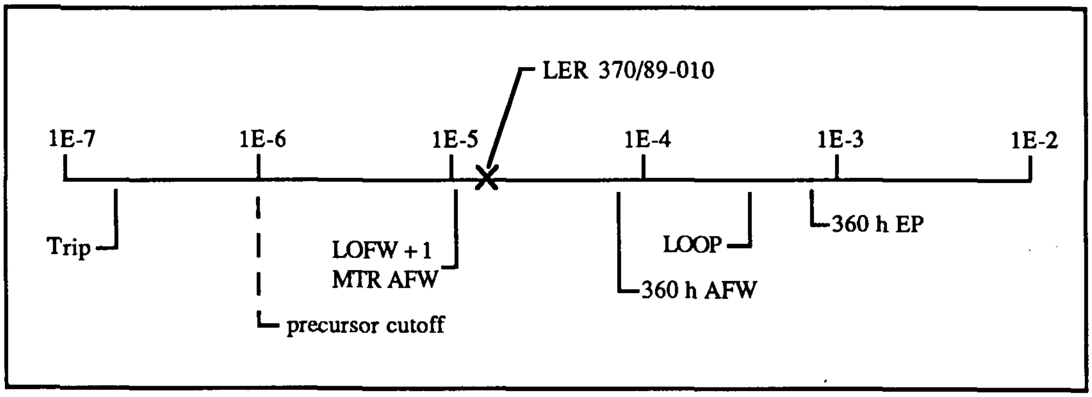
ACCIDENT SEQUENCE PRECURSOR PROGRAM EVENT ANALYSIS

LER No: 370/89-010
Event Description: Containment spray heat exchanger gasket failure
Date of Event: September 5, 1989
Plant: McGuire 2

Summary

Containment spray heat exchanger 2A suffered a gasket failure at McGuire 2 during valve stroke timing. Approximately 10,000 gal of water flowed out the failed gasket, from both the RHR system and the RWST. The event was evaluated for at-power impact. The conditional core damage probability estimated for this event is 1.6 x 10^{-5}. The relative significance of this event compared with other postulated events at McGuire is shown below.



Event Description

With McGuire in Mode 5 on September 5, 1989, valve stroke timing tests were being performed on a number of valves in preparation for entering Mode 4. Included in the set of valves was 2NS-18A, spray pump A suction isolation. After the procedure to stroke test the valve was reviewed in the control room, permission was granted to test the valve. The reactor coolant system was at 305 psi, with RHR pump B in operation.

At 1608:59, control room personnel opened valve 2NS-18A. Once the valve was fully open, pressurizer level was observed decreasing, as was RCS pressure and RHR pressure. The valve was closed ~0.5 min later. Spray pump 2A was inspected for damage, and none was found. Twenty minutes later valve 2NS-20A was reopened to return the system to its pretest valve alignment. This valve provides a flow path from the RWST to the suction of spray pump 2A.

Approximately 0.5 h after that, the control room was notified of flooding at the 716 ft elevation pipe chase. Water was coming through the spent-fuel pool-cooling system filter pit reach rod holes. One minute later, control room personnel noticed RWST level decreasing and closed 2NS-20A. Control room personnel inspected the leakage and opened and closed 2NS-20A on two more occasions to confirm that the water was coming from the 2A heat exchanger gasket.

The heat exchanger gasket was replaced 2 d later. A section of the gasket 12" to 15" long and $^1/_8$ in. to $^3/_{16}$ in. wide was found not to be compressed because of misalignment during an October, 1988 replacement. A gasket compression check was not documented in the work request related to the gasket replacement and was not required by procedure (the heat exchanger orientation also made it difficult to check gasket compression).

Two situations were believed to have contributed to the gasket failure. First, the gasket was exposed to pressures beyond design because the heat exchanger was exposed to 305 psi from the RHR system during valve stroke testing. The utility stated that the control room operator involved in the test had been concerned with test procedure cautions concerning air entrainment and had failed to realize that overpressurization via the RHR system could occur. In addition, the operator also stated that he did not remember an incident 1 year earlier at McGuire involving CVCS suction piping overpressurization during valve stroke time testing (procedures had been revised to prevent overpressurizations during valve stroke testing following that event, but the containment spray valves had not been addressed).

The second contributor to the gasket failure was bolt torque relaxation, which could have been caused by improper bolt lubrication, thermal cycling, vibration, etc. Relaxation of the initial bolt loading (150 ft-lb) resulted in a bolt load that was marginal and perhaps below that required to prevent leakage at 305 psi. The utility stated that design engineering personnel believed, however, that the bolt load was adequate to prevent gasket failure at normal operating pressures.

Approximately 10,000 gal of water leaked into the auxiliary building during the event; 2,000 gal from the RHR system and 8,000 gal from the RWST once 2NS-20A was opened. One pressure gauge was replaced, and relief valve 2NS-19 was repaired following the overpressurization.

Additional Event-Related Information

The containment spray system functions in conjunction with the RHR system and ice condensers at McGuire to remove heat from the containment following a loss of coolant accident or steam line break. Once the ice from the ice condensers has melted, the spray system can maintain containment pressure below 15 psig.

The containment spray system consists of two pump/heat exchanger trains that take suction from the RWST or the containment sump. The heat exchangers are shell and tube type. Water from the RWST or containment sump circulates through the tubes, while nuclear service water circulates on the shell side.

Leakage from the containment spray system in the containment spray pump room flows to a common RHR/containment spray pump room sump. This sump is provided with level indication (alarmed in the control room) that can be used to detect the presence of leakage. The heat exchangers are not located in the pump rooms. A leak in any other location is indicated by increased floor drain tank level.

Based on the total flows and times that valves 2NS-18A and 2NS-20A were open as reported in the LER, flow rate through the failed gasket is estimated to have been ~1300 gpm at 305 psi and 200 gpm at RWST head. These two values indicate a flow rate of ~1000 gpm at pump design pressure.

ASP Modeling Assumptions and Approach

The event was modeled as an assumed heat exchanger gasket failure caused by bolt load relaxation and improper installation. It was assumed that post-LOCA operating pressures and temperatures could fail the gasket. The exposure time assumed was one half of the period since the gasket was replaced in October 1988.

The containment spray system was assumed to be required for medium- and large-break LOCAs (medium-break LOCA frequency is ~10^{-3}/reactor year). In this scenario, if the gasket fails, the containment spray system will pump the containment sump to the auxiliary building unless the leak is isolated. Loss of containment sump inventory will fail LPR.

The likelihood of gasket failure was assumed to be 0.1. The likelihood of detecting the source of the leakage and isolating the impacted containment spray train was assumed to be 0.34. This value was used because of the flood progression observed during the actual event and the fact that inspection of the auxiliary building was required to determine the location of the leak, the level of operator stress expected during a medium- or large-break LOCA, and the expectation that significant radiation levels would exist throughout the ECCS areas of the auxiliary building once sump switchover occurred. Before sump switchover, the primary indication of leakage would be auxiliary building flooding, since RWST level would be decreasing as expected, and containment sump level would be increasing (some differences in the monitored parameters for the two containment spray trains might also be observable).

These assumptions result in a core damage probability estimate of

(medium-break LOCA frequency) $\times$ (exposure time) $\times$ (probability of gasket failure) $\times$ (failure to isolate containment spray heat exchanger leakage) = (10^{-3}/reactor year) $\times$ (0.46 year) $\times$ (0.1) $\times$ (0.34) = 1.6×10^{-5}.

Analysis Results

The conditional probability of severe core damage for this event is 1.6×10^{-5}. The dominant sequence involves failure of low-pressure recirculation as a result of loss of containment sump inventory through the containment spray heat exchanger gasket. Once the containment sump inventory was pumped to the auxiliary building, containment spray would fail as well.