LICENSEE EVENT REPORT (LER)

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

TITLE (4) Potential Safety-Related Equipment Problems Due to Degraded Grid Voltage

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

OPERATING MODE (9): 1

POWER LEVEL (10): 1 0 0

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

[ ] 20.402(b)	[ ] 20.405(c)	[ ] 50.73(a)(2)(iv)	[ ] 73.71(b)
[ ] 20.405(a)(1)(i)	[ ] 50.36(c)(1)	[ ] 50.73(a)(2)(v)	[ ] 73.71(c)
[ ] 20.405(a)(1)(ii)	[ ] 50.36(c)(2)	[ ] 50.73(a)(2)(vii)	[X] OTHER *(Specify in Abstract below and in Text, NRC Form 366A)*
[ ] 20.405(a)(1)(iii)	[ ] 50.73(a)(2)(i)	[ ] 50.73(a)(2)(viii)(A)	
[ ] 20.405(a)(1)(iv)	[ ] 50.73(a)(2)(ii)	[ ] 50.73(a)(2)(viii)(B)	
[ ] 20.405(a)(1)(v)	[ ] 50.73(a)(2)(iii)	[ ] 50.73(a)(2)(x)	Voluntary Report

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER (AREA CODE)	
B. A. Grabo, Supervisor, Nuclear Regulatory Affairs	6 0 2	3 9 3 – 6 4 9 2

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

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

SUPPLEMENTAL REPORT EXPECTED (14)

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

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

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

On December 19, 1992, at approximately 1300 MST, Palo Verde Units 1, 2, and 3 were in Mode 1 (POWER OPERATION), operating at approximately 100 percent power when APS Engineering personnel identified that preliminary auxiliary power system calculations indicated that with the switchyard voltage at its design basis minimum of 95 percent of 525 kV and with the startup transformer secondary winding fully loaded at its rated capacity of 70 MVA, downstream voltages could be less than the Class 1E 4.16 kV bus undervoltage relay setpoints. This scenario would result in shedding of Class 1E 4.16 kV loads and automatically starting and sequentially loading the emergency diesel generators (EDG). Additional preliminary analysis completed on January 14, 1993 indicated that it may be possible to have substandard voltages on the Class 1E 480 V power system, with the switchyard voltage between 95 and 100 percent and with the startup transformer secondary winding fully loaded at its rated capacity of 70 MVA, without actuation of the Class 1E 4.16 kV bus undervoltage relays nor load shed and EDG start. An investigation of this condition was initiated to develop recommendations for interim corrective actions and final resolution to ensure that plant vulnerability to these scenarios was minimized. No determinations have been made that any components would fail to perform their safety function(s). However, there exists some probability that components could fail due to low voltage. As an immediate corrective action, switchyard voltages were administratively maintained between 100 to 102.5 percent. There have been no previous similar events reported pursuant to 10CFR50.73.

I. DESCRIPTION OF WHAT OCCURRED:

A. Initial Conditions:

At 1300 MST on December 19, 1992, Palo Verde Units 1, 2, and 3 were in Mode 1 (POWER OPERATION), operating at approximately 100 percent power. On January 14, 1993, Palo Verde Units 1, 2, and 3 were in Mode 1, operating at approximately 100 percent power.

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

Event Classification: Voluntary LER.

At approximately 1300 MST on December 19, 1992, during the Electrical Design Basis Reconstitution effort, APS Engineering personnel (utility, non-licensed) identified that preliminary auxiliary power system calculations indicated that with the switchyard (FK) voltage at its design basis minimum of 95 percent of 525 kV and with the startup transformer (EA) (XFMER) secondary winding fully loaded at its rated capacity of 70 MVA, downstream voltages could be less than the Class 1E 4.16 kV bus (EB) undervoltage relay setpoints. This scenario would result in shedding of Class 1E 4.16 kV loads and automatically starting and sequentially loading the emergency diesel generators (EDG) (EK). Additional preliminary analysis completed on January 14, 1993 indicated that it may be possible to have substandard voltages on the Class 1E 480 V power system (ED), with the switchyard voltage between 95 and 100 percent and with the startup transformer secondary winding fully loaded at its rated capacity of 70 MVA, without actuation of the Class 1E 4.16 kV bus undervoltage relays nor load shed and EDG start [NOTE: The Palo Verde Electrical Distribution System (EDS) is described in Section V. ADDITIONAL INFORMATION]. An investigation of this condition was initiated in accordance with the APS Incident Investigation Program to develop recommendations for interim corrective actions and final resolution to ensure that plant vulnerability to these scenarios was minimized. No determinations have been made that any components would fail to perform their safety function(s). However, there exists some probability that components could fail due to low voltage. As an immediate corrective action, switchyard voltages were administratively maintained between 100 to 102.5 percent.

Per the Updated Final Safety Analysis Report (FSAR) 8.3.1.1.3.13 and the PVNGS Safety Evaluation Report (SER) (NUREG-0857) and its supplements (SER Section 8.4.7 Adequacy of Station Electric Distribution System Voltages), the PVNGS Electrical Distribution

System (EDS) design provides for two redundant and independent emergency buses (Class 1E 4.16 kV), and each bus has the following two levels of undervoltage protection: (1) loss of power (LOP) and (2) degraded grid voltage. Since the Class 1E motors for the PVNGS design are specified to start and accelerate loads (e.g., fan or pump) at 75 percent of the rated voltage and to operate continuously at 90 percent of the rated voltage, any bus voltage that falls between 78 and 90 percent for long time periods is considered a degraded voltage. The scheme for the first level of protection (i.e., LOP) consists of four induction disc undervoltage relays for each of the two Class 1E 4.16 kV buses for each unit. The induction disc undervoltage relays are set at 78 percent of the design voltage with an 11.4 second time delay. For each Class 1E 4.16 kV bus, the four induction disc undervoltage relays will generate a loss-of-voltage signal using two-out-of-four logic. This protection alone does not protect the plant loads from damaging low voltages which are maintained above this setpoint. The second level of undervoltage protection (i.e., degraded grid voltage) is provided by instantaneous undervoltage definite-time relays connected in parallel with each of the induction disc undervoltage relays. The instantaneous undervoltage relays are set at 90 percent of the design voltage with a time delay of 35 seconds to avoid spurious trips due to short duration transients, such as those occurring when starting large motors. The instantaneous undervoltage relays will also generate a trip signal using two-out-of-four logic. The objective is to ensure that a degraded voltage condition will not adversely affect the Class 1E equipment or prevent Class 1E equipment from performing their safety function (e.g., starting and running) in response to a design basis event.

In addition, the SER provided for the Class 1E buses to be optimized for the full load and minimum load conditions by the adjustment of the voltage tap settings on the transformers (TTC). The EDS was analyzed to determine optimum safety-related bus voltages when operating from the grid through the startup transformers. The analysis considered variations in switchyard voltages along with maximum and minimum expected plant load on the 4.16 kV and the 480 V power systems. The results of these analyses demonstrated that all Class 1E loads were capable of being started and continuously operated over the expected grid voltage range. In addition, a criterion for setting of the Class 1E load center transformer taps was accepted. A precedent was set to adjust the taps until the voltage to Class 1E 480 V electrical equipment fell within a specified range.

In response to the Electrical Distribution System Functional Inspection (EDSFI), an Electrical Design Basis Reconstitution

effort was undertaken to upgrade and reverify the voltage regulation calculations. Preliminary auxiliary power system calculations performed by APS Engineering personnel indicated that with the switchyard voltage at its design basis minimum of 95 percent of 525 kV (per the Updated FSAR 8.3.1.1.3) and with the startup transformer secondary winding fully loaded at its rated capacity of 70 MVA [i.e., a main turbine (TA) trip with a successful fast bus transfer or after the manual transfer of house loads to the startup transformer], the startup transformer secondary output voltages may be less than 90 percent of 13.8 kV. In addition, cable and transformer impedances downstream of the startup transformer would further reduce available bus voltage, resulting in downstream voltages that could be less than the Class 1E 4.16 kV bus undervoltage relay setpoints. This scenario would result in shedding of Class 1E 4.16 kV loads and automatically starting and sequentially loading the EDGs.

Additional preliminary analysis completed on January 14, 1993 indicated that it may be possible to have substandard voltages on the Class 1E 480 V power system, with the switchyard voltage between 95 and 100 percent and with the startup transformer secondary winding fully loaded at its rated capacity of 70 MVA, without actuation of the Class 1E 4.16 kV bus undervoltage relays nor load shed and EDG start. Cable and load center transformer impedances downstream of the engineered safety features (ESF) service transformers (EB) would further reduce available bus voltage, resulting in the potential for the Class 1E 480 V buses to be less than 90 percent of rated voltage without a Class 1E 4.16 kV bus undervoltage trip occurring. This scenario would result in the safety-related equipment powered from the Class 1E 480 V buses to be subject to operating below the 90 percent voltage specified for minimum continuous operation.

The scenario for the potential deficiency on the Class 1E 480 V power system requires three specific conditions to be in effect concurrently. The first condition is that the switchyard voltage must be below its nominal value of 525 kV. The second condition is that the startup transformer secondary winding must be fully loaded at or near its rated capacity of 70 MVA. This would be expected to occur during a main turbine trip with a successful fast bus transfer or a manual transfer of house loads to the startup transformer. If this is the case, the startup transformer secondary output may be providing a substandard voltage to the Class 1E 4.16 kV power system. And finally, assuming that the Class 1E 4.16 kV undervoltage relay did not actuate, did not load shed, and did not start or load the EDG on the bus, and assuming that the Class 1E 4.16 kV output is providing substandard voltages to the Class 1E 480 V power system, the third condition is that

TEXT

the Class 1E 480 V loads are called upon to function (e.g., ESF-actuated (JE) equipment attempts to load onto the Class 1E 480 V bus as a result of an ESFAS signal).

Since the Class 1E motors for the PVNGS design are specified to start and accelerate loads (e.g., fan or pump) at 75 percent of the rated voltage and to operate continuously at 90 percent of the rated voltage, any bus voltage that falls between 78 and 90 percent for long time periods is considered a degraded voltage. Operation of the ESF-actuated equipment with the voltage only slightly below 90 percent would not be expected to prevent all ESF-actuated equipment from performing their intended safety function(s). In addition, Control Room personnel could mitigate the consequences of the undervoltage condition by starting and loading the EDG in emergency mode, manually closing the breaker if the EDG had already started in response to an ESFAS signal, or taking other appropriate action in response to Control Room annunciation.

An investigation of this condition was initiated in accordance with the APS Incident Investigation Program to develop recommendations for interim corrective actions and final resolution to ensure that plant vulnerability to these scenarios was minimized. No determinations have been made that any components would fail to perform their safety function(s). However, there exists some probability that components could fail due to low voltage. As an immediate corrective action, switchyard voltages were administratively maintained between 100 to 102.5 percent. A Voltage Regulation Assessment which compared original, interim, and present design calculations was completed in October 1993. The latest revision of the investigation was submitted in November 1993. Because of the potential adverse effects on the Class 1E systems and the potential safety-related equipment problems due to degraded grid voltage, APS is submitting this information-type LER (i.e., voluntary LER). Although there have been no 10CFR50.73 reporting requirements identified, APS believes that the information provided in this voluntary LER merits disclosure to the nuclear industry.

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 which contributed to this event.

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

Not applicable - no component or system failures were involved.

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

Not applicable - no component failures were involved.

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

Not applicable - no failures of components with multiple functions were involved.

G. For a failure 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 failures that rendered a train of a safety system inoperable were involved.

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

Not applicable - there have been no component or system failures or procedural errors identified. There were no procedural errors which contributed to this event.

I. Cause of Event:

An independent investigation of this event was initiated in accordance with the APS Incident Investigation Program to develop recommendations for interim corrective actions and final resolution to ensure that plant vulnerability to these scenarios was minimized.

The underlying condition of "voltage spread" is inherent to systems with high voltage inputs and relatively low voltage distribution coupled with variations in the switchyard voltage of 5 percent or more. Optimization of bus voltages has been an ongoing issue since 1983. Tap settings which resolve undervoltage conditions during low switchyard voltages and heavy loads create a vulnerability to overvoltage conditions during high switchyard voltages and light loads. This predicament has existed since the initial design commitments to accommodate anticipated switchyard voltage variations from 95 to 102.5 percent (Updated FSAR 8.3.1.1.3). The evaluation determined that the potential for

TEXT

safety-related equipment problems due to degraded grid voltage exists because the original EDS design did not fully address the properties of voltage spread (SALP Cause Code B: Design, Manufacturing, Installation Error). Specifically,

1. Configuration control of transformer tap settings was not auditable. Changes in transformer tap settings must be supported by analysis which indicate acceptable results at minimum switchyard voltage with maximum load and maximum switchyard voltage with minimum loads for the specific tap settings.

2. The minimum loading conditions originally used in analysis were greater than actual plant operating experience has indicated.

3. The maximum loading conditions used in the previous analyses were less than those used in the current analysis. Actual plant operating experience and current industry practice support the current analysis.

4. The anticipated switchyard variance is greater than the system design could accommodate and still provide acceptable EDS voltage spread characteristics.

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

J. Safety System Response:

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

K. Failed Component Information:

Not applicable - no component failures were involved.

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

On January 15, 1993, a special meeting of the Plant Review Board (PRB) was held to discuss the potential undervoltage condition (i.e., supplying substandard voltage to the energized ESF equipment under certain conditions). The PRB determined that with the administrative corrective actions in place (reference Section III.A), the EDS was operable and capable of performing its intended function, that continued

TEXT

operation of the three units would not involve an unreviewed safety question, and that the corrective actions were sufficient to ensure continued safe operation of the units. A subsequent probabilistic risk assessment confirmed this determination.

In subsequent meetings, the PRB members asked whether any safety-related equipment would be damaged if grid voltage dropped below 100 percent and an accident occurred concurrently. Cognizant APS Engineering personnel stated that no determinations have been made that any components would fail to perform their safety function due to low voltage (i.e., unable to operate under degraded electrical conditions). However, there is some probability that components could fail due to low voltage. Some equipment has never been operated in the worst case conditions that would be outside the rating of the motor. Since the Class 1E motors for the PVNGS design are specified to start and accelerate loads (e.g., fan or pump) at 75 percent of the rated voltage and to operate continuously at 90 percent of the rated voltage, any bus voltage that falls between 78 and 90 percent for long time periods is considered a degraded voltage. Operation of the ESF-actuated equipment with the voltage only slightly below 90 percent would not be expected to prevent all ESF-actuated equipment from performing their intended safety function(s). In addition, Control Room personnel could mitigate the consequences of the undervoltage condition by starting and loading the EDG in emergency mode, manually closing the breaker if the EDG had already started in response to an ESFAS signal, or taking other appropriate action in response to Control Room annunciation.

The event did not result in any challenges to the fission product barriers or result in any releases of radioactive materials. This event did not adversely affect the safe operation of the plant or the health and safety of the public.

III. CORRECTIVE ACTION:

A. Immediate:

An investigation of this condition was initiated in accordance with the APS Incident Investigation Program to develop recommendations for interim corrective actions and final resolution to ensure that plant vulnerability to these scenarios was minimized. As an immediate corrective action, switchyard voltages were administratively maintained between 100 to 102.5 percent. In addition, for the first quarter of 1993, the PRB remained cognizant of the potential undervoltage condition and served in the oversight capacity.

TEXT

B. Action to Prevent Recurrence:

Actions to prevent recurrence were developed based upon the results of the investigation and are being tracked to completion under the PVNGS Commitment Action Tracking System. The actions to date include raising the tap settings at the Class 1E load centers for all three units, initiating an Updated FSAR change to narrow the range of anticipated switchyard voltage, replacing the undervoltage relays with solid-state relays to improve tolerance characteristics, and completing the EDS calculation.

IV. PREVIOUS SIMILAR EVENTS:

No other previous events have been reported pursuant to 10CFR50.73.

V. ADDITIONAL INFORMATION:

THE PALO VERDE ELECTRICAL DISTRIBUTION SYSTEM (EDS) DESCRIPTION

The Non-Class 1E 13.8 kV power system (EA) receives off-site power from the 525 kV switchyard (FK) on one set of buses and, on a separate set of buses, power from the unit auxiliary transformer (TB). The startup transformers (NAN-X01, NAN-X02, and NAN-X03) convert the 525 kV offsite power to the Non-Class 1E 13.8 kV power. The startup transformers have two secondary windings each rated at 13.8 kV and 42/56/70 MVA. The secondary windings are sized to start and carry half of the auxiliary loads of one unit and two trains of ESF loads, one which is from another unit. The Non-Class 1E 13.8 kV power system supplies power to Non-Class 1E 13.8 kV loads [e.g., reactor coolant pump (AB) motors and circulating water pump (KE) motors], the Technical Support Center, Emergency Operations Facility, and UPS buildings, the Non-Class 1E 4.16 kV power system (EA), the Non-Class 1E 480 V power switchgear load center system (EC), and the Class 1E 4.16 kV power system (EB).

The Class 1E 4.16 kV power system distributes the electrical power received from offsite or onsite sources to safety related loads and to selected loads that are important to the plant. The Class 1E 4.16 kV power system receives preferred offsite power through two ESF service transformers (NBN-X03 and NBN-X04) or standby power from two emergency diesel generators. The ESF service transformers (NBN-X03 and NBN-X04) convert the Non-Class 1E 13.8 kV preferred offsite power to the Class 1E 4.16 kV power, with each transformer furnishing one Class 1E load group. Load Group 1 (PBA-S03 bus) supplies safety Train A and Load Group 2 (PBB-S04 bus) supplies safety Train B. The ESF service transformers are rated at 4.16 kV and 12.5 MVA. The Class 1E 4.16 kV power system supplies power to the safety injection pump (BP) motors and the shutdown

LICENSEE EVENT REPORT (LER) TEXT CONTINUATION

FACILITY NAME	DOCKET NUMBER	LER NUMBER YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	PAGE
Palo Verde Unit 1	0 5 0 0 0 5 2 8	9 3	— 0 1 1 —	0 0	1 0 OF 1 1

TEXT

cooling system (BQ), essential spray pond (BS) pump motors, essential cooling water (BI) pump motors, auxiliary feedwater (BA) pump motors, chilled water (KM) pump motors, essential chilled water (KM) pump motors, the Class 1E 480 V load centers (ED), and the Non-Class 1E 4.16 kV - 480 V load centers (EC).

The Class 1E 4.16 kV power system receives control signals from the ESFAS system (JE), and in the case of a loss of power to the Class 1E 4.16 kV power system, generates the necessary output actuation signals to shed all Class 1E 4.16 kV loads, automatically start and sequentially load the EDGs. The standby generation Class 1E power system (EK) is capable of supplying the vital ESF loads necessary to reliably and safely shut down the affected unit.

The Class 1E 480 V power system includes both the 480 V load centers (ED) and the 480 V Class 1E motor control centers (ED). The load center transformers convert the Class 1E 4.16 kV power to the Class 480 V power and are rated at 480 V and 750 kVA. The Class 1E 480 V power system interfaces with and receives control signals from the ESFAS.

LICENSEE EVENT REPORT (LER) TEXT CONTINUATION

FACILITY NAME	DOCKET NUMBER	LER NUMBER: YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	PAGE
Palo Verde Unit 1	0 5 0 0 0 5 2 8	9 3	0 1 0	0 0	1 1 OF 1 1

TEXT