UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

November 27, 1991

Mr. B. Ralph Sylvia
Executive Vice President-Nuclear
Niagara Mohawk Power Corporation
301 Plainfield Road
Syracuse, New York 13212

Dear Mr. Sylvia:

Your remarks at the Commission Meeting on October 18, 1991, as clarified in your letter of October 23, 1991, indicated disagreement between the NRC Incident Investigation Team (IIT) and Niagara Mohawk Power Corporation concerning the function of the "D" cell batteries in the Nine Mile Point Unit 2 Uninterruptible Power Supply (UPS) Units which lost output power in the August 13, 1991, event. Specifically, you indicated in your October 23, 1991, letter that post-event testing performed in combination with other significant evidence leads Niagara Mohawk to conclude that the "D" size batteries were not intended to supply logic power while the UPS units are in service. To support this conclusion, seven items containing information were provided.

Incident Investigation Team members have reexamined the functional importance of the "D" cell control logic power batteries. This reexamination included the post-event design change which transferred ac input power for each unit's control logic power supply from a phase B maintenance supply to the individual unit's inverter output. The reexamination also included additional review of supporting material collected during the investigation and discussions with technical experts from Niagara Mohawk and the equipment vendor.

On the bases of studying the installed equipment, detailed knowledge of the unit's electronic circuitry, discussions with Exide Electronics design engineers and Niagara Mohawk personnel, IIT members conclude that the "D" cell control logic batteries continue to have functional importance in the operation of the UPS units in that they provide redundant power sources to operate the control logic should the power output from any one of the two 20 V dc power supplies be degraded or unavailable for any reason. This conclusion is supported by the Office of Nuclear Reactor Regulation.

Attachment 1 addresses the function of the "D" cell control logic batteries in greater detail. Attachment 2 provides a response to each of the seven items in your letter of October 23, 1991.

We have also reexamined related information contained in NRC Information Notice 91-64, "Site Area Emergency Resulting From a Loss of Non-Class 1E Uninterruptible Power Supplies," October 9, 1991, and NUREG-1455, "Transformer Failure and Common-Mode Loss of Instrument Power at Nine Mile Point Unit 2 on August 13, 1991," October 1991. The information contained in these two documents is consistent with that provided in Attachments 1 and 2. I sincerely appreciate your interest in this matter.

Sincerely,

James M. Taylor
Executive Director for Operations

Attachments: As stated

cc w/attachments:
The Chairman
Commissioner Rogers
Commissioner Curtiss
Commissioner Remick
T. T. Martin, Regional Administrator, Region I
W. L. Schmidt, Senior Resident Inspector
R. A. Capra, Project Director, NRR
J. E. Menning, Project Manager, NRR
D. R. Haverkamp, Chief, Reactor Projects, Region I
J. Groth, INPO

Attachment 1

Control Logic Power Supply Batteries

The team members' assessment of the importance of the control logic power supply batteries is based on a detailed review of electrical drawings and documentation, consideration of postulated failure modes, review of test data, and review of information provided to the team at a meeting with Niagara Mohawk Power Corporation and Exide Electronics representatives on November 1, 1991.

The "D" size rechargeable batteries are connected across the output of the 120 V ac/20 V dc power supplies, and provide a redundant source of dc power to the control logic circuitry. Such configurations are often used to enhance system reliability. The UPS design has many redundant features, and the use of the rechargeable batteries in parallel with the 20 V dc power supplies is an example, and is consistent with the overall design philosophy of redundancy within each UPS unit.

Subsequent to the event of August 13, 1991, at Nine Mile Point Unit 2 the 75 kVA UPSs were rewired such that the preferred ac power source to the control logic power supplies is taken from the inverter output, with the maintenance supply as backup. Prior to the event the units were wired such that the preferred power source to the control logic power supplies was the maintenance supply, with the inverter output as backup. The importance of the control logic batteries in both configurations as well as estimates of battery life are provided below.

It is important to note that the common-mode design deficiency of providing the preferred control logic power supply input source from the maintenance supply which was degraded during the August 13, 1991, event due to the transformer fault has been corrected by the wiring change. Nevertheless, reliable UPSs are needed to supply power to important loads. The control logic power supply batteries provide redundant and diverse power to the UPS control logic circuitry and improve overall UPS unit reliability for certain postulated failures described below.

I. Importance of Batteries Previous to Design Modification

Prior to the design modification the power supplies' preferred ac input power source was the maintenance supply, and the alternate source was the inverter output. The pre-modification design permitted common transients on the maintenance supply to effect the control logic ac to dc power supply output voltage. These effects could be sustained or abrupt voltage perturbations. Functional batteries are important because they limit the effects of transients on the UPS control logic circuitry by reducing voltage perturbations on the control logic power supplies' ± 20 V dc outputs.

With the pre-modification design, a maintenance supply transient was less likely to cause UPS power output loss if the control logic power supply batteries were fully functional. For example, the batteries were required when the maintenance supply degraded to between approximately

45 V ac and 92 V ac as occurred during the August 13, 1991 event. In this case, the K5 relay did not transfer the power supply input power source to the inverter output because the relay minimum drop out voltage is approximately 45 V ac. As a result, the power supply output voltage degraded below the power supply fail voltage trip setpoint, and a UPS module trip was initiated. The UPS output power was lost because the maintenance supply was significantly degraded and hence a transfer to the maintenance supply was prohibited. During the event, the maintenance supply degradation only lasted approximately 200 milliseconds (ms), and therefore functional control logic power supply batteries would have prevented the UPS power output loss.

The degraded voltage condition on the maintenance supply was simulated in tests performed by the licensee after the event. One test consisted of voltage transients being injected by dropping the K5 relay maintenance supply ac input voltage, which was effectively the control logic power supply input source, to near zero volts for approximately 100 to 200 ms. With severely degraded control logic power supply batteries, one UPS unit initiated a module trip. Another UPS unit did not initiate a module trip, which may be due to the timing of the test transient in conjunction with the internal stored energy of the control logic power supplies. With functional batteries, neither of the two UPS units initiated a module trip, thus maintaining UPS power output. Another test consisted of slowly reducing the K5 relay maintenance supply input voltage on two UPS units. With severely degraded control logic power supply batteries, module trips were initiated when the ac input voltage was reduced to below approximately 85 V ac. An IIT member witnessed similar testing performed with fresh batteries. The unit did not trip. These tests demonstrate that functional batteries were capable of reducing the effects of maintenance supply transients, and could have prevented the UPS power output loss. For these reasons, the IIT concluded that the five UPS units would not have lost their power outputs during the event if the control logic power supply batteries had been fully functional.

There are additional battery functions which demonstrate their importance. These functions remain applicable subsequent to the design modification, and therefore are discussed in Section III.

II. Battery Electrical Characteristics Versus Control Logic Power Requirements

The control logic power supply batteries' life expectancy and electrical characteristics are functions of many variables, such as battery float voltage, temperature, and discharge current. Higher operating temperatures and greater float voltage values decrease battery life. According to the battery data sheet information, the battery life is approximately 1.5 years when operating at a temperature of 45° C, and over 3 years at 30° C, with a float voltage of 2.40 V dc. At 45° C operating temperature, if the float voltage is reduced to 2.30 V dc battery life is increased to approximately 2.2 years. The highest ambient temperature near the physical location of the control logic power supply batteries in the UPS units was measured to be 45° C. Float voltage values were in the approximate range of 2.20 to 2.33 V dc. This

indicates that a battery replacement interval of one year is conservative.

The battery data sheet also clearly indicates that these batteries will provide 5 amperes of current for in excess of 10 minutes, and with less assurance considerably longer. Current requirements for the control logic of an operating UPS unit were measured at the UPS manufacturer, Exide Electronics, to be 4.44 amperes and 1.092 ampere for the +20 and -20 V dc power supplies, respectively. Control logic current requirements for a shutdown UPS unit were measured to be 1.14 and .283 ampere for the +20 and -20 V dc power supplies, respectively. This indicates that functional batteries would have been able to power the UPS control logic circuitry for the approximate 200 ms transient experienced during the event, thus preventing the UPS power output loss. This conclusion was reinforced when the UPS manufacturer stated at the November 1, 1991, meeting that functional batteries are capable of powering the control logic circuitry for 15 minutes.

Based on battery data sheet information, it is estimated that functional batteries will provide a sufficient voltage output (greater than the as found control logic power supply fail voltage trip setpoints) at the required current for about 15 minutes. For the transients analyzed, this 15 minute time interval far exceeds the time duration that the control logic power supply batteries would be required to provide power to the UPS control logic circuitry and circuit breakers. Furthermore, examination of the battery output voltage characteristics as a function of time duration and discharge current indicates that should the power supply output voltage not be restored, the batteries' output voltage would slowly deplete to the power supply fail voltage trip setpoint. At this setpoint, the batteries' remaining power will be sufficient to complete an orderly transfer of the UPS power output source to the maintenance supply. Had the batteries been fully functional during the August 13, 1991, event, the control logic circuitry would not have generated a power supply fail signal to initiate a module trip, and therefore the UPS output power would not have been lost.

III. Importance of Batteries Subsequent to Design Modification

The control logic power supply batteries are important subsequent to the design modification. The UPS units are designed to tolerate many single failures. Internal redundancy provides the UPS units the capability to continue to provide output power during certain single failures. Two examples are: the inverter will receive power from the plant storage batteries if the ac to dc converter fails; and the UPS power output source will be the maintenance supply if the inverter fails. As confirmed by the UPS manufacturer in the November 1, 1991, meeting, the control logic power supply batteries are simply another example of an internal UPS unit redundancy. The batteries power the control logic circuitry when a control logic power supply voltage output has failed.

The UPS units are less likely to experience a degraded control logic power supply input ac source following the design modification because the power supplies' preferred source is now the inverter output. Nevertheless, the batteries still perform the same basic pre-modification functions (e.g., provide a redundant source of power to the

control logic circuitry). There are three general functions that the batteries perform which substantiate their importance.

One function of the batteries is to ensure a successful transfer of the UPS output power source from the inverter output to the maintenance supply. An example of when this transfer is necessary is in the event of a sudden loss of the output voltage from a control logic power supply. This sudden loss of a plus and/or minus 20 V dc power supply output could be due to an internal component failure within a power supply. If employing degraded batteries, the UPS unit may not be able to transfer the output power from the inverter output to the maintenance supply because there would be no power to the control logic circuitry or circuit breakers. The UPS output power would then be lost, and therefore important loads would be lost. Exide Electronics representatives indicated that the transfer to the maintenance supply would not occur with a control logic power supply failure and severely degraded batteries.

The team also explored inverter failure modes which require a transfer to the maintenance supply assuming severely degraded batteries. It appears that the stored energy in both the inverter and the control logic power supplies, in conjunction with the quick control logic response to the failure, that a successful transfer is likely. The UPS manufacturer supported this conclusion at the November 1, 1991, meeting.

Another function of the batteries is to ensure a successful transfer of the UPS output power source from the maintenance supply to the inverter output. This situation is encountered during both manual and automatic restart of the UPS unit. The inverter has a voltage output rise time. The K5 relay will transfer the control logic power supply input power source from the maintenance supply to the inverter output at a minimum voltage of approximately 52 V ac. With this input voltage the control logic power supply is not capable of providing an adequate output dc voltage. Depending on the rise time of the inverter output, with degraded batteries, the control logic circuitry may initiate a power supply fail signal, and therefore a module trip. If the maintenance supply was not determined to be within pre-determined limits at this instant, the UPS power output would then be lost. At Nine Mile Point Unit 2, the UPS units are normally configured to operate in the Auto-restart mode. During the November 1, 1991, meeting, the licensee agreed that automatic restart would not be successful with degraded batteries, and indicated that they planned to further evaluate this issue.

Other functions of the batteries are to power the UPS control logic circuitry for testing when there is no ac input power to the UPS unit and to store the alarm indicator lights after complete UPS unit isolation (CB1, 2, 3, and 4 open). The alarm storage is important in that it provides data that can be used in troubleshooting the UPS unit.

Reference: Letter, "Nine Mile Point Unit 2 Uninterruptible Power Supply Failures," From B. Ralph Sylvia, Executive Vice President-Nuclear, Niagara Mohawk To Mr. James M. Taylor, Executive Director For Operations, U.S. Nuclear Regulatory Commission, October 23, 1991.

The subject letter provides the conclusion that the "D" size batteries were not intended to supply logic power while the UPS units are in service. To support this conclusion, the letter contained seven items. Each of these items, along with the Incident Investigation Team (IIT) members' response for each item is provided below.

Item 1

"The vendor manual states that the purpose of these batteries is to power logic lights and aid in troubleshooting when the unit is shutdown".

Team Response

The following statement is provided in the vendor manual.

> "A redundant logic supply, powered by the inverter output, a separate 120 VAC bypass source, and/or internal rechargeable sealed batteries, allows logic testing with no input power applied and keeps alarms indicating for as long as any source of AC control power is available."

The above statement in conjunction with troubleshooting information provided in the vendor manual suggests that in addition to allowing control logic testing with no input power, the logic power supply batteries may also aid in troubleshooting a UPS unit by powering alarm lights. It is noted that in order to power the alarm lights, it is necessary to power the control logic circuitry. In this regard, the team members agree that from vendor manual information, one purpose of the logic power supply batteries is to aid in troubleshooting a unit.

However, this is not the only function of the batteries. In order to deduce the function of the batteries, the drawings, test data, and system failure modes need to be studied, as well as the manual. The primary purpose of the "D" cell batteries is to provide a redundant source of power to the control logic. See Attachment 1 for control logic battery functions.

Item 2

"Exide Corporation representatives made statements at the September 4, 1991 meeting among NMPC, NRC, and Exide officials at NRR headquarters, that the "D" size batteries only power the logic circuit when there is neither maintenance nor normal "AC" power available".

Team Response

With no ac power available the only remaining potential source of logic power is the batteries. These "D" cell batteries provide an important source of power to the control logic during momentary interruptions or degradations of ac power to the control logic 120 V ac/20 V dc power supplies. Estimated battery life under load is about 15 minutes prior to depletion of the batteries to the "power supply fail" trip setpoint. Battery life is further discussed in attachment 1. Should ac power to the control logic ac/dc power supplies not be restored, functional batteries help ensure an orderly transfer of UPS output from the inverter output to the maintenance supply, hence maintaining power to important loads.

Item 3

"Testing conducted using the original design with the "D" size batteries still installed and effectively dead proved that complete loss of the maintenance supply would operate the K5 relay to transfer the control power to the inverter output without tripping the unit. This was also stated by the Exide design engineer. In addition, testing proved that with dead batteries if an inverter trip occurs, the UPS unit will transfer to maintenance supply without loss of load. Consequently, it is concluded that the "D" size batteries were not needed for transfer, and were never intended to serve a power supply role for UPS operation".

Team Response

IIT team members observed testing conducted using the original design with the installed "D" size batteries effectively dead. This testing showed complete loss of the maintenance supply would operate the K5 relay to transfer the control logic power to the inverter output without tripping the unit. Further, testing showed that if certain inverter trips occur, power output from the UPS unit will transfer to its maintenance supply without loss of power output. In these regards, Niagara Mohawk is correct.

However, the team notes that the above testing was conducted with nominal voltages and not degraded voltages. Degraded voltage of the inverter output as well as the maintenance supply can occur. Under such conditions the batteries provide an important backup power source. Should there be a failure of a 20 V dc supply, functional batteries ensure a successful transfer of UPS output from the inverter output to the maintenance supply. Functional batteries provide redundancy and are important for a successful transfer. This was true prior to design modifications of the preferred source of ac power to the 20 V dc power supplies and is still true following modifications.

Item 4

"When the logic control circuit is powered from the normal "AC" supply, the associated "DC" logic voltage is 20 VDC. The nine "D" cells are two volts each for a total voltage of 18 VDC. The logic circuit trip setpoint is approximately 17 VDC, or very near the 18 VDC maximum voltage of the "D" size batteries. This is, in our judgement, because the batteries are not intended to power the logic circuit for UPS operation."

Team Response

The batteries acting alone are not intended to serve as the sustained power supply for the control logic during normal unit operation. Should the nominal 20 V dc power supply fail, the control logic input voltage would drop to the battery voltage of 18.3 V dc. This value is reliably above the 16.5 V dc trip setpoint cited in the manual.

By design the voltage to the batteries, which are connected in parallel with the 120 V ac/20 V dc power supplies, is kept at a slightly higher voltage than the battery open circuit voltage in order to keep the batteries charged. High float voltage degrades battery life. Selection of these voltages was made by the designer.

Item 5

"The testing that was done to investigate the trip of the UPS was a test designed to prove logic power susceptibility to transients on the maintenance supply. It proved that the logic could trip due to a voltage transient. It did not quantify how susceptible the circuit is to transients.

As part of the testing new batteries were installed into the UPS and the test re-performed. While the UPS did not trip with new batteries, "DC" voltage spikes in the range of 2 to 3 V were seen on the oscilloscope traces. This indicates that the control logic is still susceptible to trips when connected to the maintenance supply even with fresh, fully-charged batteries".

Team Response

Fresh batteries do not remove all perturbations of the control logic power supply output. This agreement is based on observing voltage transient testing with fresh batteries installed and noting that voltage spikes were seen on the oscilloscope traces. By design, should the 20 V dc power supplies fail the control logic input dc voltage will drop to the value of the battery voltage. The approximately 2 V dc drop is not surprising, and the functional battery output voltage of 18.3 V dc is above the trip setpoints. Repeated tests performed by Niagara Mohawk showed that a unit tripped with dead batteries and did not trip with fresh batteries, when the ac input voltage to the control logic 20 V dc power supplies was momentarily interrupted.

Item 6

"The voltage output of the "D" size batteries cannot be measured or checked with the UPS in service; it can only be checked with the "AC" supply (20 VDC) disconnected and removed. There is no way to disconnect the normal supply to measure the "D" size battery voltage with the unit in service. This configuration further suggests that the batteries are not critical to the UPS in an operating condition".

Team Response

Full functional testing of the control logic power supply batteries cannot be conveniently done with the unit in service. However the UPS vendor, at the

November 1, 1991, meeting explained how testing of the batteries under partial load with the UPS configured to supply output power from the maintenance supply can be readily done. Power to important loads would not be interrupted during such a test which could be done in conjunction with other scheduled maintenance.

The importance of these batteries is very difficult if not impossible to deduce from the ease of surveillance or replacement of the batteries.

Item 7

"The location of the batteries in the cabinet is such that these batteries were not intended to be replaced with the UPS in service. Replacement requires a unit outage with loss of the load. Changing the batteries with any power being supplied to the loads would not only endanger the safety of personnel due to close proximity of 575 and 208 VAC, but would also risk loss of critical loads if these cables are touched. If the batteries are not required for reliability of the unit, which at this time they are not, then it is better to continue to supply the critical loads than to risk failure of same in order to replace a component that is not intended for reliable operation of the UPS."

Team Response

It is difficult to change out the batteries with the UPS in service. However it can be and was successfully done following the event of August 13, 1991. In addition, Exide Electronics personnel indicated at the November 1, 1991, meeting that Exide Electronics stands ready to assist the utility in maintaining the units by providing a maintenance training program. In response to this, utility personnel indicated that this maintenance training program was being evaluated.

Further, IIT members note that in order to facilitate maintenance activities without endangering the safety of personnel and/or possible loss of critical loads, the electrical system design should include provisions for a downstream manual maintenance bypass switch such as the ones provided to safety-related UPSs 2A and 2B or non-safety related UPSs 3A and 3B.

ACTION

OFFICE FOR ANALYSIS AND EVALUATION OF OPERATIONAL DATA

1. AEOD ACTION NUMBER: 91-148 2. DATE: 11/12/91

3. SUBJECT: WITS 91-00247 - SRM - BRIEFING ON IIT REPORT ON NINE MILE POINT OCTOBER 18, 1991

4. REQUESTOR: SChilk, SECY, 11/6

5. ACTION REQUESTED: A disagreement remains on the function of the "D" cell batteries in the uniteruptible power supplies. Staff should discuss the matter further with the licensee and inform the Commission of the results.

6. ASSIGNED TO: Rosenthal

7. EXPECTED COMPLETION DATE: December 4, 1991

8. EXTENDED COMPLETION DATE:

9. COMPLETION DATE:

10. DOCUMENTATION OF COMPLETION: