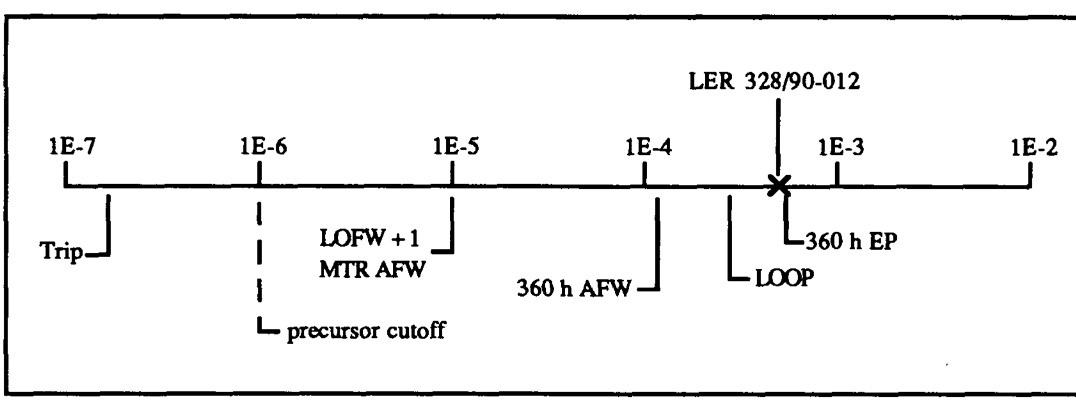
ACCIDENT SEQUENCE PRECURSOR PROGRAM EVENT ANALYSIS

LER No.:	328/90-012
Event Description:	Hydrogen accumulation in charging/SI pump suction lines
Date of Event:	August 22, 1990
Plant:	Sequoyah 2

Summary

While troubleshooting a gas-bound centrifugal charging pump (CCP) on Unit 2, it was discovered that substantial accumulations of hydrogen existed in the charging pump suction header and in a recirculation supply line from the residual heat removal (RHR) system to the charging pumps. Sufficient gas quantities were identified that successful performance of the safety injection (SI) and charging pumps could not have been guaranteed, particularly for recirculation modes.

The conditional probability of core damage associated with this event is 6.0×10^{-4}. The relative significance of the event compared to other postulated events at Sequoyah 2 is shown below.



Event Description

While performing a surveillance instruction, plant operators removed CCP 2A-A from service and placed CCP 2B-B in service. The "B" pump discharge flow and motor current were noted to be fluctuating, so "A" CCP was returned to service and the "B" pump was shut down. "B" pump was vented and restarted but still experienced abnormal flow and motor current fluctuations, so it was shut down again. Additional venting was performed, and the pump was successfully placed in service.

Additional testing and troubleshooting was initiated, including ultrasonic testing of the pumps and associated piping. This testing revealed the existence of voids in the suction piping, particularly in a vertical section of piping from the RHR system to the CCP suction line. The voids were found to be accumulations of hydrogen gas, which was believed to be stripping out of solution in the minimum flow line restricting orifices.

Further venting efforts removed about 10 ft^3 of gas from the suction piping. An additional 4.3 ft^3 was identified below motor-operated valve 2-FCV-63-8, in the line from the RHR system to the CCP suction. Similar voids were found on Unit 1 as well. Examinations on Unit 1 also revealed approximately 1.9 ft^3 of gas above valve 2-FCV-63-8. This space was vented on Unit 1, and the corresponding space on Unit 2 was also vented, although the quantity of gas there was not measured.

No means to vent the 4.3 ft^3 of gas below valve (1-) 2-FCV-63-8 existed; an engineering change was initiated to provide this. In the interim, this valve was clearance-tagged out of service on both units. This removed one train of RHR recirculation supply to the charging and SI pumps but reduced concern that hydrogen gas would be swept into the high-head pumps if an accident condition required initiation of recirculation. The CCPs were removed from service, and the positive displacement pumps were started in order to reduce the gas production rate. Frequent venting was initiated to limit gas volume in the system.

Additional Event-Related Information

Emergency core cooling at Sequoyah is provided by two low-pressure and four high-pressure injection pumps. The low-pressure injection function is provided by the RHR pumps. Two CCPs and two high-head SI pumps comprise the high-pressure system.

During power operation, the RHR pumps and the SI pumps are on standby, with suction aligned to the refueling water storage tank (RWST). In the event of an accident, the pumps are started and their motor-operated discharge valves open to supply water to the reactor coolant system (RCS).

The CCPs are normally aligned to take suction from the volume control tank (VCT) and supply the chemical and volume control system charging header. Typically, one pump will be on standby. If an SI signal is received, pump suction realigns to the RWST and discharge realigns to the RCS via the boron injection tank.

In event of a large break in the RCS, all low-pressure and high-pressure pumps provide makeup. In event of a small- or medium-sized break, RCS makeup is provided by the high-pressure pumps. When the RWST inventory is depleted, the suction supply is taken from the containment sump. This water is pumped by the RHR pumps through the RHR heat exchangers. It is returned directly to the RCS in event of a large break in the RCS. For small- and medium-sized breaks, flow exiting the RHR heat exchangers is supplied to the suction of the high-head pumps. These pumps then make up to the RCS.

ASP Modeling Assumptions and Approach

A total of about 16 ft^3 of hydrogen was apparently present in the Unit 2 charging pump suction header and RHR recirculation supply line. Analyses by the utility and the plant vendor indicate that quantities of hydrogen greater than 6 ft^3 in the suction piping would have the potential to cause gas binding and failure of multiple high-head pumps. Under accident conditions, this would be most likely to occur on transition to recirculation, when flow would tend to sweep out the hydrogen from above and below FCV-63-8 toward the high-head pumps.

This event has been modeled for Unit 2 as an unavailability of high-pressure recirculation. The period of unavailability was taken as 1 yr (the longest unavailability modeled in the yearly precursor reports), as the hydrogen voiding condition had existed for a substantial time prior to discovery.

The event was not modeled for Unit 1, as the gas quantities present were apparently less (the impact of the hydrogen in Unit 1 could not be definitively determined), and the potential consequences were accordingly less severe.

Analysis Results

The significance of this event estimated using the current ASP models is very high (6.3×10^{-3} for the 1-yr period). This is in part because these models do not recognize alternate means of providing core cooling once HPI is initiated — HPI must be used for continued core cooling. In actuality, RCS cooldown to the RHR initiation pressure using AFW or main feedwater prior to sump switchover would probably be utilized, as it historically has been for all small-break LOCAs. Once the plant was on the RHR system, then makeup using an SI or charging pump, combined with RHR, would provide core protection. The time period available for RCS cooldown would be many hours for a small-break LOCA, unless containment spray was initiated on high containment pressure following the break and was not manually terminated.

Assuming that secondary-side cooldown and initiation of RHR would be successful in 90% of all small LOCAs (without modification of the ASP models to formally address this), and that the operators would terminate containment spray if initiated, a conditional core damage probability is estimated for this event of approximately 6.0 x 10^{-4} over a 1 yr period. The dominant core damage sequence for the event involves a postulated small-break LOCA with successful high-pressure injection, failure to cooldown the RCS and initiate RHR prior to RWST depletion, and failure of high-pressure recirculation due to hydrogen in the piping between the RHR and SI/charging pumps.