123 Main Street
White Plains, New York 1
914 681.6200

**New York Power Authority**

**J. Phillip Bayne**
Executive Vice President
Nuclear Generation

October 11, 1984
IPN-84-42

Director of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. Steven A. Varga, Chief
Operating Reactors Branch No. 1
Division of Licensing

Subject: Indian Point 3 Nuclear Power Plant (IP-3)
Docket No. 50-286
IP-3 Battery Reliability Information

Reference: Letter from J. P. Bayne to S. A. Varga
dated August 30, 1984 entitled:
"Battery Reliability at the Indian Point Nuclear
Generating Plant, Unit No. 3 (IP-3)."

Dear Sir:

The attachment to this letter provides the information concerning battery reliability requested in the referenced letter.

Should you or your staff have any questions regarding this matter, please contact Mr. P. Kokolakis of my staff.

Very truly yours,

J. P. Bayne
First Executive Vice President
Chief Operations Officer

cc: Resident Inspector's Office
Indian Point Unit 3
U. S. Nuclear Regulatory Commission
P. O. Box 66
Buchanan, New York 10511

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The IP-3 battery reliability information presented below is in the same order as requested in the referenced letter. It should be noted that Station Battery No. 34 was installed as a result of a design modification made subsequent to initial power operation. The purpose of this design change was to increase the reliability and availability of the 120 volt AC system (specifically, 120 volt AC Instrument Bus No. 34).

(1) Failure Rates Per Hour

The evidence available at the time the Indian Point Probabilistic Safety Study (IPPSS) was issued was indicative of zero battery failures in $7.20 \times 10^4$ operating hours (see IPPSS Page 1.6-46). This data was then updated using Bayes' theorem of probability which resulted in the following failure rate distribution for use in the IPPSS:

| | |
|---|---|
| 5th Percentile: | $2.12 \times 10^{-9}$ failure/hour |
| Median: | $2.61 \times 10^{-8}$ failure/hour |
| 95th Percentile | $3.21 \times 10^{-7}$ failure/hour |
| Mean: | $8.35 \times 10^{-8}$ failure/hour |
| Variance: | $6.44 \times 10^{-14}$ |

The data upon which the above failure rate distribution was based is current to December 31, 1979. In order to provide a more up-to-date failure rate distribution, the battery operating history subsequent to December 31, 1979 was reviewed through May 31, 1984 which was indicative of zero battery failures in $1.35 \times 10^5$ total operating hours. This data was then updated using Bayes' theorem of probability which resulted in the following failure rate distribution:

| | |
|---|---|
| 5th Percentile: | $4.79 \times 10^{-9}$ failure/hour |
| Median: | $3.29 \times 10^{-8}$ failure/hour |
| 95th Percentile: | $2.26 \times 10^{-7}$ failure/hour |
| Mean: | $6.54 \times 10^{-8}$ failure/hour |
| Variance: | $1.26 \times 10^{-14}$ |

It should be noted that the IP-3-specific failure rate distributions discussed above provide somewhat better results (i.e., lower failure rates) than the generic failure rate distribution indicated in the IPPSS (see Table 1.6.1-4), which is derived from IEEE-500-1977 (Page 104). Using the IEEE "recommended" failure rate as the median and the IEEE "maximum" failure rate as the 80th percentile for the "catastrophic" failure mode, the generic failure rate distribution derived is as follows:

| | |
|---|---|
| 5th Percentile: | $1.25 \times 10^{-9}$ failure/hour |
| Median: | $2.08 \times 10^{-8}$ failure/hour |
| 95th Percentile: | $3.46 \times 10^{-7}$ failure/hour |
| Mean: | $8.95 \times 10^{-8}$ failure/hour |
| Variance: | $1.40 \times 10^{-13}$ |

(2) Test Intervals

The following is a synopsis of the scope and intervals of IP-3 station battery surveillance practices that are performed in accordance with IP-3 Technical Specification 4.6.B for Station Batteries No. 31, 32 and 33. (Whereas Technical Specification 4.6.B only applies to these three batteries, the surveillance specified is also performed for Station Battery No. 34).

- Every month the voltage of each cell, the specific gravity and temperature of a pilot cell in each battery and each battery voltage is measured and recorded.
- Every 3 months each battery is subjected to a 24 hour equalizing charge, and the specific gravity of each cell, the temperature reading of every fifth cell, the height of electrolyte, and the amount of water added is measured and recorded.
- At each time data is recorded, new data is compared with old to detect signs of abuse or deterioration.
- At each refueling outage each battery is subjected to a load test and a visual inspection of the plates.

The basis for the surveillance specified is to provide an indication of a cell becoming unserviceable long before it fails. The periodic equalizing charge ensures that the ampere-hour capability of the batteries is maintained. The refueling outage load test for each battery, together with the visual inspection of the plates, assures the continued integrity of the batteries.

It should also be noted that the Authority has recently proposed revisions to the battery surveillance technical specifications to upgrade certain surveillance practices to be consistent, where appropriate and where possible, with the Westinghouse Standard Technical Specifications. These revisions are included in the Authority's letters of December 29, 1983 and September 7, 1984 to the NRC.

(3) Test Conditions

The objective of the load test performed on a refueling basis is to assure the continued integrity of the batteries by demonstrating their operability (i.e., by demonstrating the capability of each battery to deliver at least 80 percent of rated name plate capacity on discharge). The test is performed by discharging each battery at a constant rate to verify its capacity. The battery discharge apparatus set-up is shown for illustrative purposes in Figure 1.

(4) Battery Configuration

The 125 volt DC system is divided into four independent buses with one battery and battery charger (supplied from the 480 volt system) serving each bus. The battery chargers supply the normal DC loads as well as maintaining proper charges on the batteries. As indicated above, Station Battery No. 34 was installed subsequent to initial power operation to increase the reliability and availability of 120 volt AC Instrument Bus No. 34. It should be noted, however, that only Station Batteries No. 31, 32, and 33 are required to ensure that all necessary engineered safeguards are started in the event of a postulated accident scenario with concurrent loss of all AC power.

Two batteries (i.e., Batteries No. 31 and 32) are 58-cell batteries that are required to maintain a minimum bank voltage of 123.6 volts DC and two batteries (i.e., Batteries No. 33 and 34) are 60-cell batteries that are required to maintain a minimum bank voltage of 127.8 volts DC. Each battery is sized to carry its expected shutdown loads following a plant trip and loss of all AC power for a period of 2 hours without battery terminal voltage falling below 105 volts.

The DC system is redundant from battery source to actuation devices which are powered from the batteries. The four batteries feed four DC power panels which in turn feed major loads. (Major battery loads with their associated operating times are given in Table 1). DC power panels No. 31 and 32 sub-feed four DC distribution panels which in turn feed relaying and instrumentation loads.

The physical locations of the DC system equipment is such as to minimize vulnerability of vital circuits to physical damage and prevent concurrent loss of all power as a result of postulated accidents.

(5) Replacement Schedule

Battery replacement at IP-3 is dependent upon two factors. The first being the results of the surveillance requirements of the technical specifications, which as indicated above provide an indication of battery degradation long before failure. The second involves the addition of new loads onto the existing batteries as a result of modifications that have been or will be made to the plant. To date, two of the four station batteries have been replaced as a result of the latter factor, whereas no battery replacement has been required as a result of the former factor.

(6) Unavailability

The IP-3 station battery surveillance practices performed in accordance with IP-3 Technical Specification 4.6.B are as specified in Item (2) above. Of these practices, the only ones performed with the plant above the cold shutdown condition are the monthly measurements of key battery parameters and the three-month equalizing charge and associated battery parameter measurements. (These practices naturally may be performed in a shutdown condition as well due to their specified frequencies). At no time when the plant is above the cold shutdown

condition are the station batteries unavailable for use as a result of these surveillance practices. If at any time a battery is not operable, IP-3 Technical Specification 3.7.B.3 which applies to Station Batteries No. 31, 32 and 33 allows one of these batteries to be inoperable for 2 hours provided the other two batteries and Battery Chargers No. 31, 32, and 33 remain operable with one battery charger carrying the DC load of the failed battery supply system. Should the battery remain inoperable for longer than the 2 hour period, the plant is required to be shutdown. The basis of these requirements is to maintain one battery charger in service on each of these batteries so that the batteries will always be at full charge in anticipation of a loss of AC power incident. This insures that adequate D.C. power will be available for starting the emergency diesel generators and other emergency uses.

In addition to the surveillance discussed above and as indicated in Item (2), the station batteries are subjected to a load test each refueling outage. However, since this test is performed while the plant is shutdown, use of the batteries is not required.

(7) Failures Per Demand

Battery hardware failures on demand were not quantified explicitly in the IPPSS electric power models because insufficient data and experience were available when the study was performed to indicate that "failure on demand" was a realistic functional failure mode for batteries under continuous trickle charge. Publication of NUREG-0666 ("A Probabilistic Safety Analysis of DC Power Supply Requirements for Nuclear Power Plants") in April 1981 raised the issue of a non-negligible "demand" failure rate for batteries. An LER review performed for the NUREG-0666 study identified a few events where significant battery degradation had occurred during normal plant operation but had been masked by the fact that the battery charger continued to supply normal DC bus voltage. The degraded battery output was discovered only after the normal charger supply was disconnected for a test or maintenance and the battery failed to maintain voltage or adequate output current. (Several of the "failures" documented in NUREG-0666 were not functional failures of the entire battery, but were reported as degraded performance under the LER reporting criteria. However, a few of the events were significant enough to exhibit characteristics of a "demand" failure after loss of the charger supply.)

Although not included in the IPPSS, the generic failure rate distribution advocated for a "failure of output on demand" contribution to battery failures in scenarios where the charger supply is unavailable (e.g., loss of AC power to charger, charger failure, charger maintenance etc.) can be derived from IEEE-500-1977 (Page 104) using the IEEE "recommended" failure rate as the median and the IEEE "maximum" failure rate as the 80th percentile for all modes leading to failure on demand. The distribution thus derived is as follows:

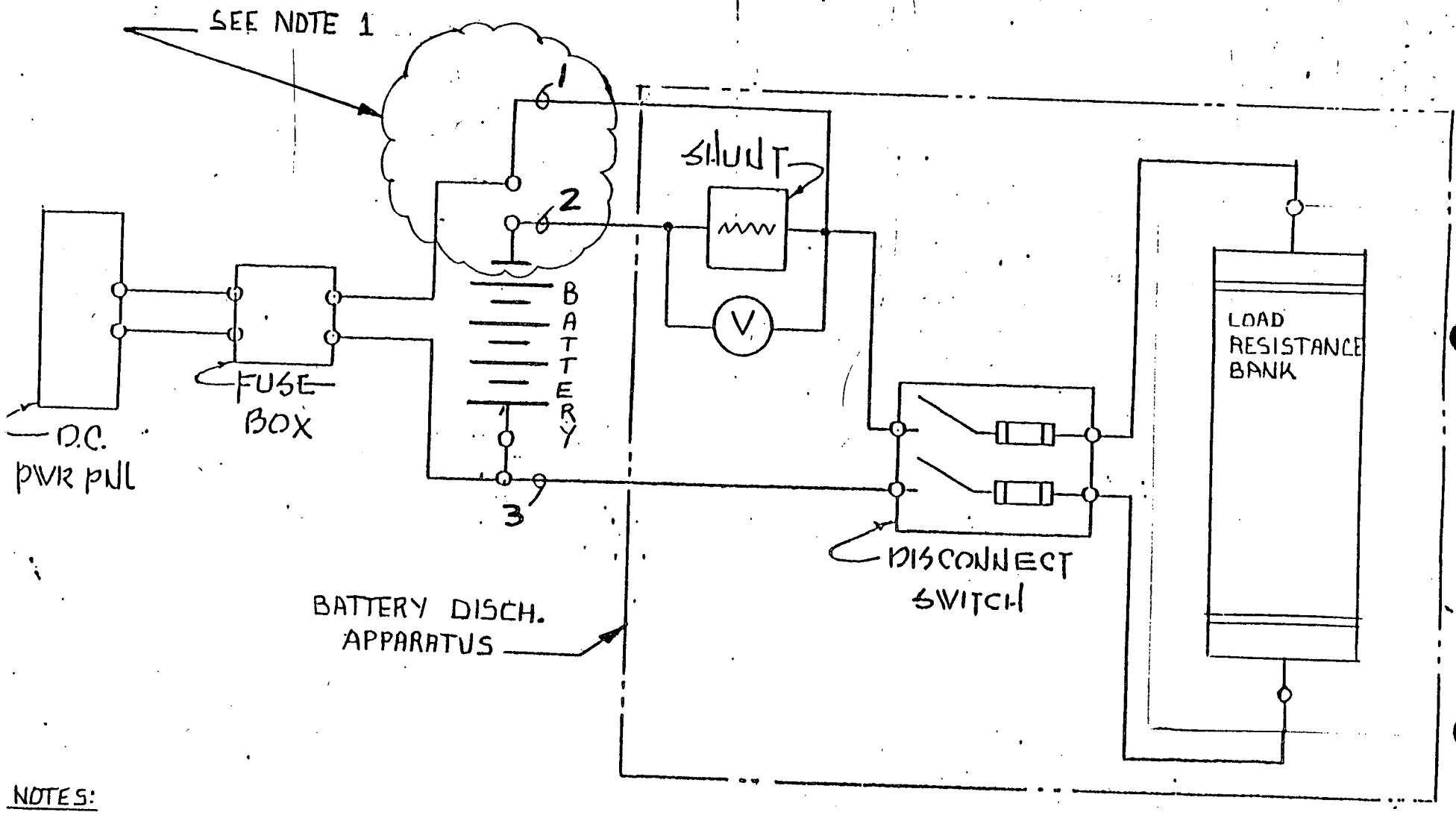
| | |
|---|---|
| 5th Percentile: | $1.45 \times 10^{-4}$ failure/demand |
| Median: | $3.47 \times 10^{-4}$ failure/demand |
| 95th Percentile: | $8.34 \times 10^{-4}$ failure/demand |
| Mean: | $4.00 \times 10^{-4}$ failure/demand |
| Variance: | $5.24 \times 10^{-8}$ |

This distribution is consistent with the data in NUREG-0666 if the "failures" which did not affect an entire battery are removed from their LER data base.

(8) Conversions Between Failure Rates and Failures Per Demand

Extrapolation of hourly failure rate data to demand failure rates based on "standby" failure rate models is not advocated. The demand failure rate distribution listed above accounts for the IEEE data for battery failures and it represents the evidence documented in NUREG-0666. Based on review of "standby" failure rate models, there have been no sound justifications for determining the relative contributions from "standby" failures and actual "demand" failures. The approach generally taken is to provide various estimates for a "standby" failure rate and to select the rate which most closely models the observed equipment performance. The approach advocated is to let the observed performance define the functional failure rate; if the evidence shows that a component has failed once every 100 demands, its failure rate per demand is approximately $1.0 \times 10^{-2}$ without regard as to whether the causes for failure occurred randomly over time between demands or occurred at the actual instant of demand. It is believed that this method provides the most realistic estimate of component demand unavailability based on actual experience.

FIG. 1




NOTES:

1. CABLE FROM FUSEBOX IS TO BE DISCONNECTED FROM THE BATTERY POST AND CONNECTED TO CABLE 1 OF BATTERY DISCHARGE TEST APPARATUS.
2. CABLES 1, 2, 3 ARE FROM BATTERY DISCH. TEST APPARATUS.

TABLE 1

MAJOR BATTERY LOADS

| | |
|---|---|
| Battery No. 31 | |
| Inverter No. 31 (7.5 KW) | 2 Hours |
| Emergency Lighting & Control Power (17 KW) | 2 Hours |
| Turbine Generator Emergency Oil Pump (60 hp) | 1 Hour |
| Battery No. 32 | |
| Boiler Feed Pump Emergency Oil Pump (15 hp) | 15 min. |
| Air Side Seal Oil Back-up Pump (25 hp) | 1 Hour |
| Inverter No. 32 (7.5 KW) | 2 Hours |
| Emergency Lighting & Control Power (23 KW) | 2 Hours |
| Battery No. 33 | |
| Control Power (1.8 KW) | 2 Hours |
| Inverter No. 33 (7.5 KW) | 2 Hours |
| Battery No. 34 | |
| Inverter No. 34 (7.5 KW) | 2 Hours |