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RECIP.NAME RECIPIENT AFFILIATION

SUBJECT: LER 94-006-00:on 941006,declared train A inoperable due to class 1E batteries in degraded condition.Root cause of failure analysis is under investigation.Submitted proposed TS amend to spec 3/4.8.2.W/941121 ltr

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

192-00912-JML/BAG/BE
November 21, 1994

JAMES M. LEVINE
VICE PRESIDENT
NUCLEAR PRODUCTION

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
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Dear Sirs:

Subject: **Palo Verde Nuclear Generating Station (PVNGS)**
Unit 2
Docket No. STN 50-529 (License No. NPF-51)
License Event Report 94-004-00
File: 94-020-404

Attached please find Licensee Event Report (LER) 94-004 prepared and submitted pursuant to 10CFR50.73. This LER reports the identification of a condition that caused the Class 1E batteries to become inoperable. This LER was originally due to be submitted on November 4, 1994. On October 25, 1994, an extension until November 21, 1994, was granted by Howard Wong, Branch Chief, Reactor Projects (Telecon). In accordance with 10CFR50.73(d), a copy of this LER is being forwarded to the Regional Administrator, NRC Region IV.

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

Sincerely,

JML/BAG/BE/pv

Attachment

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

IE22

LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Palo Verde Unit 2	0 5 0 0 0 5 2 9	1 OF 1 2

TITLE (4)
Class 1E Batteries in a Degraded Condition

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

OPERATING MODE (9)	5	THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more of the following) (11)			
POWER LEVEL(10)	0	20.402(b)	20.405(c)	50.73(a)(2)(iv)	73.71(b)
		20.405(a)(1)(i)	50.36(c)(1)	50.73(a)(2)(v)	73.71(c)
		20.405(a)(1)(ii)	50.36(c)(2)	50.73(a)(2)(vii)	OTHER (Specify in Abstract below and in Text, NRC Form 366A)
		20.405(a)(1)(iii)	X 50.73(a)(2)(i)	X 50.73(a)(2)(viii)(A)	
		20.405(a)(1)(iv)	50.73(a)(2)(ii)	50.73(a)(2)(viii)(B)	
		20.405(a)(1)(v)	50.73(a)(2)(iii)	50.73(a)(2)(x)	

LICENSEE CONTACT FOR THIS LER (12)

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

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

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS
B	E J	B T R Y	A 6 2 6	Y					

SUPPLEMENTAL REPORT EXPECTED (14)		EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
X YES (If yes, complete EXPECTED SUBMISSION DATE)	NO		1 2	3 0	9 4

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

At approximately 2200 MST on October 7, 1994, Palo Verde Unit 2 was in Mode 5 (COLD SHUTDOWN), when Train A (battery banks A and C) was declared inoperable because a projection of the test results based upon anticipated degradation indicated that they did not meet the 90% criteria of Technical Specification Surveillance Requirement (TS SR) 4.8.2.1.e, rendering both trains of Class 1E batteries inoperable. Train B (battery banks B and D) was declared inoperable (on October 1, 1994) because the measured capacity was slightly less than the required 90% capacity stated in TS SR 4.8.2.1.e.

Subsequent investigation has determined that Train B had been slightly below the 90% capacity as required by TS SR 4.8.2.1.e since February 1, 1994. Since both trains of batteries are required in Mode 1, Unit 2 operated in a condition prohibited by the plant's TS until it shutdown and reached Mode 5 on September 18, 1994. This condition is being reported per 50.73(a)(i)(B).

The Equipment Root Cause of Failure Analysis (ERCFA) has not been completed to date. The investigation has narrowed the possibilities for the degraded capacity to either the manufacturing process or the quality control process during manufacturing. This manufacturing problem has potentially led to a single cause that caused both Class 1E battery trains to become inoperable. Therefore, a 50.73(a)(2)(vii) notification is also being made by this LER.

There have been no previously similar events reported pursuant to 10CFR 50.73.

TEXT

I. DESCRIPTION OF WHAT OCCURRED:

A. Initial Conditions:

At 2200 MST on October 7, 1994, Palo Verde Unit 2 was in Mode 5 (COLD SHUTDOWN) with Pressurizer pressure of 10 psia and a Main Coolant Temperature of 107°F.

B. Reportable Event Description:

Event Classification: Any operation or condition prohibited by the plant's Technical Specifications.

Any event where a single cause or condition caused at least one independent train or channel to become inoperable in multiple systems or two independent trains or channels to become inoperable in a single system designed to: A) Shut down the reactor and maintain it in a safe shutdown condition; B) Remove residual heat; C) Control the release of radioactive material; or D) Mitigate the consequences of an accident.

At approximately 2200 MST on October 7, 1994, Palo Verde Unit 2 was in Mode 5 (COLD SHUTDOWN), when Train A (battery banks A and C) was declared inoperable because a projection of the test results based upon anticipated degradation indicated that they did not meet the 90% criteria of Technical Specification Surveillance Requirement (TS SR) 4.8.2.1.e, rendering both trains of Class 1E batteries inoperable.

TEXT

Train B (battery banks B and D) had been declared inoperable on October 1, 1994 because the measured capacity was slightly less than the required 90% capacity stated in TS SR 4.8.2:1.e. TS SR 4.8.2.1.e, states the following in part:

At least once per 60 months, during shutdown, by verifying that the battery capacity is at least 80% (Exide) or 90% (AT&T) of the manufacturer's rating when subjected to a performance discharge test. This performance discharge test may be performed in lieu of the battery service test required by Surveillance Requirement 4.8.2.1d.

Subsequent investigation has conservatively determined that Train B had been slightly below the 90% capacity as required by TS SR 4.8.2.1.e since it was last tested on February 1, 1994. Since both trains of batteries are required in Mode 1, Unit 2 operated in a condition prohibited by the plant's TS until it shutdown and reached Mode 5 on September 18, 1994.

During the recent mid-cycle outage, Unit 2 was performing TS SR 4.8.2.1.e to satisfy the IEEE Standard 450-1980 requirement to capacity test new batteries within the first two years of service. On September 23, 1994, the test results for battery banks A and C were 91.6% and 90.6% respectively. While the test results met TS SR, the capacity of the battery banks were below what was expected. As a result, the B and D battery banks were capacity tested. On October 1, 1994, the B and D battery banks were declared inoperable because the measured capacity was slightly less than the required 90% capacity stated in TS SR 4.8.2.1.e.

As a result of this unexpected degradation, Electrical Maintenance Engineering (utility, non-licensed) performed an individual cell and battery capacity evaluation on previous tests of banks A, B, C, and D, factory tests, and additional testing on the Unit 2 spare cells.

TEXT

The evaluation concluded that the failure mechanism causes the batteries to degrade during the discharge/recharge cycle, therefore, the projections for battery capacity from this evaluation indicated that all four battery banks in Unit 2 were inoperable. Subsequently, on October 7, 1994, battery banks A and C were also declared inoperable because a projection of the test results based upon anticipated degradation indicated that they did not meet the 90% criteria of TS SR 4.8.2.1.e.

Based on this new information, a condition prohibited by the plant's TS has been identified. TS 3.8.2.1 requires that both trains of Direct Current (DC) sources be operable in Modes 1 through 4. Due to the fact that the degradation mechanism is related to discharge/recharge cycling of the batteries, APS has concluded that battery banks B and D were conservatively at 89.0% and 88.3% capacity respectively following the ST performed in February 1, 1994. Therefore, battery banks B and D have been slightly below the 90% capacity as required by TS SR 4.8.2.1.e since February 1, 1994. Unit 2 operated in Mode 1 with this condition until it shutdown for the September mid-cycle outage and was in Mode 5 on September 18, 1994.

On October 9, 1994, APS submitted a proposed TS amendment to Specification 3/4.8.2, DC Sources, under emergency circumstances.

APS has concluded that the failure mechanism causes the batteries to degrade during the discharge/recharge cycle and that the projected capacities of the banks following the last capacity discharge test are: 1) Bank A, 78.82%, 2) Bank B, 82.49%, 3) Bank C, 76.73%, and 4) Bank D, 81.75%. As such, all banks were above the calculated design minimum capacity of 55.22% at all times.

TEXT

The amendment asked for approval to suspend the requirements of TS 4.0.1 and 4.0.4 until entry into Mode 4 coming out of the fifth refueling outage or upon any deep discharge of the battery. On October 13, 1994, TS amendment 71 was approved by the NRC.

Therefore, on October 13, 1994, battery banks A, B, C, and D were declared operable.

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

As stated in Section I.B above, Train B (battery banks B and D) of the Class 1E batteries were inoperable since February 1, 1994. However, based on information at the time Train B was believed to be operable because of its capability to pass the surveillance test requirements.

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

On October 6, 1994, the three worst cells from Train B, battery bank D arrived at C&D Charter Power Services, Inc. (the manufacturer) for a root cause determination. This root cause effort is being overseen by APS with the participation of C&D, AT&T (the cell designer) and Failure Prevention International (FPI, consultant).

The three cells have undergone preliminary examination to exclude sudden loss of capacity as the potential cause of failure. The three sudden failure modes are 1) open or near open circuit, 2) low impedance short circuit, and 3) massive contamination of electrode active material. Tear down of three cells revealed some signs of poor workmanship, but there was no evidence that the diminished capacity is attributable to physical damage of the cell internal components.

The cell examinations also ruled out sudden loss of capacity (due to item 1 or 2 as stated above) as a failure mode for these particular cells.

TEXT

Chemical analysis of the electrolyte and the plate's active material has ruled out massive contamination (item 3 as stated above). It was, therefore, concluded that for this cell the failure mode would be a step decline in capacity due to an active material utilization problem during the discharge/recharge cycle. APS, with concurrence from AT&T and FPI, has concluded that the discharge behavior is not indicative of a sudden discharge type failure.

Currently, the Equipment Root Cause of Failure Analysis (ERCFA) is focusing on the possibility of manufacturing problems or quality controls problems during the manufacturing process.

The ERCFA team has identified that the loss of capacity is a result of "PbO_2 grain isolation" (a reduction of active material utilization due to a loss of electronic contact between the PbO_2 grains themselves within the plate and/or between the grains and the grid). The most likely cause for this isolation can be attributed to improper curing of the positive plates during manufacturing. Chemical and microscopic analyses have been performed on samples of plates from both failed and "good" cells. The results of the analyses are still being evaluated, but no evidence has been found which would invalidate the PbO_2 isolation mechanism.

Degradation of the battery appears to be manifested during the second hour of the two hour capacity discharge test, or, in other words, the last 530 ampere-hours of the 1060 ampere-hour test. This is evident when reviewing the discharge test curves for the batteries. The actual load profile demand for the A battery channel over a two hour period only removes approximately 423 ampere-hours. If a plant demand of only 423 ampere-hours had occurred on the B and D battery from February thru October 1, 1994, Engineering believes the batteries would have behaved similar to a 100% capacity battery because only 423 ampere-hours would have been removed during the two hour demand.

TEXT

As part of the ERCFA Electrical Maintenance Engineering evaluated the capacity discharge testing at PVNGS. The following conservatism's were noted:

During capacity discharge testing at PVNGS, an extra 5 amperes were added to the required load current to be conservative for any possible tolerances in test equipment.

These extra 5 amperes results in the battery capacity to measure approximately 1% less than it would measure without the extra 5 amperes.

The capacity tests up thru October 1, 1994, were performed using the original AT&T two hour rating of 530 amperes. The new two hour AT&T rating for the same battery is now 514 amperes. Thus, if the B and D batteries had been discharged tested at the new rating of 514 amperes, the battery capacity would have measured approximately 4% better.

In summary, the extra 5 amperes added for test equipment tolerances and use of the old 530 ampere rating for two hours on the AT&T cells account for the B and D batteries performing approximately 5% less in capacity on October 1, 1994, than they would have performed otherwise. Thus, the actual capacity test on October 1, 1994, would have expected to measure approximately 5% better if they were tested at the new 514 ampere rating and the extra 5 amperes not added.

Further examination and testing will be performed to determine the cause of failure. A supplement to the LER will be made when a root cause of failure has been determined.

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

The cause of failure has not been finalized.

However, APS had determined through testing that the degradation mechanism is related to loss of positive plate activity which is aggravated by the discharge/recharge cycling of the batteries as discussed in Section I.D.

APS has concluded that the failure mechanism causes the batteries to degrade during the discharge/recharge cycle and that the projected capacities of the banks following the last capacity discharge test are: 1) Bank A, 78.82%, 2) Bank B, 82.49%, 3) Bank C, 76.73%, and 4) Bank D, 81.75%. As such, all banks were above the calculated design minimum capacity of 55.22% at all times.

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

The DC banks A and B provide control power for Alternating Current (AC) load groups 1 and 2 respectively. These banks also provide vital instrumentation and control power [JC] for channels A and B, respectively, of the reactor protection and Emergency Safety Features (ESF) systems and diesel generators [DG] A and B respectively. The DC banks C and D provide vital instrumentation and control power [JC] for channels C and D, respectively, for the reactor protection and ESF systems, and other safety-related loads as referenced in Table 8.3-6, *Class 1E DC System Loads*, of the Updated Final Safety Analysis Report (UFSAR). There was no safety significance due to the degraded capacity of the batteries. The batteries had sufficient capacity for the safety-related loads following a design basis event. See Section II for details.

TEXT

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:

As a result of the battery testing and evaluations since September 23, 1994, APS has determined that battery discharge testing decreased the capacity of batteries by approximately 10% each time they are tested.

Therefore, Train B battery banks B and D have been inoperable from February 1, 1994, to October 13, 1994.

APS has concluded that the failure mechanism causes the batteries to degrade during the discharge/recharge cycle and that the projected capacities of the banks following the last capacity discharge test are: 1) Bank A, 78.82%, 2) Bank B, 82.49%, 3) Bank C, 76.73%, and 4) Bank D, 81.75%. As such, all banks were above the calculated minimum capacity of 55.22% at all times.

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

As discussed in Section I.B., the degraded battery bank capacities were found during the performance of TS SR 4.8.2.1.e to satisfy the IEEE Standard 450-1980 requirement to capacity test new batteries within the first two years of service.

I. Safety System Response:

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

J. Failed Component Information:

The battery banks consist of AT&T LINEAGE 2000 Round Cell batteries, model KS-20472 List 1H. The cells are high specific gravity acid with a name plate rating of 1850 Ampere-Hour.

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

Four Class 1E Direct Current (DC) power banks designated as channel A, B, C, and D are provided in each unit. These channels consist of 125V DC bus [BU], 125V DC battery bank , and a battery charger [BYC].

Train A consists of channels A and C and Train B consists of channels B and D. Both DC Trains are required to be operable in Modes 1 through 4 per TS LCO 3.8.2.1 and one DC Train is required to be operable in Modes 5 and 6 per TS LCO 3.8.2.2. The DC power sources are required to ensure that sufficient power is available to supply safety-related equipment required for safe plant shutdown and the mitigation and control of accident conditions. Therefore, a change in battery capacity requirements does not involve a significant increase in the probability of an accident previously evaluated.

APS has determined, through calculation and test, that the most highly loaded battery bank can continue to perform its safety-related function with its capacity as low as 55.22% of the original installed capacity. Capacity discharge tests run in September 1994, indicate capacities of 91.6% for bank A, 89.0% for bank B, 90.6% for bank C, and 88.3% for bank D.

APS has concluded that the failure mechanism causes the batteries to degrade during the discharge/recharge cycle and that the projected capacities of the banks following the last capacity discharge test are: 1) Bank A, 78.82%, 2) Bank B, 82.49%, 3) Bank C, 76.73%, and 4) Bank D, 81.75%. As such, all banks were above the calculated minimum capacity of 55.22% at all times.

An analysis showed that the projected capacities of the battery banks will provide at least 15% margin above that required for safety-related loads. To accomplish this 11 cells in Bank A, 4 cells in Bank B, 12 cells in Bank C, and 4 cells in Bank D were replaced.

TEXT

The projected capacities are expected to be in excess of 85% for each bank. As such, the battery banks have sufficient capacity for the safety-related loads following a design basis event. In addition, the majority of the degradation of the battery cells occurs during discharge testing of the batteries.

Therefore, since no discharge testing of the batteries will be performed between now and the next refueling outage, the battery capacity will remain above that needed to fulfill the required safety function.

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

III. CORRECTIVE ACTION:

A. Immediate:

- On October 7, 1994, battery banks A and C were declared inoperable based on projection of anticipated degradation. TS LCO 3.8.2.2 Action a was entered to prevent any positive reactivity additions.

- On October 9, 1994, APS submitted a proposed TS amendment to Specification 3/4.8.2, DC Sources, under emergency circumstances. The amendment asked for approval to suspend the requirements of TS 4.0.1 and 4.0.4 until entry into Mode 4 coming out of the fifth refueling outage or upon any deep discharge of the battery. Also, several compensatory actions were placed on the Unit 2 batteries in accordance with the TS amendment submittal. On October 13, 1994, TS amendment 71 was approved by the NRC. Therefore, on October 13, 1994, battery banks A, B, C, and D were declared operable.

B. Action to Prevent Recurrence:

During the fifth refueling outage APS will replace all of the cells from the original AT&T lot in the 4 Class 1E batteries for Unit 2. Also, the 23 replacement cells and the 8 spare cells used from Units 1 and 3 will be replaced. The fifth refueling outage is scheduled to begin on February 4, 1995.

A root cause of failure is still under investigation therefore, actions to prevent recurrence have not been determined to date. A supplement will be made to the LER following a root cause of failure determination. The cause of failure is expected to be completed by December 30, 1994.

IV. PREVIOUS SIMILAR EVENTS:

There have been no similar events to this type of failure reported pursuant to 10CFR50.73.

V. ADDITIONAL INFORMATION:

On October 13, 1994, APS received NRC approval to suspend provisions 4.0.1 and 4.0.4 of TS for battery capacity testing requirements until entry into Mode 4 following the fifth refueling outage. Both trains of Class 1E batteries were declared operable on October 13, 1994, and a Unit 2 restart began. Unit 2 reached Mode 1 (POWER OPERATIONS) on October 17, 1994.