NRC Form 366 (9-83)

U.S. NUCLEAR REGULATORY COMMISSION
APPROVED OMB NO 3150-0104
EXPIRES 8/31/85

LICENSEE EVENT REPORT (LER)

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TITLE (4) Loss of the Red Instrument Bus

EVENT DATE (5) MONTH	DAY	YEAR	LER NUMBER (6) YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	REPORT DATE (7) MONTH	DAY	YEAR	OTHER FACILITIES INVOLVED (8) FACILITY NAMES	DOCKET NUMBER(S)
0 5	1 5	8 7	8 7	0 0 4	0 1	1 1	1 6	8 7	N/A	0 5 0 0 0
										0 5 0 0 0

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

OPERATING MODE (9):
POWER LEVEL (10): 10

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

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER AREA CODE	
C. W. Fay, Vice President-Nuclear Power	4 1 4	2 2 1 - 2 8 1 1

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	BYC	E I	W 1 2 0						

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 May 15, 1987, with Unit 1 and Unit 2 shut down, the station battery (D05) breaker was opened to isolate the station battery for cell replacement. When the battery (D05) breaker was opened, the battery charger (D07) caused a voltage spike on the DC bus (D01). The voltage spike affected the associated instrument bus power supply inverters (1DY01 and 2DY01) for both units and the standby (swing) inverter DYOA. This initiated a reactor protection system actuation in both units. The voltage oscillation was cleared within 10 seconds by manual reclosure of the battery breaker.

The loss of voltage on the Unit 1 red instrument bus resulted in a 2/4 power range reactor trip signal from Channels N41 and N43. N41 tripped when its power supply was deenergized. N43 was in trip due to modification work. It also resulted in a 1/2 intermediate range reactor trip signal.

The voltage perturbation on the Unit 2 red instrument bus resulted in a 1/2 IR N35 reactor trip signal as well as a 1/2 source range N31 reactor trip signal.

All reactor protection system circuitry functioned as designed during this event. An investigation into the circumstances of this event has revealed that without the filtering effect of the battery, the battery chargers will produce voltage perturbations on their respective loads (the instrument buses). Plant modifications are being proposed to eliminate this problem.

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BACKGROUND AND EVENT DESCRIPTION

On May 15, 1987, with both Unit 1 and Unit 2 shut down, a cell replacement in the D05 battery was scheduled. The battery was being isolated to replace a faulty cell (#45) which had indicated a downward trend in voltage. Because both PBNP units were off line with their respective reactor trip breakers open, the battery cell replacement was planned to be performed with the battery isolated from the DC bus. The cell replacement was planned with the battery isolated because an additional battery cell had to be removed to gain access to the faulty cell (#45) located behind a vertical support and the other cell.

The battery (D05) consists of 59 individual cells. The cells are monitored individually for degradation. When cell performance is degrading, the cell normally can be replaced without disconnecting the battery from its DC bus. Because the location of defective battery cell #45 requires the removal of another cell to facilitate access, it was considered easier and safer for the individuals performing the cell replacement to disconnect the battery (D05) from the associated DC bus (D01). Since both units were shut down with their reactor trip breakers open, the opportunity was present to replace battery cell #45 with a new cell without even remotely jeopardizing the power operation of either unit.

During a meeting to approve the application of Routine Maintenance Procedure 22, a subcommittee of the Manager's Supervisory Staff discussed the potential effect on the DC bus (D01) and instrument bus (Y01). It was believed that the battery charger would sustain the DC bus without difficulty. Therefore, an explicit statement was not included in the procedure to alert operating personnel that an RPS actuation might occur.

Using Routine Maintenance Procedure 22, replacement of battery cell #45 was started at 11:13 AM on May 15, 1987. When the breaker between the battery (D05) and DC bus (D01) was opened manually, both Unit 1 and Unit 2 reactor protection systems actuated.

The battery charger voltage spike blew the fuses in the power supply to both the "master" and "slave" control circuits associated with the Unit 1 inverter (1DY01). This caused a loss of inverter output voltage and subsequently a loss of voltage in the Unit 1 red instrument bus (1Y01).

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The battery charger voltage spike blew the fuses on the power supply line to the "master" control circuit associated with the Unit 2 inverter (2DY01); however, the "slave" control circuit remained operable. Although the Unit 2 red inverter (2DY01) remained in service, it experienced a voltage fluctuation while the battery breaker was open.

The standby inverter (DY0A) operating in a standby mode powering a dummy load was also affected by the battery charger voltage spike. Fuses in the power supply for both the "master" and "slave" control circuits also failed, resulting in loss of inverter output voltage. The standby inverter does not have an automatic transfer capability to either the Unit 1 or Unit 2 instrument bus.

PLANT SYSTEM RESPONSES

The Unit 1 and Unit 2 reactor protection systems (RPS) responded appropriately to the red instrument bus (Y01) power problems. The nuclear instrumentation system actuations were in accordance with their design. Since the reactor trip breakers were open, no additional systems were challenged.

Loss of voltage on the Unit 1 red instrument bus deenergized power range (PR) channel N41. This resulted in a trip signal from that channel. PR channel N43 had a trip signal inserted due to modification work being performed to upgrade an Appendix "R" source range instrument to meet the requirements of Reg Guide 1.97. This resulted in a 2/4 PR trip logic. Intermediate range (IR) channel N35 was also deenergized, resulting in a 1/2 intermediate range reactor trip signal. A 1/2 source range (SR) reactor trip signal did not occur when N31 was deenergized because the 2/4 PR trip logic cleared the P10 permissive which automatically blocked the SR reactor trip logic and deenergized the SR high voltage. (The IR and PR low setpoint require a manual action to block.) Both channels of SR indication were lost for approximately 35 minutes while the inverter (1DY01) and the red instrument bus (1Y01) were being returned to service. No refueling operations were in progress, and no reactivity changes were made while both SR detectors were out of service.

Voltage fluctuations on the Unit 2 red instrument bus deenergized PR channel N41. This resulted in a trip signal from channel N41. Since no other PR instrument channel was in a trip condition, neither the 2/4 PR logic required for RPS actuation nor the P10 permissive logic made up. Thus, no power range trip occurred and

the source range instruments were not affected. IR channel N35 was deenergized resulting in a 1/2 IR reactor trip signal. SR channel N31 was also deenergized resulting in a 1/2 SR reactor trip signal.

SYSTEM DESCRIPTIONS

PBNP has four 125 volt DC power buses. Each bus receives DC power from either a battery, normal battery charger or swing battery charger. The swing battery charger is shared with one other DC bus and is used only when a normal battery charger is out of service for maintenance. The swing battery charger is connected to only one DC bus at a time. Each DC bus supplies DC power to two instrument bus AC to DC power supply inverters. One inverter is associated with an instrument bus in Unit 1 and the other inverter is associated with an instrument bus in Unit 2. Each DC bus can also supply DC power to a swing inverter which can supply power to either the Unit 1 instrument bus or the Unit 2 instrument bus. The swing inverter is connected to only one instrument bus at a time and is used only when a normal inverter is out of service for maintenance. No automatic transfer capability is installed for either the swing charger or the swing inverter. Two of the DC buses utilize Westinghouse battery chargers (130 volt DC, style number 130RF-400), Westinghouse inverters (model number 125CTT 10 kVA) and 1800 ampere-hour batteries (C&D, type LC-25). The other two DC buses utilize Power Conversion Products battery chargers (model number 35-130-500), Elgar inverters (model number 253-1-103), and 1500 ampere-hour batteries (C&D, type LC-21). The DC bus involved in this incident utilized the Westinghouse chargers, inverters, and a C&D 1800 ampere-hour battery.

GENERIC IMPLICATIONS

None determined at this time.

CAUSE

Based on subsequent testing, the failure mechanism for the Westinghouse inverters may have been due to excessive current demand by the ferro-resonant circuit when the bus voltage dipped to less than 105 volts (charger ripple voltage).

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The voltage fluctuations on the DC bus were sufficient to cause the inverter silicone controlled rectifiers (SCRs) to misfire blowing the power supply fuses described above and resulted in deenergizing the Unit 1 red instrument bus and caused a voltage fluctuation on the Unit 2 red instrument bus. The cause of the RPS actuation was a direct result of these red instrument bus power supply problems. Operational experience with the Westinghouse inverters has demonstrated that they are sensitive to voltage perturbations on the DC bus. The Westinghouse inverters can operate satisfactorily with voltage fluctuations where the voltage change is such that voltage does not dip below 105 volts and the rate of voltage change is not greater than 11 hertz. The NIS is designed to actuate the RPS when power is lost or momentarily interrupted.

The DC bus voltage fluctuations were caused by the battery charger operating without the battery's filtering characteristics. The reason for this was investigated and is believed to have occurred because of either the design characteristics or the adjustments of the battery chargers. The battery chargers may not have sufficient DC filtering or feedback response to maintain a steady DC bus voltage with the battery disconnected from the bus. Ripple on the output voltage of the Westinghouse battery chargers is not specified in the technical manual; however, specifications for the Elgar chargers which have equivalent output filtering capacitors have ripple specifications of approximately 2.6 volts RMS. A check with Elgar revealed that their inverters could probably handle 2.6 volts of ripple with no detrimental consequences. Specifications for a battery charger/eliminator list ripple in the output of approximately 30 millivolts and utilize output capacitors which are approximately double the size of those in the Westinghouse chargers. Additionally, the input filtering of the Westinghouse instrument bus inverter is not sufficient to prevent DC voltage perturbations from affecting the instrument buses.

REPORTABILITY

This LER is provided pursuant to 10 CFR 50.73(a)(1)(iv), "Any event or condition that resulted in manual or automatic actuation of any engineered safety feature (ESF), including the reactor protection system (RPS)."

The Energy Industry Identification System component function identifier is BYC and system designation for the charger is EI.

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SAFETY ASSESSMENT

It has been determined that if either battery associated with the DC buses supplied by Westinghouse or blue battery chargers is disconnected from its associated DC bus, voltage perturbations on the associated instrument buses in both Unit 1 and Unit 2 may result. A dual unit turbine runback and possibly a dual unit reactor trip might occur as a result of the voltage perturbations. PBNP is designed and staffed to handle such an occurrence. While loss of one instrument bus in both units might occur until the battery is restored, redundant instrumentation from the remaining three instrument buses is available for each unit to safely operate.

The loss of SR indication for 36 minutes in Unit 1 did not present a safety hazard. The unit was in refueling shutdown status with boron concentration of 2181 ppm and all control rods fully inserted in the core. No reactivity changes were taking place, and one IR detector was available for monitoring neutron flux.

The safety and health of the public and plant employees were not affected during this event. The ideal time to remove a battery from service presented itself with both units shut down and reactor trip breakers open. In this condition, actuation of the RPS presents no significant challenge to the safe condition or control of the reactor. We know of no occurrence where similar DC bus voltage perturbations have occurred at Point Beach Nuclear Plant.

CORRECTIVE ACTION

The Westinghouse battery chargers were tested to confirm normal operation. No abnormalities were identified when each charger was supplying power to both the battery and its associated DC bus. When the battery breaker was opened, voltage fluctuations occurred when either normal battery charger or the standby battery charger was supplying power to the DC bus. Additional testing with a resistive load bank has also been done. The load bank was connected to one of the Westinghouse battery chargers in parallel with an inverter. Load was then varied and the DC bus ripple and inverter output ripple were measured. At a load of approximately 70 amps, the DC bus ripple was 14.5 V at 10.8 Hz. At a load of approximately 120 amps, the DC bus ripple was 34.1 V at 10.8 Hz. It was not possible to increase load any further without exceeding the voltage input limit of the inverter and possibly tripping it.

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Normal load on the DC bus is greater than 130 amps. The inverter output had no noise as a result of the load bank loading. These tests indicated that the cause of the problem is in the design or adjustments of the battery charger and not in the DC system or instrument bus inverters. It was concluded that to improve system reliability, the battery chargers must be modified or possibly adjusted to allow operation when the battery is disconnected. It is currently believed that the voltage perturbation may be eliminated by adjustment of the electronic control circuitry associated with the battery chargers. If adjustments will not eliminate the voltage perturbations, modification or replacement of the battery chargers may be considered.