "Loss of Residual Heat Removal Caused by Accumulator Nitrogen Injection," September 13, 1989.

Information Notice 88-23, Supplement 2, "Potential for Gas Binding of High-Pressure Safety Injection Pumps During a Loss-of-Coolant Accident," January 31, 1990.

Information Notice 90-64, "Potential for Common-Mode Failure of High Pressure Safety Injection Pumps or Release of Reactor Coolant Outside Containment During a Loss-of-Coolant Accident," October 4, 1990.

Information Notice 88-23, Supplement 3, "Potential for Gas Binding of High-Pressure Safety Injection Pumps During a Loss-of-Coolant Accident," December 30, 1990.

Information Notice 88-23, Supplement 4, "Potential for Gas Binding of High-Pressure Safety Injection Pumps During a Loss-of-Coolant Accident," December 18, 1992.

Information Notice 90-55, Recent Operating Experience on Loss of Reactor Coolant Inventory While in a Shutdown Condition," August 31, 1990.

Information Notice 93-93, "Inadequate Control of Reactor Coolant System Conditions During Shutdown," December 8, 1993.

Information Notice 94-36, "Undetected Accumulation of Gas in Reactor Coolant System," May 24, 1994.

Information Notice 95-03, "Loss of Reactor Coolant Inventory and Potential Loss of Emergency Mitigation Functions While in a Shutdown Condition," January 18, 1995.

Information Notice 96-37, "Inaccurate Reactor Water Level Indication and Inadvertent Draindown During Shutdown," June 18, 1996.

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.

for Thomas T. Martin, Director
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Attachments:
1. The Undetected Nitrogen Gas Introduction into the Reactor Vessel from the Charging Line
2. Chemical and Volume Control System
3. List of Recently Issued NRC Information Notices

Attachment filed in Jacket

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original signed by D. B. Matthews

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Tech Editor has reviewed and concurred on 10/22/96

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NAME	EBenner* WLyon*	TCollins*	AChaffee*	TMartin
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Tech Editor reviewed and concurred on October 18, 1996.

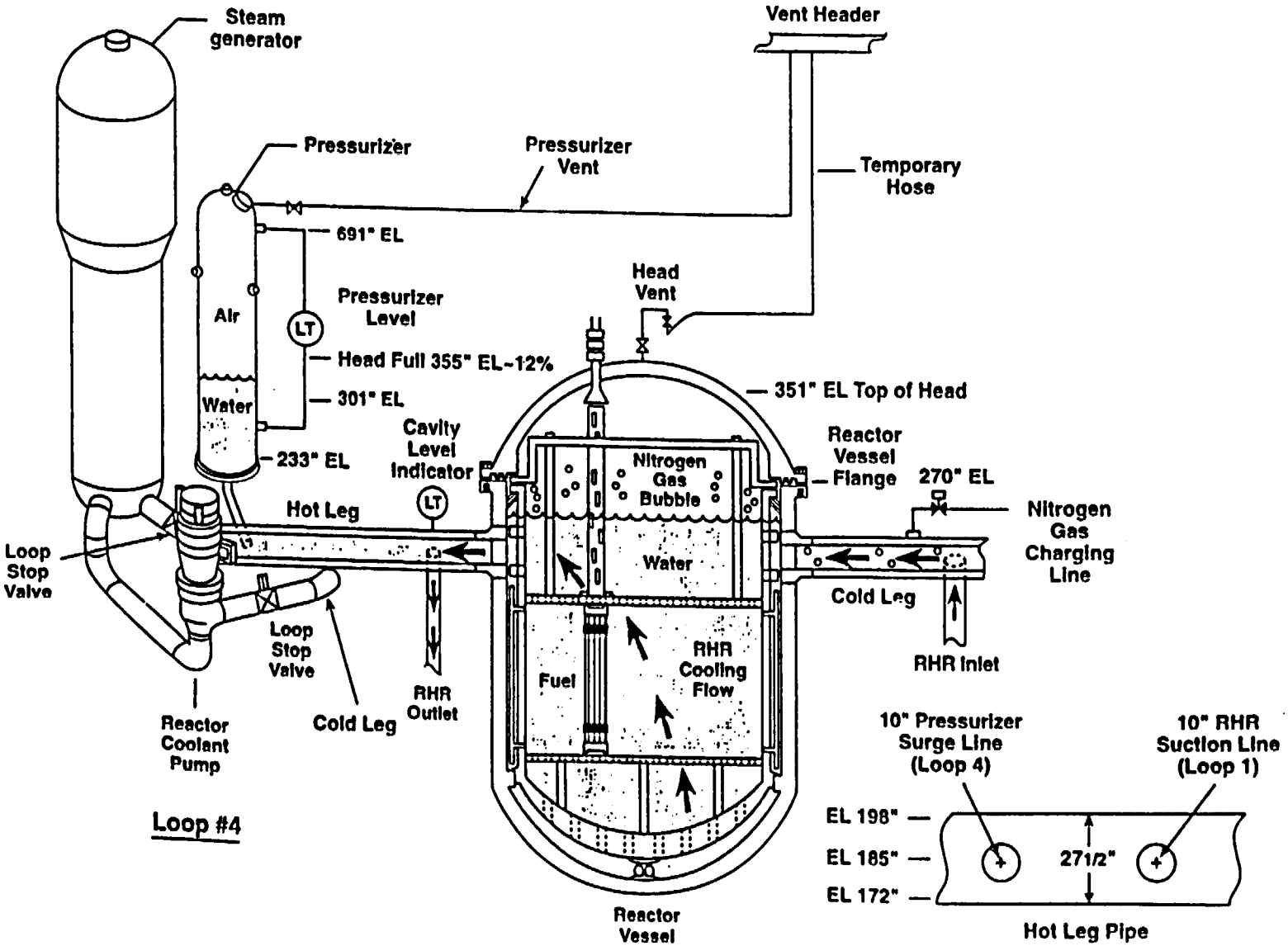
Attachment: List of Recently Issued NRC Information Notices

OFC	Contacts	BC/SRXB:DSSA	BC/PECB:DRPM	D/DRPM
NAME	EBenner EJB WLyon	~~RJones~~ TCollins	AChaffee	TMartin
DATE	10/30/96 10/30/96	11/5/96	/ /96	/ /96

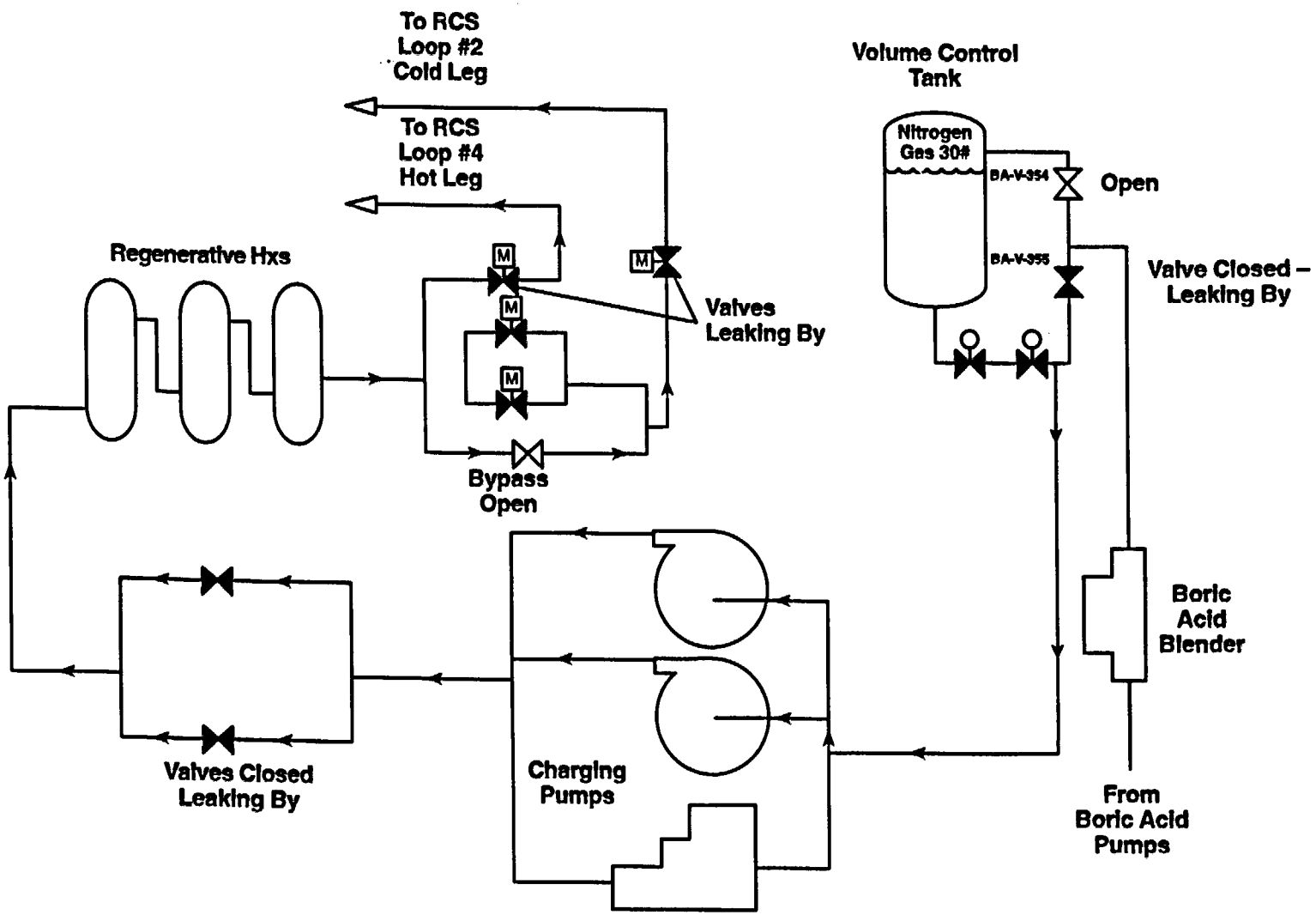
[OFFICIAL RECORD COPY]

DOCUMENT NAME: G:\EJB1\HAD_GAS.IN

THE UNDETECTED NITROGEN GAS INTRODUCTION INTO THE REACTOR VESSEL FROM THE CHARGING LINE



CHEMICAL & VOLUME CONTROL SYSTEM
NITROGEN GAS LEAK PATH FROM VOLUME CONTROL TANK TO THE RCS



LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
96-64	Modifications to Containment Blowout Panels Without Appropriate Design Controls	12/10/96	All holders of OLs or CPs for nuclear reactors
96-63	Potential Safety Issue Regarding the Shipment of Fissile Material	12/05/96	All U.S. Nuclear Regulatory Commission licensees authorized to possess special nuclear material in unsealed quantities greater than a critical mass
96-62	Potential Failure of the Instantaneous Trip Function of General Electric RMS-9 Programmers	11/20/96	All holders of OLs and CPs for nuclear power plants
96-61	Failure of a Main Steam Safety Valve to Reseat Caused by an Improperly Installed Release Nut	11/20/96	All holders of OLs or CPs for nuclear power reactors
96-60	Potential Common-Mode Post-Accident Failure of Residual Heat Removal Heat Exchangers	11/14/96	All holders of OLs or CPs for nuclear power reactors
96-59	Potential Degradation of Post Loss-of-Coolant Recirculation Capability as a Result of Debris	10/30/96	All holders of OLs or CPs for nuclear power reactors
96-58	RCP Seal Replacement with Pump on Backseat	10/30/96	All holders of OLs or CPs for pressurized-water reactors

OL = Operating License
CP = Construction Permit