AEOD TECHNICAL REVIEW REPORT

UNIT:	ARKANSAS 2	TR REPORT NO.: AEOD/T90-13
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NSSS/AE:	Combustion Engineering/Bechtel	

SUBJECT: CORROSION AND FAILURE OF SERVICE WATER PUMP IMPELLER SNAP RINGS

EVENT DATE: November 11, 1988 (LER 88-019-01)

SUMMARY

Licensee Event Report 88-019-01 for Arkansas 2, dated February 24, 1989, describes an event in which the service water (SW) pump "A" was declared inoperable due to abnormal noise and high amperage conditions on November 8, 1988. The plant was operating at full power when the event occurred. Upon disassembly of the pump, some of the impeller snap rings were found failed, and worn marks were found on the upper stage impeller. The snap rings are made of carbon steel and used to hold the impellers in position on the pump shaft. Failure of the snap rings allowed the impeller to contact the pump casing, resulting in impeller failure, and the pump became inoperable.

Similar failures had previously occurred to SW pump "B". The pump exhibited high starting current in October 1988. The pump was secured. Damage to the pump internals was observed during the subsequent disassembly of the pump. Three snap rings were corroded and deteriorated, two other snap rings were missing, and impellers were badly worn. Although SW pump "C" had not exhibited high starting current, recent inspection has shown similar snap ring corrosion. The licensee attributed the snap ring failures to corrosion from exposure to the pumped chlorinated raw water. The SW system at Arkansas 2 consists of two trains sharing three full flow pumps. These pumps are two stage vertical type, manufactured by Fairbank Morse.

The licensee indicated that the pumps had not been inspected since the last replacements of the snap rings in the period between 1986 and 1987. This was because the plant did not have a routine periodic inspection program for the service water system. The licensee's corrective actions includes establishment of a periodic inspection program of the service water pumps.

Components as well as system piping made of carbon steel are vulnerable to a corrosive raw water environment. This has been reported at plants using either sea water or fresh water for

the service water system. Therefore, carbon steel is seldom used for internal fitting of pumps handling raw water. Additionally, the corrosion process requires a great length of time to cause destruction of a pump. A proper periodic inspection program can detect snap ring corrosion prior to degradation of pump performance. Since no other failure of this type was identified in a search of operational experience data bases, the event appears to be unique and has no generic implications. Therefore, additional AEOD action does not appear to be needed.

DISCUSSION

LER 88-019-01 for Arkansas 2, dated February 24, 1989, described that on November 8, 1988, with the plant at full power, the "A" service water pump was declared inoperable due to abnormal noise and high operating current indications. Inspection of the pump was initiated. On November 11, 1988 during the disassembly of the pump, it was discovered that the upper stage impeller had worn away due to contact with the pump casing. Also, the associated snap ring was missing. The snap ring for the lower stage impeller was in place but heavily corroded. These snap rings are made of carbon steel and used to hold the pump impellers in place on the SW pump shaft. A failure of the snap rings would allow the impellers to move and contact the pump casing which results in accelerated wear of the impeller wear rings and eventual failure of the impellers.

A similar failure had previously been discovered during repair work on SW pump "B". The event occurred on October 14, 1988. Due to an observed high starting current, the pump was stopped. Upon disassembly of the pump, damage to the pump internals was observed. Three snap rings were found corroded and deteriorated, and two other snap rings were missing completely. The impellers were badly worn. The snap rings for the pump "C" were also discovered to be heavily corroded during disassembly for inspection in February 1989. However, the impellers had not moved to contact the pump casing.

The damage to the service water pumps was attributed to corrosion of the carbon steel snap rings due to exposure to the chlorinated lake water being pumped. The pumps were rebuilt and returned to operation. To preclude the recurrence of pump damage, a routine periodic inspection and overhaul of the service water pumps will be conducted by the licensee to assure detection of snap ring corrosion prior to degradation of pump performance. In addition, the licensee is conducting a search of more suitable material for the snap rings to reduce corrosion failure and increase service life of the snap rings.

FINDINGS

The service water system at Arkansas 2 consists of two independent, but interconnected, redundant flow paths which furnish cooling water to two independent trains of Engineered Safety Feature equipment under normal and emergency conditions. Three pumps are provided such that each is capable of supplying full flow of the required cooling water for one train. Thus, they meet the single failure criterion. However, the failure of the snap rings indicate that the independent service water pumps were degraded by a single cause that could result in a total loss of the service water system. The system is vulnerable to a common cause failure of an active component -- corrosion of the impeller snap ring. The licensee attributed the snap ring failure to corrosion from exposure to the pumped chlorinated raw water. The snap rings were made of carbon steel which is susceptible to corrosion damage from the raw water. The normal water supply to the system is from the Lake Dardanelle Reservoir. The water is chlorinated prior to the pump intake, to control slime and algae, and to prevent biofouling of the system. It also reacts with all oxidizable matter, organic matter, hydrogen sulfide, and ferrous iron. The three full flow pumps are identical, two stage vertical type and manufactured by Fairbank Morse Pump Company.

Because the SW pumps of Unit 1 are made by the same manufacturer and use the same water source, the service water pumps of the Unit 1 were also disassembled and inspected. The licensee found that snap rings were not used in these pumps to fasten the impellers to the shafts. To determine the generic applicability of this corrosion problem, a search of operational experience data bases was conducted for failure of snap rings on centrifugal pumps and for plants using Fairbank Morse pumps in the service water system. The data searches included the Sequence Coding and Search System (SCSS) and the Nuclear Plant Reliability Data System (NPRDS). This search did not identify any event involving snap ring failure. Although one plant was identified using Fairbank Morse pumps in the service water system, the pumps did not use snap rings to fasten the impellers. Discussion with the licensee of this plant indicated that the service water system use sea water for cooling and the pump casings and impellers are made of cast iron and bronze, respectively. None of the internal components were made of carbon steel. Since no snap ring failure other than that of Arkansas 2 has been reported, we can conclude that either the snap ring is a unique design to the Fairbank Morse pumps at Arkansas 2 or the snap rings used in other service water pumps are made of corrosion resistance materials instead of carbon steel.

Our review did identify a somewhat similar situation -- failure of the impeller cap screw of the service water pump at Surry 2 as a result of the corrosive nature of the service water. The cap screw was made of carbon steel. The event occurred on August 20, 1981, and was described in LER 81-55-01. While the plant was operating at full power, both charging pump service water pumps failed. Initially, the B pump seized when the carbon steel impeller cap screw failed. This allowed the impeller to slide off the pump shaft, binding the shaft. The redundant A pump then failed to automatically start on low system pressure. The operator attempted to manually start the pump, but the pump tripped on overload. Repetitive attempts to start the pump failed. Investigation revealed that water from the failed B pump had fallen onto the A pump (located directly underneath the B pump), shorting the motor stator windings. In accordance with plant Technical Specifications, the plant operators commenced a power rampdown in preparation for a plant shutdown.

The licensee determined that the B pump impeller cap screw had failed because of the corrosive nature of the service water. The licensee's immediate corrective action was to replace the impeller cap screw and return the B pump to service. The A pump's motor stator and bearings were then replaced. A temporary mechanical shield was placed over the A pump to prevent water from the B pump from splashing on the A pump. The licensee also inspected the impeller cap screw on the A pump as well as the Unit 1 charging pump service water pumps to ensure their integrity. The licensee's long term corrective action included replacing the charging pump service water pumps at both units with pumps more suitable to the brackish service water environment.

The problem regarding corrosion/erosion of service water system has been identified and evaluated in an AEOD case study (Ref.1). The case study found that the most commonly specified cause for corrosion/erosion degradation of the service water system at LWRs was the nature of the system's water source. Suspended solids in the water source (e.g., silt or fine sand particles) was most frequently cited as the cause of the erosion of system components. The corrosive nature of the water source was another commonly cited cause of service water equipment degradation. Components as well as system piping made of mild carbon steel are especially vulnerable to a corrosive raw water environment. This has been reported at plants using both sea water and fresh water for their service water systems. The majority of the plants have attempted to mitigate and/or prevent corrosion and erosion of service water system components and piping by replacing degraded components with components that are more metallurgically suited to the system environment, i.e., carbon steel components have been replaced with stainless steel, and fittings corroded by salt and brackish water have replaced by brass and bronze fittings. Some plants have begun frequent systematic inspections of particularly vulnerable equipment and regularly replace certain components.

At Arkansas 2, plant operational records indicate that the service water pumps had last been overhauled, including replacement of the snap rings, in 1986-1987; pump A on June 11,1986, pump B on April 2, 1987, and pump C on May 22, 1986. However, routine periodic inspection or overhaul of the service water pumps had not been established. It appears that snap ring degradation caused by corrosion due to corrosive raw water do not affect the operation of the pumps during early stages of corrosion. Thus, this type of degradation may not be detected by means of routine surveillance tests. The corrosion process requires an certain length of time to cause catastrophic failure of a pump. Had the licensee had a routine periodic inspection program in place, the corrosion of the snap rings could have been detected before it caused destruction of the pumps. Our discussion with the licensee found that the licensee has determined beryllium copper is a better material for the service and all snap rings were replaced with the rings made of this material.

CONCLUSIONS

Although the failure of snap rings appears to suggest a common-cause failure mode that could result in a total loss of the service water system, the snap rings which are made of carbon steel appear to be unique to the service water pumps at Arkansas 2, and since no other failures of this type were found in a search of the operational experience data bases, the event appears to be an isolated case. Carbon steel is known to be susceptible to corrosion damage from corrosive raw water. Therefore, it is seldom used for internal fittings of pumps handling raw water. In addition, such corrosion induces slow degradation of the snap rings and it requires a great length of time to cause destruction of a pump. A proper periodic inspection program can detect snap ring corrosion before the snap ring becomes totally damaged. Therefore, we believe that this event has no generic implications and as such require no further actions. Furthermore, the corrosion/erosion problems of plant service water systems have been addressed by case study C801 and its follow-up efforts.

REFERENCES

1. AEOD/C801, "Service Water System Failures and Degradations in Light Water Reactors," Office for Analysis and Evaluation of Operational Data, U.S. Nuclear Regulatory Commission, August 1988.