PALO VERDE
NUCLEAR GENERATING STATION

ATMOSPHERIC DUMP VALVE ENGINEERING ANALYSIS

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REVISION 2

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ATMOSPHERIC DUMP VALVE ENGINEERING ANALYSIS

REVISION 2 SUMMARY

Table IX-1:

Instructions:

Replace Revision 1 Table IX-1 with Revision 2 of Table IX-1

Summary of change:

Clarified quarterly surveillance test specified in table to reflect the currently proposed Technical Specification Surveillance Requirement.

ATMOSPHERIC DUMP VALVE ENGINEERING ANALYSIS

REVISION 1 SUMMARY

Figure VI-8:

Instructions:
Replace original Figure VI-8 with Revision 1 of Figure VI-8
Summary of change:
Clarified assumptions made for packing gland follower friction for ADV-179

Table IX-1:

Instructions:
Replace original Table IX-1 with Revision 1 of Table IX-1
Summary of change:
Corrected typographical error on Page 2, Pneumatic Subsystem Corrective Action

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ATMOSPHERIC DUMP VALVE ENGINEERING ANALYSIS

I. EXECUTIVE SUMMARY

This report has been prepared to document the activities undertaken as a result of the Atmospheric Dump Valves (ADVs) failing to operate after a Unit 3 reactor trip. The activities consisted of testing valves in all three units, examining PVNGS history with the valves, determining root causes for failures, making recommendations and developing an implementation schedule. The evaluation was conducted using APS personnel including on-site and off-site engineering groups, Licensing and Compliance personnel, vendor personnel and consultants.

On March 3, 1989, Unit 3 experienced a reactor trip, a Main Steam Isolation Signal (MSIS), and a loss of offsite power to the non-class 1E electrical distribution system. During the event, the operators attempted to operate the ADVs from the Control Room to remove decay heat from the reactor. The valves did not operate from the Control Room and an attempt to operate one of the ADVs from the Remote Shutdown Panel (RSP) was unsuccessful. Auxiliary Operators (AOs) were successful in manually opening two ADVs, one on each steam generator, for decay heat removal.

On March 5, 1989, Unit 1 experienced a reactor trip without complications. While the Unit 1 was in Mode 3, APS conducted testing on the ADVs to determine that there were no problems on that unit similar to the problems encountered in Unit 3. During the performance of the test program, Unit 1 ADV-184 failed to open when given a 50% open demand signal from the Control Room. APS determined that a more extensive test program in Units 1 and 3 would be conducted and Unit 2 as well should be shutdown until the investigation was complete.

Problems associated with the ADVs were not limited to the valves themselves, but included problems with components in their pneumatic control systems. Significant problems, causes and corrective action/recommendations include:

1) Failure to Open due to High Valve Bonnet Pressure - APS and the vendor, Control Components Inc. (CCI), have determined that excessive piston ring leakage combined with inadequate pilot valve relieving capacity create high forces in the valve bonnet, (also called balance chamber), that cannot be overcome by the forces exerted by the actuator. The vendor recommends installing a larger pilot valve and new style piston rings. APS and CCI have also determined that periodic stroking of the valve helps to keep the piston ring seated thus minimizing excessive leakage into the bonnet area of the valve.

   A monthly exercise program, coupled with weekly verifications that the bonnet pressure is low, (indicating the piston ring is maintaing a tight seal), provides a high level of confidence that the valves will open when required. However, in order to eliminate the frequent valve stroking, APS will modify the Unit 1, Unit 2, and Unit 3 valves during the current outages, as recommended by CCI.

I. EXECUTIVE SUMMARY (continued)

2) Valve Oscillations - During performance of the testing in Unit 1, several of the valves exhibited damped oscillations. To obtain data necessary to describe the observed oscillations, a higher speed (≈50 hz) data acquisition system was utilized. Concurrently, a group of consultants from Arizona State University staff was assembled to develop a mathematical model to describe, at least in a qualitative sense, the behavior of the ADV. Preliminary results of the modeling effort and the fast data acquisition have revealed that several factors may contribute to the oscillations.

The force on the valve plug changes rapidly as the plug passes approximately 15% open. This transition point (referred to as the C_v transition point), is caused by a change in the configuration of the disk stack at that region. (Refer to Section II for details on the valve construction and operation.) The change in forces on the plug as it passes the disk stack C_v transition point causes the oscillations to start. The greatest single contributing factor to preventing oscillations is the stiffness of the actuator. This is a function of the pressures in the upper and lower actuator cylinders. The stiffness of the actuator can be increased by increasing the pneumatic supply pressure to the valve positioner. Testing has shown that when the supplied pressure was at least 100 psig, no significant oscillations occurred. Modifications have been developed to increase the pressure supplied by the nitrogen accumulator to 105 psig and to rework the disk stack to smooth the C_v transition. The normal instrument air is already supplied at a pressure greater than 100 psig. The nitrogen supply pressure will be increased to 105 psig and the modification to smooth the C_v transition in the disk stack will be accomplished prior to the startup of any unit from the current outages.

3) Nitrogen System Excessive Leakage - Each ADV has an associated system to supply nitrogen at a regulated pressure to the positioner. Problems with this system included the regulator not controlling at the correct pressure, leakage through the regulator, and leakage past the relief valve seating surfaces. Excessive leakage through this system leads to inoperability of the ADVs because, at some point, the nitrogen pressure in the accumulator will not be sufficient to meet the design basis for ADV operation. The regulators and relief valves were reworked to restore the seat leakage criteria. Preventive maintenance tasks have been developed to calibrate and test the regulators. This PM task will be performed on all regulators prior to unit restart, and on a periodic basis thereafter.

The safety analysis assumes operation of the ADVs for long term heat removal and cooldown. The valves are not required in FSAR Chapter 15 events until 30 minutes after the initiating event. For the long-term cooldown analyzed event, only one ADV per steam generator is assumed available for the duration of the

I. EXECUTIVE SUMMARY (continued)

event. In order to ensure that the ADVs are capable of fulfilling their safety function, a periodic testing program has been developed to test the valves. The initial program consists of weekly and monthly tests with the data being trended by engineering.

Since commercial operation and prior to the Unit 3 event all ADVs with the exception of Unit 1 ADV-179 opened when called upon during operation and testing. Additionally, all four Unit 1 ADVs were operated in August, 1988, and the two "A" train valves called upon during the February 1989 Unit 2 trip opened as designed. The four Unit 3 ADVs had not been operated since December, 1987.

On April 12, 1989, APS notified the NRC, in accordance with 10CFR21, that a deficiency existed which can cause high bonnet pressures to occur, thereby rendering the valves inoperable. APS is implementing recommendations from the vendor to preclude the condition from recurring.

II. EQUIPMENT DESCRIPTION

The components associated with this evaluation are the ADVs and their supporting sub-components. Each unit at PVNGS is equipped with four ADVs, two per steam generator, or one for each main steam line. The discharge from these valves is manifolded into two separate discharge stacks, furnished with silencers, located on the roof of the Main Steam Support Structure.

Each ADV is equipped with both a pneumatic piston actuator and a manual hand jack mechanism. The pneumatic actuators are supplied with both non-class instrument air and a "Q" class nitrogen backup supply which has an accumulator sized for 10.5 hours of ADV operation.

The twelve ADVs at PVNGS were manufactured by CCI. The valve inlet and outlet are 12" diameter, with a 10" trim, and are a 900 lb ANSI pressure class. The body assembly is an offset globe configuration with flow over the plug, that is, the flow passes through the sides of the disk stack into the bore, and exits to the outlet port. The original design requirements for the ADVs are specified in CE document SYS80-PE-IR16 (N001-22.01-8). FIGURES II-1 and II-2 show simplified cutaway drawings of the valve and actuator and will be useful in understanding the valve operation described below:

PRINCIPLE OF OPERATION

The disk stack permits changes in flow rate while limiting flow velocity through the control element. The disk stack consists of a number of 1/8 inch thick 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. The disk stack in the ADVs consists of two types of disks. At approximately 15% open, the type of disk in the disk stack changes from a "20-turn" configuration to an "8-turn" configuration. In other words, up to approximately 15% open, the disks are 3.4 C_v/disk, and above ≈15% open the disks are 11.6 C_v/disk. This change results in about a 3 times increase in C_v/disk or a step change in the flow capacity per disk as the plug passes this transition point. This transition point is commonly referred to as the "C_v transition point".

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 valve which allows the chamber above the plug to become balanced to the downstream pressure.

II. EQUIPMENT DESCRIPTION (continued)

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 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 modulating mode, the biasing force provided by pressure acting on the differential area overcomes fluctuating pressures from the steam flow 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 valve. The controlled leak then fills the chamber above the plug providing additional seating force.

III. SAFETY FUNCTION

One pneumatic operated ADV is provided in each of the four main steam lines to allow cooldown of the steam generators when the main steam line isolation valves are closed, or when the main condenser is not available as a heat sink. Each ADV shall be capable of holding the plant at Hot Standby by dissipating core decay and reactor coolant pump heat, followed by a controlled cooldown from Hot Standby to Shutdown Cooling (SDC) entry conditions. Each valve is sufficiently sized to allow for a rupture, which renders one steam generator unavailable for heat removal, concurrent with a loss of normal A.C. power and single failure of one of the remaining two ADVs. In the event an ADV sticks open, the heat removal is bounded by that assumed in the Main Steam Line Break design bases event and the Inadvertent Opening of a Steam Generator Relief or Safety Valve Anticipated Operational Occurance (AOO).

IV. RECENT PALO VERDE HISTORY

All four ADVs on Unit 3 failed to respond when given an open signal from the Control Room and the only valve tried from the Remote Shutdown Panel also failed to respond during the plant trip of March 3, 1989. Manual local action was initiated to open one ADV per steam generator. However, during the attempts to manually operate ADV-179, its actuator was damaged. Two other valves were opened successfully by the Auxiliary Operators, and, in conjunction with a steam bypass valve, the plant was stabilized in Mode 3. The ADVs were quarantined and a thorough investigation plan was prepared to determine the root cause of failure of the ADVs to operate as expected. Results of this investigation are detailed in Section VI.4 of this report.

In an unrelated trip on March 5, 1989, Unit 1 came off-line and entered Mode 3 operation without the need for ADVs. Because of the operational anomalies noted in Unit 3 and in order to evaluate the condition of the Unit 1 ADVs, a testing procedure was developed to partially stroke Unit 1 valves while in Mode 3. Unit 1 ADV-184 was the first valve to be tested using its nitrogen accumulator as the pneumatic gas source. The valve failed to open when given demands of 10%, 20%, 30%, 40% and 50%. Based on the performance of the Unit 3 ADVs and the failure of Unit 1 ADV-184 to open, a decision was made to place Unit 2 in Mode 3 for further ADV testing and investigation.

To determine the cause for the ADV failures, an investigation plan was developed. The valves were tested using the normal instrument air and/or the nitrogen accumulator as a pneumatic supply to the actuator. Durign testing, all ADVs except Unit 1 ADV-184, (on nitrogen at 95 psig), opened when given a sufficient (e.g. ≥30%) demand signal.

Since commercial operation, and prior to the Unit 3 event, all ADVs with the exception of Unit 1 ADV-179 opened when called upon during operation and testing. Additionally, all four Unit 1 ADVs were operated in August, 1988, and the two "A" Train ADVs called upon during the February 1989 Unit 2 trip opened as designed. The four Unit 3 ADVs had not been operated since December, 1987.

V. RECENT INDUSTRY EXPERIENCE

On April 4, 1989, CCI notified APS of a potential 10CFR21 condition on the Atmospheric Dump Valves (see ATTACHMENT A). Within the notification, CCI listed eight utilities which use CCI ADVs and which of these plants were affected by the potential ADV failure. These plants are:

1. Catawba 1 & 2 (Duke Power)
2. SONGS 2 & 3 (Southern California Edison - SCE)
3. Waterford 3 (Louisiana Power & Light)
4. PVNGS 1, 2, & 3 (Arizona Public Service)

Other plants which use CCI ADVs but are not affected by the potential failure are:

1. St. Lucie 2 (Florida Power & Light)
2. South Texas Project 1 & 2 (Houston LIghting & Power)
3. Shearon Harris 1 (Carolina Power & Light)
4. Votgle 1 & 2 (Georgia Power)

The basic difference between the ADVs for the eight utilities is the actuator type and capacity. South Texas Project, Shearon Harris and Volgle use electric hydraulic actuators capable of 20,000 lbf. St. Lucie uses electric actuators capable of 15,000 lbf. Calawba, SONGS, Waterford and Palo Verde use pneumatic actuators capable of approximately 10,500 lbf.

For a complete comparison of the valves of each plant, see TABLE V.1.

APS contacted all eight utilities to discuss the CCI letter and their actions regarding the notice. With the exception of the South Texas Project, Shearon Harris, and Votgle, the rest of the plants are planning to implement the CCI recommended design changes discussed in the notification letter.

Two plants have recently experienced problems with CCI-supplied ADVs. On March 5, 1989, Catawba 1 tripped from full power operation. Following the trip, an automatic demand was placed on one of the ADVs. The valve did not respond, so the operator increased the demand to100% for 3 to 4 minutes; again, the valve did not open. The valve was successfully stroked the following day.

On April 7, 1989, SONGS 3 tripped from full power operation. The event was uncomplicated and no demands were placed upon the ADVs. Due to issues at PVNGS regarding the ADVs, SCE stroke-tested their ADVs. One ADV, tested on nitrogen, took 45 to 60 seconds to open after given the demand signal; the other ADV stroked as expected.

VI. ENGINEERING EVALUATION

A. Introduction

In order to determine the root causes of failure and the corrective actions required to prevent recurrence, it was necessary to perform quantitative testing of the valves. From a thorough review of the design and performance of the ADVs and their related components, a test plan was developed.

The test plan included dynamic testing, disassembly, and inspection of the valves. The data acquisition equipment required and test methods used were chosen based on the most probable failure modes for the ADVs.

A review of the ADV system was performed by the Engineering Evaluations Department (EED) and Nuclear Engineering Department (NED) to determine most probable failure modes of the ADV's. These failure modes are discussed briefly below:

1. Failure of the Pneumatic Positioner:
   The Instrument Air system is the only common factor among all four ADV's. Contamination in this system could affect the operation of the positioners. The positioners contain many small orifices which are susceptible to plugging by debris. The positioner technical manual states that dirt in the positioner may cause erratic operation.

2. Insufficient Demand Signal or Insufficient Time For Valves to Respond:
   The Atmospheric Dump Valve positioners respond slowly to small demand signals. This characteristic has been noted on several other occasions. Typically it requires a 30% or greater demand signal to open an Atmospheric Dump Valve and the demand signal must be present for a period of time to allow the positioner to build up enough pressure under the piston to lift the valve from its shut seat.

3. Mechanical Binding of the Stem or Plug:
   The buildup of corrosion products on the stem or plug may mechanically bind the valve to the point that the force required to operate the valve exceeds the capability of the pneumatic operator.

4. Excessive Steam Leakage Past the Internal Piston Ring:
   The design of these valves is such that when the valve is shut, steam pressure is applied to the top of the plug. This pressure is from steam leakage around the plug piston ring. When opening the valve, a pilot valve in the top of the plug vents the steam pressure from the top of the plug to the outlet port of the valve. If the leakage around the plug piston ring is greater than the capacity of the pilot valve, the top of the plug will remain pressurized and the pneumatic actuator may be unable to develop sufficient force to open the valve.

VI. ENGINEERING EVALUATION (continued)

A. Introduction (continued)

5. Failure of the "A", "B", "R", or "S" Solenoids:
   Failure of any of these solenoid valves would prevent the buildup of a differential pressure across the actuator piston and prevent the valve from pneumatically opening.

6. Excessive Leakage Through the Equalizing Valve across the Actuator's Pneumatic Piston:
   The pneumatic piston has an equalizing valve which connects the chambers above and below the piston to defeat the pneumatic operator and allow manual override operation of the valve. If this valve is open or has excessive leakage, the pneumatic operator would not be able to position the valve.

7. Supply Pressure Failure:
   A failure of the Instrument Air and class nitrogen backup system would prevent the valve from opening.

B. Test Instrumentation and Testing Methods

The test instrumentation was installed at various points on the valve and its associated pneumatic system. The parameters monitored were recorded using computer based data acquisition equipment. The test instrumentation consisted of pressure transmitters, linear voltage displacement transducers (lanyard transducers) and two data logging computers (one for high speed and one for low speed monitoring).

Various testing scenarios required different instrumentation to be installed. FIGURE VI.1 shows the location of all the instrumentation used during the ADV testing. Initial testing was performed using pressure transmitters on the positioner to monitor the pressure above the actuator piston, below the actuator piston, and signal pressure from the I/P converter. The valve position was monitored using a lanyard position transducer. A supply pressure transmitter was added on subsequent testing to monitor the performance of the nitrogen regulator. Later testing also required the addition of pressure transmitters for bonnet, or balance chamber pressure, and downstream steam pressure. Further details of the testing equipment are given in ATTACHMENT B.

VI. ENGINEERING EVALUATION (continued)

B. Test Instrumentation and Testing Methods (continued)

Three basic methods of operating the ADVs were used during the testing phase of the engineering evaluation.

1 INCREMENTAL" METHOD
A series of incremental (10%) increases in demand from 0% to a maximum of 50% demand:
0% to 10%, then
10% to 20%, then
20% to 30%, then
30% to 40%, then
40% to 50%, and finally
50% to 0%

2. STEP METHOD
A series of step changes in demand:
0% to 10% to 0%, or
0% to 20% to 0%, or
0% to 30% to 0%, or
0% to 40% to 0%, or
0% to 50% to 0%

3. MANUAL STROKING
Normal manual stroking method described in ANPP procedures.

The first two methods simulate normal operating practice: initial step changes in demand followed by modulating as plant conditions require. Additionally, either method, 1 or 2, could be conducted using either pneumatic source (class nitrogen or instrument air). In some tests, the nitrogen regulator set pressure was varied to observe system response.

C. Testing Summary

The testing methodology described in Section VI.B was first implemented in Unit 1. Test instructions 73TI-1SG04 and 73TI-9SG05 were written to allow the instrumentation and stroking of the ADVs using their nitrogen accumulators or instrument air systems. A comprehensive test summary is given in ATTACHMENT C, however, selected tests are discussed below:

UNIT 1 TESTING

UNIT 1 ADV-184

The first valve to be tested following the failures in Unit 3 was Unit 1 ADV-184. This was accomplished on March 14, 1989 using nitrogen at ≈95 psig. The valve failed to stroke when given up to a 50% open demand signal and was declared inoperable. Bonnet pressure was not available since the bonnet tap instrumentation had not been installed: This made the failure mode difficult to analyze. However, Engineering

VI. ENGINEERING EVALUATION (continued)

C. Testing Summary (continued)

has determined the most probable cause of failure was due to high bonnet pressure. Steps were initiated to install a pressure transmitter to measure the bonnet pressure during subsequent testing. This failure mode is discussed in detail in Section VI.E.1 below.

On March 21, 1989, the valve was retested with a bonnet tap installed which allowed data to be collected on the bonnet pressure. The test was performed using instrument air (≈110 psig supply pressure), and the actuator was able to overcome the additional forces due to bonnet pressure. This time ADV-184 began to open when given a 30% demand signal, but quickly shut on its own. Then a 40% demand signal was applied. The valve oscillated slightly and then opened to 40%. The test was repeated several times to a maximum open signal of 50%. Each time the valve stroked smoothly.

UNIT 1 ADV-179

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

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

UNIT 1 ADV-178

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

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

VI. ENGINEERING EVALUATION (continued)

C. **Testing Summary** (continued)

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

On April 3, the valve was tested at different nitrogen supply pressures; 110 psig, 100 psig, and 90 psig.

The oscillatory behavior is discussed in detail in Section VI.E.2 below.

UNIT 1 ADV-185

ADV-185 also experienced oscillations when tested using nitrogen. During the first test on March 18, 1989, when a 20% demand signal was given, the valve experienced oscillations. The valve continued to oscillate in a damped fashion during additional testing. The decision was made to manually stroke ADV-185. When tested again, it stroked smoothly with a 30% demand signal. During additional valve strokes using nitrogen, damped oscillations were again experienced.

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

UNIT 1 TESTING OBSERVATIONS

The testing on the Unit 1 ADVs identified several facts that have been incorporated into the corrective actions recommended in Section XII of this report. These observations were:

1. Stroking or exercising of the valves aids in reducing upper bonnet pressures allowing the valve to open and stroke more reliably.
2. Significant oscillations only occur when pneumatic supply pressure is ≤ 95 psig.
3. A total of 44 tests were performed in which the ADVs were stroked to at least 20% open. Oscillations were observed on 13 of these tests. Except for ADV-184, on nitrogen at approximately 95 psig supply pressure, all valves opened when given a sufficient, (e.g. ≥30%) demand signal.

VI. <u>ENGINEERING EVALUATION</u> (continued)

C. Testing Summary (continued)

UNIT 2 TESTING

A detailed test summary is included in ATTACHMENT C. Because Unit 2 valves worked so well during testing, only the Unit 2 testing observations are discussed here.

<u>UNIT 2 TESTING OBSERVATIONS</u>

1. All valves were stroked using nitrogen at normal pressure, 95 psig, and Instrument Air at approximately 110 psig. All bonnet pressures were low with no indication of piston ring sealing problems.

2. A total of 22 tests, stroking the ADVs to 20% or greater were performed with no oscillations observed or the valves failing to open.

UNIT 3 TESTING

Unit 3 ADVs were tested in Mode 5 using the class nitrogen supply for the motive force.

<u>UNIT 3 ADV-178</u>

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

<u>UNIT 3 ADV-184 and ADV-185</u>

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 still higher than expected. ADV-185 experienced a significant reduction in the opening force when the packing gland follower was loosened.

Subsequent disassembly of these valves also revealed an extra spring in the actuator. This discrepancy is discussed in detail in Section VI.E.3.c.

VI. ENGINEERING EVALUATION (continued)

C. Testing Summary (continued)

UNIT 3 ADV-179

ADV-179 could not be tested due to the actuator damage sustained from manual operation during the March 3rd 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).

UNIT 3 TESTING OBSERVATIONS

The testing in Unit 3 demonstrated that ADVs 178 and 185 were experiencing excessive resistance to opening from packing gland follower friction and an extra spring in the actuator. An extra spring was found in ADV-184. The valve control system was verified fully operational in the three valves tested.

D. Anomalies Noted

A comprehensive list of the anomalies noted during the testing and investigation is included as TABLE VI-1.

VI. ENGINEERING EVALUATION (continued)

E. Specific Root Causes of Failure

1. High Bonnet Pressure - Unit 1 ADV-184

Discussion:
After the Unit 3 trip on March 3, 1989 and the reported failure of the Unit 3 Atmospheric Dump Valves, test instruction 73TI-1SG04 "Atmospheric Dump Valves Functional Test" was developed to instrument and test the ADVs. The purpose of the test was to determine the forces involved in the operation of the ADVs and to characterize the positioner operation at normal operating temperature and pressure. This technique was utilized to provide time response data for the valve for various demand signals.

The test points, used to characterize the operation of the actuator and valve consisted of pressure points and position indication. The actuator pressures recorded were signal pressure, supply pressure, top piston actuator pressure, and bottom piston actuator pressure. A lanyard style position transmitter was attached to the valve stem to record valve position during the testing. These signals were recorded using an Acurex™ Autodata 10/50 Digital Recorder. The top and bottom piston actuator pressures were used to compute the force the actuator was exerting on the valve stem by multiplying the differential pressure across the actuator piston by actuator piston area.

During the performance of this procedure in Unit 1, ADV-184 failed to open when given a 50% open demand signal from the control room. The test instruction tested Unit 1 ADV-184 by giving the valve step position demand signals from 0%-10%-0% to 0%-50%-0% in ten percent increments using the class backup nitrogen accumulator 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 ≈9463 pounds. The force necessary to open a normally operating valve was calculated by CCI engineering staff to be approximately:

Weight of Plug *..	400 Lb_f
Packing Friction *..	1219 Lb_f
Piston Ring Friction *....................................	635 Lb_f
Actuator Spring Pre-Load *........................	1519 Lb_f
Un-Balanced Pressure Load on Plug *.....	3820 Lb_f**
Total Force Required to Open *................	**7593 Lb_f**

NOTES: *These are design values. ** Based on a 15 psig bonnet pressure.

It was determined that ADV-184 had a malfunction which was causing the opening force to exceed the capability of the actuator when the valve was being operated on the nitrogen gas pressure available from the nitrogen accumulator/regulator. It was also noted that after the pressure below the actuator piston had achieved maximum pressure, the pressure slowly

VI. ENGINEERING EVALUATION (continued)

E. Specific Root Causes of Failure (continued)

1. High Bonnet Pressure - Unit 1 ADV-184 (continued)

decreased causing the applied opening force to drop slightly. It was also noted that the supply pressure downstream of the nitrogen regulator was dropping at approximately the same rate.

This discovery led to the development of a revised test instruction 73TI-9SG05 "Atmospheric Dump Valve Functional Test" to be performed on the Atmospheric Dump Valves in Units 1 and 2. The purpose of this procedure was to verify all the ADVs would operate on both the non-class Instrument Air (IA) supply and the class backup nitrogen accumulator. This instruction called for stroking the valves using the class backup nitrogen system and then repeating the test using the IA system as a source of pneumatic gas. The IA system provides additional force to open the valve since it is maintained at ≈110 psig while the nitrogen system regulator maintains pressure at ≈95 psig. The instruction also required the measurement of each valve's balance chamber or bonnet pressure. An abnormally high bonnet pressure was suspected as causing the excessive force holding valve ADV-184's main plug closed. As a result, a bonnet pressure tap was added by Site Mod #1-SM-SG-017.

Since valve 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. The valve was tested in the following sequence and with the following results:

1) A 10% demand was placed into the Control Room (CR) controller. The valve did not move in response to this demand. It was determined that the force developed was insufficient to move the stem and it never went in the positive (upward) direction. This was the result of a calibration problem with the positioner.

2) A 20% demand was placed into the CR controller. The pilot valve opened. This allowed the bonnet pressure to depressurize and the condition of the seal ring to be determined. Bonnet pressure decreased to 60 psig and then slowly increased to 110 psig which is approximately 6 to 10 times greater than design.

3) A 30% 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% open, the bonnet pressure rapidly increased from 42 psig to 110 psig, and the valve shut.

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

VI. ENGINEERING EVALUATION (continued)

E. Specific Root Causes of Failure (continued)

1. High Bonnet Pressure - Unit 1 ADV-184 (continued)

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

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

The results of these tests were de-logged from the Autodata™ Recorder and the data was placed in Lotus™ worksheet files for analysis. Palo Verde's Engineering Evaluation and Nuclear Engineering Departments, as well as the CCI engineering staff evaluated the data. A resolution of the forces acting on the valve during the instrument air testing described above was performed. The results of this analysis are presented in Figures VI-2 and VI-3 and TABLE VI-2.

TABLE VI-2 shows the forces acting on ADV-184 during the tests. The first tests performed on nitrogen assume that the bonnet pressure was the same as that measured after installation of the bonnet pressure tap. The table shows that until the bonnet pressure was reduced by exercising the valve with the instrument air system, there was not enough force available from the positioner to open the valve. This transition occurred during Test 8 on the table where the bonnet pressure reduced to a value where the actuator was able to lift the plug. This reduction in bonnet pressure was momentary and when the plug lifted the bonnet pressure increased to 110 psig and the valve was forced shut. During Test 9, the bonnet pressure decreased to 44.6 psig and the actuator was able to stroke the valve. Subsequent tests had bonnet pressures of approximately 4.5 to 6.9 psig and the valve stroked normally.

FIGURE VI-2 shows the calculated force required to open a typical ADV with varying bonnet pressures. The pressure measured on ADV-184 initially was 110 psig which would require approximately 14,000 pounds of force to open the valve. FIGURE VI-3 shows the actuator differential pressure required to open an ADV with varying bonnet pressures. The maximum differential pressure available from the IA system and nitrogen accumulators are also shown. These figures show 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 decreases below approximately 60 psig, the nitrogen accumulator, (with the nitrogen regulator set at 95 psig), will not provide adequate force to open the valve. Thus, with the 110 psig bonnet pressure measured during the testing of ADV-184, neither system could provide enough force to open the valve. Therefore, it was concluded that the bonnet pressure in ADV-184 was preventing the operation of the valve. This fact was also demonstrated during testing of the other ADVs, which all opened

VI. ENGINEERING EVALUATION (continued)

E. Specific Root Causes of Failure (continued)

1. High Bonnet Pressure - Unit 1 ADV-184 (continued)

and did not have excessive bonnet pressures. It should be noted that the manual operator would function with this loading since the capacity of the manual operator is approximately 20,000 LB_f.

Root Cause of Failure:
The failure of ADV-184 to open was due to an abnormally high bonnet pressure. 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. Thus, the cause of the high bonnet pressure is attributable to excessive leakage around the piston ring. The ring design utilized in this 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, a 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 forming the 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 scenario was 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.

Either of the above scenarios could result in the observed behavior of ADV-184. The initial failure to open was due to excessive bonnet pressure. The 110 psig bonnet pressure was too great for the pneumatic operator to overcome. Upon repeated cycling of the pilot valve the bonnet pressure dropped from 110 psig to approximately 42 psig. This can be explained by either the foreign material suggested in, Scenario #1, above, being washed out by the flow of steam past the piston ring or in the case of Scenario #2, the ring moving progressively higher, closing the vertical clearance until the force from the flow over the top surface of the piston ring was overcome by the differential pressure across the piston ring

VI. ENGINEERING EVALUATION (continued)

E. Specific Root Causes of Failure (continued)

1. High Bonnet Pressure - Unit 1 ADV-184 (continued)

allowing the ring to seal against the upper surface. The root cause of the seal leakage past the piston ring cannot be determined. Cooldown and disassembly of the valves on previous similar failures has not revealed the nature of the failure.

There is however, evidence that periodic exercising of this type of valve maintains the seal ring in the energized condition. This conclusion is reinforced by the exercising program used on the Steam Bypass Control System valves (SBCS) which are of similar design. These valves are currently being stroked monthly to maintain the seal rings energized. Since the beginning of this exercise program there have been no failures to stroke due to high bonnet pressure. Additionally, the plug and piston ring modifications discussed in the conclusions below have been installed in one Unit 1 SBCS valve. The modification was installed prior to the Unit 3 trip of March 3rd and tested this April. The test indicated the new modifications functioned as expected with no detrimental effects on valve operation.

Conclusions:
The major corrective actions taken for the excessive bonnet pressure problem include:

1. A modification will be implemented during the current outages which will increase the pilot valve capacity and install an improved two-piece piston ring. These changes will result in not only less steam leakage to the bonnet area, but an increased ability to depressurize the bonnet chamber.

2. In addition to these design modifications, a new surveillance and monitoring program for the valves has been developed. This program requires monthly stroking of the ADVs and weekly bonnet pressure measurements. This additional testing provides a high level of confidence for early detection of increasing bonnet pressure.

3. Nitrogen supply pressure is also being increased to mitigate oscillations observed during the testing program (see Section VI.E.2). This increased nitrogen pressure will also provide added margin in the available force the actuator can develop. Therefore, a higher bonnet pressure could be overcome by the actuator.

These corrective actions are summarized in Section IX - Conclusions and Recommendations.

VI. ENGINEERING EVALUATION (continued)

E. Specific Root Causes of Failure (continued)

2. Valve Oscillations - Unit 1 ADV-178, ADV-179, and ADV-185

Discussions:
During the performance of Test 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. At that time, it was 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 (DCP SG-138). Since the implementation of DCP-138 and until the current testing, no other unstable or oscillatory behavior of the ADVs has been noted. However, there have been occasions when the valves overshot the demand signal and then modulated to the demand signal applied.

A summary of the current test behavior and the response of these valves is compiled in ATTACHMENT C. Only the valves in Unit 1 have experienced oscillations. As can be seen from the table, 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 at first considered a problem because the valve opened and the oscillations were dampened in a matter of seconds. However, Unit 1 ADV-185 entered an oscillation during testing which lasted 5 seconds and resulted in de-calibration 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 would allow 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 was tasked with the development of this 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 them to an acceptable level.

VI. ENGINEERING EVALUATION (continued)

E. Specific Root Causes of Failure (continued)

2. Valve Oscillations - Unit 1 ADV-178, ADV-179, and ADV-185 (continued)

Root Cause of Failure:
The preliminary results of the modeling effort and fast data acquisition have revealed 4 critical factors:

1. The forcing function for the oscillations is the C_v transition of the disk stack which occurs at ≈15% of valve stroke. 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 Atmospheric Dump Valves changes from 3.4 to 11 at ≈15% open and this results in a large step increase in flow in 125 mils of valve stroke. This rapid flow increase has two effects. First, the unbalanced pressure loading on the plug changes by approximately 1500 to 2500 LB_f. The mechanism of this change in unbalanced pressure loading on the plug is thought to be a result of pressure buildup under the unbalanced plug area due to its proximity to the disk stack. This conclusion 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% 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 of these phenomena is that the plug rapidly accelerates upward after passing the 15% 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%. 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. This makes modeling of the system extremely difficult.

3. A contributor to the onset of oscillation is the rate of acceleration the valve plug receives when passing the C_v transition within the disk stack. If the acceleration rate and subsequent response of the system to this acceleration rate occurs in a time frame matching the natural frequency of system, oscillations will occur.

VI. ENGINEERING EVALUATION (continued)

E. Specific Root Causes of Failure (continued)

2. Valve Oscillations - Unit 1 ADV-178, ADV-179, and ADV-185 (continued)

The rate of acceleration is a function of the velocity of the plug when it enters the C_v transition and the response of the positioner to the acceleration. Thus, a small change in the velocity of the plug or the response of the positioner may explain the random nature noted in the occurrence of oscillations and the amount of dampening present. This larger forcing function makes the rate 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 the 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.

On the 24th of March, 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 ≈15 psi higher than the nitrogen regulator. ADV-185 was stroked twice to 30% in a step change fashion; no oscillations occurred. ADV-178 was stroked three times to 30% using the step method; again, no oscillations occurred.

In order to show the effect of actuator pressure on the oscillations, ADV-178 was tested using nitrogen supply pressures of 90, 100, and 110 psig. It should be noted that 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. FIGURE VI-4 shows that when the valve was given a 30%

VI. ENGINEERING EVALUATION (continued)

E. Specific Root Causes of Failure (continued)

2. Valve Oscillations - Unit 1 ADV-178, ADV-179, and ADV-185 (continued)

step demand with a supply pressure of 90 psig, the valve experienced a damped oscillation which lasted 300 milliseconds. FIGURE VI-5 shows that at a supply pressure of 100 psig the valve did not oscillate. FIGURE VI-6 shows that 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 with 95 psig nitrogen and using 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.

Conclusions:
The effort to accurately model the ADVs is ongoing. As yet, a complete model of the interaction between the valve bonnet and downstream pressures is not available. The number of variables in the model, i.e. actuator cylinder pressures, bonnet pressure, and downstream pressure, make it a very complex problem. The model should be completed near the end of May, at which time a more precise understanding of the behavior of the ADVs will be available. In the interim, the oscillatory characteristics have been identified and a method of preventing oscillation will be implemented.

The solution to the oscillation phenomena described above is believed to be a combination of a modivication to the disk stack to "smooth" the C_v transition 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 and smoothing the C_v transition prevents the oscillations from occurring. This is accomplished by not allowing the plug to accelerate through the C_v transition at a rate which will excite the natural frequency of the system.

These modifications will be completed during the current outages in conjunction with the valve plug and piston ring modification. A summary of the corrective actions taken can be found in Section IX - Conclusions and Recommendations.

VI. ENGINEERING EVALUATION (continued)

E. Specific Root Causes of Failure (continued)

3.a Nitrogen Regulators and Nitrogen System Leakage

Discussion:
The regulators were procured under Purchase Order #J691 and are manufactured by Target Rock. The regulators are Model 76Q-010, 1" in size, with a design flowrate of 20 SCFM, ASME III Class 3, and have a maximum differential pressure rating of 595 psi.

Three of the regulators 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 set point 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 therefore, sufficient nitrogen may not be available for valve operation under design conditions.

Root Cause of Failure:
The root cause of the seat leakage, for one regulator, was due to foreign particles damaging the regulator seating surface. The damage was generally light caused by minute metallic slivers. See Section VI.E.3.d for a complete discussion of the Pneumatic System Cleanliness

Normal wear was the cause for the other two regulator seat leaks. The vendor, Target Rock, was on-site during the investigation of the regulator failures and concurred with this evaluation.

Conclusions:
The regulators that were found to have significant seat leakage resulting in relief valve flow. The regulators were reworked to restore seat leakage to within acceptable limits.

Preventive Maintenance tasks have been developed to calibrate and test the regulators on a periodic basis. Each of the twelve regulators will be tested for seat leakage, reworked if required and recalibrated subsequently as required. Prior to the restart from the current outages, this PM task will be performed for the four regulator's on each Unit.

The Nuclear Engineering Department is currently performing an ADV system design review to evaluate (among other things) the application of these particular Target Rock regulators in this service. If further improvements are identified as a result of this review, the changes will be made in accordance with that review.

VI. ENGINEERING EVALUATION (continued)

E. Specific Root Causes of Failure (continued)

3.b Positioners

Discussion

The positioner is a Moore model 74G, which is a two stage, high frequency response valve positioner. The positioner operates on a force-balance principle shown in FIGURE VI-7.

An operational difficulty noted with these positioners was a lack of optimum operation. This was characterized by inconsistent output level pressure values which resulted in a variation in the opening response of the ADVs. This can be attributed to a combination of insufficient maintenance and a variance in calibration/tuning methods. None of these conditions prevented, or would have prevented, the ADVs from operating.

Conclusions:

To provide optimum performance and ensure that required positioner maintenance is performed every refueling, an instrument loop Preventative Maintenance (PM) task has been developed. Prior to restart from the current outages, this PM task will be performed for the four positioner loops on each Unit. This task addresses the following components of the loop for each ADV:

- Manual Controller and Valve Position at Main Control Board
- Manual Controller and Valve Position Indicator at Remote Shutdown Panel
- Valve Position Transmitter
- Valve Position Open/Close Limit Switches
- I/P Converter
- Moore™ Valve Positioner

VI. ENGINEERING EVALUATION (continued)

E. Specific Root Causes of Failure (continued)

3.c Actuator Spring

Discussion:
The atmospheric dump valves and pneumatic actuators are manufactured by CCI. The complete assemblies were procured by Bechtel under Purchase Order #J-601A.

During the Unit 3 ADV actuator disassembly to support the Unit 3 Root Cause of Failure (RCF) analysis, three (3) internal springs were discovered inside the actuator in three Unit 3 ADVs: ADV-184, ADV-178, and ADV-185. The current vendor drawings for the actuators associated with these valves indicate only two (2) springs are to be installed in these valves. The additional spring in the actuators was to be removed prior to the start-up of Unit 3. According to the vendor (CCI), in a letter to ANPP dated 4/6/89 (see ATTACHMENT D), the third spring was to be removed to gain more operating margin for the valves. It was further stated that the valves will operate with three springs provided the piston ring seals as expected. The effect of the third spring can be seen in the table below:

#of Actuator Springs	Pre-Load (LBf)	Spring Constant (LBf/in)
2	1519	168.5
3	3282	269.6

The Design Change Package (DCP) to remove the extra spring was issued in August, 1983 under DCP #3CM-SG-305. Startup Work Authorization SWA #10003, and Work Order #171688 were generated to perform the work described in the DCP. Although the DCP was signed as "complete" by the Bechtel Engineer, the Startup Engineer, and the Quality Control Group, the existence of the springs indicate the work was not performed.

Although testing performed in Units 1 and 2 did not indicate a presence of an additional spring in their actuators, an extensive review of the paperwork associated with the DCP performed in Units 1 and 2 was initiated. The results of this review will be documented under Incident Investigation Report #3-1-89-030.

Conclusions:
The Unit 3 ADV actuators must be reworked during the current outage to remove the third spring as noted on the CCI drawing.

Additionally, the Unit 1 and Unit 2 ADVs will be disassembled and inspected for discrepancies during their 1989 outages.

VI. ENGINEERING EVALUATION (continued)

E. Specific Root Causes of Failure (continued)

3.d. Pneumatic System Cleanliness

Discussion
Based upon the foreign particle contamination noted on the nitrogen regulator seats, a concern was raised with respect nitrogen and instrument air cleanliness. The Instrument Air (IA) and the Nitrogen (GA) systems for this section has a design cleanliness classification of Class C per the Line List, 13PZZG014, as defined per ANSI N45.2.1-1973. Both the IA & GA system were flushed and met these cleanliness requirements during initial plant startup programs.

A review of the ADV actuator and sub-components was done to determine the device with the most limiting air quality requirements. The technical manual for the Moore™ valve positioner states air quality should conform to the Instrument Society of America standard ISA-S7.3, "Quality Standard for Instrument Air". This standard states: Particle Size - The maximum particle size in the air stream at the instrument shall be three (3) microns.

To evaluate the current state of system cleanliness, field testing was performed and documented via EER 89-GA-003. This testing entailed the use of a HIACO/ROYCO™ Model 5300 Particle Sensor. The testing was performed on Units 1 & 2 on the systems which had possible particulate contamination as evidenced by seat leakage of the nitrogen regulators. The testing was performed by establishing a flow of 20 SCFM to simulate a nitrogen flow greater than the normal maximum flow of the positioner of 12 SCFM, with this flow any particle migration would be assured. A sample flow of 1 SCFM was side streamed off the main purge flow and routed through the particle counter with a sample duration of one minute; this was repeated four times at each sample point.

Conclusion:
The results of the testing demonstrated that the nitrogen gas stream contains no particles greater than 5 microns. These test results demonstrate that the Class C cleanliness requirements are being met and the particle size requirements of ISA-S7.3 are being closely approached. The instrument air supply for Units 1 and 2 ADVs are currently equipped with 3 micron (nominal) filters (IAN-F15) and the Unit 3 filter is being installed during this refueling outage. A PM task is being generated to change these filters every six months. The Nuclear Engineering Department has completed an evaluation which concludes that particles in the 3 to 5 micron range would not be detrimental to positioner operation. This evaluation was based on discussions with the positioner vendor and the fact that the most limiting clearance in the positioner is 11 mils.

Additional flushing, testing, and evaluation of the instrument air and nitrogen quality will be completed prior to Unit 2 startup; this is documented in the Instrument Air Report prepared by the Nuclear Engineering Department. A more permanent resolution to the problem will be accomplished by implementing the commitments made in APS's response to Generic Letter #88-14.

VI. <u>ENGINEERING EVALUATION</u> (continued)

E. Specific Root Causes of Failure (continued)

3.e Environmental/Equipment Qualification Problems

During this investigation, two environmental/equipment qualification (EQ) issues arose. The first involved three non-qualified pressure gages installed on the positioner which were to be removed prior to placing the ADVs into service. The second issue concerned the type of "O" rings installed in the valve actuator. The actuator is supposed to contain several "O" rings composed of Viton. These discrepancies are discussed below from an environmental/ equipment qualification standpoint.

Positioner Gauges

<u>Discussion:</u>
The positioners were supplied with three pressure gauges; actuator top supply pressure, actuator bottom supply pressure, and the control signal pressure. The gauges were used during initial testing of the ADVs. However, these gauges were to be removed prior to placing the ADVs in service since they are not environmentally qualified. The ADVs were placed in service with the non-qualified gauges installed.

An engineering evaluation (EERs 89-SG-049 and 89-SG-092) was performed to determine the impact of the gauges on ADV operation/operability. If, during an event, the gauges broke off the positioner, a leak path of the air or nitrogen would be established upstream of the valve actuator.

For a closed ADV, failure of the gauges will not cause the valve to open. For an open ADV, failure of the gauges on the control signal port or the actuator bottom supply port would cause the ADV to drift shut, as designed on a loss of IA or nitrogen. However, this condition would render the ADV unavailable for remote operation from the control room or remote shutdown panel. Failure of the gauge connected to the actuator top supply port, will cause the ADV to drift shut. Manual operation of the affected ADV would still be possible.

<u>Conclusions:</u>
The gauges have been removed and the ports plugged in accordance with the vendor drawing.

Incident Investigation Report #3-1-89-030 is investigating why the gauges were not removed during implementation of DCP #3CM-SG-305.

VI. ENGINEERING EVALUATION (continued)

E. Specific Root Causes of Failure (continued)

3.e Environmental/Equipment Qualification Problems (continued)

Buna-N versus Viton O-rings

Discussion:
During disassembly of the ADVs in Unit 3, an O-ring for the actuator piston was determined to be Buna-N instead of Viton which is the material that was qualified. A design change was to have been implemented that replaced the originally supplied Buna-N with Viton, but the one Unit 3 valve was found to have a Buna-N O-ring.

Conclusions:
An engineering change evaluation has analyzed the difference and has determined that Buna-N is an acceptable material. Due to the shorter service life of the Buna-N, and to maintain a configuration consistent with the vendor recommendation, Palo Verde will inspect and replace any Buna-N O-rings with Viton during the next refueling outage for each Unit.

Incident Investigation Report #3-1-89-030 is investigating why the "O" ring was not replaced during implementation of DCP #3CM-SG-305.

VI. ENGINEERING EVALUATION (continued)

E. Specific Root Causes of Failure (continued)

3.f. Check Valves

Discussion:
Spring loaded check valves are installed to provide a class/non-class break between the class nitrogen backup and the instrument air supplies for the ADVs. The check valves also prevent loss of nitrogen accumulator pressure when a decay in instrument air pressure occurs.

During the ADV testing program, back leakage of these check valves was measured and found to be acceptable. No leakage of these check valves was detected for the Unit 1 and 2 check valves. For the Unit 3 check valves, leakage was measured at less than 0.5 scfm for a pair of the valves. These check valves are scheduled to be reworked during the Unit 3 refueling outage.

Conclusions:
Because the check valves are used for isolating the class nitrogen backup from the IA system, they will added to the Section XI test program and leakage will be checked on a periodic basis. Prior to the restart from the current outages, the applicable Section XI testing will be performed for each of the four check valves.

VI. ENGINEERING EVALUATION (continued)

E. Specific Root Causes of Failure (continued)

3.g. Packless Isolation Valves

Discussion:
To reduce nitrogen leakage, the originally supplied, packed manual isolation valves were replaced with "packless-type" valves. The packless valves were not designed to open against full line differential pressure over the seat.

For the manual isolation valves on the accumulators, bi-directional flow is a requirement. These valves, (V337,342,363, & 354) were installed with the valve flow arrow towards the accumulators for flow to charge the accumulators.

During recent testing with the accumulators charged, the outlet valves had to be opened for reverse design flow direction by reducing the differential pressure to less than 25 psi. This was done by opening the nitrogen supply valves, (V336,341,356, & 362) to eliminate any reverse differential pressure. This valve opening sequence requirement was known and was being controlled by a yellow caution tag, on each of the valves.

It should be noted that the accumulator isolation valves, (V337,342,363, & 354) are administratively controlled, normally open valves and did not interfere with ADV operation on any of the units. Thus, opening against a reverse flow direction differential was not a normal valve line-up. Also, during each recharging of the accumulators these valves were verified to be open by accomplishing pressure build-up in the accumulators.

Conclusions:
In order to eliminate the potential for the existing configuration to prevent accumulator gas flow, a Site Modification will be prepared. This Site Mod arrangement will eliminate the need for bi-directional flow. Thus, the packless valves will only be required to open in their design flow direction. This modification is a human factor improvement item only, and is not required to correct ADV operational deficiencies.

VI. ENGINEERING EVALUATION (continued)

E.4. Unit 3 Failure Analysis

Background:
This section addresses the failure of all of the Atmospheric Dump Valves (ADV) to respond as expected following the March 3, 1989 Unit 3 Reactor Trip and Main Steam Isolation Actuation . During this event, the operators were unable to open the ADV's after giving them a 20% or less open demand signal form the Control Room, and 30% or less open demand signal (for ADV-178) from the remote shutdown panel. In order to control the reactor coolant system temperature, the operators took manual control and opened ADV-178 (Steam Generator #1 Line 2) and ADV-185 (Steam Generator #2 Line 1). During manual operation of ADV-185 the manual engagement coupling fork failed. Manual operation of ADV-179 (Steam Generator #2 Line 2) was also attempted at this time. During this process, it's valve operator was broken.

Maintenance, Surveillance, and Test History:
The Unit 3 Atmospheric Dump Valves were last tested during the unit's power ascension test program. Power ascension test procedure 73PA-3SG01 cycled all four ADV's while the reactor was at 35% power on December 23, 1987. There have been no significant maintenance activities since that time. A comprehensive history of maintenance and surveillance activities performed on the ADV's will be included as a final portion of the Root Cause once the failure mode of the ADV's is determined.

Change Analysis:
An analysis of the differences between Unit 3 ADv's and the ADV's in Units 1 and 2 was performed. The only difference noted was in the Instrument Air supply to the main steam support structure. Units 1 and 2 have a 3 micron filter installed in the Instrument Air supply header to the main steam support structure. This modification is scheduled to be implemented in Unit 3 with site modification 3-SM-IA-003.

Summary of Data:
The following facts were obtained from the Operator Statements given following the reactor trip.

1. None of the ADV's opened in a timely manner when given a 20% or less open demand signal from the Control Room.

2. ADV-178 did not open in a timely manner when given a 30% or less demand signal from the Remote Shutdown Panel. (No attempt was made to open the other ADVs from the Remote Shutdown Panel.)

Investigation into the broken operator on valve ADV-179 revealed the manual override assembly attachment bolts were pulled out of the upper cap of the piston assembly. Interviews with the operators indicated they were trying to

VI. ENGINEERING EVALUATION (continued)

E.4. Unit 3 Failure Analysis (continued)

open the valve with a 24 inch pipe wrench. A reenactment of their operation of the valve revealed they were turning the manual operator handwheel in the wrong direction. This resulted in the damage to the actuator. (Note: The procedure for opening the ADVs has been revised and the valve handwheels have been labeled to indicate which direction will open the valve. See Incident Investigation Report #2-3-89-001 for more information.)

The operators also reported the ADV-185 was difficult to open manually. The manual engagement clevis was damaged during the manual operation of ADV-185.

Unit 3 Atmospheric Dump Valve and Actuator Testing:
Testing was performed to determine equipment response time, actuator characteristics, and operation forces necessary to operate ADVs 178, 184 and 185. All testing was performed with the Unit in Mode 5, Cold Shutdown. ADV-179 testing was not possible due to the damage sustained from manual operation. All Unit 3 testing was performed in accordance with test plans prepared, reviewed and approved within the quarantine guidelines imposed by the NRC.

The testing performed during the investigation was summarized in Section VI.C above but is repeated here for convenience.

ADV-178

When ADV-178 was given a 10% open demand signal, the valve moved to 6% smoothly but the actuator force require to move the valve was ≈5300 lb_f. Additional stroking to 40% consistently required excessive force to move the valve (up to 8400 lb_f).

In order to identify the source of the excessive resistance, the packing gland follower was loosened and approximately 50% of the packing was removed from the valve. Retesting the valve showed a significant reduction in actuator force required to open the valve, but still much higher than originally predicted. The actuator was decoupled from the valve and retested. Stroking the actuator alone required twice the predicted force.

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 but were still higher than expected. ADV-185 experienced a significant reduction in the opening force when the packing gland follower was loosened.

ADV-179

ADV-179 could not be tested due to the actuator damage from manual operation during the March 3rd transient. However, when the actuator was disassembled, no damage or excessive wear was noted.

VI. ENGINEERING EVALUATION (continued)

E.4. Unit 3 Failure Analysis (continued)

Valve and Actuator Disassembly:
Each of the four ADV actuators were disassembled and inspected. ADV-179 contained two springs inside the actuator cylinder. There was no damage or excessive wear evident. ADVs 178, 184 and 185 were disassembled and found to contain three springs inside the actuator cylinder (one more than current design). The three springs from ADV-184 were coated with rust and the top actuator plate indicated some slight pitting. This was evaluated and determined to be an isolated incident and not to have impacted the operability of the valve. The other three actuators did not show any indications of damage or excessive wear.

All four valves were disassembled and inspected. The packing gland followers were seized to the valve stem on ADV-178, ADV-179 and ADV-185. Preliminary results from ADV-179 indicate calcium silicate had hardened in the area between the gland follower and the valve stem; probably the result of overtightening the packing gland causing packing material to extrude into the space between the gland follower and the valve stem. Each of the valve's internal assemblies were removed during the teardown and inspection. No major damage or excessive wear was found. The inspection did reveal minor steam erosion, small burrs, minor scratches and scoring. Small amounts of debris were also removed from the valve internals. CCI concurred that these minor discrepancies are the result of normal valve wear and the valve disassembly. Nothing was found in any of the four valve internals that would prevent normal valve operation.

Conclusions:
The most probable root causes of failure for the Unit 3 valves to operate have been determined, although their relative contributions are indeterminate. There are several problems that have been discovered during testing and disassembly that contributed to the failure. Specifically:

1. ADVs -178, -184 and -185 were found to have three actuator springs vice the two required by design.
2. ADVs -178, -179, and -185 had their packing gland followers seized to the valve stem.

The extra spring requires a minimum additional force of approximately 1500 to 1700 pounds to operate. The seized packing follower requires an additional force of approximately 4000 pounds. The valve disassembly and inspection did not reveal anything else to prevent the valves from operating normally.

ADV-178 and ADV-185 had the extra spring and the seized packing follower. The force required to operate these valves very nearly exceeds the maximum force available from the actuator on nitrogen. ADV-179 had a seized packing follower and ADV-184 had an extra spring. These singular items probably added enough extra force to prevent the valves from opening when compared to the demand given and time allowed for the actuator force to build. All of the Unit 3 testing was performed in Mode 5, Cold Shutdown. Therefore, it was not possible

VI. ENGINEERING EVALUATION (continued)

E.4. Unit 3 Failure Analysis (continued)

to determine if excessive piston ring leakage and the resultant high bonnet pressures were present in these valves.

The valve operator is capable of generating approximately 10,500 pounds of force when supplied by 95 psig nitrogen. Figure VI-8 contains the calculated and measured forces required to operate each ADV. The calculated force due to bonnet pressure assumes 15 psig steam pressure in the valve bonnet.

Based on average Mode 3 bonnet pressures measured on Unit 1 and 2 ADVs and frictional forces measured under Mode 5 conditions on Unit 3 ADVs, it is probable that the combination of the third actuator spring and packing follower friction for ADV-178 and ADV-185, prevented these valves from operating. The assumed bonnet pressure and packing gland follower friction most likely prevented ADV-179 from operating.

ADV-184 probably failed to open based on the magnitude and duration of the open demand signal. However, if a bonnet pressure of approximately 30 psig existed for this valve, it could not have been pneumatically opened regardless of the magnitude and duration of the demand signal.

In summary, based upon as-found conditions, cold valve operating forces, and assuming the design residual bonnet pressure of 15 psig, it is unlikely that 3 of the 4 valves would have operated on nitrogen at 95 psig, and unlikely that the fourth valve would have opened with the short duration, low demand signal imposed.

Even though the relative contribution from each root cause is indeterminate, the corrective actions recommended for all the ADVs (see Section IX - Conclusions and Recommendations), will prevent these failures in the future.

VII. CONTROL COMPONENTS INCORPORATED (CCI) ANALYSIS

The valve vendor, Control Components Incorporated, was contacted immediately following the Unit 3 event and were on-site during the entire testing and inspection phase of the investigation. They prepared a report that addressed Unit 1 ADV-184's failure to open and the oscillations observed during testing. This report is included as ATTACHMENT E.

VIII HISTORICAL REVIEW OF THE ATMOSPHERIC DUMP VALVES

A historical review of the ADVs was conducted, covering the period from Pre-operational Testing of Unit 1 to the Unit 3 event of March 3, 1989.

The following documents were reviewed :

- Applicable Test Procedures
- Industry Generated Documents (e.g. NOMIS, NPRDS, SOERs, LERs)
- Regulatory Requirements (e.g. IEBs, IENs, Generic Letters, NUREGS)
- Maintenance History (e.g. Work Requests, Work Orders, Vendor Manuals, Surveillance Tests, Failure Data Trending Reports)
- Engineering Documents (e.g. Startup Field Requests, Non-Conformance Reports, Engineering Evaluation Requests, Engineering Action Requests, Engineering Change Evaluations, Reportability Evaluation Report)
- Design Basis and Requirements (e.g. UFSAR, CESSAR, Vendor Interface Documents, Purchasing Documents, Drawings and Drawing Change Documents)
- Design Change Documents (e.g. Plant Change Requests, Site Modifications, Temporary Modifications, Field Change Requests, Design Change Packages)

During the required Phase I through IV testing of the units, several problems were recorded with the valves and their failure to operate as expected. The valves were either reworked or the system retuned, with all work being done by the vendor, or under the supervision of the vendor.

During the historical review of the valves, several anomalies were noted in the operation of the valves. These were grouped into three main categories:

1. Failure to open
2. Large oscillatory motions
3. Sticking or binding of the valve plug

These events tended to be random with low repeatability, resulting in great difficulty in identifying the root cause of failure. Evaluation of the applicable documentation and correspondence to date indicates that the Engineering resolutions and recommendations as a result of this investigation can be categorized in accordance with the previously identified anomalies.

Additional information with respect to the historical review and the actions taken in response to the failures noted can be found in ATTACHMENT F.

IX CONCLUSIONS AND RECOMMENDATIONS

The Palo Verde Engineering Departments have performed an in depth review of the history, operation, maintenance, and design of the atmospheric dump valves. A preliminary mathematical model of the valves' dynamic behavior has been developed by Arizona State University's staff. The results of these analysis and the problems found are summarized in the recommended corrective action summary table. (TABLE IX-1)

This table divides the required actions into:

- Actions Prior to any Unit Restart,
- Actions During Unit Operations

The corrective actions are designed to eliminate the anomalies noted with the Unit 1 and 3 ADVs. Subsequent monitoring/testing activities following the planned modifications will ensure the atmospheric dump valves remain operable during modes required by the PVNGS Technical Specifications. Through this increased monitoring/testing program, the valve modifications will be evaluated to confirm the required level of reliability has been reached for the ADVs.

The specific failures that have occurred have been evaluated and the root cause determined.

1. <u>Failure to Open</u>
   This has been attributed to high bonnet pressure that prevented the actuator from lifting the main plug. The piston ring which allows the bonnet to depressurize when the pilot valve is open was leaking excessively. This steam flow into the bonnet was greater than the pilot valve could vent and resulted in higher downward forces than the actuator could overcome, thus preventing the actuator from lifting the plug. When Unit 1 ADV-184 was operated on instrument air the additional force from the higher pressure of the instrument air system allowed the plug to move and the piston ring to reenergize and subsequently provide a good seal. The valve was subsequently operated and the piston ring remained energized. This phenomena has been observed previously; the piston ring being reenergized after the valve was exercised.

   The data from the testing and Palo Verde's previous experience indicates that exercising the atmospheric dump valves maintains the sealing ability of the piston ring. A solution for the bonnet pressure problem is accomplished by monitoring the bonnet pressures weekly and stroking the valves monthly to provide assurance of the continued operability of the valves. These activities are being performed by Maintenance task 36MT-9SG01 and Surveillance Test 4XST-XSG03. In order to eliminate the need for frequent ADV stroking and bonnet pressure monitoring, the pilot valve and piston ring modifications (see FIGURES IX-1 and IX-2) will be performed. These modifications will be accomplished under Site Mod #1,2,3 SM-SG-018. This modification increases the C_v of the pilot valve which improves its' ability to depressurize the bonnet, thus making the valve less sensitive to changes

IX CONCLUSIONS AND RECOMMENDATIONS (continued)

in piston ring leakage and improving the operating margin of the actuator. The piston ring will also be modified under the same Site Mod to provide a two piece, more reliable seal.

2. <u>Valve Oscillations</u>
Three ADVs in Unit 1 experienced oscillations as they passed through the disk stack C_v transition region, (≈15% open). This occurred during the testing program when the nitrogen pressure was approximately 95 psig and the nitrogen regulators were being set without a minimum flow requirement. No valves in Unit 2 experienced this oscillation.

The cause of the oscillations is the large change in force on the plug at the disk stack C_v transition. This force change provides the forcing function necessary to excite the valve into an oscillation. Several other variable factors determine whether that forcing function will result in an oscillation. These factors include the top and bottom actuator cylinder pressures and the rate at which the force is applied. These variable factors make the oscillations occur randomly. Through mathematical modeling of the valve and testing it was determined that the greatest contributor to preventing oscillations was actuator stiffness. The pressures in the top and bottom of the actuator determine the response of the actuator to changes in valve position. The higher the pressures the more resistance to a change in valve position and the more stable the actuator operation. The test data and the mathematical model both confirm that the oscillations are prevented by an actuator with a high upper actuator cylinder pressure.

This information and the data from the supply pressure sensitivity study performed on valve ADV-178 are the basis for the recommendation to increase the nitrogen supply pressure from its current setpoint of 95 PSIG to a value of 105 psig (Site Mod 1,2,3 SM-SG-020 and 1,2,3 SM-SG-023). This recommendation also includes implementing a procedure which sets the nitrogen regulator at a minimum flow requirement consistent with the expected demand of the positioner.

The increased nitrogen supply pressure not only mitigates an oscillation but also provides more margin in the ability of the actuator to lift the plug. The other corrective action being taken is the disk stack rework which will smooth the C_v transition and eliminate the forcing function that excites the oscillations.

IX CONCLUSIONS AND RECOMMENDATIONS (continued)

3. Nitrogen Sub-system
During testing of the ADVs in units 1 and 2 various anomalies were noted when the class nitrogen backup subsystem was aligned to operate the valve. Although none of the problems observed would have prevented or contributed to the observed failures the performance of the system was outside the design basis. These problems were nitrogen consumption outside the design limit, regulator set pressure not controlling at the correct pressure, foreign particle contamination, and relief valve leakage. Excess nitrogen consumption resulted in Unit Two valves being declared inoperable. Engineering's review concluded that the root cause for the problems was inadequate preventative maintenance and testing.

To ensure that the nitrogen system will be available to support the ADVs all nitrogen subsystems will be flushed to ensure cleanliness, regulators will be calibrated and tested to verify proper performance, the systems will be checked for leakage to verify that the the system can supply nitrogen to meet its design basis. Surveillance testing will now be done to verify that the nitrogen system is not leaking more than the design basis and the regulator will now be checked by regular PMs.

Engineering recommendations have been categorized in the following manner:

1. Actions to be performed prior to Unit Restart.

4. Actions following the modifications and during subsequent Unit Operation.

TABLE IX-1 presents these recommended corrective actions in a matrix form.

An additional action recommended by Engineering is to install a manual block valve upstream of each ADV. This recommendation is not required to prevent a recurrence of any root cause determined by this investigation. However, its implementation may enhance plant availability in the future.

Also, the Nuclear Engineering Department is conducting a Long-Term Design Review to evaluate the current design of the ADV System. This review will initiate other changes to the ADV System which would further improve the reliability and operation of the ADVs.

ATTACHMENT A

CCI Letter to APS
Identifying Potential Deficiency
Under 10CFR20.21

ATT A.

Control Components Inc.
An IMI valve company

April 4, 1989

Mr. Ben Mendoza
Arizona Public Service
Palo Verde

Subject: Atmospheric Dump Valves
Potential Significant Deficiency Under 10CFR-21

Dear Mr. Mendoza:

We are hereby notifying you of a potential significant deficiency that may be reportable under the requirements of 10CFR-21. We are not reporting this directly to the Nuclear Regulatory Commission (NRC). We at CCI do not have the systems expertise that would permit us to decide if this is a significant deficiency. However, because of the NRC's interest and their prior contact for information regarding plants with a similar design, we have sent a copy to Rich Lobel of the Events Assessments group in Washington D.C.

CCI has completed it's analysis of the Atmospheric Dump Valves for your site. This analysis was prompted by the failure of the APS-Palo Verde valves to open. The Palo Verde valves are similar in design and rely upon the same principle of operation.

The analysis has been aimed at calculating a worst case bonnet pressure after the pilot valve has been opened. If the leakage by the piston ring is larger than the ability of the pilot plug to drain the bonnet, excessive pressure remains in the bonnet. If the pressure is too high, the actuator cannot overcome the forces holding the main plug on the seat.

Our calculation indicates that the atmospheric dump valves at your site may fail to open. The cause of the failure is speculative but the result is a piston ring that fails to seal. The high bonnet pressure resulting does not permit the actuator to open the valve. That is; the actuator force with the current air pressure supply available is not large enough to overcome the pressure force holding the plug closed.

As noted above, the cause of failure is not known. The condition cannot be made to occur on demand and in fact appears randomly. Our speculation is that pipe scale and other dirt particles get into the piston ring cavity and prevent the ring from sealing. Until the recent Palo Verde testing in March 1989, we have been unable to verify that an excessive bonnet pressure existed.

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Telephone: (714) 858-1877 ☐ FAX: (714) 858-1878 ☐ Telex: 685500

The resolution to this problem is to increase the pilot valve capacity. This requires rework of the plug to enlarge the pilot flow area and a new stem to seal the pilot valve when closed.

A second change is to use a two piece wedge style piston ring to assure a good seal. This change is not as significant as increasing the pilot capacity but adds extra margin.

Plants for which there is a concern that a random failure may occur and to whom this letter was sent are:

1) Arizona Public Service - Palo Verde 1, 2 & 3 - 4 Valves Each
2) Louisiana Power & Light - Waterford 3 - 2 Valves Each
3) Duke Power - Catawba 1 & 2 - 4 Valves Each
4) Southern California Edison - San Onofre 2 & 3 - 2 Valves Each

Plants for which there is no concern are:

1) Florida Power & Light - St. Lucie 2 - 4 Valves Each
2) Houston Power & Light - South Texas Project 1 & 2 - 4 Valves Each
3) Georgia Power - Vogtle 1 & 2 - 4 Valves Each
4) Carolina Power & Light - Shearon Harris 1 - 3 Valves Each

This list of eight plants are the only ones that have designs similar to the Palo Verde valves. Other atmospheric dump valves exist at other plants but their design is not the same as for the plants noted above.

The plants for which there is no concern have also been analyzed. Our findings are that the valves have sufficient actuator force and plug pilot flow capacity to assure opening of the valves. An information copy of this letter has been sent to these plants.

Please contact myself, Ron Adams, or Curtis Sterud at CCI if you have any questions or for additional information.

Sincerely,

CONTROL COMPONENTS INC.

H.L. Miller
Vice President, Engineering

/jf

cc: CGSterud
REAdams
EJVillalva
RETopping

ATTACHMENT B

Test Equipment Details

ATTACHMENT B
Test Equipment Details

Initially, the test set-up utilized the Acurex™ Autodata 10/50 Digital Recorder which has the ability to convert the raw data into engineering units and display the resulting parameters in real time. However, the maximum scan rate achieve using the Autodata 10/50 is 125 milliseconds. After initial analysis of the data, it was determined that a higher scan rate would be necessary to allow for a complete analysis of the noted valve oscillations. Using an 80286 based computer system with analog to digital capabilities, a more desirable scan rate of 20 milliseconds was obtained. A function generator was used to verify the scan rate of the high speed data logging computer and a dial-a-volt calibrator was used to verify the linearity, hysteresis and repeatability of the A/D converter card. All other test equipment used was calibrated in accordance with the applicable M&TE calibration procedures.

The pressure measuring devices used were Rosemount Alphaline Absolute and Gage pressure transmitters were calibrated to .5% of full scale accuracy which includes the combined effects of linearity, hysteresis and repeatability. The response time is set to 0.2 seconds and is adjustable to 1.67 seconds for dampening. The power supply used was a HP 4334 set in the constant current mode for the transmitters and set in the constant voltage mode for the lanyard position transducer. The output of the pressure transmitters was shunted across a precision 250 OHM resistor converting the signal to 0-5 volts which was read by the digital voltage meter of the computers. The position measuring device is a Celesco Lanyard Position Transducer which is a Lanyard attached spring loaded potentiometer. This is field calibrated using a standard calibration fixture to determine slope and linearity. A HP 3468 DVM was used to perform constant checking of instrumentation during the testing.

The following ranges of instrumentation were used:

RANGE	PARAMETER	MEASURED RANGE	ACCURACY
0-300 psia	Above Actuator	0-150 psi	.5%
0-300 psia	Below Actuator	0-150 psi	.5%
0-50 psia	Position Signal	2.5-15 psi	.5%
0-100 psig	Nitrogen Supply Press	0-100 psi	.5%
0-1100 psig	Bonnet Press	0-1000 psig	.5%
0-1100 psig	Downstream	0-1000 psig	.5%
0-20 inches	Valve Position	0-100% or 0-12.3"	N/A

ATTACHMENT C

Comprehensive Test Summary

UNIT 1 ATMOSPHERIC DUMP VALVE TESTING - PREPARED 4/13/89

VALVE	TEST DATE	TEST METHOD	TEST SUMMARY
178	18-Mar	STEP/NITROGEN	30% DEMAND; NO BONNET PRESSURE AVAIL.; SMOOTH STROKING TO 30%
		INCREMENTAL/NITROGEN	20% DEMAND; NO BONNET PRESSURE AVAIL.; SUBSTANTIAL VALVE OSCILLATIONS TO 62%; VALVE SHUT; TEST TERMINATED
	21-Mar	STEP/NITROGEN	10% DEMAND; 32 - 8 PSIG BONNET PRESSURE; PILOT MOVEMENT ONLY
		STEP/NITROGEN	20% DEMAND; 13 - 5 PSIG BONNET PRESSURE; SMOOTH STROKING TO 22%
		STEP/NITROGEN	30% DEMAND; 10 - 6 PSIG BONNET PRESSURE; SMALL VALVE OSCILLATIONS DAMPED TO 30% OPEN.
		STEP/NITROGEN	40% DEMAND; 10 - 5 PSIG BONNET PRESSURE; SMOOTH STROKING TO 44%
		STEP/NITROGEN	40% DEMAND; 10 - 5 PSIG BONNET PRESSURE; SMOOTH STROKING TO 45%
	23-Mar	STEP/NITROGEN	30% DEMAND; 10 - 12 PSIG BONNET PRESSURE; SUBSTANTIAL VALVE OSCILLATIONS TO 62%; OSCILLATIONS DAMPED WITHIN 2 SECS; VALVE MODULATED TO 30%
		STEP/NITROGEN	30% DEMAND; 8 - 10 PSIG BONNET PRESSURE; SUBSTANTIAL VALVE OSCILLATIONS TO 57%; OSCILLATIONS DAMPED WITHIN 2 SECS; VALVE MODULATED TO 30%
		STEP/NITROGEN	30% DEMAND; 6 - 7 PSIG BONNET PRESSURE; SUBSTANTIAL VALVE OSCILLATIONS TO 64%; OSCILLATIONS DAMPED WITHIN 2 SECS; VALVE MODULATED TO 31%
		STEP/NITROGEN	30% DEMAND; 6 - 7 PSIG BONNET PRESSURE; SUBSTANTIAL VALVE OSCILLATIONS TO 60%; OSCILLATIONS DAMPED WITHIN 2 SECS; VALVE MODULATED TO 33%
	24-Mar	STEP/IA	30% DEMAND; NO INSTRUMENTATION INSTALLED; SMOOTH STROKE TO 30%
		STEP/IA	30% DEMAND; NO INSTRUMENTATION INSTALLED; SMOOTH STROKE TO 30%
		STEP/IA	30% DEMAND; NO INSTRUMENTATION INSTALLED; SMOOTH STROKE TO 30%
	25-Mar	STEP/IA	30% DEMAND; 6-8 PSIG BONNET PRESSURE; SMOOTH STROKE TO 30%
		STEP/IA	30% DEMAND; 6-8 PSIG BONNET PRESSURE; SMOOTH STROKE TO 30%
		STEP/IA	30% DEMAND; 6-8 PSIG BONNET PRESSURE; SMOOTH STROKE TO 30%
		STEP/IA	30% DEMAND; 6-8 PSIG BONNET PRESSURE; SMOOTH STROKE TO 30%
	3-Apr	STEP/NITROGEN	30% DEMAND; 110 PSIG NITROGEN SUPPLY; SMOOTH STROKE TO 20%
			30% DEMAND; 100 PSIG NITROGEN SUPPLY; SMOOTH STROKE TO 20%
			30% DEMAND; 90 PSIG NITROGEN SUPPLY; SLIGHT OSCILLATIONS DAMPED IN 300 ms; SMOOTH STROKE TO 30%

UNIT 1 ATMOSPHERIC DUMP VALVE TESTING - PREPARED 4/13/89

VALVE	TEST DATE	TEST METHOD	TEST SUMMARY
179	16-Mar	INCREMENTAL/NITROGEN	10% DEMAND - NO VALVE MOVEMENT; 20% PILOT MOVEMENT; 30% - SMOOTH STROKING TO 34%; 40% - SMOOTH TO 44%; 50% - SMOOTH TO 50% +. NO TEST INSTRUMENTATION INSTALLED. 93 PSIG NITROGEN SUPPLY PRESSURE.
	6-Apr	STEP/NITROGEN	30% DEMAND; 95 PSIG NITROGEN SUPPLY; SUBSTANTIAL OSCILLATIONS; POSITIONER DAMAGED, TEST TERMINATED
	8-Apr	MANUAL	TWO 30% STROKES WERE PERFORMED TO CHARACTERIZE THE BONNET AND BACK-PRESSURES DURING THE Cv TRANSITION
184	14-Mar	STEP & INCREMENTAL/N2	VALVE FAILED TO OPEN WITH A 50% DEMAND SIGNAL -- NITROGEN PRESSURE WAS APPROXIMATELY 95 PSIG -- BONNET PRESSURE TAP NOT INSTALLED
	21-Mar	STEP/IA*	10% DEMAND; 1145 PSIG BONNET PRESSURE; NO VALVE MOVEMENT
		STEP/IA*	20% DEMAND; 60-110 PSIG BONNET PRESSURE; PILOT MOVEMENT ONLY
		STEP/IA*	30% DEMAND; 56 - 42 PSIG BONNET PRESSURE; VALVE STEPPED TO 20% THEN SHUT
		STEP/IA*	40% DEMAND; 44-34 PSIG BONNET PRESSURE; SMALL OSCILLATIONS; OPEN TO 40%
		STEP/IA*	40% DEMAND; 8 - 2 PSIG BONNET PRESSURE; SMOOTH STROKING OF VALVE TO 45%
		STEP/IA*	30% DEMAND; 7-2 PSIG BONNET PRESSURE; SMOOTH STROKING TO 32%
		INCREMENTAL/IA*	50% DEMAND; 9-4.5 PSIG BONNET PRESSURE; SMOOTH STROKING 53%
			* Nitrogen Regulator problems encountered -- IA used for testing

UNIT 2 ATMOSPHERIC DUMP VALVE TESTING - PREPARED 4/13/89

VALVE	TEST DATE	TEST METHOD	TEST SUMMARY
178	18-Mar	INCREMENTAL/NITROGEN	50% DEMAND; NO BONNET PRESSURE AVAIL.; SMOOTH STROKE TO 50%
	23-Mar	STEP/NITROGEN	30% DEMAND; 2-8 PSIG BONNET PRESSURE; SMOOTH STROKE TO 30%
		STEP/NITROGEN	30% DEMAND; 2-8 PSIG BONNET PRESSURE; SMOOTH STROKE TO 30%
		STEP/NITROGEN	30% DEMAND; 2-8 PSIG BONNET PRESSURE; SMOOTH STROKE TO 30%
		STEP/NITROGEN	30% DEMAND; 2-8 PSIG BONNET PRESSURE; SMOOTH STROKE TO 30%
179	18-Mar	INCREMENTAL/NITROGEN	50% DEMAND; NO BONNET PRESSURE AVAIL.; SMOOTH STROKE TO 50%
	20-Mar	STEP/IA	30% DEMAND; NO BONNET PRESSURE AVAIL.; SMOOTH STROKE TO 30%
		INCREMENTAL/IA	50% DEMAND; NO BONNET PRESSURE AVAIL.; SMOOTH STROKE TO 50%
	23-Mar	STEP/NITROGEN	30% DEMAND; 2-8 PSIG BONNET PRESSURE; SMOOTH STROKE TO 30%
		STEP/NITROGEN	30% DEMAND; 2-8 PSIG BONNET PRESSURE; SMOOTH STROKE TO 30%
		STEP/NITROGEN	30% DEMAND; 2-8 PSIG BONNET PRESSURE; SMOOTH STROKE TO 30%
		STEP/NITROGEN	30% DEMAND; 2-8 PSIG BONNET PRESSURE; SMOOTH STROKE TO 30%
184	18-Mar	INCREMENTAL/NITROGEN	NITROGEN REGULATOR PROBLEM; TESTING SECURED
	20-Mar	INCREMENTAL/IA	50% DEMAND; NO BONNET PRESSURE AVAIL.; SMOOTH STROKE TO 50%
	8-Apr	STEP/NITROGEN	10% DEMAND; PILOT DID NOT OPEN AFTER 1 MIN 15 SECS; TEST SECURED
		STEP/NITROGEN	20% DEMAND; 6 PSIG BONNET PRESSURE; SMOOTH STROKE TO 20%
		STEP/NITROGEN	30% DEMAND; 3 PSIG BONNET PRESSURE; SMOOTH STROKE TO 30%
		STEP/NITROGEN	30% DEMAND; 3 PSIG BONENT PRESSURE; SMOOTH STROKE TO 30%
		INCREMENTAL/NITROGEN	30% DEMAND; 6-3 PSIG BONNET PRESSURE; SMOOTH STROKE TO 30%
185	18-Mar	INCREMENTAL/NITROGEN	50% DEMAND; NO BONNET PRESSURE AVAIL.; SMOOTH STROKE TO 50%
	23-Mar	STEP/NITROGEN	30% DEMAND; 2-10 PSIG BONNET PRESSURE; SMOOTH STROKE TO 30%
		STEP/NITROGEN	30% DEMAND; 2-10 PSIG BONNET PRESSURE; SMOOTH STROKE TO 30%
		STEP/NITROGEN	30% DEMAND; 2-10 PSIG BONNET PRESSURE; SMOOTH STROKE TO 30%
		STEP/NITROGEN	30% DEMAND; 2-10 PSIG BONNET PRESSURE; SMOOTH STROKE TO 30%

UNIT 3 ATMOSPHERIC DUMP VALVE TESTING - PREPARED 4/13/89

VALVE	TEST DATE	TEST METHOD	TEST SUMMARY
178	27-Mar	STEP/NITROGEN	10% DEMAND; VALVE COLD, STROKED SMOOTHLY TO 6%; 5300 LBf MAX FORCE
		STEP/NITROGEN	20% DEMAND; VALVE COLD, STROKED SMOOTHLY TO 14%; 7000 LBf MAX FORCE
		STEP/NITROGEN	40% DEMAND; VALVE COLD, STROKED SMOOTHLY TO 31%; 8200 LBf MAX FORCE
		STEP/NITROGEN	40% DEMAND; VALVE COLD, STROKED SMOOTHLY TO 33%; 8400 LBf MAX FORCE
	30-Mar	STEP/NITROGEN	30% DEMAND; VALVE COLD; 1/2 PACKING REMOVED; STROKED TO 20%; 4200 LBf MAX FORCE
		STEP/NITROGEN	30% DEMAND; VALVE COLD; 1/2 PACKING REMOVED; STROKED TO 20%; 4300 LBf MAX FORCE
		INCREMENTAL/NITROGEN	50% DEMAND; VALVE COLD; 1/2 PACKING REMOVED; STROKED TO 38%; 4900 LBf MAX FORCE
	1-Apr	SEE TEST SUMMARY	ACTUATOR STROKED DE-COUPLED FROM VALVE STEM; SPRING PRELOAD CALCULATED AT APPROX. 3000 LBf WITH A SPRING CONSTANT OF APPROX. 277 LBf/IN; (design values are much less)
	6-Apr	DISASSEMBLY	ACTUATOR DISASSEMBLED -- FOUND EXTRA SPRING IN ACTUATOR -- EXPLAINS 4/1 DATA ABOVE
179	20-Mar	DISASSEMBLY	ACTUATOR BROKEN DURING MANUAL OPERATION ATTEMPT FOLLOWING TRIP -- VALVE AND ACTUATOR DISASSEMBLED -- PACKING GLAND FOUND SEIZED - NO VALVE INTERNAL PROBLEMS NOTED.
184	1-Apr	STEP/NITROGEN	10% DEMAND; VALVE COLD; STROKED TO 10%; 4500 LBf MAX FORCE
		STEP/NITROGEN	20% DEMAND; VALVE COLD; STROKED TO 20%; 5000 LBf MAX FORCE
		STEP/NITROGEN	30% DEMAND; VALVE COLD; STROKED TO 33%; 5600 LBf MAX FORCE
		STEP/NITROGEN	40% DEMAND; VALVE COLD; STROKED TO 43%; 6100 LBf MAX FORCE
		STEP/NITROGEN	50% DEMAND; VALVE COLD; STROKED TO 53%; 6450 LBf MAX FORCE
		STEP/NITROGEN	10% DEMAND; VALVE COLD; STROKED TO 12%; 4300 LBf MAX FORCE
		STEP/NITROGEN	20% DEMAND; VALVE COLD; STROKED TO 21%; 4900 LBf MAX FORCE
		STEP/NITROGEN	30% DEMAND; VALVE COLD; STROKED TO 33%; 5500 LBf MAX FORCE
		STEP/NITROGEN	40% DEMAND; VALVE COLD; STROKED TO 43%; 5900 LBf MAX FORCE
		STEP/NITROGEN	50% DEMAND; VALVE COLD; STROKED TO 52%; 6300 LBf MAX FORCE
		STEP/NITROGEN	80% DEMAND; VALVE COLD; STROKED TO 77%; 7100 LBf MAX FORCE
		STEP/NITROGEN	80% DEMAND; VALVE COLD; STROKED TO 77%; 7000 LBf MAX FORCE
		STEP/NITROGEN	80% DEMAND; VALVE COLD; STROKED TO 76%; 7000 LBf MAX FORCE
	7-Apr	DISASSEMBLY	ACTUATOR DISASSEMBLED -- FOUND EXTRA SPRING IN ACTUATOR -- ALSO FOUND RUST ON SPRINGS AND PITTING ON PISTON.
185	1-Apr	INCREMENTAL/NITROGEN	90% DEMAND; VALVE COLD; STROKED TO 60%; 11,500 LBf MAX FORCE
		INCREMENTAL/NITROGEN	90% DEMAND; VALVE COLD; STROKED TO 68%; 11,500 LBf MAX FORCE
		INCREMENTAL/NITROGEN	90% DEMAND; VALVE COLD; PACKING GLAND FOLLOWER LOOSENED; STROKED TO 77%; 6,900 LBf MAX FORCE
	7-Apr	DISASSEMBLY	ACTUATOR DISASSEMBLED -- FOUND EXTRA SPRING IN ACTUATOR

UNIT 1 ATMOSPHERIC DUMP VALVE TESTING - PREPARED 4/13/89

VALVE	TEST DATE	TEST METHOD	TEST SUMMARY
185	18-Mar	STEP/NITROGEN	10% DEMAND; NO BONNET PRESSURE AVAILABLE; OPENED AND MODULATED @ 10%
		STEP/NITROGEN	20% DEMAND; SUBSTANTIAL VALVE OSCILLATIONS EXPERIENCED; VALVE SHUT; TEST SECURED DUE TO POSITIONER CALIBRATION PROBLEMS; POSITIONER RECAL'D.
	23-Mar	STEP/NITROGEN	30% DEMAND; 30 - 36 PSIG BONNET PRESSURE; VALVE "STEPPED" TO 30%
		STEP/NITROGEN	30% DEMAND; 23 - 29 PSIG BONNET PRESSURE; VALVE "STEPPED" TO 30%
		STEP/NITROGEN	30% DEMAND; 25 - 30 PSIG BONNET PRESSURE; SMALL OSCILLATIONS DAMPED TO APPROXIMATELY 36%.
		STEP/NITROGEN	30% DEMAND; 30 - 36 PSIG BONNET PRESSURE; VALVE "STEPPED" TO 38%
		MANUAL STROKE	5 TIMES TO APPROXIMATELY 20%.
		STEP/NITROGEN	30% DEMAND; VALVE STROKED SMOOTHLY TO 30%
		STEP/NITROGEN	30% DEMAND; 30 - 40 PSIG BONNET PRESSURE; VALVE OPENED TO 39% WITH MINOR OSCILLATIONS FOR APPROXIMATELY 2 SECS.
		STEP/NITROGEN	30% DEMAND; 27 - 40 PSIG BONNET PRESSURE; PILOT LIFTED WITH ZERO DEMAND; VALVE OPENED TO APPROXIMATELY 39% WITHOUT OSCILLATIONS.
		STEP/NITROGEN	30% DEMAND; 9 - 11 PSIG BONNET PRESSURE; VALVE OPENED TO 39% WITHOUT VALVE OSCILLATIONS
	24-Mar	STEP/IA	30% DEMAND; NO INSTRUMENTATION INSTALLED; SMOOTH STROKE TO 30%
		STEP/IA	30% DEMAND; NO INSTRUMENTATION INSTALLED; SMOOTH STROKE TO 30%
	25-Mar	STEP/IA	30% DEMAND; 10-12 PSIG BONNET PRESSURE; SMOOTH STROKE TO 30%
		STEP/IA	30% DEMAND; 30 PSIG BONNET PRESSURE; SMOOTH STROKE TO 30%
		STEP/IA	30% DEMAND; 30 PSIG BONNET PRESSURE; SMOOTH STROKE TO 30%
		STEP/IA	30% DEMAND; 30 PSIG BONNET PRESSURE; SMOOTH STROKE TO 30%
	4-Apr	STEP/NITROGEN	30% DEMAND; 95 PSIG NITROGEN SUPPLY; 25 PSIG BONNET PRESSURE; SUBSTANTIAL OSCILLATIONS; TEST TERMINATED
			30% DEMAND; 95 PSIG NITROGEN SUPPLY; 7 PSIG BONNET PRESSURE; SMOOTH STROKE TO 30%

ATTACHMENT D

CCI Letter to APS
Three Springs vs. Two Springs
In ADV Actuator

Control Components inc.
An IMI valve company

April 6, 1989

Mr. Ben Mendoza
Arizona Public Service
Palo Verde Nuclear Generating Station

Subject: Three Springs Vs. Two Springs in ADV's

Dear Mr. Mendoza:

The third spring was removed from the ADV actuators to gain more operating margin for the valves. Our calculations today also confirm that the valves will operate with three springs provided the piston ring seals as expected.

A brief chronology associated with this issue is:

1) July 2, 1982 CCI and Bechtel (Norwalk) meeting, CCI advised we plan to remove a spring from the actuators. Reference meeting minutes dated 7/15/82, EJVillalva (CCI) to D. Zody (Bechtel).

2) July 12, 1982 CCI letter, EJVillalva to W.G. Bingham, transmitted calculations to Bechtel showing actuator pressures with 2 and 3 spring configurations.

3) July 26, 1982 CCI and Bechtel (Norwalk) meeting, actuator sizing was again discussed. CCI advised that there was a 7 psi margin with two springs. Reference meeting minutes dated 7/27/82, EJVillalva to D. Zody.

4) August 5, 1982 CCI letter, EJVillalva to W.G. Bingham, CCI said 80 psi actuator pressure was ok but wished to reiterate that higher air pressure was desirable.

5) May 26, 1983 meeting at Palo Verde site, CCI hand delivered field change package for deleting one spring from the actuator assembly.

22591 Avenida Empresa ☐ Rancho Santa Margarita, California 92688
Telephone: (714) 858-1877 ☐ FAX: (714) 858-1878 ☐ Telex: 685500

All the actuator assemblies were shipped with three springs except the Unit 2 qualification valve, which was shipped without an actuator. The qualification actuator was shipped later after testing and refurbishment. There have been no spare actuators shipped to Palo Verde.

VALVE SHIP DATE HISTORY

Unit 1 - 1/31/80
Unit 2 - 4/30/80 (3 valves)
Unit 3 - 9/30/81 (1 valve)
10/23/81 (3 valves)
Qual Valve/Actuator 1983

We hope that the above information satisfies your needs. If you have any questions, please call.

Sincerely,

CONTROL COMPONENTS INC.

H.L. Miller
Vice President, Engineering

/jf

cc: CGSterud
REAdams
EJVillalva

ATTACHMENT E

CCI Analysis

* * * TELECOPY * * *

Control Components Inc.
An IMI valve company

22591 Avenida Empresa
Rancho Santa Margarita, California 92688
Tel. (714) 858-1877 • FAX (714) 858-1878 • Telex 685500

DATE March 29, 1989

TO: APS - Palo Verde

Attn: Gerald Sowers
MGR ENGR EVAL.

FAX No. 602-393-3504

FROM: Curtis G Storud

Ext.

SUBJ: APS - ADV'S

REF:

Transmitted is CCI's Report on the ADV's.

CG Storud

NOTE: If this transmission is not clear, please call (714) 858 1877, X340 or X362.

Our equipment is Group III, Automatic, 24 hours Access.

cc:

Control Components Inc.
An IMI valve company

To DISTRIBUTION

From C.G. Sterud, Principal Engineer

Cust

File No. or Ref. LR-89-6

Subj APS - Atmospheric Dump Valves (ADV)

Date 3/29/89

INTRODUCTION

This report addresses what CCI believes to be the causes of the two problems noted on the ADV's at Palo Verde Nuclear Generation Station.

These problems are:

1) The valve will not open beyond 4% with maximum air pressure in the bottom of the actuator.
2) When the plug moves past the 15% open position, there is a jump in rate of opening. Occasionally this jump is a significant overshoot of the required position and results in oscillation for 2 to 4 seconds. The oscillation stroke can be as high as 60%. System control is not effected by the short term oscillation. Inoperable damage to the valves is not expected due to this oscillation.

PROBLEM #1

The valve design is what we call "pressurized seat". This design is used where ANSI B16.104 Class V leakage is required. See the "pressurized seat plug-principal of operation", Appendix A. This design has performed very well in nuclear as well as in super critical fossil power plants to provide a control valve and block valve function.

The cause of the valve only opening the pilot plug and the actuator not being able to lift the main plug is excessive bonnet pressure. When the pilot plug lifts, the fluid in the bonnet is dumped downstream, to balance the plug so as to minimize the load for the actuator to stroke the valve. If the piston ring balance seal on the plug is a "good seal", the balanced plug is easily achieved. If there is a significant leak past the piston ring, the bonnet pressure is somewhat higher than the downstream pressure. This pressure drop across the plug results in additional load on the actuator. When the leak of the piston ring is such that the bonnet pressure load on the plug exceeds the capability of the actuator, the valve cannot be opened past the pilot valve opening stroke.

Over the past few years this problem has occurred with pressurized seat valves. Of the approximately 50 pressurized seat valves in 3600 psi fossil plants, only one failure of this type occurred. That occurrence was when the piston rings were worn away due to twice daily modulating control for extensive periods.

11-81

In the nuclear service, CCI has over 200 valves of this type, which have been in service for the last several years. The "stuck at pilot open" problem has occurred least often with 8" plug valves, and most often with 12" plugs. The occurrence seems to be most likely if the valve is not energized over a period of time. When a valve exhibits the problem, it has been found that stroking the valve for 3 or 4 cycles "re-seats" the piston ring and the valve is operable.

The reason for occasional excessive piston ring leakage is unknown. Best guesses are:

1) Dirt or foreign material such as corrosion products (magnetite) building up on sealing surfaces of the piston ring when the valve is closed. The piston ring is not energized against its sealing surfaces when the pilot plug is closed because the pressure is equal on both sides of the piston ring. When the pilot plug is opened, there is excessive piston ring leakage because the "dirt" holds the piston ring off the sealing surfaces. The 3 or 4 strokes referred to above, probably allows washing away of the "dirt" and the piston ring seal is more effective.

2) There is a vertical clearance of approximately .005" for the piston ring. The piston ring is resting .005" away from the upper sealing point. Speculation is that when the pilot valve is opened the fluid rushing past this .005" upper clearance, results in a dynamic pressure holding the piston ring down, away from its sealing surface. To address this scenario, we have incorporated "wave springs", which hold the piston ring in contact with its sealing surface at all times. We have had at least one instance of a valve not opening as required with a wave spring energized piston ring.

To investigate this piston ring problem, CCI made a fixture in which we can flow test with air (at 1200 psi) the 12" size piston ring. We tested the present design for 100 "openings". One time we found excessive leakage which would result in high bonnet pressure. These tests were performed in late 1986 as a result of erratic performance on non-safety valves at San Onofre.

We intentionally put a .010" high spot of metal on the piston ring to simulate dirt and measured the leakage Cv. This measured Cv corresponds to a leak which would result in excessive bonnet pressure.

We tested the piston ring with the wave spring. No excessive leakage was experienced. We tested piston rings with variations in end gap configurations, i.e., straight cut and overlap cut. No excessive leakage.

We also tested the same gap with labyrinth grooves instead of a piston ring. The Cv of the testing ranged from 1.0 to 16. A new two piece piston ring by Dover Corporation had the lowest and most consistent Cv.

A second test series was the pilot plug area. We made full size models of the existing plug pilot and a new design pilot area. These two models were flow tested on a low pressure air flow system for Cv.

From the above mentioned testing, we can be quite accurate in predicting bonnet pressure with a given pilot configuration and piston ring seal.

We have written a spreadsheet program for the IBM computer, which simulates the flow thru the pressurized seal valve and predicts bonnet pressure.

At Palo Verde, Unit 1, and for valve #ADV-184, we found a problem valve that would only open 4%. A pressure tap was put into the bonnet and we measured 100 psi, which required approximately 14000# of actuator load. We only had 12000# of actuator load. After three attempts to operate the bonnet pressure reduced to the point the valve could open. Pressure taps were installed in 3 valves on Unit 1 and 4 valves on Unit 2. In subsequent testing no valve "stuck" showing the randomness of the failure. However, valves #184 & 185 on Unit 1 showed higher actuator loads when opened, which corresponded to higher bonnet pressures. On both of these valve the actuator load can be predicted based on the measured bonnet pressure.

In the past we have installed pressure taps on valves which had failed to open. The valves were always operable after instrumentation was installed. So we could never prove excessive bonnet pressure to be the cause of failure. The tests at APS on #184 is the first measured valve failure.

Mechanical binding due to thermal expansion mismatch, hoop deflection due to pressure and flow and galling due to high piston ring rub forces have been suggested to be the problem. These suggestions have been presented since the problem first occurred. Many valves have been disassembled and examined. No inordinate rubbing has been found or no visible reason for binding has been observed. We have done thermal and stress analysis and can find no mismatch or fit problems.

CCI is convinced that the cause of the valve only being able to stroke to the pilot open position is excessive bonnet pressure due to excessive piston ring leakage. The excessively leaking piston ring condition is random and cannot be predicted. There is evidence that cycling of the valve reduces the probability of the excessive leak condition.

The solution to the problem:

1) Modify the plug to the large pilot Cv.
2) Install the two piece piston ring designed by Dover Corporation for additional margin.

PROBLEM #2

When the valve moves past the 15% open position there is a jump in rate of opening. Occasionally a valve will have a jump of such magnitude that overshoot of signaled position results. Oscillations of up to 60% stroke for about 4 seconds have occurred.

CCI has analyzed the valve for probable cause. We issued a letter* on June 10, 1985 to APS and the Bechtel Corporation, which gave our position at that time.

The analysis done in 1985 showed that the large jumps in position could not happen due to actuator air pressure loadings. Forces must come from within the valve to produce the 60% oscillations.

One of the sources of internal loadings was shown to be a sudden increase in downstream pressure due to a 3/1 change in flow per 1/8" stroke change at the 15% valve position. This was estimated to result in approximately 560# of vertical change in load on the plug.

Recent test data taken at Palo Verde on 7 ADV's in Units 1 & 2 shows that there is a much greater change in downstream pressure from what we calculated in 1985. Therefore the forcing load is some number greater than 560 lbs. In addition the test data shows predictable actuator loads up to 15% stroke but only approximately half the load we would predict for the actuator at greater than 25% stroke position.

In light of the new test data, the following is what we feel is the cause of the oscillating condition:

1) The disk stack has 1/8" thick disks of 3.4 Cv/disk, up to about 15% stroke. Then from 15% up are 1/8" thick disks of 11.6 Cv/disk. As can be seen there is about a 3 times increase in Cv at 15% stroke.

   This change in Cv results in a rapid change in flow at this position when the plug moves up. Two things happen with this rapid increase in flow. First, downstream pressure immediately beneath the plug increases probably on the order of 50 to 100 psi. The bonnet pressure above the plug cannot be increased by 50 to 100 psi in the same short time span. The piston ring leakage is too slow for bonnet pressurization so the sudden downstream pressure must equalize thru the pilot seat area. The area of the plug bottom face is approximately 80 in^2. That means a 4000 to 8000 lbs load for a very short time. The plug will most certainly move up. The air pressure in the bottom of the actuator at the time of the jump is about 60 psi. When the plug moves up due to the downstream pressure change, the stem moves up too. The stem pilot would stay open if the air in the actuator pushes the stem up as fast as the plug moves.

   In 1985 we suggested higher pilot spring force to counter pilot seat closing with this occurrence but now we feel the spring is unnecessary. The stronger spring would hold the pilot open on loss of air pressure and the valve would leak in the fail closed position.

   The upward motion of the plug and actuator piston is dampened by the compression of the fluid above the plug and piston. It has been noted that with high air pressure (approximately 100 psi) the jump/oscillation has been minimal where as with 90 psi actuator pressures, the oscillation is a frequent occurrence. The actuator with 90 psi in the bottom and 30 psi in the top is not as "stiff" as the actuator with 110 psi in the bottom and 50 psi in the top. So one of the ways to address this problem is actuator air pressure and positioner output adjustment.

There is another force acting on the plug. That is the fluid exiting the disks and deflecting off the plug seat angle (45 degree seat angle). The first 15% of stroke has 20 turn disks and low capacity per disks. The rest of the stroke has 8 turn high capacity disks. The 8 turn disks have 3 times the mass flow and approximately 50% higher velocity than the 20 turn disks. This fluid flow exerts a significant additional sustained upward force on the plug. Based on the difference between calculated and measured forces this disk exit force is apparently 2200 lbs. This force could contribute to the oscillation as well as the difference between measured and calculated actuator forces.

All of the previous discussions relate to the jump in position at 15% and 3/1 disk Cv change. If the first four 8 turn disks above 15% stroke are reduced in Cv by welding, the rate of change in flow would reduce. This reduction would result in less pressure spike and less unbalance across the plug.

The solution to the oscillation problem is:

Weld characterize the disk stack at the 15% stroke position for smoother transmission of flow as the plug moves open.

Be sure the positioner output adjustment is for stiffest actuator (90 psi ok with welded disk stack).

SUMMARY

To implement the above solutions we have created a draft work plan, which is attached as Appendix B. The plan shows the pilot capacity increase on page 2-11 and 2-14. The weld characterizing of the disk stack is shown on page 2-9.

C.G. Sterud
Principal Engineer

/jf

Attachment

DISTRIBUTION

HLMiller
REAdams

* - Letter, CCI to Bechtel Corporation, subject Arizona Public Service Palo Verde Nuclear Generating Station, Atmospheric Dump Valves. VKNagpal to Bingham, June 10, 1985.

ATTACHMENT F

History of PVNGS ADVs

HISTORICAL REVIEW OF THE IDENTIFICATION AND RESOLUTION OF PROBLEMS SURROUNDING ADV OPERATION

I. Unit 1 Startup History

II. Unit 2 Startup History

III. Resolution of Recommendations

A. CCI letter dated June 10, 1985

B. J. T. Bashe (Crane Valve Services) letter dated May 7, 1985

C. Les Driskell letter dated July 18, 1985

D. Bechtel final recommendations dated September 23, 1985

IV. Unit 1 Capacity Testing

V. Cancellation of Disk Stack Modification

VI. Unit 2 Capacity Testing and Unit 3 Startup Testing

VII. Summary of EER's/PTRR's Between 8/85 and 3/89

VIII. Program to Evaluate Additional Modifications

HISTORICAL REVIEW OF THE IDENTIFICATION
AND RESOLUTION OF PROBLEMS SURROUNDING
ADV OPERATION

During construction and startup, testing of the Atmospheric Dump Valves (ADV's) was conducted in three phases: pre-core cold functional testing, pre-core hot functional testing, and finally capacity testing during power ascension. Unit 1 also conducted post-core hot functional tests due to unresolved problems that had occurred during pre-core tests. The dates for the testing were as follows:

	Unit 1	Unit 2	Unit 3
Pre-Core Cold Functional	May 1983	Jun 1985	Oct 1986
Pre-Core Hot Functional	Jun-Jul 1983 Jul-Aug 1984	Jun-Jul 1985	Nov 1986
Post-Core Hot Functional	May 1985	N/A	N/A
Power Ascension ADV Capacity Test	Sept 1985	Jul 1986	Dec 1987

No valve operational problems were identified during pre-core cold functional testing on any of the three units. During hot functional testing, only Unit 1 experienced problems with valves sticking with one failing to open on some commands. Both Unit 1 and Unit 2 experienced problems with valve oscillations. Unit 3 had no problems identified during their testing.

Unit 1 Startup History

Functional problems with the ADV's were initially identified during Unit 1's pre-core hot functional testing in June 1983. During test 91HF-1SF03 all four valves experienced jerky or erratic motion. Based on the testing results, the ADV's were not considered acceptable for operation.

During the same period of time that 1983 hot functional testing was occurring, CCI proposed making modifications to the ADV's in accordance with their Field Change Request 1396. This Field Change incorporated lessons learned at San Onofre where their CCI valves had to be rebuilt numerous times before they operated smoothly, evenly and consistently (Reference: APS letter PVNGS-RJB-M83-39 dated July 19, 1983). As stated in CCI's Field Change,

the proposed modifications were designed to correct the following problems:

1. Pressure in bonnet cavity cannot equalize with the under the plug pressure when pilot seat is initially opened.

2. Clearance between piston ring and bushing guide is too loose, allowing piston ring to possibly tilt.

3. Clearance between the plug's minor O.D. and the I.D. of the internals is tight, causing plug to get caught during stroke.

These modifications had been made at San Onofre Unit's 2 and 3 and appeared to have corrected their problems. Bechtel incorporated all the recommendations contained in Field Change Request 1396 into DCP SM-SG-305 which was implemented on all Unit 1 valves in May, 1984.

The Unit 1 steam bypass control valves (SBCV's) also experienced problems with sticking and binding during 1983 hot functional testing. It was determined that, on three of the eight valves, hydraulic binding caused by excessive piston ring leakage was the cause. The problem was corrected by disassembly and reworking/replacing the piston rings. C-E concluded that the problems identified, up to that point, were not generic problems (Reference: C-E letter V-SF-917 dated June 28, 1983). Instead, it was felt that methods of establishing the piston ring gap during assembly, dimensions/gaps in piston ring sealing surfaces greater than design, or dirt in system was the cause of the hydraulic binding. Each of these concerns was correctable without design change and efforts were made to address each of them. In a meeting between CCI, Bechtel, and C-E on July 26, 1983, CCI stated that "satisfactory operation of similar valves at other sites pointed to a system problem at PVNGS as opposed to a valve problem" (Reference Meeting Summary: C-E letter V-CE-20395 dated July 27, 1983).

With DCP SM-SG-305 modifications completed, ADV hot functional testing was again performed in July/August of 1984. Two of the ADV's oscillated excessively. The oscillatory behavior was not repeatable. CCI proposed that condensate in the discharge lines was causing pressure pulses leading to the oscillations. As a result, Bechtel developed DCP OJ-SG-121 to install drains and traps on the discharge piping. This modification was completed on Unit 1 in April 1985.

In May of 1985, the Unit 1 ADV's were retested using test procedure 73PE-1SG01. Two of the ADV's operated satisfactorily and two did not. A consultant, J.T. Bashe, from Crane Valve Services was brought to the site to witness the testing of the valves that were not operating correctly and to provide recommendations which

would result in four operable ADV's. Control Components Inc. also provided a field engineer to witness the testing. The observations and recommendation made by Mr. J.T. Bashe are stated below in a summary of his report:

May 7, 1985 J.T. Bashe (Crane) letter "Test Report for APS Covering Post Core Hot Functional Testing of ADV's.

Background:

Mr. Bashe observed that CCI had previously proposed (following 1984 HFT) condensate in the discharge piping as a cause of oscillations. APS installed drains and traps (DCP 1-OJ-SG-121) prior to the 1985 testing but the CCI recommendation did not work.

All valves were disassembled (following previous HFTs). Pilot valve capacity had been increased. Following these modifications, valve performance during testing in 1984 and 1985 was improved but problems still occurred with some of the valves.

Testing For Problem Resolution:

A test program was developed and implemented for the remaining concerns with valves 179 and 184. Actuator pressures, bonnet pressures, valve position, and I/P demand signals were instrumented and recorded.

Mr. Bashe concluded that, based on the testing, "pilot chamber flow rates appeared close to design."

"The hot running clearances between the plug and the cage appear adequate under conditions of perfect concentricity. However, perfect concentricity is improbable due to the cage set being built up of five pieces, each of which nests together with clearance."

Final Conclusions:

"Performance of valves has all the symptoms of internal friction requiring high breakout forces."

"The registration of the detail parts and the bonnet help to explain the random occurrence of the (oscillations) problem." (Stack up problem of cage set)

"Problem (oscillations) may be eliminated by changing the actuation system to a stiffer design."

NOTE: During the final 1985 testing, N2 was increased to 95 psig based on concern with previous testing on ADV

184 which experienced problems with stroking at a design value supply pressure of 80 psig. (Actual supply pressure decreased to 76 psig during one test.) This increase in pressure provided a stiffer actuation system and generally improved modulation according to Mr. Bashe. However, Crane recommended an electric motor as the appropriate solution to alleviate the problem.

All of the ADV's on Unit 1 were considered operable following the May 1985 testing. The filter regulator output pressure was raised from 80 psig to 95 psig for final testing. This combined with previous valve modifications and increased stroking (both manual and pneumatic) resulted in the valves passing their acceptance criteria.

Several meetings between Bechtel and CCI occurred between 1984 and 1985 concerning the resolution of identified ADV problems. The most recent prior to the series of letters described below was a May 16, 1985 meeting. Bechtel summarized the conclusions of that meeting and requested additional CCI analysis in a May 31, 1985 letter which is summarized below:

May 31, 1985 Bechtel letter to CCI

Bechtel requested CCI to perform a detailed engineering analysis that would evaluate parameters within the ADV design that could account for the recently observed valve operating characteristics and substantiate the need to perform corrective actions that would require valve disassembly. The parameters and their possible effect were:

Body to trim clearance	- too large: valve difficult to open
Cv of Pilot valve	- too low: valve difficult to open
Disk stack transition Cv	- too large: valve oscillation
Valve packing	- too tight: valve difficult to open
Spring between Pilot and plug	- if pilot goes closed: bonnet pressure increases and valve opening difficult

This letter indicated that problems with pilot Cv or body to trim clearance would make the valve difficult to open, not prevent valve from opening.

Bechtel wrote a letter to the ANPP Project Director on June 3, 1985 summarizing the discussions that had been taking place

between Bechtel, CCI, and ANPP Engineering. Based on the contents of this letter and on interviews with two of the engineers that were involved with ADV testing, it is clear that there was a general belief that many of the problems that were occurring with the ADV's were caused by frictional forces in the valves and that there was a break-in period required before for the valves would operate correctly. In referring to Unit 1 testing Bechtel states, "It is our understanding that during repeated manual operation of the valves, the valves stroked smoothly with no obvious excess effort to lift the valve off the seat, or to move the valve through its complete travel. In addition, following repeated manual operation, all four ADV's have been successfully operated using the pneumatic actuator...it is feasible that the repeated stroking "conditioned" the valves or cleared vent paths of possible accumulated rust or other contamination." The independent evaluation made by Mr. J.T. Bashe reached this same conclusion regarding frictional forces. As stated in his report, "Performance of the values has all the symptoms of internal friction requiring high breakout forces."

In a June 10, 1985 letter to APS and Bechtel, CCI responded to the previous Bechtel request by providing benefits for the design change parameters discussed in previous meetings. The items addressed were:

1. Body to trim clearance: No quantitative analysis on the effects of this parameter. If the trim-body clearance is negative, excessive leakage could result.

2. Improvement of increasing Cv of Pilot: Such a change would significantly improve valve operating margin.

3. Disk stack Cv: Current Cv changes from 23 to 36; Modification would change Cv from 23 to 29. This will reduce the upward force on the plug; however, CCI stated that this Cv transition is not expected to move the plug upward and close the pilot valve.

4. Pilot valve spring: Proposed changing force of spring from 150 lbf to 1100 lbf extended. This would increase margin if excursion events are causing pilot to close.

5. Valve packing: Proposed removal of lower packing and replace with metallic spacer. This would be equivalent to 2 to 7 psi available margin for actuator.

NOTE: New piston ring was not proposed.

This CCI letter provided qualitative and quantitative benefits of the design change parameters. Recommendations for implementation were not made. CCI indicated that the above either improved operating margins (items 1,2,5) for the valve to open or they minimized/eliminated large oscillations (items 3,4). Some of the above items are not presently recommended by CCI as useful solutions to the indicated problem (items 4,5) (Reference: CCI letter to APS dated March 29, 1989).

During this period of time several other factors were influencing the determination of the cause of the problem with the Unit 1 ADV's. It was known by Bechtel that SONGS and Waterford had experienced the same problems with CCI valves during startup. After being rebuilt they operated smoothly. All modifications made on SONGS valve internals were made on APS valves (DCP SM-SG-305). In addition, CCI advocated that particles in the piston ring gap resulting from cleanliness problems in new systems were one of the most likely causes of excessive piston ring leakage. This condition could be improved by flowing the system and exercising the valves.

Although excessive bonnet pressure was discussed as a potential cause of valve stroking difficulties, high bonnet pressures had never been confirmed to exist. Attempts to monitor bonnet pressure on two of the Unit 1 valves during 1985 testing were ineffective due to problems with data measurement. Based on previous CCI valve history, excessive piston ring leakage, if it existed, could be corrected by reworking the valves and/or exercising the valves enough to ensure the piston ring was seated correctly. This method relied on ensuring tolerances were precise, on the one hand, and depending on the expectation that the parts would work themselves into place on the other. However, CCI had a history that indicated this method would work. Once the initial difficulties were worked out, the CCI valves at other utilities appeared to function reliably.

Based on the concern raised regarding electric motor actuators, Bechtel initiated efforts to develop DCP's to install a DC motor while the startup group initiated a temporary modification to install a motor on one Unit 1 valve for demonstration purposes. The temporary modification was installed during June 1985 on ADV-184 and the valve was stroked satisfactorily. Following the test, the motor was removed.

Unit 2 Startup History

Unit 2 testing commenced as Unit 1 final testing conclusions were being finalized. Prior to Unit 2 testing, all valve modifications required by DCP SJ-SG-305 had been completed. In addition, drains and traps had been installed on the discharge piping in accordance with the requirements of DCP SJ-SG-121.

Nevertheless, difficulties arose with valve oscillations and jerky motion.

In an attempt to verify whether high bonnet pressure was causing the observed behavior, bonnet pressure taps were installed on all four valves and the remainder of the testing was conducted with the ADV's instrumented to measure critical parameters. Repeated testing never confirmed that bonnet pressure was a problem since high bonnet pressures were never measured.

Bechtel brought in an engineering consultant, Mr. Les Driskell, to review the Unit 2 testing and make recommendations that would improve valve operation. The results of his evaluation are provided in the following summary:

July 18, 1985 Les Driskell, P.E. Report on Unit 2 Testing Concerns

Summary of Failure to Open Concern:

Failure to open has not occurred since pilots were modified. (Based on information Mr. Driskell reviewed.)

If failure to open caused by excessive leakage past piston ring seal is experienced in the future, possible remedies are:

(a) Improved seal design
(b) Increase pilot valve capacity
(c) Installation of external pilot valve

Mr. Driskell concluded: (a) was a developmental activity and not acceptable at the time; (b) entails risks due to increasing the unbalanced area of pilot poppet and degrading the guiding of the pilot valve; (c) Mr. Driskell advocated this idea.

Summary of Instability Concern:

Positioner performance was good except when starved. "Valve positioner helped stabilize the oscillations rather than exacerbate them." (On the one test observed by Mr. Driskell)

"If further testing discloses that instability may still occur, there are minor and major modifications to be considered.

(a) Increase stiffness of pilot valve spring
(b) Add volume boosters
(c) External pilot
(d) Use electro mechanical or hydraulic actuator"

Mr. Driskell concluded: (a) pilot would fail open on loss of air and may not help problem; (b) good idea, recommended two models of boosters (c) advocated the idea of an external pilot; (d) has many negatives. Even an extremely expensive electro mechanical actuator would not mean acceptable reliability.

Mr. Driskell went on to state:

"With (150) psig air supply in adequate volume available to the valve actuator, and with positioner adjusted to keep maximum total mass of air in the actuator cycle, there is an excellent probability that S/U difficulties have been resolved."

NOTE: Mr. Driskell was under the impression that Unit 2 testing had been conducted at 150 psig IA pressure. This was not the case. Testing was conducted at 110-120 psig when using IA.

"Exercising Grafoil packing reduces friction so stroking during testing period will lessen the tendency for instability. Hence, there is good reason to believe startup difficulties will disappear."

Final Recommendation: "In the unlikely event that problem recurs:"

1. Install volume boosters
2. Install external pilot

Unit 2 Hot Functional Testing was completed soon after the Les Driskell report was issued. Bechtel summarized the results of the Unit 2 testing in the following report:

August 5, 1985 Bechtel Report: "Unit 2 ADV Evaluation of Operating Problems During HFT July 1985"

Bechtel highlighted significant problems, in summary, that had occurred with Unit 1 ADV's during pre-core HFT in August 1984 and post-core HFT during May 1985. With regard to oscillation, CCI had recommended, based on pre-core HFT, that water accumulating downstream of valves could result in pressure pulsations leading to oscillations. Bechtel installed drain lines but erratic performance of the valves still occurred. Bechtel went on to say, "CCI proposed modifications to the valve internals" (June 10, 1985 letter) "to reduce the probability of (Unit 1 problems). These proposals were based on theoretical hypotheses which could not be verified by past data. Specifically, the bonnet pressure

and valve downstream pressure data was not available." Noting this, Unit 2 ADV's were instrumented to measure bonnet and downstream pressure during testing.

Conclusions

"Bonnet pressure readings during valve opening clearly disclosed that bonnet pressure rapidly dropped from upstream pressure to the discharge pressure. This reading provides assurance that the seal rings are acting properly and the pilot valve Cv sizing is adequate."

The filter-regulator capacity was less than required by the Moore positioner. "The basic problem which permitted the break-free characteristics to become oscillatory behavior...was air starvation of valve positioner due to undersized air filter regulator."

"Test data collected...indicates that at approximately 15%, the valve is attempting to break free and go into oscillation. However, the properly calibrated positioner/ control system is adequately responding to prevent valve oscillation."

Recommendations

1. The existing filter regulator should be eliminated and replaced with a larger device or a filter only.

2. At a convenient outage, the Cv transition should be "smoothened" by welding the disk stack as recommended by CCI.

Although the report indicated that bypassing the filter regulator accomplished two things; 1) increased flow to the positioner and 2) increased pressure, the report conclusions considered the flow as the significant contributor to oscillation problems. This was reinforced since testing using N2 at 95 psig with the filter regulator bypassed did not cause any oscillations.

At this point, Bechtel and APS felt that the problems that had occurred with the ADV's had been satisfactorily resolved. Failure to open was still attributed to high breakaway friction which had been corrected by valve modifications (DCP SM-SG-305), valve rework, and by repeated stroking of the valves. The large oscillations were controlled by bypassing the filter regulator and increasing N2 pressure to 95 psig. The final modification that Bechtel felt was necessary in order to prevent oscillations from occurring was to weld the disk stack; thus making the valve transition through the 15% open region smoother. They did not consider this an operability concern.

Hot functional testing of SBCV's on Unit 2 resulted in some problems similar to the Unit 1 valves with regard to failure to open or sticking. Combustion Engineering had the responsibility for SBCV design; however, the following two letters demonstrate that Bechtel was involved with the design concerns. Since Bechtel was also working on the ADV concerns, they had this common experience available when addressing corrective actions for ADV's.

August 12, 1985 CE letter to Bechtel "Enhancement of Steam Bypass Valves"

C-E Recommendations for SBCV's

Immediate

1. Maintain clean system.
2. Do not modify working valves that have been successfully tested.
3. Cycle each valve once/month with valve isolated.

Long Term

1. Add wave springs to any valve disassembled or any requiring disassembly.
2. Wait on modifying pilot area since modification is untested and is currently being manufactured by CCI for installation in one valve at SONGS 3. Recommended that concept be tested at SONGS prior to use at Palo Verde.
3. Stellite coat valve plugs.

August 30, 1985 Bechtel to ANPP Project Director, "Enhancement of Steam Bypass Valves"

Bechtel reviewed CE's recommendations and made the following recommendations for SBCV's.

1. Add wave spring under piston ring.
2. Increase air supply pressure by replacing air filter regulators with high capacity air filters.
3. Felt CE's immediate recommendation on not modifying valves that were tested satisfactorily was only acceptable for short term.
4. Endorsed other long-term CE recommendations; with exception of: a) stellite coat of plug was secondary to maintaining clean system and b) felt that increasing air pressure was desireable and should be accomplished by removing the filter regulator and replacing with a filter.

September 6, 1985 ANPP Project Director's letter to Bechtel Project Manager, "ADV Operability Improvement Recommendation"

ANPP requested final recommendations for ADV long-term resolution to improve operability and ensure reliability.

September 23, 1985 Bechtel letter to ANPP Project Director, "ADV Operability Improvement Recommendation"

Bechtel referenced Unit 1 and Unit 2 HFT results. "This experience on Units 1 and 2 appears to parallel experience reported from other plants employing CCI valves in this application. To the best of our knowledge from plants we have contacted and from information provided by CCI, once initial startup problems have been resolved, the valves with pneumatic actuators have performed satisfactorily."

Bechtel also addressed the proposed modification for replacing the pneumatic actuator with a motor actuator. Bechtel was developing DCPs (OJ-SG-135 and OJ-SG-137) for replacement of the pneumatic actuators. A motor actuator had been installed as a T-MOD on one valve in Unit 1 for test which was satisfactory.

Bechtel stated, "Review of industry data on the reliability of motor operated valves and air-operated valves (from Washington, November NUREG/CR-1728, and NUREG/CR-1363) indicate that reliability is about the same with the air-operated valves being slightly more reliable."

Recommendation

1. Pneumatic actuators remain in place.
2. Implement DCP OJ-SG-138 to replace filter regulators with filters.
3. At a convenient outage, weld disk stack to "smoothen" the Cv transition.

Resolution of the Recommendations

This section will address recommendations made by the valve manufacturer, consultants, and the PVNGS architect engineer regarding ADV performance and describe the resolution of each of those recommendations. Rework performed to verify valve internal tolerances or to rework of piston rings is not included since that activity is considered a normal startup function to ensure the component is built within design. Attachment 1 contains a summary of all proposed modifications. The following specifically

addresses the recommendations made by CCI, Crane Valve Services, Mr. Les Driskell, and Bechtel.

CCI Letter Dated June 10, 1985

Five different design change parameters were addressed in the June 10, 1985 CCI letter. Each of these along with their resolution is described below:

Parameter 1: Body to trim clearance.

The CCI letter discussed the effect of having too large of a clearance which was to increase the leakage to the valve bonnet area. No changes were proposed since existing assembly method ensure the clearance is not excessive.

Resolution: None Required

Parameter 2: Increase the Cv of the Pilot Area.

Two options were discussed; either machine existing parts or use new parts (pilot valve). If piston ring does not seal well, then high bonnet pressure will result. Either modification will compensate for increased leakage, with the new parts the most effective.

Resolution: It was clear that making the modifications could correct the problem discussed. However, no direct evidence existed that confirmed that high bonnet pressures existed. Following this letter, Unit 2 instrumented the bonnet areas of their ADV's. Bechtel concluded following Unit 2 Hot Functional Testing that the pilot valve Cv was adequate (see Unit 2 Startup History: Bechtel Report dated August 5, 1985). In addition, a consultant, Mr. Les Driskell, felt that increasing the pilot valve capacity entailed risks. (See Unit 2 Startup History: July 18, 1985 Les Driskell P.E. Report on Unit 2 Testing Concerns.) Finally, C.E. and Bechtel felt that modifying the pilot valve should wait until the modification was tested at SONGS which was in the process of performing the modification on SONGS 3 valves.

Parameter 3: Disk Stack Transition Cv

At approximately 15% open the valve plug passes through a transition where the valve Cv changes from 23 to 36 within 1/8 inch of movement (1 disk). This causes a downstream pressure pulse which adds an upward force on the plug. Modifying the disk stack will change the valve Cv from 23 to 29 at this same

location which will cause a much smaller downstream pressure increase.

Resolution: This modification was designed to minimize valve oscillations. At the time this letter was written the cause of oscillations could not be explained. CCI felt the pilot valve was going closed when the plug moved upward, but that "the Cv transition, on its own, was not expected to cause this." Nevertheless, Bechtel recommended that, at a convenient outage, the Cv transition modification should be made. (See Bechtel Final Recommendations section of this report.)

<u>Parameter 4</u>: Pilot Valve Spring Replacement

Proposed replacing the existing 150 lbf pilot spring with one that would provide 1100 lbf fully extended and 2600 lbf when the pilot is fully closed. This would increase the downward force on the plug when the pilot was open by at least 950 lbf and provide increased margin valve plug excursions.

Resolution: It was only a theory that the pilot valve was closing during valve excursions. The Bechtel consultant, Mr. Les Driskell, reviewed this proposal and felt it was not warranted because the pilot valve would fail open upon a loss of air. Therefore, the proposal was not implemented. CCI now agrees with this decision. In a March 29, 1989 letter to APS, CCI, stated "In 1985 we suggested higher pilot spring force to counter pilot seat closing but now we feel the spring is unnecessary. The stronger spring would hold the pilot open on loss of air pressure and the valve would leak."

<u>Parameter 5</u>: Valve Packing Configuration

The existing packing friction was estimated to be 500 lbf to 1,500 lbf. Removing the lower set of packing and replacing it with a metallic spacer would reduce the friction to half the current value. This would be equivalent to an additional 2 to 7 psig actuator air pressure margin for the operation of the valves.

Resolution: Removing half of the packing would potentially lead to excessive packing leakage. By raising actuator supply pressure, the same additional margin could be obtained. It is not clear whether this option received a serious evaluation. Initial concerns with valve

packing friction went away after the exercising program led to the valves operating satisfactorily.

J. T. Bashe (Crane Valve Services) Letter Dated May 7, 1985

A consultant, Mr. J.T. Bashe, from Crane Valve Services reviewed Unit 1 testing and functional problems in May 1985. This occurred approximately one month before CCI issued their June 10, 1985 letter addressing valve internal modifications. However, CCI's letter was written in response to Bechtel's request and was based on discussions that had been taking place in may 1985. It is reasonable to assume that Mr. Bashe was aware of some of the issues that were being discussed. Mr. Bashe's final recommendations.

Recommendation: Change the actuation system to a stiffer design. An electric motor actuator...is the appropriate solution to the problem. (Assuming internal valve modifications will not be performed.)

Resolution: During June 1985 a motor was installed on Unit 1's ADV-184 to demonstrate feasibility. Bechtel initiated DCP's to install electric motor actuators. In July 1985, Mr. Les Driskell, an engineering consultant concluded that electro-mechanical actuators had many negatives and would not improve actuator reliability. Bechtel recommended that pneumatic actuators remain in place in September 1985. Nevertheless, work on two DCP's (DCP 10J-SG-135 and 10J-SG-137) was continued until cancelled in January 1986.

Recommendation: Trim and bonnet clearance and registration problem should be restudied.

Resolution: This was a CCI design consideration. The effects of having excessive clearances was commented on by CCI in their June 10, 1985 letter. They felt that it was improbable that clearances large enough to cause a problem could exist using existing assembly techniques. No design changes were issued by CCI as a result of this concern.

Les Driskell Letter Dated July 18, 1985

Les Driskell, a private engineering consultant, was brought on site to review Unit 2 ADV testing and functional concerns. He concluded his review with the following recommendations:

Recommendation: Install volume boosters between the positioner and the actuator.

Resolution: The volume boosters recommended by Mr. Driskell were not environmentally qualified and there were no known ones, at the time, that were. In addition, Mr. Driskell indicated in his report that "an augmented air supply could cause excessive speed of operation and initiate valve oscillation". This was contrary to the problem it was trying to solve. During Unit 2 testing it was determined that the air filter regulator was undersized and could not provide an adequate amount of air to the valve positioner. With the filter regulator bypassed, Unit 2 valves stroked smoothly and without oscillation. Subsequently, Bechtel developed DCP OJ-SG-138 to replace the filter regulator with a filter only.

Recommendation: Install an external pilot valve.

Resolution: Mr. Driskell proposed this recommendation only if the fail to open problem recurred. It did not. Furthermore, since measured bonnet pressures during Unit 2 testing indicated that the pilot valve Cv was satisfactory, installing an external pilot valve was not considered necessary.

Bechtel Final ADV Recommendations Date September 23, 1985

Bechtel had been involved since initial hot functional testing began with resolving the ADV operational difficulties. Following the 1985 hot functional testing, when it appeared that the last of the major ADV problems had been corrected, ANPP requested that Bechtel provide final recommendations to improve operability. Bechtel's recommendations and their resolution were:

Recommendation: The pneumatic actuators should remain in place.

Resolution: DCP work was still in progress to replace the pneumatic actuators with motor actuators in the event that another solution to the valve oscillation problem could not have been found. Finding the filter regulator starving the positioner on Unit 2 seemed to solve this problem. This led Bechtel to conclude that "available data and recent PVNGS operating experience does not justify the added expense at this time". ANPP concurred and the

actuators were not replaced.

<u>Recommendation:</u>	Replace filter regulators with filters only.
Resolution:	DCP OJ-SG-138 was developed and implemented on all three units.
<u>Recommendation:</u>	At a convenient outage, weld the disk stack to modify the Cv transition.
Resolution:	A plant change request (PCR 85-13-SG-090) was submitted to review this recommendation and initiate a design change. System Engineering cancelled the request in October 1985, based on the recent successful operation of the ADV's. In 1988, System Engineering initiated efforts to reevaluate modifications that could improve ADV operation. CCI was contacted and responded with a January 4, 1989 letter that proposed modifying the ADV plug/pilot, piston ring, and disk stack.

<u>Unit 1 Capacity Testing</u>

Unit 1 began its power ascension testing during August of 1985. Beginning at the end of August and continuing during September 1985, ADV and SBCV capacity testing was performed using test procedure 73PA-1SG01 Rev. 0. No concerns were identified with the operation of any of the four ADV's. One of eight SBCV's (PV-1005) experienced difficulty in stroking on the first attempt. After isolating and stroking the valve, it later stroked satisfactorily.

Having just completed identifying what was felt to be the corrective action for valve oscillation concerns (i.e., filter regulator capacity), degraded performance of any of the ADV's would have prompted additional evaluation. Instead, the previous conclusins were confirmed to have improved the ADV operation since none of the ADV's exhibited their previous problem behavior.

<u>Cancellation of Disk Stack Modification</u>

Among Bechtel's final recommendations (see section on Unit 2 History) was a recommendation to "smoothen" the Cv transition by welding the disk stack as recommended by CCI, at the next convenient outage. This recommendation was based on Unit 1 and Unit 2 testing observations which indicated that valve perturbations were occurring at approximately 15% open. A Plant

Change Request was submitted but was later cancelled by System Engineering as indicated by the following documents:

> September 30, 1985 Plant Change Request (PCR 85-13-SG-090) submitted to change Cv of the Disk Stack.
>
> October 16, 1985, System Engineering cancelled PCR 85-13-SG-090. "OPS and SE do not concur with CCI and PCR resolution"

Written guidelines existed at the time to control the Plant Change Process in order to complete actions necessary to make Unit 1 fully operational. When the decision to cancel this PCR was made, Unit 1 had completed capacity testing without experiencing any of the previously identified problems. After bypassing the filter regulator, Unit 2 successfully completed hot functional testing of their ADV's. Because the disk stack modification was not believed by System Engineering to be necessary in order to ensure that the valve would perform adequately, the system engineer cancelled the request. There is no evidence to indicate that this decision received any review above the system engineer.

This decision had no impact on the valve's ability to open. Bechtel and CE felt this modification was an improvement that could be performed during a future outage.

<u>Unit 2 Capacity Testing and Unit 3 Startup Testing</u>

In July of 1986 Unit 2 performed ADV and SBCV capacity testing using test procedure 73PA-2SG01 Rev. 0. No problems were identified with the stroking of any of the ADV's or SBCV's.

Unit 3 began its hot functional testing of ADV's in November of 1986 in accordance with 91HF-3SF02 Rev. 0. Previous design modifications that had been identified on Unit's 1 and 2 had been implemented on Unit 3 prior to the testing. All four ADV's met the acceptance on their first attempt which required the valves to "respond smoothly to control input without jerky movements, without over or undershoot, and not drift from setpoint". One discrepancy was noted. During the 10.5 hour N2 accumulator test, ADV-179 began to stroke erratically. Investigation showed that N2 regulator SGA-PCV-310 was the cause due to drifting from setpoint.

Unit 3 performed ADV and SBCV capacity testing in December 1987. All four ADV's stroked satisfactorily.

Unit 2 capacity testing and Unit 3 startup testing further confirmed that the ADV's were performing acceptably. The design modifications that had been made were working. Testing results had improved with each of the Units and no problems had been identified since the final corrective actions had been implemented in July 1985. Previous valves that had performed unsatisfactorily in the

past (Unit 1 particularly) had demonstrated correct operation and now Unit 3 ADV's were stroking without oscillations or failure to open problems occurring.

EER/PTRR'S

Between the time ADV hot functional testing (HFT) was completed on Unit's 1 and 2 (July, 1985) and March 3, 1989 three (3) EER's have been submitted to evaluate concerns with Atmospheric Dump Valves operating erratically. One of these EER's indicated a problem with one valve failing to open when given a small demand signal.

A review of the Post Trip Review Reports (PTRR's) from August 1985 through March 3, 1989 indicated five (5) occurrences (four Unit 1 and one Unit 2) where concerns were raised with ADV operation. Three of these occurrences, each on Unit 1, described erratic operation. Two other occurrences were related to the "slow to respond to a signal" valve operating characteristic.

Combined EER and PTRR events since HFT indicated:

1. One non-repeatable occurrence of failure to open following a 15% demand signal.

2. Three occurrences on Unit 1 with a valve indicating erratic behavior [ADV-178 2 times, ADV-179 1 time].

3. Three occurrences where a valve indicated sluggishness or was slow to operate.

Two of the three occurrences where erratic behavior occurred were a result of positioner problems. Two of the three occurrences where sluggishness or slowness to respond occurred appear to be instances where the valve operated correctly, however, the valve operating characteristics were not understood completely by the operating personnel. The remaining occurrence of sluggishness was actually drifting of the valve. This was determined to be caused by a partially clogged IA filter.

Recently, all four Unit 1 ADV's were operated in August 1988 and two Unit 2 "A" train ADV's in February 1989. On each occasion the valves operated as designed.

Prior to the March 3, 1989 event, Unit 3 ADV's had not been operated since December 1987.

A summary of EER's and PTRR's is included as Attachment 2.

Program to Evaluate Additional Modifications

Following the Unit 1 Reactor Trip Event in July, 1988 (PTRR 1-88-004), System Engineering initiated actions to evaluate performing design changes to make both the ADV's and SBCV's more reliable. SONGS had completed installing CCI valve modifications on their SBCV's in 1988. This included the modification to the pilot area that C.E. and Bechtel recommended be tested at SONGS prior to use at Palo Verde. ANPP System Engineering made a Site visit to SONGS and CCI to review the new design changes. A program was developed to install the new design change on one SBCV in Unit 1. Based on the performance of this valve, a decision would be made regarding additional SBCV and ADV modifications.

In November 1988 the proposal for changes to SBCV's was received from CCI and a testing procedure and T-Mod were developed by System Engineering. A new plug and piston ring were ordered from CCI in December 1988 and received the end of January 1989.

In late 1988, System Engineering requested that CCI submit a proposal for modifications to the ADV's. Their proposed changes were included in a January 4, 1989 letter to ANPP's B. Mendoza. Following the Unit 1 reactor trip event of March 5, 1989, the new SBCV plug and piston ring were installed on Unit 1 SBCV PV-1001. This modification was subsequently tested prior to Unit 1 entering their Refueling Outage.

DESCRIPTION OF MODIFICATION	PROBLEM BEING ADDRESSED	PROPOSED BY/REFERENCE	RESOLVED?	COMMENTS/CONCLUSIONS
"SONGS-2" MODIFICATIONS TO INCREASE PILOT VALVE AREA, MODIFY PISTON RING GAP (FIELD CHANGE 1396)	VALVES TEND TO "STICK" AT PILOT SONGS-2 MODS MADE TO REDUCE LEAKAGE PAST PISTON RING INTO BONNET AND INCREASE FLOW THROUGH PILOT TO REDUCE PRESSURE	CCI / FIELD CHANGE REQUEST 1396 (6/83)	YES	1. MODIFICATIONS MADE IN 1984-1986. 2. PREVENTED MAGNITUDE OF PROBLEM AT ANPP THAT SONGS HAD BUT DID NOT SOLVE ALL PROBLEMS.
WAVESPRING- 17-4 PH MATERIAL WAVE SPRING ADDED UNDER PISTON RING TO HOLD RING IN "ENERGIZED" POSITION	LEAKAGE PAST PISTON RING DUE TO PISTON RING NOT "ENERGIZING"	CCI / PVNGS-JBH-M83-32 (8/19/83) V-CE-32738 (8/12/85)	YES	1. CCI NEVER RECOMMENDED FOR ADVs 2. INSTALL ON SBCVs BUT DID NOT IMPROVE PERFORMANCE. 3. CCI CURRENTLY DOES NOT RECOMMEND THIS TO CORRECT PISTON RING LEAKAGE.
UPGRADE PILOT VALVE SPRING TO 1100 LBF EXTENDED	EXCURSIONS OF VALVE MAY CLOSE PILOT LEADING TO HIGHER BONNET PRESSURES	CCI / LETTER TO BECHTEL (6/10/85)	YES	1. LES DRISKELL DISAGREED BASED ON PILOT VALVE FAILING OPEN ON LOSS OF PNEUMATIC PRESSURE. 2. CCI NO LONGER RECOMMENDS THIS FOR SAME REASON. 3. DOES NOT FIX CAUSE OF EXCURSIONS.
REPLACE PNEUMATIC ACTUATORS WITH DC MOTOR OPERATORS	PROVIDE FOR "STIFFER" ACTUATOR TO PREVENT OSCILLATIONS	CRANE VALVE / UNIT 1 REPORT (5/7/85)	YES	1. INSTALLED A DC MOTOR ACTUATOR ON ONE UNIT 1 VALVE FOR DEMONSTRATION. 2. DEVELOPED DCPs TO FULLY ASSESS MODIFI-CATION. 3. NOT INSTALLED BASED ON COST-BENEFIT ASSESSMENT. 4. RELIABILITY WOULD NOT HAVE BEEN IMPROVED.
STELLITE COAT PLUG EXTERIOR	INCREASE CORROSION RESISTANCE OF PLUG - SINCE PISTON RING SEALS AGAINST O.D. OF PLUG, ANY CORROSION PITTING WILL INCREASE PISTON RING LEAKAGE AND REDUCE POTENTIAL FOR BINDING	CCI / V-CE-33087 (10/4/85)	YES	1. ALL ADV PLUGS STELLITE COATED. 2. DUE TO RELATIVELY LITTLE CORROSION ON NEW VALVES, PROBABLY NOT IMPORTANT DURING S/U, BUT ENSURED LONG TERM PERFORMANCE. 3. LATER MOD MADE TO SBCVs.
DRAINS AND TRAPS OFF DISCHARGE PIPING	WATER ACCUMULATION COULD LEAD TO PRESSURE PULSES ACCELERATING PLUG WHICH LEADS TO OSCILLATIONS	CCI / CRANE LETTER UNIT 1 (5/7/85)	YES	1. INSTALLED PER DCP 2. DID NOT SOLVE PROBLEM WITH OSCILLATIONS
INSTALL VOLUME BOOSTERS TO ACTUATOR	IMPROVE POSITIONER'S ABILITY TO COM-BAT VALVE INSTABILITY	LES DRISKELL / REPORT ON UNIT 2 TESTING (7/18/85)	YES	1. NO VOLUME BOOSTERS AVAILABLE THAT WERE QUALIFIED. 2. POSITIONER COULD BE IMPROVED BY OTHER OPTIONS (i.e. RAISING PRESSURE, REMOVING FILTER REGULATOR).

Attachment 1

DESCRIPTION OF MODIFICATION	PROBLEM BEING ADDRESSED	PROPOSED BY/REFERENCE	RESOLVED?	COMMENTS/CONCLUSIONS
ELIMINATE LOWER RING OF VALVE PACKING AND REPLACE WITH METALLIC SPACER	REDUCE FRICTION CAUSED BY PACKING FORCES FROM 1500 LBF TO 800 LBF TO INCREASE MARGIN FOR VALVE OPERATION	CCI / LETTER TO BECHTEL (6/10/85)	NO	1. NOT CONSIDERED GOOD FIX SINCE PACKING LEAKS WOULD INCREASE. 2. NEVER FORMALLY RECOMMENDED BY CCI.
EXTERNAL PILOT VALVE	INCREASE PILOT VALVE Cv. KEEP PILOT FROM BEING AFFECTED BY VALVE PLUG MOVEMENTS	LESS DRISKELL / REPORT ON UNIT 2 TESTING (7/18/85)	YES	1. RECOMMENDED ONLY IF PROBLEM RECURS. IT DID NOT. 2. CCI WAS AGAINST THIS IDEA. 3. TESTING DATA DID NOT INDICATE PROBLEM WITH PILOT VALVE Cv.
INCREASE ACTUATOR AIR PRESSURE	GENERATE MORE FORCE TO OVERCOME ANY BINDING	V-CE-32738 (8/12/85) BECHTEL LETTER (8/30/85) DCP OJ-SG-138	YES	1. REPLACED FILTER REGULATOR INCREASING IA TO VALVE FROM 85 TO 110 PSIG. 2. INCREASE N2 PRESSURE FROM 80 TO 95 PSIG. 3. ALL TESTING SAT. ON UNIT 2 FOLLOWING CHANGES.
REPLACE POSITIONER FILTER REGULATOR WITH FILTER	INCREASE VOLUME OF AIR TO POSITIONER TO MINIMIZE POTENTIAL FOR OSCILLATIONS	BECHTEL / DCP 0J-SG-135	YES	1. IMPLEMENTED ON ALL 3 UNITS. 2. TESTING ON UNIT 2 AND UNIT 3 RESULTED IN NO OSCILLATIONS AFTER MODIFICATION MADE UNITL 1989.
DOUBLE PILOT VALVE FLOW AREA (FROM 2.5 in2 TO 4.9 in2	INCREASED PILOT VALVE AREA WILL VENT MORE STEAM FROM BONNET . (COMPENSATE FOR PISTON LEAKAGE)	CCI / LETTER TO BECHTEL (6/10/85)	YES	1. BASED ON THEORETICAL HYPOTHESIS THAT COULD NOT BE VERIFIED BY PAST DATA. 2. LES DRISKELL STATED IT WOULD ENTAIL RISKS. 3. CE & BECHTEL RECOMMENDED WAIT FOR SONGS TO EVALUATE.
WELD DISK STACK ABOVE BOTTOM 8 DISKS	SMOOTH OUT Cv TRANSITION. CURRENT 23 TO 36. MODIFIED WOULD BE 23 TO 29. WOULD HELP OSCILLATION PROBLEM.	CCI, CE, BECHTEL / CCI LETTER TO BECHTEL (6/10/85) BECHTEL LETTER (9/23/85)	NO	1. RECOMMENDED AT NEXT CONVENIENT OUTAGE. 2. NOT CONSIDERED A VALVE OPERABILITY CONCERN.

Attachment 1

EER 85-SG-049 (7/9/85)	Valves SGE-V341, 356, and 343 have slight amount N2 leaking through packing. Resolution: Recommended replacement with packless design, but wait until final determination on whether DC motor would be used on ADV's. (See EER 85-SG-140)
EER 85-SG-061 (5/8/85)	ADV's 1JSGA-HV184 and HV179 experienced rapid oscillations during troubleshooting IAW WO 86106 and WO 86107. Resolution: CCI (Larry Stratton) concurred that no significant damage occurred. This problem occurred during post-core HFT and was resolved prior to declaring valves operable. The EER was evaluating whether any damage occurred during the oscillations. Note: Concern was damaging anti-rotation plate if valve went full open and full closed during oscillation.
EER 85-SG-068 (6/4/85)	Position indication gearing on motor operator used for TMOD on Unit 1 ADV 184 damaged. Resolution: Replace damaged gearing when operator returned to Unit 3.
EER 85-SG-100 (9/12/85)	Discrepancies in N2/IA pressure requirements on vendor drawing documents. Resolution: T-Mod 1-85-SG-336 set N2 and IA pressures as high as system allowed on Unit 1. PCR 1-85-13-SG-078 written for Units 2 and 3.
EER 85-SG-140 (12/5/85)	Readdressed leakage problem (12/5/85) on nitrogen system valves. (See EER 85-SG-049) Resolution: PCR 85-13-SG-100 issued to replace existing valves with packless valves.

EER 85-SG-160 (12/2/85)	Unit 1 ADV 184 would not open with a 15% demand signal during 73PA-1SF09. PTRR 1-85-007 item.	
	Resolution:	Restroked valve the following day with Operations Engineering present and could find no problem with valve. Discussed the fact that it takes 20-30 seconds for A delta P to develop in order to open the valve.
EER 86-SG-037 (4/5/86)	Concern on problems that had occurred in past with sticking prompted request to evaluate stroking requirements to ensure freedom of movement.	
	Resolution:	Operations Engineering answered as if this request was based on problems during 1985 testing that had been corrected. Stated no comments have been received in past few months about problems with ADV's and SBCV's sticking. Only one SBCV had a previous report of sticking (SG-1005) but wave spring was installed and the problem did not recur. ADV's are slow responding and were thought to be stuck, but each time the ADV was stroked after it was reported stuck, the valve operated normally.
EER 86-SG-144 (7/22/86)	Previously installed bonnet tap plug leaking on 2JSGBHV0185.	
	Resolution:	Seal weld bonnet cavity pressure tap.
EER 86-SG-181 (9/15/86)	Nitrogen supply solenoid valve SGB-PV-306B changed from fail open to fail close on loss of power. Address Appendix R concern.	
	Resolution:	Appendix R assumes one train of DC power available. Change does not impact Appendix R analysis.
EER 86-SG-250 (9/23/87)	Loss of loop power to ADV's from PNB-D26 causes control to be shifted from control room to remote shutdown panel.	

	Resolution:	PCR 87-13-SG-016 initiated to replace control station modules.
EER 87-SG-133 (8/18/87)	Address problem with nitrogen system solenoid isolation valve and pressure regulating valve having excessive leakage.	
	Resolution:	Repair or rework to stop suspected leakage on solenoid and/or regulating valves.
EER 87-SG-131 (7/17/87)	Nitrogen accumulator solenoid isolation valves and PCV's are leaking by. Address operability concerns with the amount of leakage present.	
	Resolution:	Calculations in progress to determine positioner usage requirements.
EER 88-SG-101 (8/8/88)	Loss of power causes ADV nitrogen solenoids to fail close which leads to loss of control for that ADV assuming normal IA is not available. Address operability concerns. (Note: Similar to EER 86-SG-181).	
	Resolution:	Redundancy, separation, and ability to manually operate made this no problem.
EER 88-SG-110 (8/16/88)	Unit 1 ADV-179 did not respond properly during 7/6/88 reactor trip event. Valve response was erratic when it should have modulated closed.	
	Resolution:	One of the needle valve air passages was blocked with foreign matter (water, oil, dust). Submitted WR's to blow out air passages on the air positioners on all three units.
PTRR 1-86-001 (1/9/86)	ADV HV-179 responded slowly. It did not appear to be responding with a 10% open signal from the Control Room. It was given a 22% signal and a return to 10%. The valve opened and was observed to operate normally.	
	Resolution:	Referenced EER 85-SG-160. The response is indicative of this type of valve and is within design criteria.

PTRR 1-86-003 (2/3/86)

Unit 1 SBCV's cycled quick open, closed, and quick open again causing MSIS.

Resolution: C.E. evaluated and recommended revising SBCS Tave-low setpoint to prevent quick open when less than 75% power.

ADV operated erratically. At ≈ 10% open indication valve went to 30%. Demand lowered to ≈ 7% and valve came back to 10%. Later, setpoint was raised to ≈ 12% and ADV indicated it went full open. Permissives closed and valve reclosed.

Resolution: Function of the valves is such that types of erratic valve movements are to be expected.

PTRR 2-86-004 (6/25/86)

SBCS valves 1007 and 1008 would not respond to open signals.

Resolution: Upon loss of power and restoration SBCV's are in emergency off. Operators did not know this. SBCV system functioned as designed.

ADV's were slow to open (a large demand signal required initially to produce valve motion) and were sluggish.

Resolution: Recommended lesson plans for initial training and requalification be revised to address operating characteristics and control functions of ADV's during loss of power condition.

ADV-185 indicating light did not indicate valve opening.

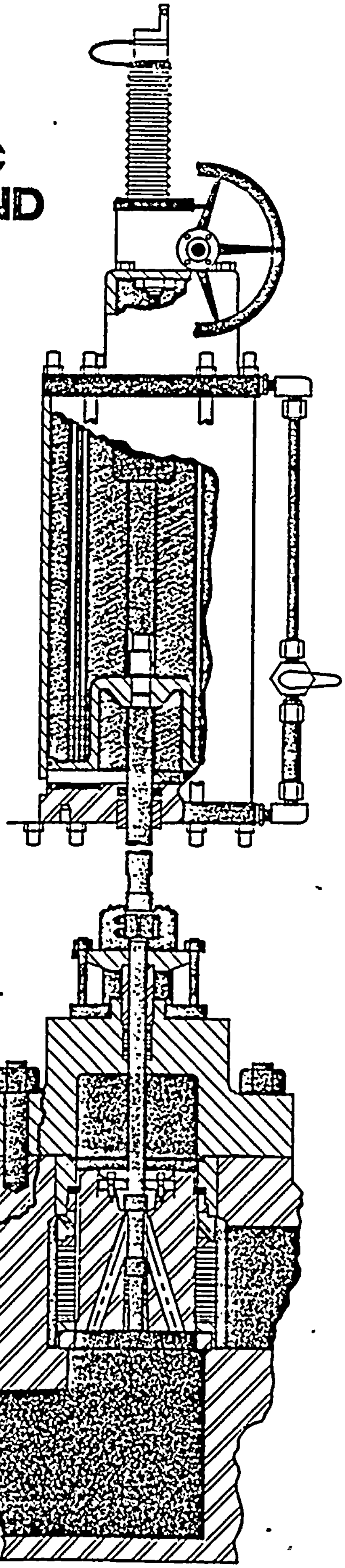
Resolution: ADV-185 was verified to operate properly. Indication problem only.

PTRR 1-86-012 (9/11/86)	ADV HV-185 drifted between 5% and 10% with setpoint at 15% and ADV HV-178 operated erratically.	
	Resolution:	Implemented action plan comprised of valve stroking, bypassing inline filter, troubleshooting I/P converter and positioner. Determined that IA filters were partially clogged and that ADV-178 valve positioner needed recalibration. Both valves then stroked satisfactorily. Deferred troubleshooting I/P converter until next Mode 5.
PTRR 1-88-004 (7/6/88)	ADV HV-179 operated erratically.	
	Resolution:	See EER 88-SG-110.

FIGURES II-1and II-2

ADV Valve and Actuator Simplified Cutaway Drawings

ATMOSPHERIC DUMP VALVE AND ACTUATOR



4/27/89

FIGURE II-1

ATMOSPHERIC DUMP VALVE VALVE POSITIONS

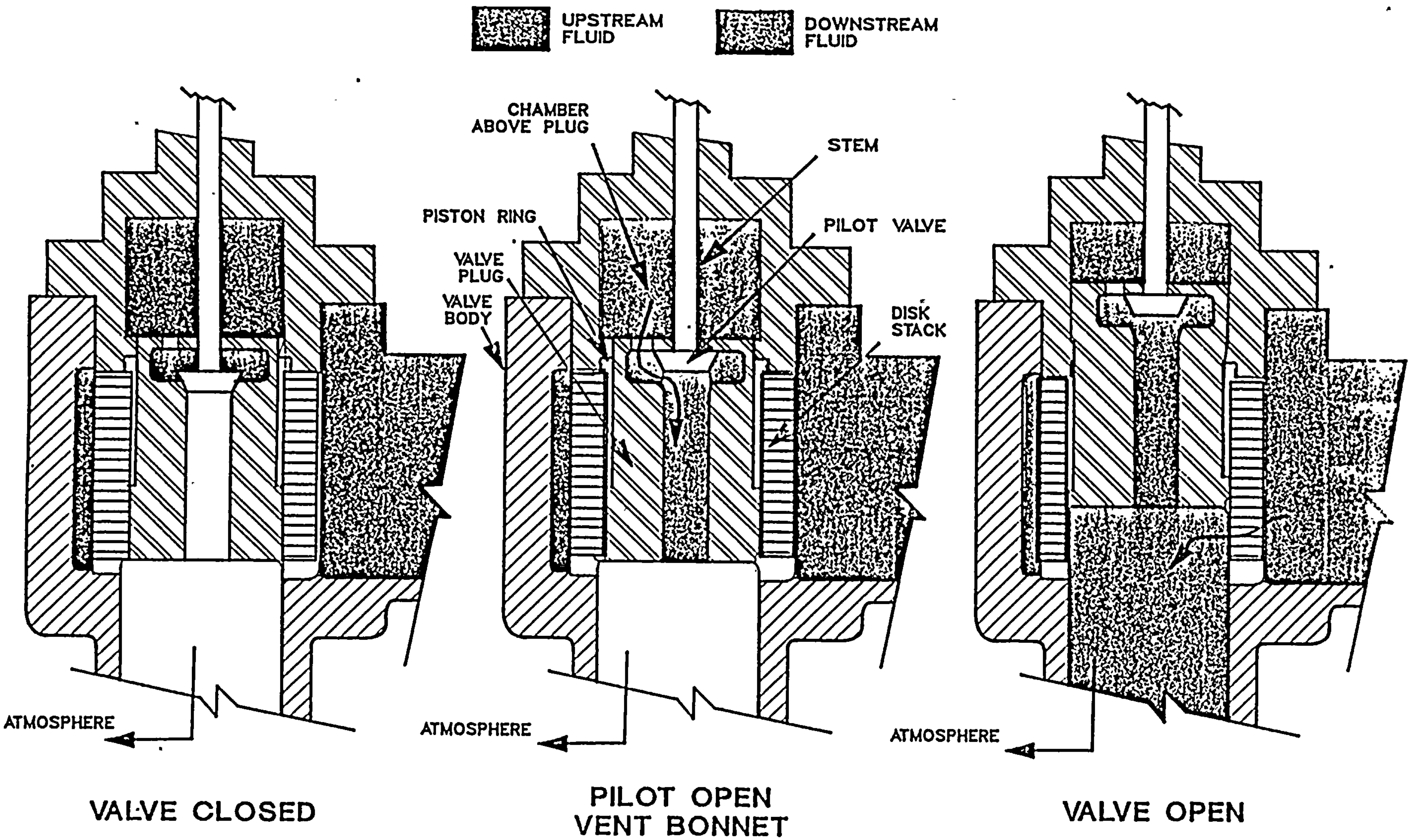


FIGURE VI-1

Test Instrumentation

ATMOSPHERIC DUMP VALVE AND CONTROL EQUIPMENT

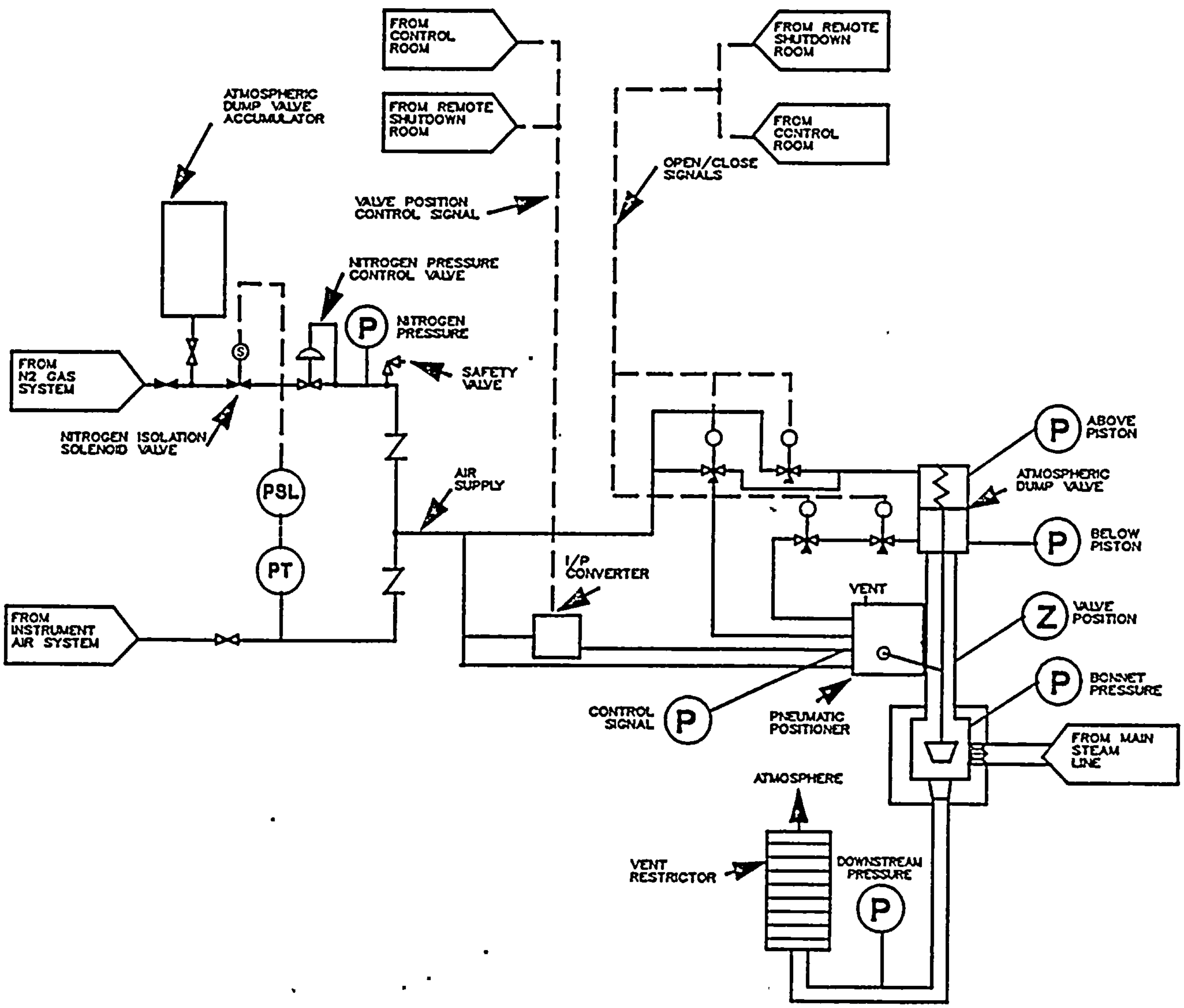
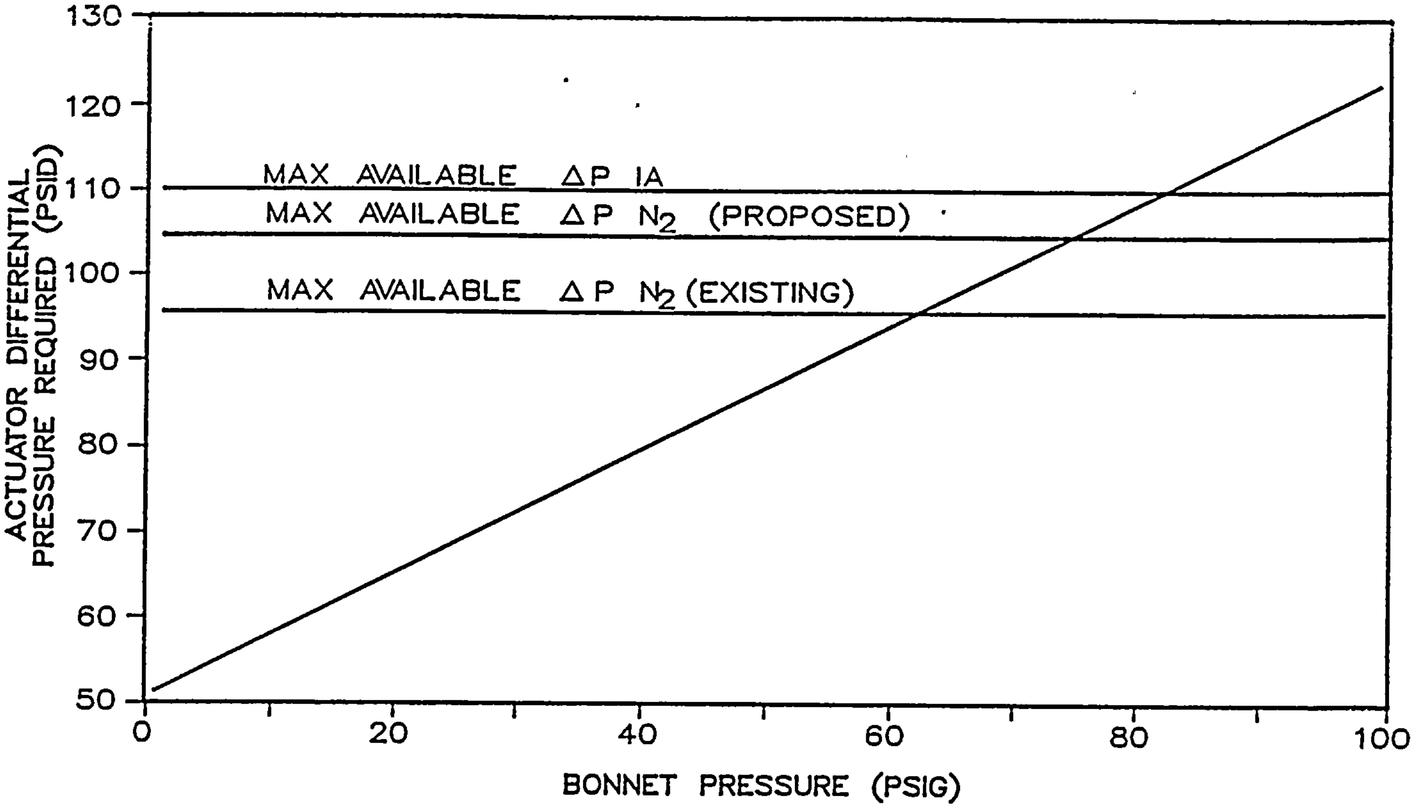


FIGURE VI-2 & VI-3

Calculated Force and Actuator D/P Required to Open a Typical ADV vs. Bonnet Pressure

ACTUATOR DELTA-P vs. BONNET PRESSURE



OPENING FORCE vs. BONNET PRESSURE

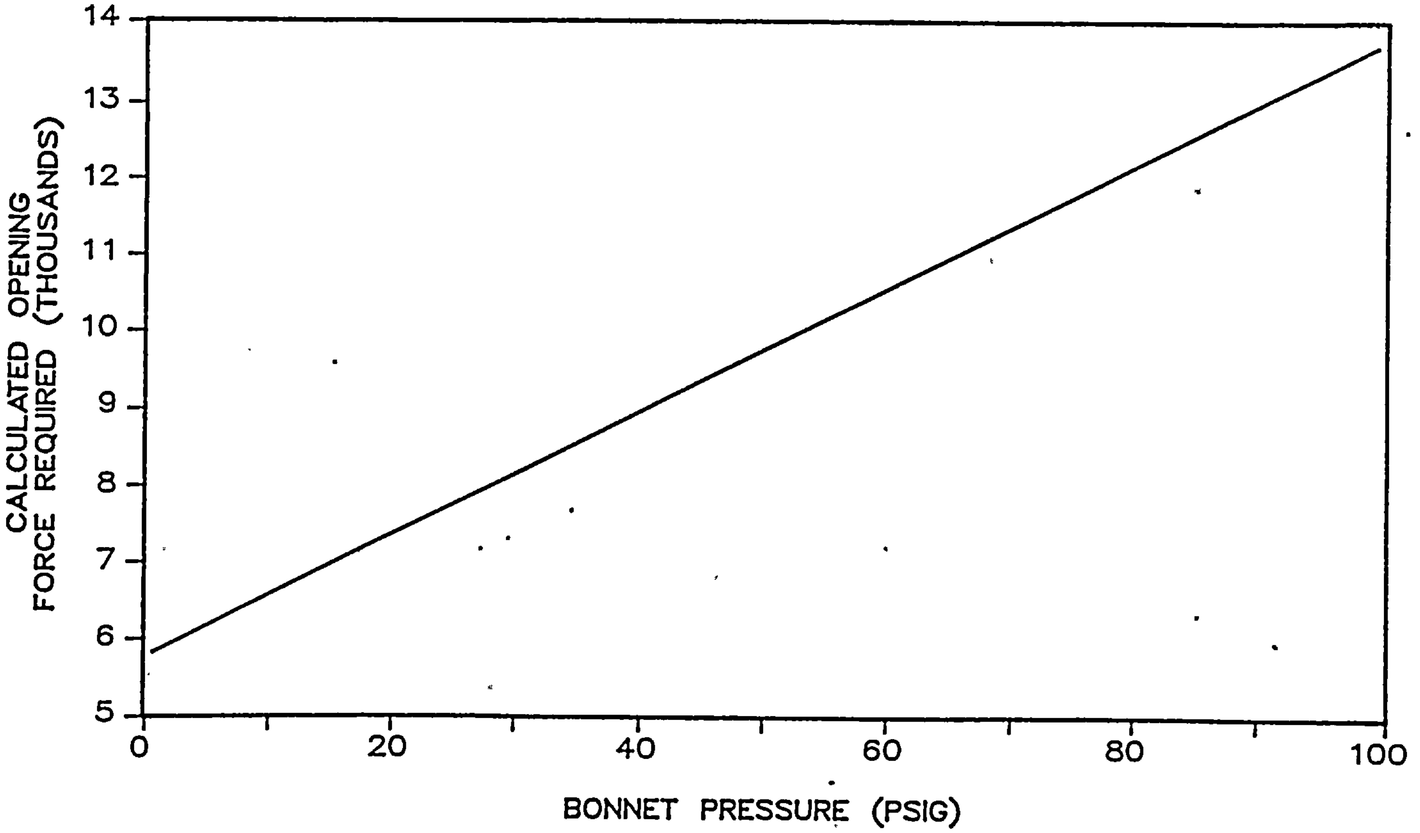


FIGURE VI-4, VI-5, and VI-6

Unit 1 ADV-178 - 30% Step Demand at Various Nitrogen Supply Pressures

FIGURE VI-4

UNIT 1 ADV-178 STROKE

(90 PSIG NITROGEN SUPPLY PRESSURE)

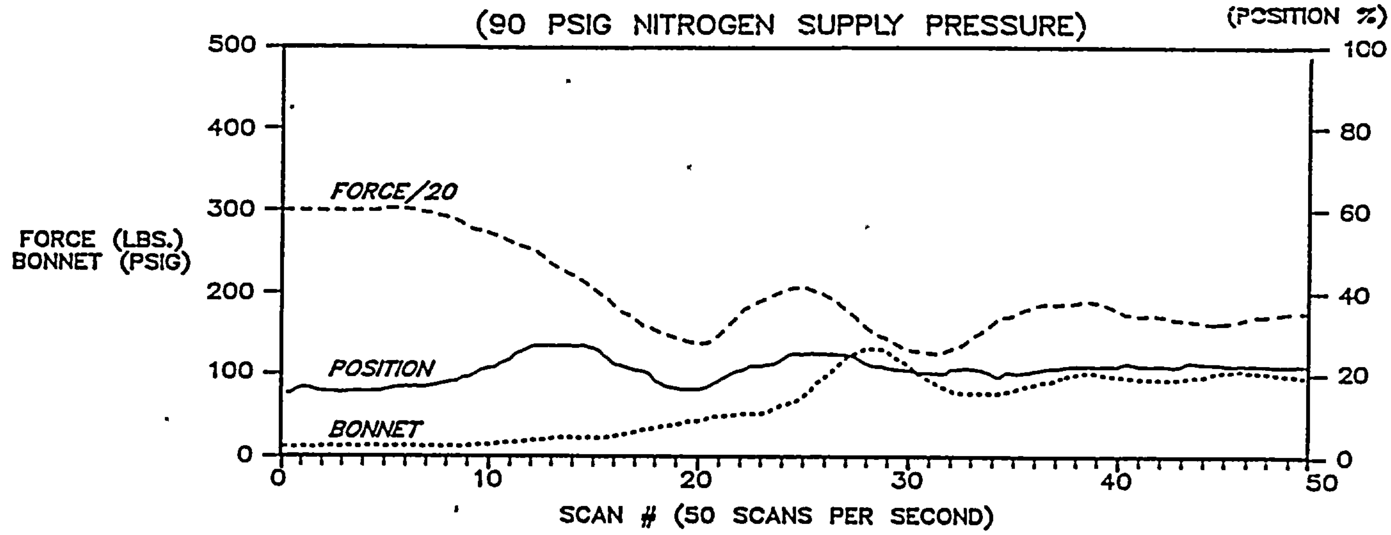


FIGURE VI-5

UNIT 1 ADV-178 STROKE

(100 PSIG NITROGEN SUPPLY PRESSURE)

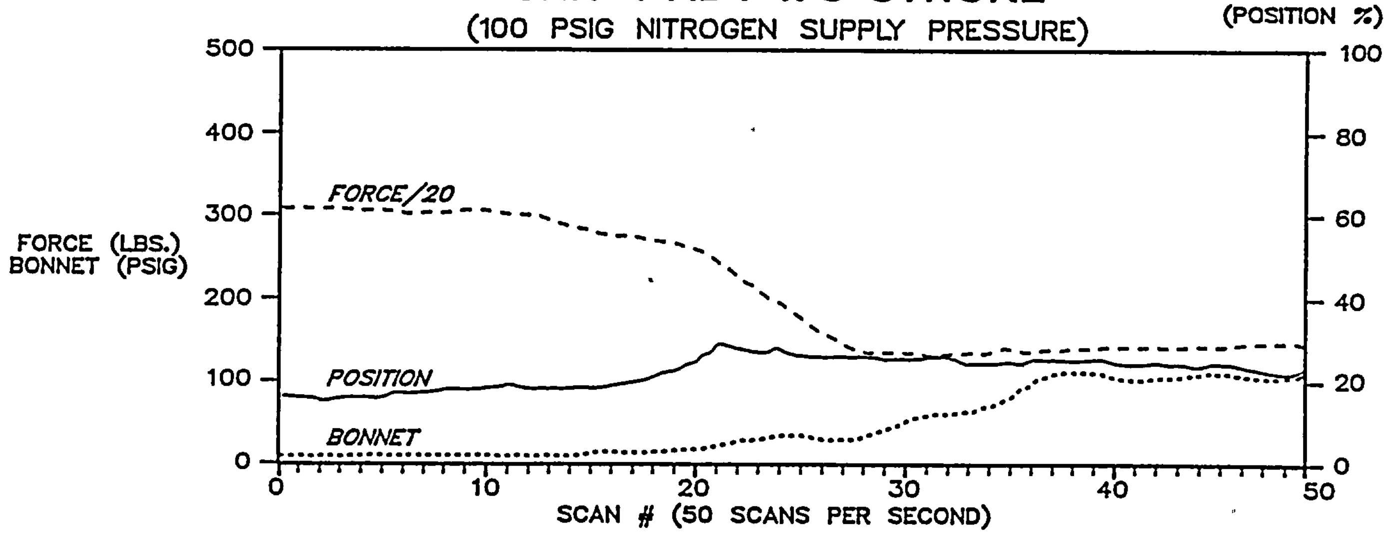


FIGURE VI-6

UNIT 1 ADV-178 STROKE

(110 PSIG NITROGEN SUPPLY PRESSURE)

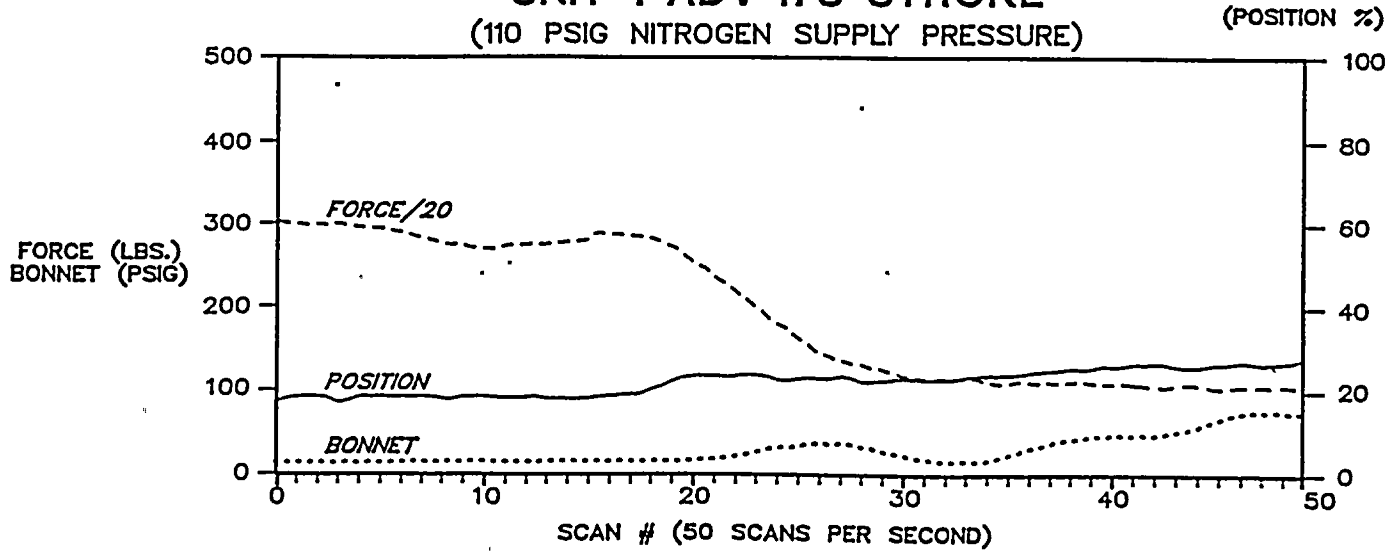


FIGURE VI-7

Cross-Section Diagram
of Positioner

MODEL 74 MOORE POSITIONER

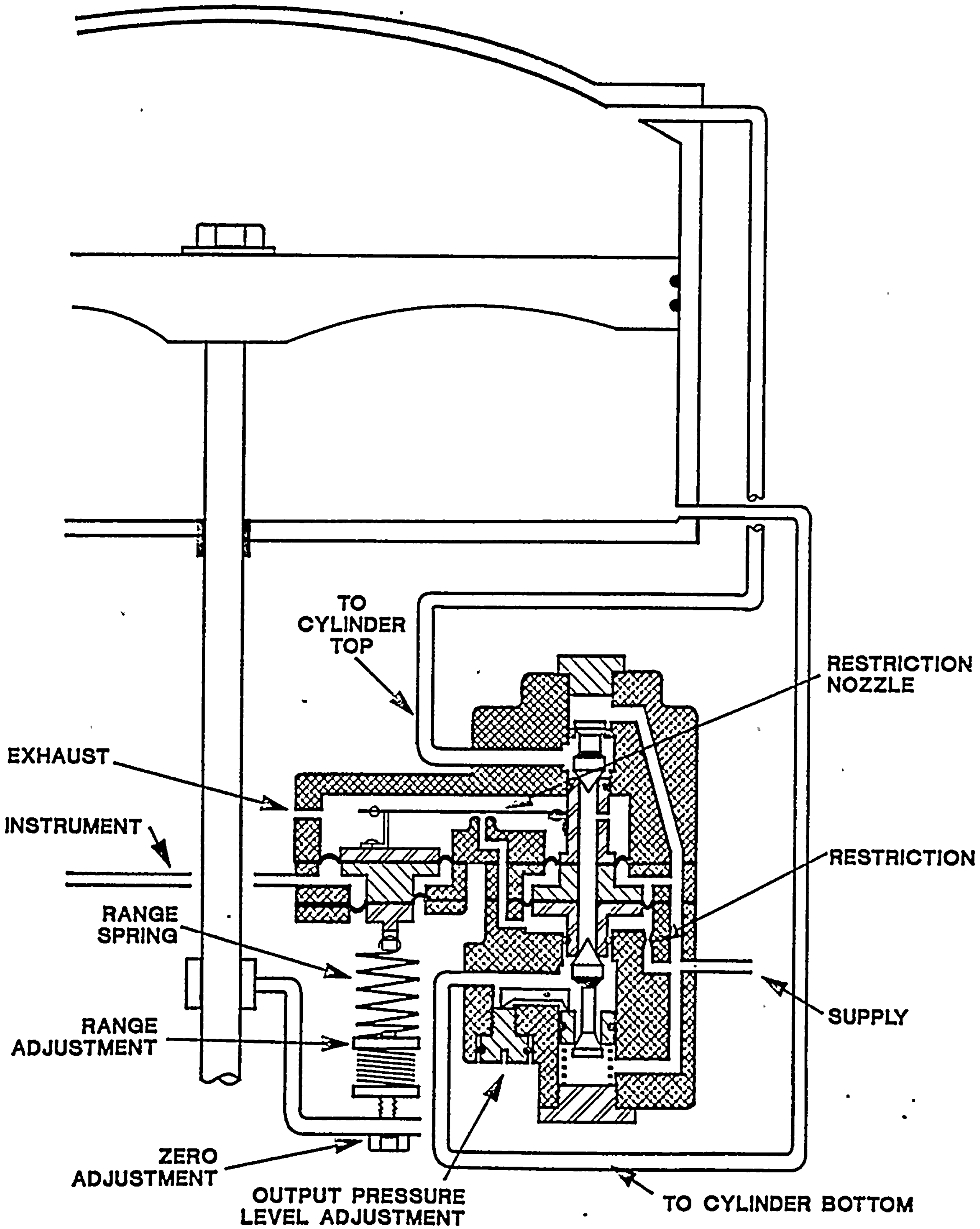


FIGURE VI-8

Unit 3 Failure Analysis Summary

UNIT 3 FAILURE ANALYSIS SUMMARY - REVISION 1

CONTRIBUTING FORCE	ADV-178	ADV-179	ADV-184	ADV-185
PLUG WEIGHT, LBf (1)	400	400	400	400
PISTON RING FRICTION, LBf (1)	635	635	635	635
UNBALANCED FORCE ON PLUG - INCLUDING BONNET PRESSURE, LBf (2)	3820	3820	3820	3820
TWO SPRING PRELOAD, LBf (1)	-------	1519	-------	-------
THREE SPRING PRELOAD, LBf (1)	3282	-------	3282	3282
PACKING AND/OR PACKING GLAND FOLLOWER FRICTION, LBf	3500 (3)	4600 (4)	1219 (1)	4600 (3)
TOTAL FORCE REQUIRED TO MOVE PLUG (LBf)	11,637	10,974	9,356	12,737
MAXIMUM FORCE AVAILABLE FROM ACTUATOR (95 psig nitrogen supply)	10,577	10,577	10,577	10,577
TOTAL POSSIBLE FORCE ON PLUG, LBf (With Maximum D/P of 95 psid) (positive is upward)	-1060	-397	1221	-2160
CALCULATED BONNET PRESSURE WHICH WOULD HAVE PRECLUDED VALVE OPERATION (psig) Regardless of Demand Signal & Time	Less Than 15 psig	Less Than 15 psig	Approximately 30 psig	Less Than 15 Psig

NOTES:
(1) THESE VALUES ARE BASED ON DESIGN VALUES
(2) THESE VALUES ARE BASED ON A 15 PSIG BONNET PRESSURE.
(3) THESE VALUES WERE DETERMINED DURING TESTING.
(4) NO TESTING WAS PERFORMED ON ADV-179 SINCE IT'S ACTUATOR WAS DAMAGED. TWO OTHER VALVES (ADV-178 AND ADV-185) ALSO HAD THEIR PACKING GLAND SEIZED TO THE VALVE STEM. ASSUMING THE HIGHEST OBSERVED VALUE OF FRICTION IS THE MOST CONSERVATIVE APPROACH. THIS WOULD BE THE FRICTION OBSERVED ON ADV-185, OR, 4600 LBf.

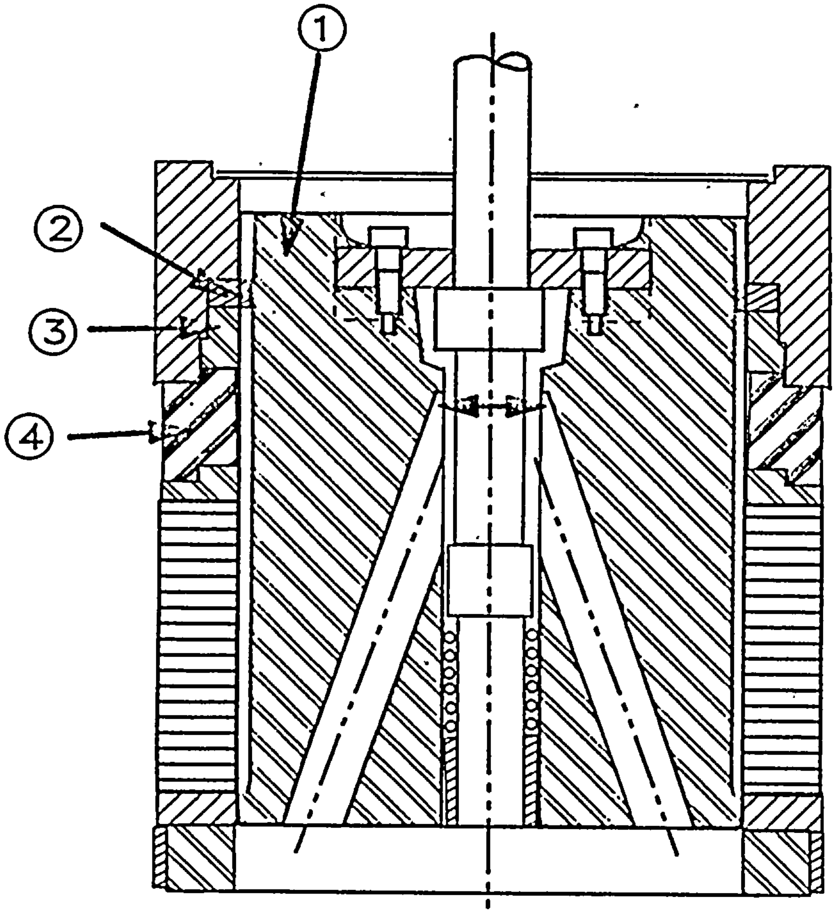
FIGURE IX-1

Proposed
Valve Plug Modification

FIGURE IX-1

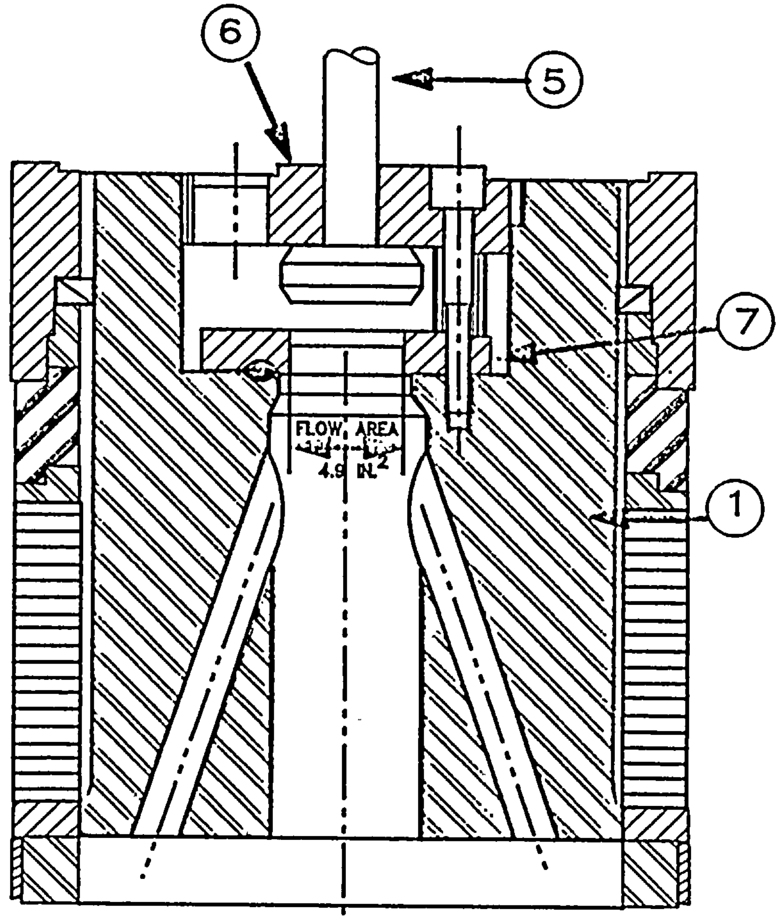
ADV INTERNAL MODIFICATIONS

EXISTING:



FLOW AREA = 2.5 INCHES ^{2}

CHANGE TO:



(1) MAIN VALVE PLUG (REWORKED)

(5) MAIN VALVE STEM (PILOT VALVE PLUG) (NEW)

(6) RETAINING PLATE (NEW)

(7) PILOT VALVE SEAT RING (NEW)

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FIGURE IX-2

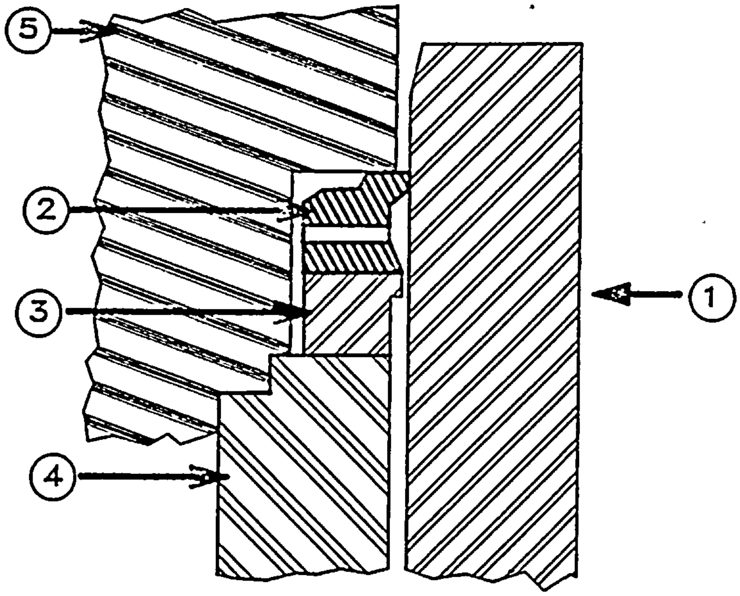
Proposed
Piston Ring Modification

FIGURE IX-2

ADV INTERNAL MODIFICATIONS

EXISTING:

① PLUG ASSEMBLY
② ONE–PIECE PISTON RING
③ GUIDE BUSHING
④ DISK STACK
⑤ SPACER



CHANGE TO:

① PLUG ASSEMBLY
② TWO–PIECE PISTON RING (NEW)
③ GUIDE BUSHING
④ DISK STACK
⑤ SPACER

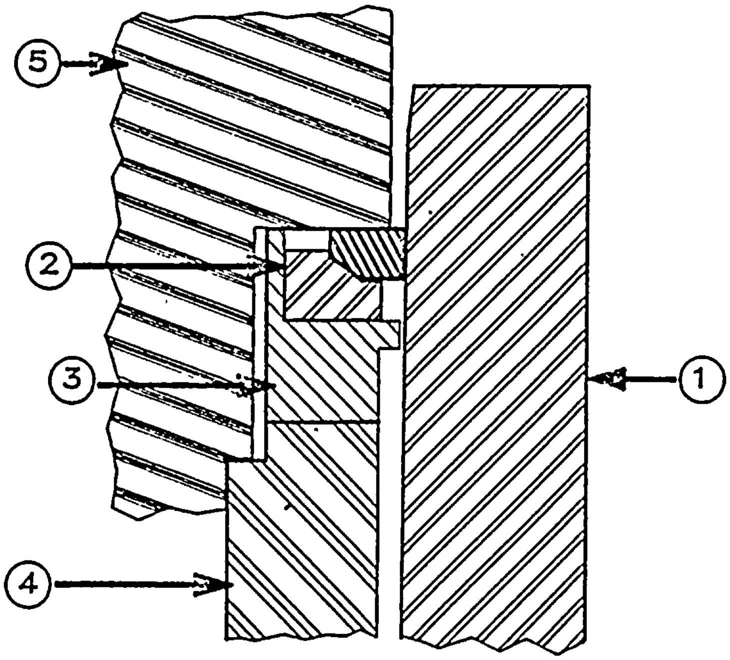


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TABLE V-1

ADV Comparison for Various Utilities

PWR ATMOSPHERIC DUMP [illegible] DESIGN INFORMATION

UTILITY AND PLANT # OF UNITS # OF VALVES	VALVE STYLE	PLUG SIZE	VALVE STROKE	ACTUATOR TYPE (1)	MAX. ACT. PWR. (LBF)	MAX DESIGN FLOW (LBM/HR) @ SAT. TEMP.	MAX VALVE Cv	RESISTOR Cv	P IN @ REACTOR TRIP (PSIA)
APS - PALO VERDE ++ UNITS 1,2, AND 3 12 VALVES	OFFSET GLOBE	10 " 10.13	12"	111 sq in. * PN Spring to Close	10,577 @ 95 psi	1,470,000 @ 1000 psi	830	1,696	1,150
LP & L - WATERFORD UNIT 3 2 VALVES	ANGLE	10 " 10.13	10"	111 sq in. * PN Spring to Close	10,577 @ 95 psi	800,000 @ 885 psi	508	1,202	885
SCE - SAN ONOFRE UNITS 2 & 3 4 VALVES	ANGLE UPSIDE DOWN	8 " 7.935	10"	111 sq in. ** PN Spring to Close	10,577 @ 95 psi	795,000 @ 795 psi	539	450	960
DUKE POWER - CATAWBA (2) UNITS 1 & 2 8 VALVES	ANGLE	8 " 7.935	8"	111 sq in. * PN Spring to Close	10,577 @ 95 psi	500,000 @ 1200 psi	195	1,347	1,200
CP & L - SHEARON HARRIS UNIT 1 3 VALVES	OFFSET GLOBE	8 " 7.875	8"	ELECTRIC HYDRAULIC	20,000	427,000 @ 1106 psi	350	1,505	1,200
GP - ALVIN VOGTLE UNITS 1 & 2 8 VALVES	OFFSET GLOBE	8" 7.875	8"	ELECTRIC HYDRAULIC	20,000	596,000 @ 1200 psi	350	1,505	1,200
FP & L - ST. LUCIE UNIT 2 4 VALVES	ANGLE	8" 7.937	10"	ELECTRIC	15,000	275,000 @ 985 psi	486	1,347	985
HL & P - SOUTH TX PROJ UNITS 1 & 2 8 VALVES	OFFSET GLOBE	8" 7.875	8"	ELECTRIC HYDRAULIC	20,000	1,050,000 @ 1300 psi	420	696	1,300

NOTES: (1) All PN pneumatic actuators have springs for fail close. The spring seated load is 1519 lbs. The spring rate is 167 lbs/in.
(2) Duke calls these steam generated power operated relief valves.
* Actuator manual override 80 ft-lbs maximum required to open
** CCI manual override 90 ft-lbs maximum required to open, spring seated load is 2420 and maximum rate is 191 lbs/in.
++ Data with current internals (e.g. prior to planned plug/piston ring/disk stack modifications)

PWR ATMOSPHERIC DUMP VALVES DESIGN INFORMATION

UTILITY AND PLANT # OF UNITS # OF VALVES	PILOT SEAT Cv	BONNET PRESSURE		ACTUATOR LOAD		ACTUATOR D/P	
		BAD* PISTON RING - psia	GOOD PISTON RING - psia	BAD* PISTON RING - LBf	GOOD PISTON RING - LBf	BAD* PISTON RING - psid	GOOD PISTON RING - psid
APS - PALO VERDE ** UNITS 1,2, AND 3 12 VALVES	27	210	30	21,187	7,136	191	64
LP & L - WATERFORD UNIT 3 2 VALVES	26.7	149	17.5	16,573	6,124	149	55
SCE - SAN ONOFRE UNITS 2 & 3 4 VALVES	17.9	198.6	18.3	14,039	4,863	126	50
DUKE POWER - CATAWBA UNITS 1 & 2 8 VALVES	17.9	252	20.3	15,875	5,014	143	45
CP & L - SHEARON HARRIS UNIT 1 3 VALVES	21.26	214	20.5	13,408	4,513	-	-
GP - ALVIN VOGTLE UNITS 1 & 2 8 VALVES	21.26	214	20.5	13,408	4,513	-	-
FP & L - ST. LUCIE UNIT 2 4 VALVES	18.9	194	19.5	11,270	3,068	-	-
HL & P - SOUTH TX PROJ UNITS 1 & 2 8 VALVES	21.26	232	21.5	14,256	4,755	-	-

NOTES: * "BAD" simply means the piston ring is not functioning properly for whatever cause
** Data with current (un-modified) valve internals

CCI SUPPLIED WORST CASE ANALYSIS

PWR ATMOSPHERIC DUMP VALVES - MODIFIED DESIGN RESULTS

UTILITY AND PLANT # OF UNITS # OF VALVES	PILOT SEAT Cv	UPGRADE PILOT AND PISTON RINGS			UPGRADE PILOT ONLY		
		BONNET PRESS- psia	ACTUATOR LOAD - LBf	ACTUATOR D/P - psid	BONNET PRESS - psia	ACTUATOR LOAD - LBf	ACTUATOR D/P - psid
APS - PALO VERDE UNITS 1,2, AND 3 12 VALVES	74.0	28.0	7,628	68.0	79.2	11,466	103.0
LP & L - WATERFORD UNIT 3 2 VALVES	74.0	23.0	6,504	58.6	60.0	9,249	83.0
SCE - SAN ONOFRE UNITS 2 & 3 4 VALVES	30.9	30.9	5,525	50.0	118.0	9,321	84.0
DUKE POWER - CATAWBA UNITS 1 & 2 8 VALVES	30.9	45.7	6,203	55.7	149.0	11,039	99.0
CP & L - SHEARON HARRIS UNIT 1 3 VALVES	29.4	48.9	5,817	-	157.0	10,740	-
GP - ALVIN VOGTLE UNITS 1 & 2 8 VALVES	29.4	48.9	5,817	-	157.0	10,740	-
FP & L - ST. LUCIE UNIT 2 4 VALVES	22.0	51.5	4,587	-	168.0	10,041	-
HL & P - SOUTH TX PROJ UNITS 1 & 2 8 VALVES	29.4	52.3	6,126	-	170.0	11,394	-

CCI SUPPLIED WORST CASE ANALYSIS

TABLE VI-1

List of Generic Anomalies
Noted During on the ADV System

TABLE VI-1

THE FOLLOWING GENERAL PROBLEMS ON THE ADV SUBSYSTEM WERE DISCOVERED DURING THE ADV INVESTIGATION. WORK REQUESTS/WORK ORDERS HAVE BEEN SUBMITTED FOR CORRECTION OF THE DISCREPANCIES.

Positioner:

Positioner out of calibration; i.e. pilot valve opened with a 0% demand signal.
Positioner linkage broken/needed adjustmen
Unqualified gauges installed on positioners.
Positioner leakage

Actuator:

Actuators found with 3 springs versus the required 2.
Potential unqualified "O" rings installed in actuator

Nitrogen System Components:

Nitrogen regulator seat leakage
Leaking fittings
Nitrogen accumulator system leakage
Leaking nitrogen system relief valve
Leaking nitrogen system solenoid valves
Seat leakage on nitrogen supply valves
Nitrogen supply valve sticking

Manual Actuator:

Missing clevis (lost during manual operation)
Broken manual operator
Damaged clevis bracket

ADV Performance Problems:

ADV failed to open on nitrogen due to high bonnet pressure
Unit 3 ADVs did not open remotely during 3/3/89 event
ADV oscillations

Miscellaneous:

HIC (Hand Indicating Controller) cover damaged
Valve control room position indicator out of service

TABLE VI-2

Unit 1 ADV-184 Test Data

TABLE IX-1

Recommended
Corrective Action Matrix

ENGINEERING RECOMMENDED CORRECTIVE ACTIONS MATRIX - REVISION 2

PROBLEMS NOTED DURING ADV INVESTIGATION	ROOT CAUSE(S)	CORRECTIVE ACTIONS: ACTIONS TO BE TAKEN PRIOR TO UNIT RESTART FROM CURRENT OUTAGES	CORRECTIVE ACTIONS: ACTIONS TO BE TAKEN FOLLOWING CURRENT OUTAGES
ATMOSPHERIC DUMP VALVES			
A. EXCESSIVE BONNET PRESSURE REQUIRING HIGH FORCES TO OPEN VALVES (U1 ADV-184)	A1. PISTON RING LEAKAGE GREATER THAN RELIEVING CAPACITY OF THE PILOT VALVE RESULTING IN EXCESSIVE BONNET PRESSURE	A1. INCORPORATE CCI RECOMMENDED MODIFICATIONS a) Increase plug pilot capacity b) Modify piston ring c) Modify disk stack to provide a smooth Cv transition A2. INCREASE NITROGEN REGULATOR PRESSURE FROM 95 TO 105 PSIG A3. INSTALL BONNET PRESSURE TAPS IN UNIT 3 ADVs	A1. PERFORM MONTHLY STROKING PROGRAM (30% STROKE) and PERFORM WEEKLY BONNET PRESSURE CHECKS A2. EVALUATE DATA FROM STROKING PROGRAM/BONNET PRESSURE CHECKS AND ADJUST FREQUENCY OF PERFORMANCE AS REQUIRED A3. PERFORM QUARTERLY STROKING ST ON ATMOSPHERIC DUMP VALVES
B. HIGH FORCES TO OPEN VALVES (U3 ADV-178 & ADV-185)	B1. TESTING PROGRAM REVEALED EXCESSIVE PACKING/PACKING FOLLOWER FRICTION B2. DISASSEMBLY OF UNIT 3 ADV ACTUATORS REVEALED 3 OF 4 ACTUATORS CONTAINED 3 SPRINGS INSTEAD OF 2 (CURRENT DESIGN)	B1. INSPECT UNIT 1 AND 2 ACTUATORS AND REMOVE EXTRA SPRING IF FOUND B2. REMOVE EXTRA SPRINGS IN THE 3 UNIT 3 ADVs B3. INITIATE INCIDENT INVESTIGATION REPORT TO DETERMINE WHY THE EXTRA SPRING WAS IN THE ACTUATORS (Ref. IIR #3-1-89-030)	B1. EVALUATE DATA FROM STROKING PROGRAM TO ENSURE HIGH FORCES DO NOT OCCUR
C. VALVE OSCILLATIONS (U1 ADV-178, -184 and -179)	C1. MAJOR FACTORS THAT CONTRIBUTE TO THE OSCILLATIONS ARE: a) Cv transition in disk stack provides a high stepwise force input to plug b) Relatively low actuator "stiffness" due to 95 psig nitrogen supply pressure	C1. INCORPORATE CCI RECOMMENDED MODIFICATIONS a) Increase plug pilot capacity b) Modify piston ring c) Modify disk stack to provide a smooth Cv transition C2. INCREASE NITROGEN REGULATOR PRESSURE FROM 95 TO 105 PSIG	

6 !

PROBLEMS NOTED DURING ADV INVESTIGATION	ROOT CAUSE(S)	CORRECTIVE ACTIONS	
		ACTIONS TO BE TAKEN PRIOR TO UNIT RESTART FROM CURRENT OUTAGES	ACTIONS TO BE TAKEN FOLLOWING CURRENT OUTAGES
PNEUMATIC SUBSYSTEM			
A. NITROGEN REGULATORS EXHIBIT SEAT LEAKAGE CAUSING HIGH DOWNSTREAM PRESSURE	A1. WEAR AND/OR DEBRIS DAMAGED THE SOFT SEAT A2. NO PM EXISTED TO IDENTIFY PROBLEMS OR DEGREDATION OF SYSTEM	A1. REPLACED DAMAGED/WORN REGULATOR PARTS A2. VERIFY NITROGEN SUBSYSTEM CLEANLINESS A3. DEVELOP AND PERFORM A PM TASK TO ADJUST REGULATOR SETPOINT	A1. MONITOR PERFORMANCE OF REGULATORS DURING OPERATION OF ATMOSPHERIC DUMP VALVES A2. PERFORM PM AS REQUIRED A3. NUCLEAR ENGINEERING DEPARTMENT PERFORM OVERALL DESIGN REVIEW OF ADV SUBSYSTEM
B. EXCESSIVE NITROGEN LEAKAGE	B1. LEAKING FITTINGS B2. REGULATOR NOT CONTROLLING AT THE CORRECT PRESSURE B3. RELIEF VALVE LEAKING OR WEEPING AT LOWER THAN 125 PSIG SET PRESSURE B4. NO PERIODIC TESTING TO DETERMINE STATUS OF SYSTEM	B1. NITROGEN ACCUMULATOR DROP TEST TO BE PERFORMED ON ALL VALVES. LEAKING FITTINGS AND RELIEF VALVE PROBLEMS TO BE CORRECTED B2. INSTITUTE CORRECTIVE ACTIONS REQUIRED FOR REGULATORS B3. DEVELOP AND IMPLEMENT QUARTERLY NITORGEN LEAKAGE ST B4. DEVELOP ST AND TEST SECTION XI CHECK VALVES FOR LEAKAGE	B1. PERFORM QUARTERLY NITROGEN LEAKAGE ST B2. EVALUATE THE NEED FOR MODIFICATION TO INSTALL DOUBLE VALVE ISOLATION (INCLUDING A LEAKOFF VALVE) BETWEEN ACCUMULATOR AND HIGH PRESSURE NITROGEN SYSTEM B3. NUCLEAR ENGINEERING DEPARTMENT PERFORM OVERALL DESIGN REVIEW OF ADV SUBSYSTEM
C. DIFFERENT POSITIONERS EXHIBIT DIFFERENT CONTROL CHARACTERISTICS	C1. NO PM EXISTED TO ADJUST OR MONITOR CALIBRATION OF POSITIONERS	C.1 DEVELOP AND PERFORM A PM TASK TO CALIBRATE AND ADJUST THE POSITIONERS	C1. MONITOR PERFORMANCE OF POSITIONERS DURING MONTHLY STROKING OF ADVs C2. PERFORM PM AS REQUIRED (if deficiencies are noted) AND DURING REFUELING OUTAGES
D. NITROGEN AND INSTRUMENT AIR SYSTEM CLEANLINESS -- NITROGEN REGULATOR EXPERIENCED FAILURE DUE TO DEBRIS IN NITROGEN LINE	D1. INDETERMINATE - PROBABLE INSUFFICIENT FLUSH FOLLOWING MAINTENANCE OR CONSTRUCTION ACTIVITIES	D1. FLUSH/SAMPLE NITROGEN SUBSYSTEM, IA AND HIGH PRESSURE NITROGEN SUPPLIES TO VERIFY CLEANLINESS D2. INSTALL 3 MICRON INSTRUMENT AIR FILTER IN MSSS SUPPLY LINE TO ADVs. (UNIT 3 ONLY -- COMPLETED IN UNITS 1 AND 2) D3. IMPLEMENT CORRECTIVE ACTIONS NOTED IN INSTRUMENT AIR REPORT (NED REPORT)	D1. IMPLEMENT COMMITMENTS MADE BY ANPP IN RESPONSE TO GENERIC LETTER 88-14
EQUIPMENT QUALIFICATION AND CONFIGURATION CONTROL ISSUES			
A. UNQUALIFIED GAGES LEFT ON POSITIONERS DURING OPERATION	A1. UNDER INVESTIGATION -- SEE IIR #3-1-89-030	A1. REMOVE UNQUALIFIED GAGES PER VENDOR TECH MANUAL	A1. UNDER INVESTIGATION -- SEE IIR #3-1-89-030
B. ADDITIONAL SPRING FOUND IN U-3 ACTUATORS	B1. UNDER INVESTIGATION -- SEE IIR #3-1-89-030	B1. REMOVE ADDITIONAL SPRING FOUND IN ACTUATORS	B1. UNDER INVESTIGATION -- SEE IIR #3-1-89-030
C. BUNA-N "O" RINGS FOUND IN U-3 ACTUATORS (SHOULD HAVE BEEN CHANGED TO VITON BEFORE OPERATION)	C1. UNDER INVESTIGATION -- SEE IIR #3-1-89-030	C1. REPLACE ANY UNIT 3 BUNA-N "O" RINGS WITH VITON	C1. UNDER INVESTIGATION -- SEE IIR #3-1-89-030

PROBLEMS NOTED DURING ADV INVESTIGATION	ROOT CAUSE(S)	CORRECTIVE ACTIONS	
		ACTIONS TO BE TAKEN PRIOR TO UNIT RESTART FROM CURRENT OUTAGES	ACTIONS TO BE TAKEN FOLLOWING CURRENT OUTAGES
PACKLESS ISOLATION VALVES			
A. CURRENT ORIENTATION OF VALVES CAN RESULT IN INABILITY TO OPERATE VALVES IN SOME OPERATIONAL CONDITIONS	A1. VALVE INSTALLED SO THAT IT EXPERIENCES BI-DIRECTIONAL FLOW	A1. NONE	A1. RE-ORIENT VALVES TO ELIMINATE BI-DIRECTIONAL FLOW THROUGH THE VALVES
ADV OPERATING PROCEDURES			
A. INCONSISTENT UNDERSTANDING OF ADV OPERATION AND OPERATING CHARACTERISTICS	A1. SEE INCIDENT INVESTIGATION REPORT IIR #2-3-89-001	A1. SEE INCIDENT INVESTIGATION REPORT IIR #2-3-89-001	A1. SEE INCIDENT INVESTIGATION REPORT IIR #2-3-89-001
B. PROBLEMS IN MANUALLY OPERATING THE ADVs	B1. SEE INCIDENT INVESTIGATION REPORT IIR #2-3-89-001	B1. SEE INCIDENT INVESTIGATION REPORT IIR #2-3-89-001	B1. SEE INCIDENT INVESTIGATION REPORT IIR #2-3-89-001
MISCELLANEOUS			
A. ADV BLOCK VALVES NEVER INSTALLED	A1. PREVIOUS DECISION	A1. NONE	A1. INSTALL BLOCK VALVES UPSTREAM ADVs