AEOD ENGINEERING EVALUATION REPORT*

UNIT: H. B. Robinson, Unit No. 2
DOCKET: 50-261
LICENSEE: Carolina Power & Light Company
NSSS/AE: Westinghouse/Ebasco

EE REPORT NO.:AEOD/E325
DATE: November 21, 1983
EVALUATOR/CONTACT: W. Lanning

SUBJECT: VAPOR BINDING OF AUXILIARY FEEDWATER PUMPS AT ROBINSON, UNIT 2

EVENT DATE: April 19, 1983

REFERENCE: Carolina Power & Light Company, Licensee Event Report 83-044, Docket 50-261, dated May 18, 1983.

SUMMARY

Robinson has experienced 4 failures of AFW pumps due to low discharge pressure trips caused by steam formation in the AFW piping and pump casings. The steam was formed when hot water from the feedwater system leaked through two check valves and a motor-operated valve in the piping to either the motor- or steam-driven AFW pumps. Although the backleakage has caused only a single train of the AFW system to fail, the potential exists for both trains to fail simultaneously since backleakage has occurred repetitively in both trains. Three events have also occurred at Cook-2 involving backleakage and elevated temperature of the AFW piping and pump casing.

The evaluation concludes that Robinson has implemented acceptable corrective actions to prevent steam formation in the AFW system. Since the design of the Robinson AFW system is typical of other operating PWRs, an IE Information Notice should be issued to inform other licensees of the potential for steam binding of the AFW system.

An AEOD case study is recomended to further evaluate the generic implications for other AFW systems and develop appropriate recommendations to minimize the potential for steam binding of the system. Generic technical specification changes should be evaluated to require that appropriate surveillance procedures be implemented, if not already available, to detect leakage and prevent steam formation in the AFW system.

*This document supports ongoing AEOD and NRC activities and does not represent the position or requirements of the responsible NRC program office.

DISCUSSION

During the review of operating experience, the referenced LER was identified as a significant event and warranted AEOD evaluation because of the potential for common mode failure of the auxiliary feedwater (AFW) system. The purpose of this engineering evaluation is to summarize the event, evaluate the safety implications, and determine whether additional licensee or NRC actions are necessary.

Following a manual reactor trip on April 19, 1983, the two motor-driven auxiliary feedwater pumps started automatically on low steam generator level. After about 2 minutes, the "B" AFW pump tripped. During testing of the pump, a significant amount of steam was vented from the pump casing. The pump trip was attributed to a protection trip signal generated by the pressure instrumentation in response to a low discharge pressure.

The discharge piping from the motor-driven AFW train is connected to the main feedwater piping near the steam generator. Hot water (about 425°F) from the feedwater system leaked through two check valves and a motor-operated valve in the piping to the AFW pumps. This water flashed in the discharge piping and pump casing because the AFW system was at a lower pressure than the feedwater system. When the AFW pumps started, the instrumentation in the discharge piping sensed a low pressure and signalled a pump trip. The low discharge pressure was caused by steam binding of the pump which reduced the flow and prevented the discharge pressure from increasing above the low pressure setpoint in the 30 seconds required for the discharge pressure sensor to time out. Condensation effects would contribute to the low pressure condition.

The potential exists for both motor-driven AFW pumps to trip due to backleakage in any one of the discharge piping runs to the steam generators because both pumps share a common discharge header. This is evidenced by the elevated temperature measurements obtained for both pump casings during the licensee's investigation of the event. The steam-driven pump has separate discharge piping and was not affected directly. However, the motor-driven and steam-driven pumps share a common suction header from the condensate storage tank and backleakage could affect all pumps.

Although the pumps have a common suction header, the relatively cold condensate storage tank water would tend to mix with the hotter water from the steam generators reducing the potential for water at the suction of the AFW pumps to be near saturation conditions and flash when pumped. This would depend, of course, on the leakage rate and the time available to raise the temperature of the suction water. Based on this event, the combination of these two factors did not adversely affect either the second motor-driven AFW pump since it did not cavitate or the steam-driven pump since the suction water remained cooled.

Robinson had experienced prior leakage through the discharge piping and consequent trips of the motor-driven AFW pump "A" on June 11 and 16, 1981 (LER 81-016). The unit was at 93% power during the second event with only a single AFW pump remaining to provide emergency feedwater because the steam-driven pump was inoperable. The valves were repaired and the backleakage significantly reduced. The pump tripped again on June 19, 1981 (LER 81-17) after a reactor trip, but the cause was attributed to improper throttle valve setting of the discharge valve although steam binding could have caused the low pressure trip.

On July 21, 1983, a similar event (LER 83-016) occurred resulting in the steam-driven AFW pump being declared inoperable due to potential steam binding. Hot water from the feedwater system leaked through the discharge check valve and the motor-operated valve producing steam at the suction vent and discharge drain of the pump. The discharge piping from the steam-driven pump is connected to the feedwater bypass piping. The potential existed for pump cavitation and trip on low discharge pressure following an automatic start. The steam was discovered during a routine check of the AFW train and the pump had not been required to operate. On August 17, 1977, the steam-driven train experienced a failure of a check valve to close which caused the relief valves on the suction header to lift.

Other failures of the motor-operated valves occurred on September 5, 6 and 18, 1979 when they failed to open (LERs 79-32, 79-33 and 79-34). The cause for the failures was due to a thermal overcurrent relay trip resulting from the failure of the torque switch to de-energize the motor after the valve was fully closed. Excessive wear of the worm gear prevented proper operation of the torque switch. The excessive wear is believed to have occurred during previous events when the valve stuck closed due to thermal binding caused by the leaking upstream check valve. Thermal binding can lead to deformation of the valve internals and leakage. The three check valves and the three motor-operated valves were replaced with the same type (4-inch Crane,model 973, drawing NY434112-5379-306) in 1980 to correct the backleakage.

The design of the AFW system at other operating plants also generally include check valves and motor-operated valves in series to prevent backleakage from the feedwater system to the AFW system. This suggests a potential generic concern. However, a review of operating experience for the past 2 years identified only three similar events. These events occurred at Cook-2 (LERs 81-32, and 81-63) where the valves leaked in the steam-driven train and an abnormally high temperature was observed for the pump casing, suction and discharge piping. The pump had not been required to operate in any event. The Resident Inspector identified the third event which occurred on January 6, 1983. This event was not reported in an LER because the mode of operation did not require the AFW system to be operable.

Although the design of the AFW system at Cook is similar to Robinson, the motor-operated valve in the pump discharge piping is locked-open during operation. The isolation of the AFW system from the main feedwater system is achieved by two check valves (4-inch Atwood Morrill, drawing #20216F). The reason for the check valve leakage is attributed to improper valve assembly rather than design deficiencies reported for the Robinson valves. Nevertheless, the potential for backleakage may be greater at Cook than Robinson, because the motor-operated valve does not provide isolation capability. However, the consequences of backleakage at Cook is significantly less, because the motor-driven pumps do not share a common discharge header, e.g., both pumps cannot become steam bound due to leakage in a single discharge line. All the pumps do share a common suction from the condensate storage tank. Like Robinson, there are no temperature indicators for the auxiliary feedwater. The events at Robinson and Cook suggest that backleakage is a potential generic concern since different check valve designs are employed in the AFW system and both units have experienced backleakage resulting in inoperable trains of the AFW system.

A special interim procedure has been implemented at Robinson to vent both the motor- and steam-driven pumps once each shift. In addition, the temperature of the pump casings are monitored locally and the pumps are operated as necessary to ensure that the water in the AFW system remains cool and well below saturation conditions. Cook also monitors the temperature during routine checks by the auxiliary operator during shift inspections.

In the longer term, Robinson is evaluating a design change or replacement of the check valves located in each of the AFW pump discharge piping. Depending on the results of the evaluation, the check valve leakage should be corrected during the refueling outage beginning in December 1983 or during the steam generator replacement outage beginning in June 1984. A program is also underway to improve the performance of limitorque valves by developing valve performance histories to monitor and identify valve degradation in the future.

FINDINGS AND CONCLUSIONS

Robinson has experienced four events in the past two years involving failures of AFW pumps due to steam binding resulting from leakage of feedwater to the AFW system. It appears that the failure of the check valve to prevent backflow causes the motor-operated valve to leak and is the primary cause for the events. Based on operating experience the leakage in one AFW train has not affected the other train although the potential exists for common mode failure. The primary concern is, however, that backleakage will occur simultaneously in each of the AFW trains causing failure of the AFW system to perform its safety function.

The safety implications of the four events at Robinson is that the leakage of feedwater to the AFW system constitutes a common cause failure that can render both trains of the AFW system inoperable. Although the events to date have involved the failure of a single train, all of the events have been caused by the simultaneous leaking of two or three isolation valves in series. These events should not be considered random failures of single AFW trains, but as contributing events leading to potential loss of AFW capability due to a common cause failure. The trend of these events compare similarly to the trend of the reactor trip breaker failures at Salem and other plants before the Salem ATWS events.

Since the design of the AFW system at Robinson is typical of other PWRs, the potential for backleakage exists in other operating plants evidenced by the events at Cook-2. Monitoring of the temperature of the AFW pump casing, suction and discharge piping should be performed on a routine schedule to detect leakage into the AFW system and prevent steam binding of the system.

Robinson has implemented procedures to ensure that the water in the AFW system remains cool to prevent steam formation. These preventive actions should ensure that the AFW pumps are available to perform their safety function until the check valves are redesigned or replaced to correct the leakage problem. Efforts to improve the performance of the motor-operated valves are also underway. The licensee's actions appear acceptable and no additional actions are believed necessary at this time.

RECOMMENDATIONS

The Office of Inspection and Enforcement should consider issuing an information notice to inform other licensees of the potential for loss of AFW capability due to backleakage and steam formation in the AFW system.

In the near future, AEOD should complete a case study to evaluate the generic implications for all PWRs and identify and establish the bases for changes to technical specifications. In addition, the requirements to include the AFW pump discharge motor-operated and check valves in the inservice testing programs should be evaluated.