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SUBJECT: LER 89-005-01:on 890412,atmospheric dump valve deficiency.
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Arizona Public Service Company

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

192-00520-JGH/TDS/DAJ
September 12, 1989

U. S. Nuclear Regulatory Commission
NRC Document Control Desk
Washington, D.C. 20555

Dear Sirs:

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Unit 1
Docket No. STN 50-528 (License No. NPF-41)
Licensee Event Report 89-005-01
File: 89-020-404

Attached please find Supplement Number 1 to Licensee Event Report (LER) No. 89-005-00 prepared and submitted pursuant to 10CFR50.73. In accordance with 10CFR50.73(d), we are herewith forwarding a copy of the LER to the Regional Administrator of the Region V office.

This report is also being submitted to include the information requested by 10CFR21. In accordance with 10CFR21.21(b)(2), three copies of this report are being provided to the Director, Office of Nuclear Reactor Regulation.

If you have any questions, please contact T. D. Shriver, Compliance Manager at (602) 393-2521.

Very truly yours,

J. G. Haynes
Vice President
Nuclear Production

JGH/TDS/DAJ/kj

Attachment

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U.S. NUCLEAR REGULATORY COMMISSION
APPROVED OMB NO. 3150-0104
EXPIRES: 8/31/88

LICENSEE EVENT REPORT (LER)

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TITLE (4)
Atmospheric Dump Valve Deficiencies

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

OPERATING MODE (9): 4
POWER LEVEL (10): 0 0 0

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: *(Check one or more of the following)* (11)

[ ] 20.402(b)	[ ] 20.405(c)	[ ] 50.73(a)(2)(iv)	[ ] 73.71(b)
[ ] 20.405(a)(1)(i)	[ ] 50.36(c)(1)	[X] 50.73(a)(2)(v)	[ ] 73.71(c)
[ ] 20.405(a)(1)(ii)	[ ] 50.36(c)(2)	[ ] 50.73(a)(2)(vii)	[X] 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)	10CFR21
[ ] 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 AREA CODE	
Timothy D. Shriver, Compliance Manager	6 0 2	3 9 3 - 2 5 2 1

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

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS

SUPPLEMENTAL REPORT EXPECTED (14)

[ ] YES *(If yes, complete EXPECTED SUBMISSION DATE)* [X] NO

EXPECTED SUBMISSION DATE (15): MONTH | DAY | YEAR

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

On April 12, 1989 APS completed an evaluation of a deficiency identified by the manufacturer of the PVNGS Units 1, 2, and 3 Atmospheric Dump Valves (ADV's). The ADV's are manufactured by Control Components Incorporated (CCI). Based upon APS's evaluation, it was determined that the deficiencies reported by CCI constituted a reportable condition pursuant to 10CFR21 and consequently 10CFR50.72 and 73.

On April 4, 1989, CCI notified APS that an evaluation had been performed and that excessive internal valve leakage could result in the inability to remotely or manually operate the PVNGS ADV's. The cause of the excessive leakage is the result of an internal piston ring which does not seat properly. Excessive leakage by the piston ring results in high internal pressures which would preclude opening of the valve.

As corrective action, the ADV internals have been redesigned and are being replaced in Units 1, 2, and 3. No previous similar events have been reported pursuant to 10CFR50.73.

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TEXT (If more space is required, use additional NRC Form 366A's) (17)

This report is also being provided pursuant to the provisions of 10CFR21. The narrative below includes information requested by 10CFR21(b)(3); however, it is formatted to report this event in accordance with the requirements of 10CFR50.73.

I. DESCRIPTION OF WHAT OCCURRED:

A. Initial Conditions:

The following plant conditions existed when the event described in this LER was determined to be reportable at approximately 1254 MST on April 12, 1989.

Palo Verde Unit 1 was in Mode 4 (HOT SHUTDOWN) at approximately 2000 pounds per square inch (psi) and 325 degrees Fahrenheit (F).

Palo Verde Unit 2 was in Mode 3 (HOT STANDBY) at normal operating temperature and pressure.

Palo Verde Unit 3 was in Mode 6 (REFUELING) at approximately 82 degrees F.

B. Reportable Event Description (Including Dates and Approximate Times of Major Occurrences):

Event Classification: Condition which could have prevented the fulfillment of a safety function.

Note: This section includes information requested by 10CFR21 concerning the nature of the defect and dates for which information was obtained/developed.

On April 12, 1989 at approximately 1254 MST Arizona Public Service (APS) determined that deficiencies identified by the manufacturer of the PVNGS Unit 1, 2, and 3 Atmospheric Dump Valves (ADV)(SB)(V) constituted a reportable condition pursuant to 10CFR21 and 10CFR50.73.

On March 3, 1989, a Palo Verde Unit 3 reactor trip occurred from approximately 98 percent power (Reference Unit 3 LER 530/89-001-00). Following the reactor trip, Control Room personnel (utility, licensed and non-licensed) attempted to remove decay heat and control steam generator (AB)(SG) pressure utilizing the Atmospheric Dump Valves (ADV's)(SB)(V). Control Room personnel could not remotely operate the ADV's from the Control Room or Remote Shutdown Panel. Heat removal was subsequently established by manually opening the ADV's.

Because of the ADV problems encountered during the Unit 3 reactor trip event, APS engineering personnel have been conducting an extensive evaluation of the ADV design and operation. The original equipment manufacturer, Control Components Incorporated (CCI), has been assisting during the APS evaluation. On April 4, 1989 CCI sent a letter to APS providing notification that a "potential significant deficiency" existed with the ADV design. Following receipt of this information, APS conducted an evaluation pursuant to 10CFR21 to determine the reportability of the information contained in the CCI notification. Further information was received from CCI on April 10, 1989 informing APS that local manual operation of the ADV's would not be possible if the deficient condition were to occur.

On April 12, 1989, PVNGS Engineering completed the evaluation and determined that the deficiency identified by CCI constituted a reportable condition.

The following discussion is intended to assist the reader in understanding the ADV's principle of operation. The disk stack (Figure 1) permits changes in flow rate while limiting flow velocity through the control element. The disk stack consists of a number of disks into which labyrinth flow passages have been etched to allow a fixed impedance. Impedance in the passages is developed by a series of right-angle turns, with a specific number of turns in each passage to limit the velocity to an acceptable level. Since each disk has a known flow capacity, flow through the control element can be accurately measured and controlled. The position of the plug within the disk stack bore determines flow by exposing more or fewer disk passages.

With the valve in the closed position, upstream pressure fills the chamber above the plug by way of a controlled leak across the piston ring. This provides a seating load equal to the inlet pressure times the full area of the plug.

When a signal to open the valve is received, the actuator lifts the stem, opening the pilot seat which results in the chamber pressure above the plug equalizing with the downstream pressure. Upstream pressure acts upon the differential plug area and provides an axial biasing force which causes the plug to remain on the main seat.

As the valve stem continues to move in the opening direction, the pilot valve shoulder engages the plug to lift it off the main seat. The axial biasing force causes these opposing faces to remain in contact under all operating conditions.

When the plug is in the modulated mode, biasing force provided by

pressure acting on the differential area overcomes fluctuating pressures from the fluid jets exiting the disk stack.

When a signal to close the valve is received, the actuator moves the stem in the closing direction. The biasing force on the plug causes it to follow the stem until the main seat is contacted. The actuator then seats the pilot section. Controlled leakage by the piston ring then fills the chamber above the plug providing additional seating force.

C. Status of structures, systems, or components that were inoperable at the start of the event that contributed to the event:

Other than the ADV problems discussed in this LER, there were no structures, systems, or components inoperable at the start of the event which contributed to the event.

D. Cause of each component or system failure, if known:

Note: This section includes information requested by 10CFR21 concerning the nature of the defect and dates for which information was developed.

After the Unit 3 trip on March 3, 1989 and the reported malfunction of the Unit 3 Atmospheric Dump Valves, test instruction 73TI-3SG04 "Atmospheric Dump Valves Functional Test" was developed to instrument and test the ADV's. The purpose of the test was to determine the forces involved in the operation of the ADV's and to characterize the positioner operation at normal operating temperature and pressure. This technique was used to provide time response data for the valve for various demand signals. The results of the testing are summarized below:

1. <u>Test Results</u>

<u>Unit 1 ADV 184</u>

The first valve to be tested following the ADV malfunctions in Unit 3 was the Unit 1 ADV-184. Testing began on March 14, 1989 using nitrogen gas supply at approximately 95 psig. ADV-184 was tested by giving the valve stepped, position demand signals from 10 percent to 50 percent in ten percent increments. The class 1E backup nitrogen accumulator (ACC) was used as the pneumatic supply source. Unit 1 ADV-184 did not open during the performance of this test even though the force exerted by the actuator on the valve stem was approximately 9463 pounds-force. The force necessary to open a normally operating valve was calculated by CCI engineering staff to be approximately 7593 pounds-force. It was noted

that after the pressure below the actuator piston had achieved maximum pressure, the pressure slowly decreased, slightly dropping the applied opening force. The supply pressure downstream of the nitrogen regulator also dropped at approximately the same rate.

Based on this testing, the "Atmospheric Dump Valve Functional Test" procedure was revised to also test the remaining ADV's in Units 1 and 2. The purpose of this procedure was to verify that all PVNGS ADV's would operate on both the non-class Instrument Air (IA)(LD) supply and the Class 1E backup nitrogen system. The instruction called for stroking the valves using the class backup nitrogen system and then repeating the test using the IA system. The IA system provides additional force to open the valve since it is maintained at approximately 110 psig while the nitrogen system regulator maintains pressure at approximately 95 psig. The instruction also required the measurement of each valve's bonnet pressure. An abnormally high bonnet pressure was suspected of causing the excessive force holding ADV-184's main plug closed. As a result, a bonnet pressure tap was added to ADV-184.

Since ADV-184 had already been tested using the nitrogen accumulator, that portion of the test was deleted and the valve was stroked using the normal IA supply. On March 21, 1989, the valve was retested with bonnet pressure instrumentation installed to allow data collection. The test was performed using instrument air (approximately 110 psig supply pressure).

1) A 10 percent demand was placed into the Control Room (CR) controller. The valve did not move in response to this demand. The force developed was insufficient to move the stem in the positive (upward) direction.

2) A 20 percent demand was placed into the CR controller. Only the pilot valve opened. This allowed the bonnet pressure to decrease to 60 psig. The bonnet pressure then slowly increased to 110 psig (this is approximately 6 to 10 times greater than design).

3) A 30 percent demand was placed into the CR controller. The pilot valve opened and the bonnet pressure decreased to approximately 42 psig. The valve jumped to 20 percent open, the bonnet pressure rapidly increased from 42 psig to 110 psig, and the valve shut.

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4) A 40 percent demand was placed into the CR controller. The bonnet depressurized to between 44 and 34 psig. The valve jumped open to 38 percent, closed to 6 percent, and then opened smoothly to 40 percent.

5) The valve was then given another 40 percent open demand signal. The bonnet depressurized to between 2 and 8 psig, and the valve opened smoothly to 45 percent.

6) A 30 percent demand signal was repeated. The bonnet depressurized to between 2 and 7 psig and the valve stroked smoothly to 32 percent. The valve was then given an incremental demand signal from 10 percent to 50 percent pausing at each 10 percent increment to allow the valve to stabilize prior to increasing demand. The valve stroked smoothly through this range of operation.

<u>Unit 1 ADV-179</u>

ADV-179 was tested, without bonnet pressure instrumentation, on March 16, 1989 and given 10 percent incremental open demand signals up to a total of 50 percent. Nitrogen was used to stroke the valve with an initial pressure of approximately 93 psig. It stroked very smoothly and followed within 6 percent of the demand signal. As a result of this test, ADV-179 was confirmed to be operable.

Since initial stroking of ADV-179 was done without instrumentation, the test was repeated on April 6, 1989 with a 30% demand signal using nitrogen. The valve went into substantial oscillations and the positioner feedback arm broke loose from the valve stem causing the valve to open to 100 percent. The permissive switches were closed in the control room, closing the valve and terminating the test.

<u>Unit 1 ADV-178</u>

On March 18, 1989, ADV-178 was given both incremental and step demand signals using nitrogen at approximately 95 psig. As the valve opened through approximately 15 percent to 20 percent open, it exhibited an oscillation lasting several seconds. The maximum amplitude of the oscillation was between approximately 20 percent and 60 percent. Because of the oscillation, the valve was closed. Similar oscillations had been observed during startup testing.

Testing of ADV-178 was repeated using nitrogen on March 21 and March 23, 1989 following the installation of the bonnet pressure tap. During approximately one-half of the tests, the valve experienced damped oscillations.

On March 24 and 25, 1989, the valve was tested on instrument air (at approximately 110 psig supply pressure). During these tests, no oscillations were observed.

On April 3, 1989 the valve was tested at different nitrogen supply pressures; 110 psig, 100 psig, and 90 psig. The valve experienced damped oscillations during one test at 90 psig.

Unit 1 ADV-185

ADV-185 was tested using nitrogen on March 18, 1989. A 20 percent demand signal was given and the valve oscillated. The valve continued to oscillate in a damped fashion during additional testing. APS decided to manually stroke ADV-185. Following manual stroking, ADV-185 stroked smoothly with a 30 percent demand signal. During additional valve strokes using nitrogen, damped oscillations were observed.

On March 24 and 25, 1989, ADV-185 testing was repeated using instrument air at approximately 110 psig. All strokes were smooth and closely followed the input demand signal.

On April 4, 1989, ADV-185 was tested using nitrogen at approximately 95 psig. A 30 percent demand signal was given and the valve experienced significant oscillations. The permissive switches were closed in the control room, closing the valve and terminating the test.

Unit 2

All Unit 2 ADV's were stroked using nitrogen at normal pressure (95 psig) and most using instrument air at approximately 110 psig. A total of 22 tests were performed stroking the ADV's to 20 percent or more. No oscillations were observed and no instances occurred where the valves did not open.

Unit 3 ADV-178

When ADV-178 was given a 10 percent open demand signal, the valve moved to 6 percent open smoothly, but the actuator force required to move the valve was approximately 5300 pounds-force. Additional stroking to 40 percent consistently required excessive force to move the valve (up to 8400 pounds-force). In order to identify the source of the excessive resistance, the packing gland follower was loosened and approximately 50 percent of the packing removed from the valve. Retesting the valve resulted in a significant reduction in actuator force required to open the valve, but

still much higher than predicted. The actuator was decoupled from the valve. Stroking the actuator alone required twice the predicted force. When the actuator was disassembled, an extra spring was found. This explained the excessive force required to stroke the actuator.

Unit 3 ADV-184 and ADV-185

When ADV-184 and ADV-185 were stroked, the forces required to move the valves were closer to the predicted values (determined from design values), but were higher than expected. ADV-185 experienced a significant reduction in he opening force when the packing gland follower was loosened. Subsequent disassembly of these valves also revealed an extra spring in the actuator.

Unit 3 ADV-179

ADV-179 could not be tested due to the actuator damage sustained from manual operation during the March 3, 1989 transient. When the actuator was disassembled the packing gland follower was found seized to the valve stem. The valve actuator did contain the proper number of springs (2).

2. Root Causes

High Bonnet Pressure

The Unit 1 ADV-184 malfunction was due to an abnormally high bonnet pressure. APS discovered that unless the bonnet pressure is less than approximately 80 psig, the IA system will not provide enough force to open the valve and unless the bonnet pressure is less than approximately 60 psig, the nitrogen backup system (with the nitrogen regulator set at 95 psig) will not provide enough force to open the valve. It should be noted that the manual operator would function with the loading discovered on ADV-184 since the capacity of the manual operator is approximately 20,000 pounds-force.

High bonnet pressure may be caused by either the failure of the pilot valve to function or excessive leakage around the piston ring. Proper functioning of the pilot valve was verified by the opening of the pilot valve to the correct position during testing. Thus, the cause of the high bonnet pressure is attributable to excessive leakage around the piston ring. The ring design used in the ADV is a self-energizing piston ring. This means the force to seat the ring is a result of the differential pressure across the piston ring. When the ring is energized, it is held tightly

against the plug and upper portion of the bonnet, forming a seal. If anything interferes with the ring moving up into position against its sealing surfaces, excessive leak-by and high bonnet pressure may result. Two scenarios have been proposed whereby this can happen:

1) Corrosion products or other foreign material buildup on the sealing surfaces of the piston ring and valve while the valve is closed and there is no pressure differential across the piston ring. These corrosion products interfere with the seal ring's close tolerance, metal-to-metal seal and allow excessive steam leakage past the piston ring.

2) The vertical clearance of the piston ring in the valve is approximately 5 mils. It is possible that when a valve is opened, flow around the outside and across the top of the piston ring produces a dynamic loading which prevents it from energizing and forming a tight seal against the top sealing surface. This potential problem was previously addressed by CCI with the addition of a wave-spring underneath the piston ring. The purpose of this spring was to hold the piston ring against the top sealing surface when the valve was shut and no differential pressure was available to hold the ring in position. This solution was not successful and CCI is no longer recommending this modification.

One or both of the above scenarios could result in the observed behavior of the Unit 1 ADV-184. In either case, the bonnet pressure dropped after repeated cycling. Either the foreign material was washed out by the flow of steam past the piston ring or the piston ring moved progressively higher. The piston ring moving higher results in reduced vertical clearance. When the differential pressure across the piston ring overcomes the force from the flow over the top surface of the piston ring, the piston ring will seal against the top surface. The root cause of the seal leakage past the piston ring cannot be determined. Cooldown and disassembly of the valves on previous similar malfunctions did not reveal the cause of the piston ring failure.

There is evidence that periodic exercising of the ADV's maintains the seal ring in the energized condition. This conclusion is reinforced by the exercising program used on the Steam Bypass Control System (SBCS) valves (JI)(V) which are of similar design. The SBCS valves are currently being stroked monthly to maintain the seal rings energized. Since the beginning of the SBCS valve exercise program, there have been no failures to stroke due to high bonnet pressure.

Valve Oscillations

As described above during the performance of 73TI-9SG05, "Functional Test of the Atmospheric Dump Valves," when using the nitrogen accumulators as a pneumatic gas source, Unit 1 ADV-178, ADV-179, and ADV-185 exhibited damped oscillations.

These oscillations were similar to oscillations observed during startup testing. APS previously concluded that the oscillations were caused by a filter regulator in the supply to the positioner. The filter regulator was thought to have prevented the positioner from receiving a sufficient gas supply for proper operation. The filter regulator was replaced by an in-line filter upstream of the positioner and no other unstable or oscillatory ADV behavior had been noted until the current testing. However, there have been occasions when the valves overshot the demand signal and then modulated to the applied demand signal.

Only the valves in Unit 1 have experienced oscillations. The oscillations appear to be random in nature and may occur on one stroke and not appear on the next stroke under similar conditions. The oscillations were not considered a problem because the valves opened and the oscillations were dampened in a matter of seconds. However, during the testing described above, Unit 1 ADV-185 entered an oscillation during testing which lasted 5 seconds and resulted in decalibration of the positioner. The oscillation was terminated by placing a zero demand signal in the positioner and removing the permissives. A review of the data taken during the oscillation indicated some amount of dampening was present. Unit 1 ADV-179 also entered an oscillation which was only moderately damped, but during the initial portion of the oscillations the feedback arm of the positioner came loose, rendering the positioner ineffective in dampening the oscillation.

The initial testing and observation of the oscillations indicated that data at a faster scanning rate would be necessary. A new test configuration was developed which allowed scanning at 50 hertz. It was also felt that a mathematical model of the valve would be helpful in gaining a qualitative understanding of the oscillations. A group of consultants from Arizona State University were tasked with the development of a model. The goal of this modeling effort and subsequent testing using the fast data acquisition equipment was to understand which parameters led to the severity of the oscillations and what could be done to eliminate or mitigate the oscillations to an acceptable level.

The results of the modeling effort and fast data acquisition have revealed four (4) critical factors:

1) The forcing function for the oscillations is the C_v transition of the disk stack which occurs at approximately 15 percent open. A large C_v indicates a low flow resistance and thus, a large flow change for a given change in valve position. The C_v of the ADV's changes from 3.4 to 11 at approximately 15 percent open and this results in a large step increase in flow for a small change (125 mils) in valve stroke. This rapid flow change has two effects. First, the unbalanced pressure loading on the plug changes by approximately 1500 to 2500 pounds-force in a direction which assists in opening the valve. The mechanism of this change is thought to be a result of pressure buildup under the unbalanced plug area due to its proximity to the disk stack. This is based on a review of the test data which shows that all the valves modulate with substantially less force than is required for the first 15 percent of stroke. Secondly, the rapid change in flow causes a change in the pressure under the plug. This results in the pressure under the plug exceeding the bonnet pressure and forces the plug upward until the bonnet pressure equals the pressure under the plug either by compression of the bonnet volume or equalization of the pressure through the pilot valve. The net result of both phenomena is that the plug rapidly accelerates upward after passing the 15 percent transition point. This is the "jump" in valve position noted by observers. Normally, this jump has no effect except to cause the valve to stroke rapidly between 15 and 25 percent. Occasionally, this rapid acceleration will cause the valve to oscillate.

2) The frequency of the oscillations is approximately 3.5 hertz. This frequency corresponds to the natural frequency of the system defined by the plug weight, actuator springs, air pressure in the upper and lower actuator, and downstream and bonnet pressure differences. The only fixed parameters in this system are the plug weight and spring constants in the actuator. All the other factors in the determination of the natural frequency are variables. Based upon the above factors, modeling of the system is extremely difficult.

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3) A contributor to the ADV oscillation is the frequency of the forcing function under the valve plug when passing the C_v transition within the disk stack. If the frequency matches the natural frequency of system, resonant oscillation will occur.

The frequency of the forcing function is a function of the velocity of the plug when it enters the C_v transition, the tailpipe configuration, and the response of the positioner to the acceleration. Thus, small changes in the velocity of the plug or response of the positioner may explain the random nature noted in the occurrence of oscillations and the amount of dampening present. This forcing function makes the magnitude at which it is applied less important in exciting an oscillation. The preliminary results of the modeling study show that the magnitude of the forcing function required to produce an oscillation is reduced by approximately half if it occurs at a rate near the natural frequency of the system.

4) The greatest single contributor in mitigating the oscillations has been the stiffness of the actuator. The actuator stiffness is the resistance of the actuator to movement. This property is a function of the pressures in the upper and lower actuator cylinders. Any tendency of the valve plug to move in either the up or down direction is resisted in direct proportion to these pressures. If the valve attempts to move upward, the force preventing its movement is the change in upper actuator cylinder pressure resulting from the decreased upper actuator cylinder volume. Since, for practical purposes, pressure times volume equals a constant, any volume change is directly proportional to an increased actuator pressure. This increased pressure acts upon the area of actuator piston to oppose the upward movement. The actuator pressures are a function of the supply pressure to the positioner. The higher the supply pressure to the positioner, the stiffer the actuator response. The sensitivity of the oscillations to actuator stiffness was also demonstrated during the testing and in the APS study, "A Study of Atmospheric Dump Valve Stability."

On March 24, 1989 the two valves which had previously oscillated on nitrogen (Unit 1 ADV-185 and Unit 1 ADV-178), were stroked using instrument air. The instrument air pressure to the positioner is approximately 15 psig higher than the nitrogen

regulator. ADV-185 was stroked twice to 30 percent in a step change fashion and no oscillations occurred. ADV-178 was stroked three times to 30% using the step method and no oscillations occurred.

To show the effect of actuator pressure on the oscillations, ADV-178 was tested using nitrogen supply pressures of 90, 100, and 110 psig. When these supply pressures were changed, the nitrogen regulator was recalibrated using a new procedure which specified a calibration flow rate for the pressure setpoint. When the valve was given a 30 percent step demand with a supply pressure of 90 psig, the valve experienced a damped oscillation which lasted 300 milliseconds. At a supply pressure of 100 psig the valve did not oscillate. With a supply pressure of 110 psig, the valve did not oscillate nor overshoot the demanded position. A review of the test data indicated that the valves which oscillated had upper actuator cylinder pressures of 30 psig or less. The Unit 2 valves using 95 psig nitrogen and the previous regulator setting method typically had upper actuator cylinder pressures greater than those of Unit 1 at the C_v transition point. This difference accounts for the fact that none of the valves on Unit 2 oscillated. The results of these studies led to the recommendation for a nitrogen regulator setpoint change to 105 psig. This change and the new regulator setting procedure will add approximately 10 psi to the upper actuator cylinder pressures and prevent the valves from oscillating.

The effort to accurately model the ADV's is documented in the APS study, "A Model of the Atmospheric Dump Valves at PVNGS."

Based upon the results of the APS studies, the conclusions above were confirmed. Namely, as the valve passes through the C_v transition point, oscillation will occur if the actuator upper cylinder pressure drops such that the resulting stiffness of the system is incapable of counteracting the increased unbalanced force beneath the plug. The ADV models duplicated the test results. The solution to the oscillation phenomena described above is believed to be a combination of a modified disk stack to "smooth" the C_v transition, a pilot valve change and an increased nitrogen supply pressure to the positioner. The oscillations are a result of interactions between the spring mass system of the actuator and the downstream and bonnet pressures in the valve body. Increasing the stiffness of the actuator, changing the pilot valve, and smoothing the C

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TEXT (If more space is required, use additional NRC Form 366A's) (17)

transition prevents the oscillations from occurring. This is accomplished by reducing the unbalanced force under the plug to a rate which will not excite the natural frequency of the system.

Nitrogen Regulators and Nitrogen System Leakage

The regulators used on the ADV's are manufactured by Target Rock. The regulators are one (1) inch Model 76Q-010, ASME Section III Class 3, with a design flowrate of 20 Standard Cubic Feet per Minute (SCFM) and have a maximum differential pressure rating of 595 psi.

Three of the regulators have exhibited excessive seat leakage under low flow conditions, (i.e., less than 1 to 2 SCFM). This leakage caused downstream pressure to rise to the setpoint of the downstream relief valve, 125 psig, resulting in nitrogen loss through the relief valve. The associated ADV was declared inoperable since the storage capacity of the nitrogen accumulator cannot be guaranteed and sufficient nitrogen may not be available for valve operation under design conditions.

The root cause of the seat leakage for one regulator was foreign particles damaging the regulator seating surface. The damage was generally light and was caused by minute metallic slivers. Normal wear was the root cause of the other two regulator seat leaks. The manufacturer was onsite during the investigation of the regulator leaks and concurred with the results of the evaluations. The regulators that were found to have significant seat leakage resulting in the relief valve lifting were reworked to restore seat leakage to within acceptable limits.

APS contracted with Sargent and Lundy to perform a design evaluation of the ADV nitrogen subsystem. The design evaluation was conducted to ensure that the ADV's can be operated using only the available nitrogen gas supply. The design review was conducted from the standpoint of overall system reliability as well as individual component reliability. Sargent and Lundy concluded that overall, the existing system is adequate; however, individual components can be made more reliable. Recommendations were provided by Sargent and Lundy and evaluated by APS. The recommendations will be implemented as appropriate in accordance with pre-established schedules.

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E. Failure mode, mechanism, and effect of each failed component, if known:

The failure mode, mechanism, and effect of potential ADV failures are discussed in Sections I.D and II.

F. For failures of components with multiple functions, list of systems or secondary functions that were also affected:

Not applicable - the ADV's do not have multiple functions.

G. For failures that rendered a train of a safety system inoperable, estimated time elapsed from the discovery of the failure until the train was returned to service:

The information requested by the above is not considered appropriate for the event being described in this LER. There have been no ADV failures at PVNGS wherein the capability to remotely and locally operate the ADV's was lost as a result of the causes described in Section I.D.

H. Method of discovery of each component or system failure or procedural error:

The inability to remotely operate the ADV's was originally discovered during the reactor trip event discussed in Section I.B. Subsequent malfunctions were discovered during testing conducted after the Unit 1 trip. The cause of the ADV malfunctions due to excessive bonnet pressure was identified by CCI and provided to APS on April 4, 1989 as discussed in Section I.B. There have been no procedural errors discovered.

I. Cause of Event:

The cause of the event being reported in this LER has been determined to be an inadequate design by the original equipment manufacturer.

J. Safety System Response:

Not applicable - there were no safety system responses and none were necessary.

K. Component Information:

Note: This section includes information requested by 10CFR21 concerning the identification of the firm supplying the basic component and the number and location of the relays at Palo Verde.

The PVNGS design incorporates the use of four (4) ADV's per unit (twelve total) as a means of providing decay heat removal in the event of a loss of off-site power. These valves are located between the steam generator and Main Steam Isolation Valves (SB)(V). The ADV's are manufactured by Control Components, Inc. (CCI) in accordance with Specification 13-JM-601A. They are model number B3G9-10-12P8-31NAS1. The valves are pilot operated, pneumatically actuated drag valves. The valves are powered by a double acting, spring to close, pneumatic piston actuator. The actuator area is approximately 111 square inches developing over 10,000 lbf of thrust when one side is fully pressurized and the other side is vented to atmosphere. The design relieving capability is 1.47 x 10E06 pounds-mass (lbm) per hour.

II. ASSESSMENT OF THE SAFETY CONSEQUENCES AND IMPLICATIONS OF THIS EVENT:

The ADV's are used to remove decay heat from the steam generator in the event that the main condenser (SG) is unavailable for service for any reason including a loss of ac power. The decay heat is dissipated by venting steam to the atmosphere. In this way, the reactor coolant system (RCS)(AB) can either be maintained at hot standby conditions or cooled down. The system instrumentation and controls for the atmospheric dump valves are described below.

- Initiating Circuits and Logic

  There are no automatic initiating circuits for operation of the atmospheric dump valves.

  The atmospheric dump valves are positioned by a controller (manual loading station) from either the main control room or the remote shutdown panel as part of the capability for emergency shutdown from outside the control room. Each valve has two separate permissive control circuits. Valve position indication is provided at each remote control station. A handwheel is also provided with the atmospheric dump valve for local manual operation.

- Bypasses, Interlocks, and Sequencing

  No bypasses, interlocks, or sequencing are provided for the atmospheric dump valves.

- Redundancy

  Two (2) redundant, atmospheric dump valves are provided for each steam generator.

The major accident scenarios which credit the use of the ADV's are:

- 6.3.3.4 - Post Loss of Coolant Accident (LOCA) Long Term Cooling
- 15.1.4 - Inadvertent Opening of a Steam Generator Relief or Safety Valve (MSSV)
- 15.3.1 - Total Loss of Reactor Coolant Flow
- 15.4.1 - Uncontrolled Control Element Assembly (AA)

Withdrawal from a Subcritical or Low Power Condition

- 15.6.3 - Steam Generator Tube Rupture

In the event that all four (4) ADV's could not be opened upon demand, reactor decay heat will be removed through the Main Steam Safety Valves (MSSV's). The MSSV's will open when pressure in the steam generator reaches the pressure relief setpoints. Steam release will continue until the pressure is reduced to the safety valve reset pressure. The safety valves will continue to cycle in this manner as steam generator pressure increases and decreases. The RCS will remain at hot standby conditions during this pressure relief cycling. Hence, the RCS pressure boundary integrity will be maintained and the safety analysis will bound the consequences of the reported deficiency.

APS has reviewed Chapters 6 and 15 of the Combustion Engineering Standard Safety Analysis Report (CESSAR) and the PVNGS Updated Final Safety Analysis Report (UFSAR) and determined that the earliest the ADV's are required for any of the accident scenarios is 30 minutes from the onset of the particular accident. In these scenarios, the ADV's are used to cooldown the plant in the event of a loss of off-site power coincident with the particular accident. APS has reviewed the Chapter 15 CESSAR events and has found several instances wherein manual operation of the ADV's is performed for plant cooldown. However, it should be noted that the safety analyses do not make a distinction between "remote manual" or "local manual" operation of the ADV's. APS considers that remote or local manual operation of the ADV's are equally valid methods of performing the manual operation discussed in the safety analyses.

APS was informed by the valve manufacturer on April 10, 1989 that neither the pneumatic actuator nor handwheel alone can produce sufficient force to open the valve for valve inlet pressures of 1150 psia and the worst case piston ring seal leakage is assumed. However, CCI hypothesized that if the pneumatic actuator is given a signal to open (remote manual operation) and the handwheel (local manual operation) is used to open the valve in conjunction with the pneumatic

actuator, the combination will provide sufficient opening force to open the valve even with the valve inlet pressure equal to the lowest set MSSV plus accumulation (approximately 1302 psia) and worst case piston ring seal leakage assumed. Although the procedures are in place for remote or local operation of the ADV's, no procedures were in place for the combined remote/local operation of the valve at the time the ADV failed to open remotely at PVNGS. Hence, credit is not taken for the combined remote/local manual operation from a 10CFR21 reportability standpoint.

The loss of the remote and local manual operation (no credit taken for the combined remote/local operation) of the ADV's will not allow the successful completion of recovery operations from postulated accidents for entry to shutdown cooling conditions (350 degrees F).

Based on the above, the failure of all 4 ADV's to open due to a failure of their pneumatic actuators and handwheel assemblies has been determined to be safety significant. Loss of the remote and local operation of the ADV's adversely affects the ability of the plant to achieve or maintain safe shutdown conditions.

The consequences of the reported deficiency (loss of both remote and local valve operation) will result in the loss of the safety function (i.e., decay heat removal) of the ADV's to the extent credited in the safety analyses presented in Chapter 6 and 15 of the UFSAR/CESSAR.

III. CORRECTIVE ACTIONS:

This section contains the information requested by 10CFR21 concerning the corrective action which has been, is being, and will be taken; the organizations responsible for the corrective action; and the length of time for accomplishing the corrective action.

A. Immediate:

PVNGS initiated an extensive investigation of the ADV malfunctions. As a result of APS concerns regarding the operability of the ADV's, Palo Verde Unit 1 remained shutdown following a reactor trip on March 5, 1989. Palo Verde Unit 2 was shutdown on March 15, 1989. Palo Verde Unit 3 remained shutdown and began a refueling outage on March 8, 1989.

B. Action to Prevent Recurrence:

Based upon the results of the engineering investigations of the ADV problems discussed in Section I, APS has re-designed the ADV internals, is installing ADV block valves to support testing/repairs, and is implementing additional periodic testing to ensure continued ADV operability. The details for implementing the

ADV modifications, installing the block valves and the schedule for ADV testing are included in the APS "Atmospheric Dump Valve Engineering Analysis March/April 1989" which was provided under separate cover with APS's response to the PVNGS March 1989 Augmented Inspection Team (AIT) Report dated May 18, 1989 (Reference: 102-01285-WFC/TDS/SCT/RAB dated May 29, 1989).

APS also performed an engineering analysis of the Compressed Gas System utilized for ADV operations. Based upon the results of this investigation, corrective actions were developed and are being implemented in accordance with pre-established schedule. The details of the corrective actions are described in the APS, "Compressed Gas System Evaluation and Analysis Report; NED Study 13-MS-A20," which was provided under separate cover with the APS response to the March 1989 AIT Report.

IV. PREVIOUS SIMILAR EVENTS:

There have been no previous similar events reported pursuant to 10CFR50.73.