11/19/73

Arkansas Power & Light

Arkansas Nuclear One - Unit 1

Backstop Failure

Summary Report

Summary

On August 25, 1973, the Allis-Chalmers supplied reactor coolant pump motor on pump No. P32B (Motor serial No. 38824) was damaged to the extent that the rotor shaft had to be removed and sent back to the Allis-Chalmers factory for repairs. In addition, the Marland Clutch reverse device, also supplied by Allis-Chalmers, was damaged and required extensive refurbishment.

Detailed examination of the damaged parts and analysis of events leading up to the failure led to the conclusion that the most probable cause of the damage was failure of the anti-reverse device to prevent reverse rotation of the pump and motor rotor assembly. The rotor propelled by back flow from one or more operating pumps was accelerated in the reverse direction for a short period of time prior to engagement of the clutch. The device once triggered has very little if any slippage, thus, very high torques were applied in stopping the 32000 lb rotating mass. The remaining AP&L clutches were all removed for detailed inspection. It was determined that three of the four clutch assemblies had insufficient clearance to allow free rotation of the roller cage assembly relative to the stationary cam. This would allow free rotation of the rotor shaft in either direction. The clearances between the stop lugs and cam and also the clearance between the roller cage cam have since been modified to assure freedom of motion required for proper functioning of the device. It was also determined that unit P32C clutch had failed to a lesser extent than the B unit. Damage to the unit C clutch was greater than observed when a torque of 125,000 ft. lbs. was applied to the test unit during early development testing at the Marland Clutch Co. We, therefore, had a reliable measure of the forces involved in producing the damage. The C unit had experienced torques in excess of 125,000 ft. lbs. and the B unit failure torques were approximately 200,000 ft. lbs. Since neither reverse motor nor back flow torques from other operating pumps can conceivably reach this amplitude, one must conclude that the forces required to produce the damage were a result of stored flywheel kinetic energy.

Discussion:

A simplified sketch (EXHIBIT "A") has been prepared to show the basic principal of operation of the Marland anti-reverse device. Springs are provided to position the rollers on the cam ramp in a manner which will allow very little reverse rotation prior to their engagement with the outer race. The springs must have sufficient tension to overcome any frictional forces which would prevent free rotation of the roller cage assembly relative to the stationary cam. If the cage advance springs are tensioned too much, however, they will break down the lubricating oil film and skid against the outer race while in the free running mode. This would quickly wear out the clutch. Since the springs must of necessity be very delicate, it can easily be seen that freedom of motion of the roller cage relative to the cam is essential to proper functioning of the device. Inspection of the failed Unit B clutch assembly determined that the roller cage could be rotated by hand firmly against the cam stop shoulder and, on occasion, it would stick there.

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COPY No. 1

QUALITY ASSURANCE

MANUAL

OPERATIONS

ARKANSAS POWER & LIGHT

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APL-TOP 1

Discussion: (Cont'd)

The examination also revealed that the stop lugs which function to limit roller cage travel in order to prevent the rollers from contacting the cam shoulders were wedging against the cam ramp face where there should be clearance in order for the lugs to freely rotate against the ramp shoulder. The stop lugs have been since modified to provide .030 inch clearance in this area. It was also noted that the clearance between the inside diameter of the roller cage and outside diameter of the cam was in some cases so small that a .006 inch shim would stick the roller cage. This was not considered enough clearance for the following reasons:

1) The assembly is subjected to a drop in temperature during the coast down cycle due to decreasing velocity and change in hot recirculated back stop lube system oil to lower temperature oil from the discharge side of the lift system heat exchanger.

2) The cage has a smaller mass than the cam and would shrink more rapidly.

3) The cage is made of aluminum which has a coefficient of expansion approximately twice that of the cam. It would, thus, shrink more during the cool-down cycle.

4) The oil which cools the clutch assembly is directed on the cam roller. It would cool the cage more rapidly than the cam during the coast down cycle.

5) In addition to the above, the imprint of the cam outside profile was observed on the inside diameter of the roller cage.

The radial clearance between the outside diameter of the cam and the inside diameter of the roller cage has since been modified from the original .006 inch to .030 inch.

Evidence that the damage occurred during reverse rotation of the pump was substantiated by the obvious direction in which the loads were applied to the key which drives the clutch outer race. After shearing the drive key, the shaft rotated approximately 90° before stopping. This observation results in a minor difference in conclusions separately arrived at by B&W engineers and Allis-Chalmers.

Allis-Chalmers stated that an angular rotation of 23-1/2° to 80° would produce enough impact loading to shear the key. B&W feels that, since the key was tightly wedged between the coupling and shaft and continued to rotate for 90° prior to stopping the shaft, at least several revolutions of the shaft would have been required to produce the noted damage. If the shaft only rotated 90° and was stopped in 90°, then a force ratio of one to one would be evident. Since our system cannot produce a torsional force of 200,000 ft. lbs., it is more probable that the shaft had turned several revolutions prior to the clutch engaging. The maximum back flow torque that our system can apply to an idle pump is approximately 16,300 ft. lbs.

The damaged B pump motor was no-load tested after removal of the failed anti-reverse device to assure proper functioning of the motor. The rotor shaft was magnetic particle tested. No discontinuities were observed. The flywheel was ultrasonically tested with acceptable results. The damaged shaft key-way was milled oversize and a [illegible]f key was inserted. A new key-way was milled 180° from the damaged section. The damaged portion of the rotor shaft was then turned true. The B motor rotor assembly was then determined to be straight within the original fabrication tolerances by dial indicator checks between centers. The C motor rotor assembly was not damaged. All damaged anti-reverse clutch parts were replaced. The units have all been assembled and no-load tested with acceptable performance since the incident.

lusion:

The primary purpose of the anti-reversing device is to prevent reverse rotation of the pump motor during normal operation with reverse flow through a non-operating pump. The maximum reverse torque that a non-operating pump will be subjected to is 16,300 ft. lbs. If this torque were allowed to accelerate the pump in the reverse direction, we would expect to experience equipment damage upon application of normal starting torque. The device is designed to engage only when the pump comes to zero speed.

FSAR Amendment No. 28, Item 4.29, dated August 18, 1972, discussed the anti-reverse device in relation to the guillotine break in the pump suction and concluded that the operation of this device is not required from a safety standpoint.

From the above we have concluded that the device performs no safety function and the incident is not safety related in any way.