

TENNESSEE VALLEY AUTHORITY

CHATTANOOGA, TENNESSEE 37401

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MAR 16 1987

WBRD-50-390/86-64

10 CFR 50.55(e)

U.S. Nuclear Regulatory Commission  
Attn: Document Control Desk  
Office of Nuclear Reactor Regulation  
Washington, D.C. 20555

Attention: Mr. Stewart Ebnetter

WATTS BAR NUCLEAR PLANT UNIT 1 - FAILED MOTOR PINION KEY AND MOTOR SHAFT IN  
LIMITORQUE OPERATOR - WBRD-50-390/86-64, - SECOND INTERIM REPORT

The subject deficiency was initially reported to NRC-Region II Inspector  
Morris Branch on October 9, 1986, in accordance with 10 CFR 50.55(e) as NCR  
W-477-P. Our first interim report was submitted on November 12, 1986.  
Enclosed is our second interim report. We expect to submit our final report  
on or about November 2, 1987. We consider 10 CFR Part 21 applicable to this  
deficiency.

If there are any questions, please call R. D. Schulz at (615) 365-8527.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

*J. A. Damer*  
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Enclosure

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U.S. Nuclear Regulatory Commission

MAR 16 1987

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ENCLOSURE  
WATTS BAR NUCLEAR PLANT UNIT 1  
FAILED MOTOR PINION KEYS AND MOTOR  
SHAFT IN LIMITORQUE OPERATOR  
WBRD-50-390/86-64  
NCR W-477-P  
10 CFR 50.55(e)  
SECOND INTERIM REPORT

DESCRIPTION OF DEFICIENCY

During preventive maintenance for the actuator on valve 1-FCV-63-72A (residual heat removal (RHR) pump suction to containment sump isolation valve), the motor shaft-pinion gear key connection was found to be damaged. The key was found deformed and approximately one third of the way out of its slot. The motor shaft was found to be cracked in two places (see attached photographs). The redundant train valve actuator (1-FCV-63-73B) was then examined, which revealed a similarly deformed key, still in complete engagement with no motor shaft cracking. The failed actuators are model SB-3, manufactured by Limatorque Corporation, Lynchburg, Virginia, equipped with 100 ft-lb motors. These were provided to TVA by Westinghouse Corporation, Pittsburgh, Pennsylvania, under the NSSS contract (54114-1). These are the only two size 3 actuators with 100 ft-lb motors used in safety-related applications for each unit at WBN.

SAFETY IMPLICATIONS

The damage identified could result in a sudden failure of the key and/or motor shaft, rendering the valves inoperable. Failure of these valves to operate could result in loss of the ability to recirculate water from containment following a loss of coolant accident (LOCA). Therefore, this deficiency, could have adversely affected the safety of operations of the plant.

INTERIM PROGRESS

These failures appear to be related to the condition identified in March 1981 in OIE Information Notice 81-08, which addressed failure of motor pinion keys in Limatorque SMB-4 actuators with motor torque in excess of 100 ft-lbs. The subject valves utilize 100 ft-lb motors and, since they do not meet the criteria, the keys were not inspected or replaced. The failed motor shaft and both motor pinion keys were submitted to TVA's Central Laboratory for a metallurgical failure analysis.

The TVA metallurgical report on the shaft and key failures was provided to Limatorque Corporation for evaluation. Limatorque responded by letter, dated January 20, 1987, stating that their calculations indicated the failures did not result from underdesigned components. The Limatorque calculations used the locked rotor torque capability of the motor and motor inertia to determine the maximum loads applied to the motor pinion key. This would be considered the worst-case condition, including abnormal operating configurations. These calculations indicated safety factors greater than three for both motor pinion key shear stress and contact stress. Based on their calculations, Limatorque was unable to explain the failures, but indicated that partial engagement of the key was a contributing factor in one case. In addition, Limatorque responded to TVA's indicated desire to replace the key with higher strength steel, stating that while unnecessary, it would be acceptable.

A copy of TVA's failure report was also submitted to Westinghouse Corporation for review and response. Their response, dated February 9, 1987, concurred with Limitorque's response and added that discussions with Limitorque and with the Westinghouse division providing the Limitorque actuators indicated that no other user had reported this failure for this actuator. Westinghouse considers the root cause of the failure to be the incomplete engagement of the key and does not believe that review for generic implications is warranted, as this is the only reported failure.

Further inspection by TVA has revealed that some deformation occurred on the sides of the keyway slots for both shafts, apparently from the impact of the key on the shaft.

The TVA metallurgical report on the failures indicates that the metallurgical properties of the two keys and the failed shaft are within the limits of the material specifications (AISI type 1018 carbon steel for the keys and AISI type 1144 for the shaft), and that no metallurgical defects were involved in the failures.

TVA considers, at present, that the mechanism for failure of the motor shaft was initiated by slight deformation of the key, which resulted in increased clearance between the key and shaft. This increased clearance resulted in higher impact loading, which, after repeated cycling, further deformed the key. These factors eventually led to the key working one-third to one-half of the way out of the slot. This reduced the contact area between the key and shaft, which significantly increased the overall loading and moved the load concentration to the open outer end of the shaft keyway slot. This increased loading eventually resulted in brittle fracture of the shaft initiating at the sharp keyway slot corners and propagating back into the shaft approximately 1-1/2" by ductile tearing of the metal. This conclusion is based on visual examination of the nonuniform shaft and keyway deformation and the metallurgical failure analysis.

TVA wiring configurations do not allow instantaneous motor reversal. Powered motor operation must be stopped before reversing the motor. In addition, for these valves, there have been no recorded occurrences of torque- or limit-switch failures or of excessive unseating forces. Because of this history and the worst-case calculations by Limitorque, TVA does not consider abnormal operating conditions to be a cause or a contributing factor for the failure.

Both Limitorque and Westinghouse considered incomplete key engagement to represent a significant factor in the failure. TVA agrees that this was the primary cause of the motor shaft failure. However, neither Limitorque nor Westinghouse addressed the key working its way out of full engagement or why the key which maintained full engagement was cracked and deformed. It should be noted that the keys for both valves were staked in place at the factory.

TVA considers that the root cause of these failures has not yet been adequately defined. Therefore, TVA will perform further root cause investigation. Present plans include disassembly and inspection of the identical valves installed on WBN unit 2, further communication with Limatorque, testing of type 1018 keys under normal operating conditions, and possible identification and inspection of type SB-3-100 actuators in service at other TVA facilities.

TVA expects to provide the final report to address root cause and actions to prevent recurrence for this deficiency on or about November 2, 1987.

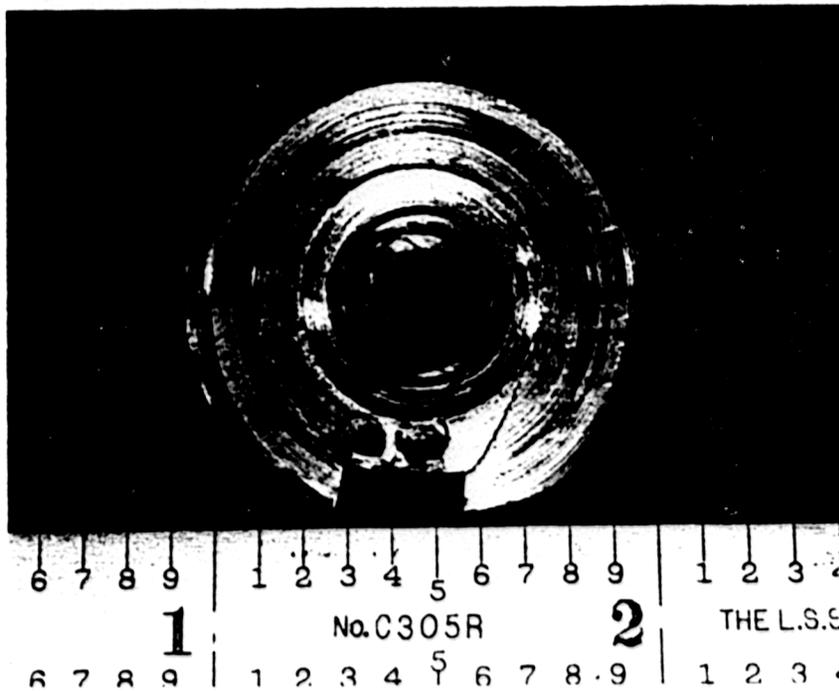


Figure 1 - End view of shaft showing cracks which initiated at the corners of the keyway.

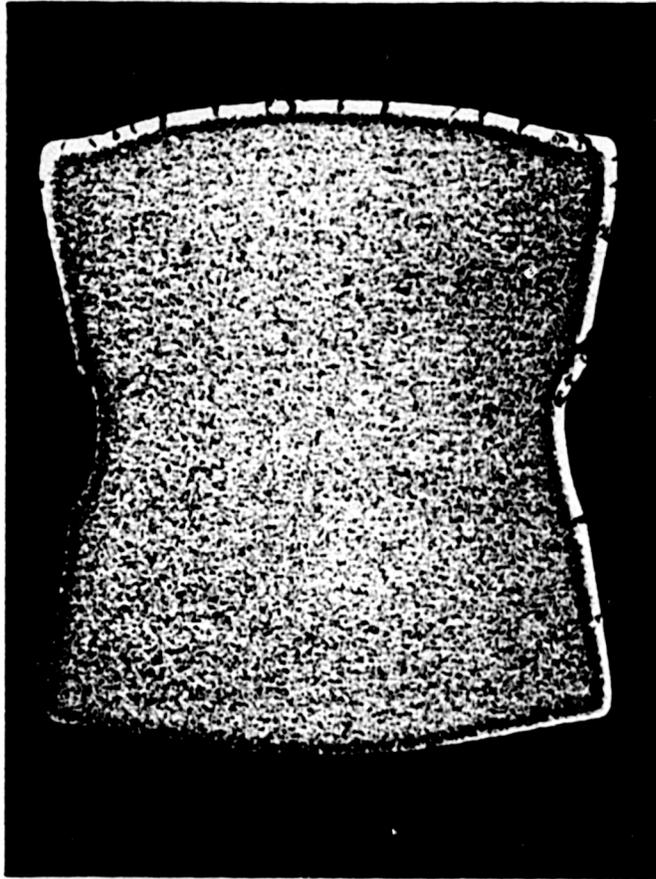


Figure 2 - Photograph of key at 12X magnification showing deformation at centerline and cracking in the case.