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
									N/A	0 5 0 0 0
1 0	0 6	9 4	9 4	- 0 0 4	- 0 2	0 6	2 8	9 5	N/A	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		
			20.405(a)(1)(iii)	X	50.73(a)(2)(i)	X	50.73(a)(2)(viii)(A)		below and in Text, NRC Form		
			20.405(a)(1)(iv)		50.73(a)(2)(ii)		50.73(a)(2)(viii)(B)		366A)		
			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, Section Leader, 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	MANUFAC-TURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFAC-TURER	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
YES (If yes, complete EXPECTED SUBMISSION DATE)	X NO				

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 percent 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 percent capacity stated in TS SR 4.8.2.1.e.

Subsequent investigation has determined that Train B had been slightly below the 90 percent 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 (POWER OPERATION), Unit 2 operated in a condition prohibited by the plant's TS until it shutdown and reached Mode 5 on September 18, 1994.

The Equipment Root Cause of Failure Analysis (ERCFA) has determined that the failure mode results from a step decline in capacity caused by a loss of positive active material. The loss of capacity is most likely due to the result of poor production control during manufacturing. No credible mechanism for sudden discharge failure has been found.

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

This supplement to LER 94-004 is being submitted to include EIIS codes, update corrective actions, and correct minor typographical errors.

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) (EJ) (BTRY) was declared inoperable because a projection of the test results based upon anticipated degradation indicated that they did not meet the 90 percent criteria of Technical Specification Surveillance Requirement (TS SR) 4.8.2.1.e, rendering both trains of Class 1E batteries inoperable.

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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 percent 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 percent (Exide) or 90 percent (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 4.8.2.1.d."

Subsequent investigation has conservatively determined that Train B had been slightly below the 90 percent 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 percent and 90.6 percent 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 percent capacity stated in TS SR 4.8.2.1.e.

As a result of this unexpected degradation, Electrical Maintenance Engineering (utility, nonlicensed) 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.

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 percent 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 percent and 88.3 percent capacity respectively following the ST performed in February 1, 1994. Therefore, battery banks B and D have been slightly below the 90 percent 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 percent, 2) Bank B, 82.49 percent, 3) Bank C, 76.73 percent, and 4) Bank D, 81.75 percent. As such, all banks were above the calculated design minimum capacity of 53 percent 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:

The failure mode results from a step decline in capacity caused by a loss of positive active material. Improper curing or contamination during fabrication may have been factors contributing to loss of positive active material. The loss of capacity is most likely the result of poor production control during manufacturing. No credible mechanism for sudden discharge failure has been found.

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

Based on testing of the Unit 2 spares, the degradation mechanism appears to be aggravated by charge/discharge cycling of the cells and is not age related. Deep discharge cycling of the cells resulted in a loss of capacity for the Round Cells installed in Unit 2 during cycle 5. Each subsequent cycle degraded about the same fraction of capacity. The test results indicated that the battery capacities tended to stabilize at approximately 55 percent after 6 capacity discharge tests.

TEXT

APS has concluded that the failure mechanism for the Unit 2 cells 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 percent, 2) Bank B, 82.49 percent, 3) Bank C, 76.73 percent, and 4) Bank D, 81.75 percent. As such, all banks were above the calculated design minimum capacity of 53 percent 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 (JC) and Emergency Safety Features (ESF) (JE) systems and diesel generators (DG) (EK) A and B respectively.

The DC banks C and D provide vital instrumentation and control power 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).

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 percent 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 percent, 2) Bank B, 82.49 percent, 3) Bank C, 76.73 percent, and 4) Bank D, 81.75 percent. As such, all banks were above the calculated minimum capacity of 53 percent 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. The cells, each having a nominal ICV (individual cell voltage) of 2.08 VDC, are series connected to provide the 125 VDC battery bank voltage.

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).

TEXT

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 53 percent of the original installed capacity. Capacity discharge tests run in September 1994, indicate capacities of 91.6 percent for bank A, 89.0 percent for bank B, 90.6 percent for bank C, and 88.3 percent 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 percent, 2) Bank B, 82.49 percent, 3) Bank C, 76.73 percent, and 4) Bank D, 81.75 percent. As such, all banks were above the calculated minimum capacity of 53 percent at all times.

An analysis showed that the projected capacities of the battery banks will provide at least 15 percent 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.

The projected capacities are expected to be in excess of 85 percent for each bank. As such, the battery banks have sufficient capacity for the safety-related loads following a design basis event.

TEXT

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.

- To eliminate transportability to Units 1 and 3, previous battery test data from Units 1 and 3 were reviewed and compared to the Unit 2 battery performance data. Additional testing on the Unit 1 and 3 spares provided reasonable assurance that the observed Unit 2 failure was not transported to Unit 1 or 3.

B. Action to Prevent Recurrence:

During the Unit 2 fifth refueling outage APS replaced 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 were replaced. The Unit 2 fifth refueling outage began on February 4, 1995. In addition, two cells in Unit 1, which were from the same lot as the original Unit 2 cells, were replaced during the fifth refueling outage for Unit 1 which began on April 1, 1995.

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.

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TEXT

APS has been working with AT&T and C&D Power to obtain replacement batteries for installation into Unit 2 during the fifth refueling outage. As a result of the degradation identified in the Unit 2 batteries, which is not evident in the batteries of Unit 1 or Unit 3, APS Engineering revised the commercial-grade dedication requirements for the replacement batteries.

The dedication was revised to require two successful two-hour capacity discharge test within a nominal capacity value of each other.

It was reasoned that the Unit 1 and Unit 3 battery banks, and each of their spare cells had not shown degradation on their second, and in some cases, third discharges whereas the Unit 2 batteries showed degradation on its second discharge.

APS has completed testing on four banks of replacement cells. In order to provide backup cells for Unit 2 in case problems were uncovered while operating until the fifth refueling, one bank of batteries were shipped directly to Palo Verde prior to dedication testing at the C&D factory. These batteries exhibited degradation of capacity during their second discharge test. Tests performed at the factory on the other three battery banks showed acceptable capacity upon their second test. APS then decided to perform additional discharges of some batteries at Palo Verde, upon receipt, to preclude 1) charging method differences between the method employed by APS and by the factory, and 2) transportation difficulties as a potential causes of the observed capacity reduction. Each of these batteries has exhibited reduced capacity upon the second discharge at Palo Verde and each subsequent discharge.

Some of the possible causes of the loss of capacity have been investigated by APS. The most probable cause is the frequency at which the cells were discharged and recharged.

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TEXT

Due to the effort to assure that the replacement cells were acceptable to use, repeated charging and discharging was performed on the battery strings. It is most probable that discharging and then recharging over relatively short intervals (approximately 10 days) does not allow sufficient time for the cells to recover.

At this point in time, APS has not established a final root cause for the replacement cell performance. However, enough testing has been performed (37 discharge tests on 343 cells) to be able to confidently predict the installed capacity of the selected cells. Four additional groups of batteries have been manufactured and have completed two successful discharge tests at the factory. These cells will be used as replacement cells for Unit 2.

APS is continuing to work with AT&T and C&D Power to determine the cause of the capacity reduction. It has been shown by APS however, that enough cells can be obtained prior to the fifth refueling outage which, when installed, will assure that all four channels of batteries will be greater than or equal to 100 percent capacity.

Results of the joint APS, AT&T and C&D Power testing will be assessed against conclusions drawn for the cells installed in Unit 2 cycle 5.