NON-PUBLIC?: N
ACCESSION #: 8912190.264
LICENSEE EVENT REPORT (LER)

FACILITY NAME: Palo Verde Unit 2 PAGE: 1 OF 15

DOCKET NUMBER: 05000529

TITLE: Reactor Trip Due to Low Steam Generator Level
EVENT DATE: 02/16/89 LER #: 89-003-01 REPORT DATE: 12/15/89

OTHER FACILITIES INVOLVED: DOCKET NO: 05000

OPERATING MODE: 1 POWER LEVEL: 100

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR SECTION:
50.73(a)(2)(iv) OTHER: (Special Report 2-SR-89-003)

LICENSEE CONTACT FOR THIS LER:
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COMPONENT FAILURE DESCRIPTION:
CAUSE: SYSTEM: COMPONENT: MANUFACTURER:
REPORTABLE NPRDS:

SUPPLEMENTAL REPORT EXPECTED: NO

ABSTRACT:

At approximately 0345 MST on February 16, 1989, Palo Verde Unit 2 was in Mode 1 (POWER OPERATION) at approximately 100 percent power when a Feedwater Control System (FWCS) malfunction resulted in a reactor trip due to low level in Steam Generator (SG) number 1.

Immediately prior to the trip the Control Room staff observed both SG levels decreasing. Both master controller outputs were cycling full scale. SG number 1 economizer valve was fully shut and SG number 2 economizer valve was 10 percent open. A Control Room Operator placed SG number 1 economizer valve in manual and inserted approximately 17 percent open demand when the reactor tripped.

Immediately following the trip an Auxiliary Feedwater Actuation Signal was initiated. At approximately 0345 MST a Safety Injection Actuation Signal (SIAS)/Containment Isolation Actuation Signal (CIAS) was generated due to the overcooling of the Reactor Coolant System. SG number 1 level

continued to increase and at approximately 0347 MST a Main Steam Isolation Signal was received and terminated the cooldown. The cause of the event was a small amount of debris in the restrictor on the vertical relay within the economizer valve pneumatic positioner. Immediate corrective action taken was to replace the pneumatic relays in both FWCS's.

This submittal also provides Special Report 2-SR-89-003 in accordance with Technical Specification 3.5.2 ACTION b.

END OF ABSTRACT

I. DESCRIPTION OF WHAT OCCURRED:

A. Initial Conditions:

At approximately 0345 MST on February 16, 1989, Palo Verde Unit 2 was in Mode 1 (POWER OPERATION) at approximately 100 percent power when a Feedwater Control System (FWCS)(JB) malfunction resulted in a reactor (RCT)(AC) trip.

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

Event Classification: Any event or condition that resulted in manual or automatic actuation of any Engineered Safety Feature (ESF)(JE), including the Reactor Protection System (RPS)(JC).

At approximately 0345 MST on February 16, 1989, Palo Verde Unit 2 was operating in Mode 1 (POWER OPERATION) at approximately 100 percent power when an FWCS malfunction resulted in a reactor trip on Low Steam Generator (SG) (AB) number 1 lev
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and an Auxiliary Feedwater Actuation Signal (AFAS)(BA) actuation. Subsequent to the trip, number 1 SG was overfed using main feedwater resulting in a Safety Injection Actuation Signal (SIAS)(JE), Containment Isolation Actuation Signal (CIAS) (JE), and Main Steam Isolation Signal (MSIS)(JE). A Notification of Unusual Event (NUE) was declared at 0352 MST due to SIAS actuation and was terminated at 0449 MST when the SIAS was reset.

Prior to the event, on February 13, 1989 during Main Turbine (TRB)(TA) Stop valve (V)(TA) testing, an FWCS transient occurred. The number 1 economizer valve (FCV)(SJ) started to close in response to the testing but subsequently appeared to stick at approximately 35 percent open. The feedwater pump (FWP)(P)(SJ) speed increased to restore SG level. Manual control of the "B" feedpump was used to gain control of feedwater flow. The SG level fell to a low of approximately 5 percent narrow range (NR). Once SG level was regained (approximately 55 percent NR), the operator returned feedpump speed to automatic control and took manual control of the economizer valve. The valve subsequently responded properly. The secondary operator (utility, licensed) manually stroked the valve approximately 10 to 15 percent open and closed from the 70 percent open position and then restored the valve to its normal position of approximately 85 percent open for 100 percent power operation. With all components returned to automatic, all systems functioned properly. During the transient, oscillations from 50 to 85 percent in the master controller output

for FWCS number 1 were observed. These oscillations in the master controller would be expected for the transient induced in the system by the erratic operation of the number 1 economizer valve. The opportunity to learn from the transient on February 13, 1989 was reduced because the Temporary Data Acquisition System (TDAS) (IQ) data was not reviewed. The Shift Technical Advisor (STA)(utility, non-licensed) did discuss the transient with the Shift Supervisor (utility, licensed), but he inferred from that conversation that there would be no need for the transient data and proceeded to reinitialize the data disk. This reinitialization is done every 12 hours. When the data disk was reinitialized, the specific behavior of the number 1 economizer valve in the February 13, 1989 event was lost. Had this information been retained it may have aided in the troubleshooting. It was also noted that the STA was not called immediately when the transient occurred.

After several discussions involving the Plant Manager (utility, non-licensed), System Engineer (utility, non-licensed), and Operations Standard Advisor (utility non-licensed), a work request was generated to troubleshoot FWCS number 1. Troubleshooting the FWCS was made based on the following

considerations:

1) There were no apparent problems maintaining SG level.

2) There were no apparent problems with the master controller in automatic due to the observed stable FWCS conditions since the February 13, 1989 transient.

3) The decision was made to instrument both FWCSs and initiate small perturbations by controller setpoint changes, stop valve testing or initiating rapid steam generator blowdowns during the troubleshooting to observe system response.

Additionally, the decision was made not to perform any high risk Preventive Maintenance Tasks or initiate the scheduled high rate SG blowdown until the system was instrumented.

A work order was generated to perform the troubleshooting (measure the input and output of the economizer valve signal characterizer module, SCM) based on guidance by the System Engineer. The System Engineer would personally direct the troubleshooting work order which would also require Shift Supervisor concurrence. It would also require that the associated parameter (i.e. the economizer valve) be placed in manual when connecting the recorder to the SCM.

Through discussions with the System Engineer and the Instrument and Control (I&C) Supervisor (utility, non-licensed), it was decided to

utilize a standard four-channel Gould recorder for troubleshooting. However, due to mechanical problems with the recorder, it could not be used. After further discussions between I&C personnel and the System Engineer it was determined to use an eight-channel digital recorder.

The digital system recorder was obtained from Measuring and Test Equipment (M&TE) with prefabricated cables which included triaxial connectors, coaxial wire, coaxial signal wire connector, and individual wires for connection to the system.

At approximately 1830 MST on February 15, 1989, the eight-pen

Digital Recorder System was connected to the number 1 FWCS. The digital recorder has an internal circuit wherein the inner shields of the triax connectors are connected together. This is different than the standard four-channel recorder and was not recognized by the System Engineer present or the I&C Technician (utility, non-licensed). This resulted in the SCM for SG number 1 economizer valve being shorted from input to output through the recorder. With a reasonably stable SG level, the internally cross-connected recorder had very little impact on the master controller output (i.e. the resulting program was very close to the required program). The System Engineer was present for the installation of the recorders as required by the work order.

The recorder was then connected to FWCS number 2. This resulted in cross-connecting the inputs and outputs of both SCMs for SGs number 1 and 2. The effect of tying the two FWCSs together was not observed until the SG 2 economizer valve was returned to automatic control. The Control Room Operator observed SG 2 level increasing abnormally and, at about 70 percent NR, placed the economizer valve in manual. By manually decreasing the controller output he was able to turn the level rise and return level to its normal range (55 percent NR). The recorder was then removed from FWCS number 2 and the economizer valve controller was returned to automatic. Proper automatic SG level control of both FWCSs was observed. There was no abnormal response on number 1 FWCS.

The Shift Supervisor called the Operations Manager (utility, licensed) and described the event. Based on the fact that the recorder had apparently functioned properly on number 1 FWCS the Operations Manager directed the Shift Supervisor to consult the Lead System Engineer (utility, non-licensed) and to leave the recorder installed in SG1 FWCS if the Lead System Engineer concurred. The recorder had been connected to FWCS number 1 for about 9 hours prior to the event and the FWCSs appeared to be functioning normally in the automatic mode during this time.

Prior to the reactor trip on February 16, 1989 at approximately 0345 MST, the Control Room received several alarms (ALM)(IB) including condensate pump (P)(SD) strainer (STR)(SD) Hi DP alarms and FWCS Trouble alarms. The condensate pump strainer Hi DP alarms were concurrent with the perturbation in the feedwater system when the number 1 economizer valve closed.

The Secondary Operator (utility, licensed), Shift Supervisor (utility, licensed), and Primary Operator (utility licensed) positioned themselves at Main Control Boards (CBD) B05 and B06 to evaluate the situation. The Secondary Operator, Shift Supervisor, and Primary Operator observed both SG levels decreasing rapidly with level in SG number 1 decreasing below NR indication. Both master controller outputs were observed to be cycling full scale with one to two second intervals. The feed pumps and number 2 SG economizer control valve followed the oscillations of the number 1 SG FWCS but at a slower rate due to FWCS lead/lag circuits and the physical abilities of the mechanical devices to respond to electronic signals. Immediately prior to reactor trip, Control Room personnel observed continued decreasing levels in SG number 1, the SG number 1 economizer valve was fully closed, and the SG number 2 economizer valve was 10 percent open. The Secondary Operator observed that the SG number 1 economizer control valve manual/auto controller demand signal was zero and prepared to open the number 1 SG economizer control valve manually in an attempt to restore SG number 1 level. The Secondary Operator took manual control of the SG number 1 economizer valve, and opened the valve to mitigate the underfeed situation that was in progress.

While the Secondary Operator was attempting to manually open the SG number 1 economizer valve, the reactor tripped. This occurred 27 seconds after the initial secondary disturbance was noted. At the time of the trip, the Secondary Operator had manually inserted an approximately 17 percent open demand signal to the number 1 SG economizer control valve. Three seconds after the trip, TDAS indicated that the SG number 1 economizer control valve was 17 percent open. The CRS diagnosed the initial event correctly and the appropriate recovery procedure 42RO-2ZZ05, Loss of Feedwater, was implemented.

At approximately 0345 MST approximately 14 seconds after the reactor trip, an AFAS for SG number 1 was generated due to low low SG number 1 level. The AFAS 1 was a result of SG level "shrink" from the reactor trip and from the excessive main feedwater flow. The AFAS signal was generated as designed and the Auxiliary Feedwater system performed its intended function.

The Control Room Supervisor (CRS)(utility, licensed) directed

the Control Room Operators to monitor plant safety functions. The Secondary Operator began his post trip safety function monitoring actions as required. The Secondary Operator verified proper response of the Auxiliary Feedwater System. During the monitoring of the plant safety functions, the Secondary Operator did not take actions to either restore the economizer control valve controller to auto or to manually close the valve to prevent the cooldown. The Shift Supervisor noted that the level in SG number 1 was increasing but was unaware that the SG number 1 economizer valve was not closed. When SG number 1 level was at approximately 65 percent WR, the Shift Supervisor directed the Secondary Op
rator to throttle
auxiliary feedwater flow to decrease steam generator feedwater flow.

Following the reactor trip, number 1 SG level continued to increase due to the number 1 SG economizer valve being 17 percent open. The number 1 economizer valve being in manual defeated the Reactor Trip Override (RTO) automatic controls for the SG number 1 economizer control valve and the valve remained open. Normally following a reactor trip, an RTO of the FWCS occurs to provide initial control of the SG level and limit the Reactor Coolant System (RCS)(AB) cooldown. The RTO logic (which is a non-safety related system) is designed to close the economizer valves, set the Main Feedwater Pump Turbines (MFWPTs) to minimum speed, and control downcomer valves to maintain SG level. When SG level increases above the RTO reset level, FWCS control is transferred to single element control for maintaining SG level.

As a result of the economizer valve in manual, the RTO logic was defeated and excessive feedwater occurred. The resulting overfeeding of the SG caused a cooldown of the primary system. At approximately 0345 MST a SIAS/CIAS, was generated due to overcooling of the primary system.

The SIAS/CIAS setpoints are selected to assure adequate makeup of RCS coolant in the event of a loss of RCS inventory, The volumetric decrease in the RCS liquid, due to the cooling, results in a pressure reduction similar in nature to a loss of inventory. The High Pressure Safety Injection (HPSI)(BQ) pumps responded as required. The design response for SIAS at high pressure is for the HPSI pumps to inject as they did in this event. The HPSI pumps started due to the SIAS and responded properly to inject water into the RCS to restore RCS pressure

and pressurizer level. The Safety Injection (SI) system, as well as charging pumps, repressurized the RCS. The SIAS actuation was verified to have occurred per design during the resetting of the SIAS actuation. The CIAS also was

verified to have provided containment isolation per design.

With the number 1 SG economizer valve still in manual, overriding the RTO trip logic, the SG continued to fill. At approximately 0347 MST, an MSIS was received at 91 percent NR in SG number 1. The MSIS isolated main feedwater which terminated the RCS cooldown.

At approximately 0352 MST on February 16, 1989, the Shift Supervisor declared a Notification of Unusual Event (NUE). The NUE was declared pursuant to EPIP-02 (Emergency Classification) as a result of the initiation of a SIAS on low pressurizer pressure. At approximately 0400 MST on February 16, 1989 the appropriate state and local agencies were notified via the Notification and Alert Network (NAN). The Nuclear Regulatory Commission (NRC) Operations Center was notified at approximately 0444 MST on February 16, 1989. The actions of EPIP-02 were performed in a timely manner. Stable conditions were achieved and the NUE was terminated at 0449 MST on February 16, 1989. The NUE was reported in Special Report 2-SR-89-002.

The STA was notified and responded to the control room. The CRS did not direct the STA to perform Appendix BB per 42EP-2ZZ01, Emergency Operation. This was contrary to an approved procedure. Consequently, Appendix BB was not performed. Normally the Duty STA will initiate Appendix BB following a reactor trip without CRS direction.

The control room staff stabilized the plant and directed efforts towards resetting ESFAS actuations per the appropriate procedures.

Following plant stabilization, the STA completed an Event Notification Worksheet which was reviewed by the Shift Supervisor. A notification to the NRC via the Emergency Notification System (ENS) phone was made by the STA. Initial observations by the Control Room staff indicated that there was a problem with the actuation of the "A" Essential Chiller

following the SIAS. The initial notification via the ENS stated that all ESF equipment operated correctly. Based on the information available at the time of the call, the information relayed to the NRC by the STA was not accurate (i.e. that the chiller did not appear to automatically start as designed). A follow-up call was made by Compliance (utility, non-licensed) to the NRC via the ENS phone stating that "the "A" Essential Chiller did not start automatically. However, a control room operator manually started the "A" Essential Chiller successfully." Subsequent evaluation has determined that the "A" Essential Chiller did function as designed in that the automatic start was concurrent with the operator's attempt to manually start the "A" Essential Chiller.

During the course of the event, the RCP Vibration readings required to be taken at 0400 were missed. A review was made of the on-line Bently-Nevada vibration monitoring data during the time frame that the readings were missed and no abnormalities were noted in RCP vibration. The control room staff's work load at the time of the missed readings was the major cause of the deficiency.

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

Not applicable - no structures, systems, or components were inoperable at the start of the event that contributed to the event.

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

Not applicable - there were no component or system failures.

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

Not applicable - no failed components were involved.

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

Not applicable - no failed components were involved.

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

Not applicable - no safety systems were rendered inoperable.

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

The Primary Operator was unsuccessful in shutting down the Essential Chiller on the first attempt because of procedural inadequacy in Emergency Procedure 42EP-2ZZ01. The procedure did not provide sufficient guidance to ensure that all required actions were taken prior to securing the essential chillers.
In this case, the diesel generators must be shutdown prior to securing the essential chiller.

I. Cause of Event:

Reactor Trip

The cause of the reactor trip and AFAS was a malfunction of the number 1 steam generator economizer valve. Debris in the pneumatic positioner of the number 1 SG economizer valve initiated the erratic behavior of the FWCS. This was also the cause of the transient encountered on February 13, 1989. A small amount of debris, approximately 10 mils in diameter (by microscopic examination), was present in the restrictor on the vertical relay within the Fisher Pneumatic Positioner Model 3570 on the SG #1 economizer valve. This would have prevented the valve from operating properly. The manufacturer concurs in this evaluation.

The number 1 economizer valve exhibited erratic pneumatic relay operation during testing conducted after the event. I&C personnel observed that the valve initially opened nominally, but as the open demand increased the valve slowly drifted closed by itself (i.e. the valve closed fully with a 75 percent open demand).

The debris was evaluated in an attempt to determine its source. The debris appearance was not that of "desiccant" but looked to be representative of a metal particle. The overall instrument air system is currently under monitoring activities associated

with generic letter 88-14 and has been demonstrated to meet ANSI standards for instrument air system. Further analysis of the debris can not be performed as the particle was lost due, presumably, to normal air movements during the examination process.

Additionally, the inlet filter on the pneumatic regulator for the number 1 SG economizer valve was examined and no indications of contaminants were identified. This regulator is on a branch line immediately before the number 1 SG economizer valve positioner.

Other investigations of the FWCSs (calibration checks, physical inspection, and testing) found no deficiencies. Testing was also performed on the FWCSs Reactor Trip Override (RTO)(JB) circuit which verified proper operation.

The event was compounded by improper installation of the recorder leads due to a personnel error on the part of the I&C Technician (utility, non-licensed) and the System Engineer (utility, non-licensed). The leads cross-connected the input to the output of the SCM as described in Section I.B. The improper installation of the recorder equipment compounded the February 16, 1989 transient by rendering the number 1 FWCS master controller output inoperable during a portion of the event. During subsequent

testing with the digital recorder connected across the economizer valve SCM (i.e., input to output shorted) and with representative input values, it was found that the master control output would "clamp" to zero. The "clamping" would remain in place until an i
terruption of either the input or
output of the master control occurred.

The number 1 economizer valve slowly closing caused both FWCS master controller outputs to oscillate in an attempt to control level. During this period, the number 1 FWCS master controller output reached an output value low enough to cause the recorder to "clamp" the output to zero. Since the number 1 FWCS master controller was "clamped", the number 1 economizer valve received a zero signal and number 1 MFWP was controlled by the number 2 FWCS master controller. An auctioneer circuit for the MFWP selects the highest signal for either the number 1 or 2

FWCS master controller (except during RTO).

SG number 2 feedwater flow increased (due to increased feed pressure) as number 1 economizer valve closed. FWCS number 2 responded by reducing both feedwater pump speeds and repositioning number 2 economizer valve. The number 2 FWCS master controller responded properly to this event by controlling pump speed and number 2 economizer valve position to maintain SG number 2 level.

CIAS/CIAS and MSIS

The cause of the SIAS/CIAS and MSIS was an overfeeding to the number 1 SG due to the number 1 economizer valve being left in manual at 17 percent open and the excessive feedwater header pressure due the "B" MFWP being in manual at a high speed setting (5450 rpm vice approximately 3800 rpm for this condition). The "B" MFWPT controller was transferred to manual just prior to the reactor trip. Members of both operating crews, the offgoing and the oncoming, were interviewed in an attempt to determine when 'B' MFWP was placed in manual. None of the individuals interviewed could recall placing the pump speed controller in manual.

PVNGS determined that the pump went to manual 8 seconds prior to the reactor trip. As indicated by the TDAS plots, the pump speed was tracking feedwater control system demand until 8 seconds prior to the trip.

Several different items were investigated to see if there was any other mechanism that could have caused the MFWP to shift to manual. The only mechanism identified would be a momentary loss of power on the shift during the fast bus transfer. It is concluded that a loss of power did not occur based on the fact that the same

power supply is shared by both feed pumps and the 'A' MFWP stayed in automatic. In addition, the manual/auto controller will not revert to manual unless power is lost for greater than 1 second. PVNGS has concluded that the manual pushbutton was inadvertently depressed at the time indicated.

In response to the initial transient, both feedwater pumps followed the demand signal from FWCS number 2. During RTO, the

control for the MFWP is shifted to its applicable FWCS master controller versus going through the auctioneering circuit.
After the trip, the 'A' MFWP speed decreased to 3670 rpm as designed due to the RTO logic. However, the 'B' MFWP remained at high speed as a result of being in manual.

Both FWCSs entered the RTO mode. FWCS number 1 master controller was still "clamped" low at this time. FWCS number 2 master controller functioned as required; however, the 'B' MFWP was in manual and remained at high speed as designed. The number 2 downcomer valve immediately responded to the RTO by opening due to the average RCS temperature being above the setpoint and subsequently responded properly thereafter. The economizer valve went closed as designed.

FWCS number 1 master controller output was "clamped" at the onset of the transient but became "unclamped" as the FWCS number 1 came out of RTO when SG number 1 level increased to 52 percent prior to the MSIS. At that time, resetting RTO caused the master controller output to control the number 1 downcomer valve as designed.

Transient information was provided to I&C Engineering for an independent assessment. Additionally, the vendor design engineer (contractor, non-licensed) for the FWCS and a vendor system design engineer (contractor, non-licensed) were involved in the analysis at PVNGS. The vendor of the FWCS electronic modules was also consulted.

The economizer valve left approximately 17 percent open and the 'B' MFWP controller in manual added to the severity of the cooldown transient and subsequently caused an MSIS actuation to occur which further complicated recovery operations. This was a cognitive personnel error in that the control room personnel did not recognize actual plant conditions and was contrary to procedural guidance.

There were no unusual characteristics of the work location (i.e. Control Room) except the addition of various alarms which annunciated and the rapid pace of events which occurred. However, simulator training and emergency procedures are adequate to provide

operators with experience to compensate for these conditions.

During recovery operations an auxiliary feed flow indicator