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AUTH.NAME AUTHOR AFFILIATION
GRABO,B.A. Arizona Public Service Co. (formerly Arizona Nuclear Power
LEVINE,J.M. Arizona Public Service Co. (formerly Arizona Nuclear Power
RECIP.NAME RECIPIENT AFFILIATION

SUBJECT: LER 95-006-00:on 930418,identified that motor pinion key for containment spray header isolation valve occurred.Caused by improper key matl.All identified valves had motor pinion keys replaced.W/950525 ltr.

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P R I O R I T Y 1 D O C U M E N T

Arizona Public Service Company
PALO VERDE NUCLEAR GENERATING STATION
P.O. BOX 52034 • PHOENIX, ARIZONA 85072-2034

192-00933-JML/BAG/BE
May 25, 1995

JAMES M. LEVINE
VICE PRESIDENT
NUCLEAR PRODUCTION

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
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Washington, DC 20555

Dear Sirs:

Subject: **Palo Verde Nuclear Generating Station (PVNGS)**
Units 1, 2, and 3
Docket Nos. STN 50-528, 50-529, 50-530
License Nos. NPF-41, NPF-51, NPF-74
Licensee Event Report 95-006-00

Attached please find Licensee Event Report (LER) 95-006 prepared and submitted pursuant to 10CFR50.73. This LER reports the failure of AISI 1018 motor pinion key material. The material properties did not provide sufficient margin to withstand the shock loads associated with normal operation and diagnostic testing of the motor operated valves. In accordance with 10CFR50.73(d), a copy of this LER is being forwarded to the Regional Administrator, NRC Region IV.

If you have any questions, please contact Burton A. Grabo, Section Leader, Nuclear Regulatory Affairs, at (602) 393-6492.

Sincerely,

James M. Levine

JML/BAG/BE/pv

Attachment

cc: L. J. Callan (all with attachment)
K. E. Perkins
K. E. Johnston
INPO Records Center

IE22

LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Palo Verde Unit 1	0 5 0 0 0 5 2 8	1 OF 1 0

TITLE (4)

AISI 1018 Carbon Steel Key Material Did Not Provide Sufficient Margin for Operation of MOVs

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAMES	DOCKET NUMBERS
									Palo Verde Unit 2	0 5 0 0 0 5 2 9
0 4	1 8	9 3	9 5	- 0 0 6 -	0 0	0 5	2 5	9 5	Palo Verde Unit 3	0 5 0 0 0 5 3 0

OPERATING MODE (9)	N	THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more of the following) (11)			
POWER LEVEL(10)	0 0 0	20.402(b)	20.405(c)	50.73(a)(2)(iv)	73.71(b)
		20.405(a)(1)(i)	50.36(c)(1)	50.73(a)(2)(v)	73.71(c)
		20.405(a)(1)(ii)	50.36(c)(2)	X 50.73(a)(2)(vii)	OTHER (Specify in Abstract below and in Text, NRC Form 366A)
		20.405(a)(1)(iii)	50.73(a)(2)(i)	50.73(a)(2)(viii)(A)	
		20.405(a)(1)(iv)	50.73(a)(2)(ii)	50.73(a)(2)(viii)(B)	
		20.405(a)(1)(v)	50.73(a)(2)(iii)	50.73(a)(2)(x)	

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER
Burton A. Grabo, Section Leader, Nuclear Regulatory Affairs	AREA CODE 6 0 2 3 9 3 - 6 4 9 2

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFAC-TURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFAC-TURER	REPORTABLE TO NPRDS
B	B E	2 0	L 2 0 0	Y	B	B Q	2 0	L 2 0 0	N
B	B P	2 0	L 2 0 0	N					

SUPPLEMENTAL REPORT EXPECTED (14)		EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
YES (If yes, complete EXPECTED SUBMISSION DATE)	X NO				

ABSTRACT (Limit to 1400 spaces, i.e., approximately fifteen single-space typewritten lines) (16)

On April 18, 1993, Palo Verde Unit 2 was defueled when it was identified by APS Valve Services Maintenance personnel that the motor pinion key for Unit 2 Train A Containment Spray header isolation valve was sheared. Subsequent motor pinion key failures occurred on October 18, 1993 (Unit 1), March 23, 1994 (Unit 3), April 2, 1994 (Unit 3) and April 13, 1994 (Unit 3).

The evaluations for these events determined that the failures were due to improper key material. The above events were determined to have a common-mode failure and on April 25, 1995, the above events were determined to be reportable per 10CFR 50.73.

As of May 16, 1995, all of the identified valves have had their motor pinion keys replaced except for two (2) valves in Unit 3. These two valves were determined not to be a high priority for key replacement; therefore, their key replacements will be performed during the fifth refueling outage (3R5) for Unit 3 in the fall of 1995. The evaluation identified 227 valves that were susceptible to this type of failure. Out of these valves only five (5) actual failures were identified.

There have been no previously similar events reported pursuant to 10 CFR 50.73 in the last three years specific to sheared motor pinion keys.

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TEXT

1. REPORTING REQUIREMENT:

This LER 528/529/530/95-006 is being written to report events where a single cause or condition caused at least one independent train or channel to become inoperable in multiple systems or two independent trains or channels to become inoperable in a single system designed to: (B) Remove residual heat, (C) Control the release of radioactive material or (D) Mitigate the consequences of an accident as specified in 10 CFR 50.73(a)(2)(vii).

Specifically, on April 18, 1993, at approximately 1700 MST, it was identified by APS Maintenance personnel (utility, nonlicensed) that following completion of as-found static diagnostic testing, the Unit 2 Train A Containment Spray (BE) header isolation valve 2JSIAUV0672 motor pinion key was sheared and the motor was free-wheeling without moving the valve stem.

Concurrently with the above equipment root cause of failure investigation, Valve Services Engineering (VSE) personnel (utility, nonlicensed) were investigating Limitorque's Maintenance Update 92-02 for potential impact on Units 1, 2, and 3. Because of the safety significance of the Containment Spray isolation valves, work requests were written to replace the motor pinion key material in all of the Containment Spray isolation valves (all three units). On September 10, 1993, VSE's evaluation concluded and identified a total of 227 valves that were susceptible to this type of failure and scheduled their replacement of the motor pinion keys based on their susceptibility for failure. Four (4) additional motor pinion keys were found sheared while performing motor pinion key replacements on 225 of the 227 valves, as follows:

On October 18, 1993, at approximately 1600 MST, it was identified by Valve Services Maintenance (VSM) personnel (utility, nonlicensed) that during the scheduled replacement of the motor pinion key for Unit 1 Train B Containment Spray header isolation valve 1JSIBUV0671, the installed motor pinion key was sheared.

On March 23, 1994, at approximately 0100 MST, it was identified by VSM personnel that during the scheduled replacement of the motor pinion key for Unit 3 Train B Containment Spray header isolation valve 3JSIBUV0671, the installed motor pinion key was sheared.

TEXT

On April 2, 1994, at approximately 0200 MST, it was identified by VSM personnel that during the scheduled replacement of the motor pinion key for Unit 3 Train B Low Pressure Safety Injection (LPSI) (BP) header isolation valve 3JSIBUV0615, the installed motor pinion key was sheared.

On April 13, 1994, at approximately 1700 MST, it was identified by VSM personnel that during the scheduled replacement of the motor pinion key for Unit 3 Train A Containment Isolation (BD) valve 3JSICHV0321, the installed motor pinion key was sheared.

On January 20, 1995, it was identified in the Nuclear Assurance Corrective Action Audit that the above events should be reevaluated as a whole for any reportability concerns.

Upon further investigation and evaluation of the above events, a common-mode failure was determined to have existed that caused two independent trains to become inoperable, and these events were determined to be reportable on April 25, 1995.

2. EVENT DESCRIPTION:

On April 18, 1993, Unit 2 was defueled with the core (AC) off-loaded to the Spent Fuel Pool when it was identified by VSM personnel, following completion of as-found static diagnostic testing of Unit 2 Train A Containment Spray header isolation valve 2JSIAUV0672, that the motor pinion key was found to have been sheared.

The functional requirement of 2JSIAUV0672 is to provide Containment Spray header isolation and containment isolation (NH) in Modes 1 through 4 (POWER OPERATION through HOT SHUTDOWN). During power operation, the valve is normally closed and opens upon a Containment Spray Actuation Signal (CSAS) (BE) to provide containment spray.

APS Valve Services Engineering (VSE) personnel (utility, nonlicensed), upon discovery of the sheared motor pinion key, initiated an investigation in accordance with the APS Incident Investigation Program. As part of the investigation, the work order history for 2JSIAUV0672 was reviewed and it was determined that the actuator had been replaced in December 1991.

TEXT

It appears that the failed motor pinion key was in service for only one plant operating cycle, and based on a reasonable estimate for the number of valve strokes required to perform as-left diagnostic testing, as-left and as-found local leak rate testing (LLRT), and periodic ASME Section XI testing, the actuator is assumed to have been cycled less than fifty (50) times prior to failure.

The investigation concluded that improper fabrication of the motor pinion keyway was not a probable cause of the failure and that the 10 CFR Part 21 Notification issued by Limitorque on this subject on March 20, 1990, did not apply. Comparison of the applied 8 thousand pounds per square inch (ksi) shear stress with the material shear strength of 21 ksi suggested that the failure was not simply a shear failure and may have been the result of an additional shock load acting on the motor pinion key.

The failed key material was sent for metallurgical examination and was determined to be American Iron and Steel Institute (AISI) 1018 carbon steel with a hardness of 93 hardness Rockwell B scale (HRB). A replacement key was fabricated by Limitorque from AISI 4140 alloy steel, and the valve was returned to service. Additionally, work orders (WOs) were initiated to replace the existing motor pinion keys installed in Train B JSIBUV0671 (all three units) and Train A JSIAUV0672 (Units 1 and 3) as soon as possible.

Prior to this failure Limitorque issued Maintenance Update 92-02 to inform utilities of ten (10) maintenance topics. On December 23, 1992, APS VSE personnel initiated an investigation of these topics' one of which was the replacement of AISI 1018 motor pinion key material with AISI 4140 material. This part of the investigation was completed on September 10, 1993 and work requests were written to replace the motor pinion keys on the susceptible valves. VSE personnel identified that seventy-two (72) valves per unit and eleven (11) individual valves (6 in Unit 1; 4 in Unit 2; and 1 in Unit 3) were susceptible to this type of failure and scheduled their replacement of motor pinion keys based on their susceptibility for failure.

On October 18, 1993, Unit 1 was in Mode 1, at approximately 95 percent power, when it was identified by APS Maintenance personnel, during the performance of the aforementioned motor pinion key replacement for Unit 1 Train B Containment Spray header isolation valve 1JSIBUV0671, that the installed motor pinion key was found to have been sheared.

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TEXT

The motor pinion replacement WO had been initiated as a result of the root cause analysis performed for the condition identified previously on April 18, 1993.

The functional requirement of 1JSIBUV0671 is to provide Containment Spray header isolation and containment isolation in Modes 1 through 4. During power operation, the valve is normally closed and opens upon a CSAS to provide containment spray.

VSE personnel, upon discovery of the sheared motor pinion key, initiated an investigation in accordance with the APS Incident Investigation Program. The failed key material was visually examined and hardness tested on November 24, 1993, and was measured to be 89 HRB. On this basis, the properties of the failed key were considered similar to AISI 1018 plain carbon steel.

The work history for 1JSIBUV0671 was reviewed and it was concluded that the failed part was the original AISI 1018 key that was initially provided by Limitorque. The apparent root cause of the motor pinion key failure is related to inertial shock loads imposed on the actuator during operation.

The originally provided AISI 1018 material properties may not provide the key with sufficient margin to withstand the shock loads associated with the high stem speed of the actuators installed on JSIAUV0672 and JSIBUV0671.

On March 23, 1994, Unit 3 was in Mode 5 (COLD SHUTDOWN) when it was identified by VSE personnel, during the performance of the scheduled motor pinion key replacement for Unit 3 Train B Containment Spray header isolation valve 3JSIBUV0671, that the installed motor pinion key was found to have been sheared. The motor pinion replacement WO had been initiated as a result of the root cause analysis performed for the condition identified previously on April 18, 1993.

VSE personnel, upon discovery of the sheared motor pinion key, initiated an investigation in accordance with the APS Incident Investigation Program.

The motor pinion gear was found to have rotated approximately 90 degrees on the motor shaft until further slippage was prevented, presumably by the motor pinion gear setscrew or by wedging of the sheared key fragments.

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TEXT

The MOV had most recently been electrically stroked open and closed during quarterly performance of ASME Section XI stroke timing and position indication verification surveillance testing on January 11, 1994.

The failed key material was hardness tested on August 31, 1994, and was measured to be 97 HRB. On this basis, the properties of the failed key were considered similar to AISI 1018 plain carbon steel. The root cause of failure is that the AISI 1018 material properties do not provide the key with sufficient margin to withstand the shock loads associated with the high stem speed of the actuators installed on JSIAUV0672 and JSIBUV0671.

On April 2, 1994, Unit 3 was defueled when it was identified by VSM personnel, during the performance of the scheduled motor pinion key replacement for Unit 3 Train B LPSI header isolation valve 3JSIBUV0615, that the installed motor pinion key was found to have been sheared. The motor pinion replacement WO had been initiated as a result of the root cause analysis performed for the condition identified previously on April 18, 1993.

The functional requirement of 3JSIBUV0615 is to provide LPSI header isolation and containment isolation in Modes 1 through 4. During power operation, the valve is normally closed and opens upon a Safety Injection Actuation Signal (SIAS) (JE) (BP/BQ).

VSE personnel, upon discovery of the sheared motor pinion key, initiated an investigation in accordance with the APS Incident Investigation Program. On August 31, 1994, the failed key material was hardness tested, and the metallurgical results showed that the key was fabricated from a resulfized grade of low carbon steel and many non-metallic sulfide inclusions were present. This type of material is weaker than the AISI 1018 material originally specified for this motor actuator. The root cause of failure was determined to be due to the inferior grade of steel that was found in the key for the loading conditions that exists for this MOV.

On April 13, 1994, Unit 3 was defueled when it was identified by VSM personnel, during the performance of scheduled motor pinion key replacement for Unit 3 Train A High Pressure Safety Injection (HPSI) long term loop recirculation isolation valve 3JSICHV0321, that the installed motor pinion key was found to have been sheared. The motor pinion key replacement WO had been initiated as a result of the root cause analysis performed for the condition identified on April 18, 1993.

TEXT

The functional requirement of 3JSICHV0321 is to provide containment isolation in Modes 1 through 4. Additionally, the valve provides a flow path for hot leg injection flow following a design basis event requiring safety injection flow. The valve is normally closed during power operation and is not designed to reposition automatically on a safety signal.

VSE personnel, upon discovery of the sheared motor pinion key, initiated an investigation in accordance with the APS Incident Investigation Program. On August 31, 1994, the failed key material was hardness tested and was measured to be 91 HRB.

On this basis, the properties of the failed key were considered similar to AISI 1018 plain carbon steel. Visual examination of the failed key remnant suggests that the failure occurred progressively over time and was not the result of a single catastrophic loading.

The apparent root cause of failure is that the AISI 1018 key material properties do not provide sufficient margin to withstand the shock loads associated with normal operation and diagnostic testing of MOVs JSICHV0321 and JSIDHV0331.

The above events were determined to have a common-mode failure, and on April 25, 1995, the above events were determined to be reportable per 10CFR 50.73.

3. ASSESSMENT OF THE SAFETY CONSEQUENCES AND IMPLICATION OF THIS EVENT:

An Equipment Root Cause of Failure Analysis (ERCFA) was performed on the above conditions and it was determined that the AISI 1018 key material properties do not provide sufficient margin to withstand the shock loads associated with normal operation and diagnostic testing of the subject motor operated valves (MOVs). Visual examinations of the failed key remnants suggest that the failures occurred progressively over time and were not the result of a single catastrophic loading.

The motor pinion keys on 225 of the 227 susceptible valves have been replaced and a total of 5 failures have been identified. The significance of these failures is described below.

The Safety Injection (SI) system (BP/BQ) is designed to provide core cooling in the unlikely event of a Loss-of-Coolant Accident (LOCA). The SI system accomplishes this functional requirement by use of redundant active and passive injection subsystems.

TEXT

The SI system is designed to meet its functional requirements even with the failure of a single active component during the injection mode of operation or with the single active or limited leakage passive failure of a component during the recirculation mode of operation.

Therefore, the motor pinion key failures for MOVs 3JSIBUV0615 and 3JSICHV0321 did not impact the capability of the SI system from performing its design basis function because of the availability of the redundant train.

The function of containment heat removal systems is to remove heat from the containment atmosphere to limit, reduce, and maintain at acceptably low levels containment pressure and temperature following a LOCA or secondary system pipe rupture. The only active containment heat removal system at Units 1, 2, and 3 is the containment spray system (CSS). The CSS, in addition to containment heat removal, also serves as a fission product removal and control system.

The CSS consists of two independent 100 percent capacity loops each containing a containment spray pump, a shutdown cooling heat exchanger, a spray header, and associated valves, piping, and instrumentation.

Therefore, the motor pinion key failures for MOVs 2JSIAUV0672, 1JSIBUV0671, and 3JSIBUV0671 did not impact the capability of the CSS from performing its design basis function because of the availability of the redundant train.

MOVs JSIAUV0672, JSIBUV0671, JSIBUV0615, and JSICHV0321 all provide containment isolation in Modes 1 through 4. During power operation, the above valves are normally closed; therefore, the requirement for containment isolation was met. Additional redundancy for containment isolation is provided by check valves on the piping inside containment and that the piping is normally filled with water, each would help ensure that the containment atmosphere would be isolated from the outside environment in the event of a release of radioactive material to the containment atmosphere or pressurization of the containment.

This event did not result in any challenges to the fission product barriers or result in any releases of radioactive materials. Therefore, there were no adverse safety consequences or implications as a result of this event. This event did not adversely affect the safe operation of the plant or the health and safety of the public.

TEXT

4. CAUSE OF THE EVENT:

An evaluation for each event was performed in accordance with the APS Incident Investigation Program. The evaluations concluded that the apparent root cause of failure is that the AISI 1018 key material properties do not provide sufficient margin to withstand the shock loads associated with normal operation and diagnostic testing of some MOVs (SALP Cause Code B: Design, Manufacturing, Installation Error).

No unusual characteristics of the work location (e.g., noise, heat, or poor lighting) directly contributed to this event. There were no personnel or procedural errors which contributed to this event.

5. STRUCTURES, SYSTEMS, OR COMPONENTS INFORMATION:

MOVs 1JSIBUV0671, 3JSIBUV0671, and 2JSIAUV0672 are comprised of a Limitorque SB-0 actuator mounted on an eight-inch Borg Warner flex wedge gate valve.

The actuators and the valve are oriented vertically to the piping through which flow is controlled. The MOVs are driven by 25 FT-LB, 3600 RPM AC motors.

MOV 3JSICHV0321 is comprised of a Limitorque SB-0 actuator mounted on a three-inch Borg Warner globe valve. The actuator and the valve are oriented 45 degrees to the piping through which flow is controlled. The MOV is driven by a 25 FT-LB, 1900 RPM DC motor.

MOV 3JSIBUV0615 is comprised of a Limitorque SB-3 actuator mounted on a twelve-inch Borg Warner globe valve. The actuator and the valve are oriented vertical to the piping through which flow is controlled. The MOV is driven by a 150 FT-LB, 3600 RPM AC motor.

No additional structures, systems, or components were inoperable at the start of the event which contributed to this event. There were no additional component or system failures involved; therefore, no safety systems were rendered inoperable. No components with multiple functions were involved. There were no safety system actuations and none were required. The failure mode mechanism is described in Section 2.

TEXT

6. CORRECTIVE ACTIONS TO PREVENT RECURRENCE:

Immediate corrective action for the above MOVs was to replace the existing motor pinion keys with AISI 4140 motor pinion keys and return them to service.

Work orders were written to replace the motor pinion keys in the other train and in the other two units. VSE personnel identified that seventy-two (72) valves per unit and eleven (11) individual valves (6 in Unit 1; 4 in Unit 2; and 1 in Unit 3) were susceptible to this type of failure and scheduled their replacement of motor pinion keys based on their susceptibility for failure. The systems affected consisted of SI; Chemical and Volume Control (CA/CB); Auxiliary Feedwater (BA); Containment Purge (BD); Essential Cooling Water (BI); Condensate (KA); Nuclear Cooling Water (CC); and Radioactive Waste Drains (WK).

As of May 16, 1995, all of the identified valves have had their motor pinion keys replaced except for two (2) valves in Unit 3. The two valves in Unit 3 are Train B Seal Injection (CB) valve 3JCHBHV0255 and HPSI pump Train A discharge valve 3JSIAHV0698.

Limitorque's Maintenance Update 92-02 identified actuators that could potentially experience a key failure based on motor size and torque output. The two Unit 3 valves were determined not to be a high priority for key replacement based on these criteria. Their key replacements will be performed during the fifth refueling outage (3R5) for Unit 3 in the fall of 1995.

7. PREVIOUS SIMILAR EVENTS:

There have been no similar events to this type of failure reported pursuant to 10CFR50.73 where motor pinion keys have affected MOV operability in the past three years. LER 528/529/530/94-010 was submitted on February 7, 1994; however, this LER dealt with misalignment of the close torque switch contact bar.