August 11, 2004

MEMORANDUM TO: Dwight D. Chamberlain, Director
Division of Reactor Safety, Region IV

FROM: James E. Lyons, Deputy Director ***/RA/***
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

SUBJECT: RESPONSE TO TASK INTERFACE AGREEMENT - TIA 2004-01, REQUEST FOR EVALUATION OF TECHNICAL SPECIFICATIONS AND OTHER REQUIREMENTS INTENDED TO CONTROL DEGRADATION OF CLASS 1E STATION BATTERIES AT ARKANSAS NUCLEAR ONE, UNIT 2 (TAC NO. MC1994)

EXECUTIVE SUMMARY

During an inspection at Arkansas Nuclear One, Unit 2 (ANO-2) in 2003, inspectors noted what seemed to be a non-conservative implementation of Technical Specification (TS) 3.8.2.3 and applicable portions of Institute of Electrical and Electronics Engineers (IEEE) Standard-450, "Recommended Practice for Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Generating Stations and Substations." These licensing basis requirements are intended to provide the framework for assuring the capability of the Class 1E station batteries to perform as required by the accident analysis and to ensure they perform as expected, should a station blackout occur. The Office of Nuclear Reactor Regulation has performed a detailed analysis of the condition of battery 2D11 and has determined that no evidence exists to indicate that it will not function when called upon. As a precaution, it is recommended that augmented monitoring as detailed in this response be performed by the licensee prior to the scheduled replacement of the battery 2D11 during the next outage.

BACKGROUND

On February 9, 2004, Region IV submitted Task Interface Agreement (TIA) 2004-01. The purpose of this TIA is to determine whether ANO-2, is in compliance with their TS and other requirements related to their Class 1E Batteries.

The concern was that Entergy Operations, Inc. (the licensee) appeared to have applied a non-conservative implementation of TS 3.8.2.3 and applicable portions of IEEE Standard-450. Specifically, a response was requested for each of the three requests listed below.

RISK SIGNIFICANCE

In the TIA 2004-01 request, you explained that the Class 1E batteries are moderately risk significant. In the request, a table was provided that indicated that the core damage frequency attributable to a battery 2D11 malfunction, when required to respond to design basis conditions, is considered to be moderately significant. The regional inspectors involved are concerned as to whether or not the licensee's maintenance practices, which are consistent with their interpretation of the requirements, will provide reasonable assurance that the batteries will perform their safety function when called upon.

REQUESTED ACTIONS/EVALUATIONS

Request 1 **We request assistance in determining whether the Technical Specification Surveillance values for low individual cell voltages were based on a battery operating at the nominal float voltage specified in the vendor manual; or is the licensee correctly able to operate the battery at a higher equilibrium point without recalculating the low cell limits for the maintenance action limits and other technical specification limits.**

The TS surveillance values for low individual cell voltages were based on a value recommended by the battery manufacturers (2.13 volts (V)) and a calculation of the open circuit voltage for a lead acid battery with a specific gravity (SG) of 1.215 (2.07V). The licensee may operate the battery at a higher float voltage (i.e., higher than the vendor's specified range), if the results of an engineering analysis (usually completed by the vendor) provide assurance that the battery will be capable of providing its intended safety function when called upon. In addition, the minimum allowable cell voltage does not imply that the battery is malfunctioning or will not be capable of providing its intended safety function when called upon at that voltage but could be an indication of high internal losses.

Battery cells are typically of flooded lead acid construction with a nominal SG of 1.215. The SG corresponds to an open circuit battery voltage of approximately 120V for a 58 cell battery (i.e., cell voltage of 2.065V per cell (Vpc)). The open circuit voltage is the voltage maintained when there is no charging or discharging. Once fully charged with its open circuit voltage ≥ 2.065 Vpc, the battery cell will maintain its capacity for 30 days without further charging per manufacturer's instructions.

To find the voltage for a battery with a 1.215 SG, the value "x volts" is extrapolated between a battery with a 1.2 SG (open circuit voltage = .849V) and a battery with a 1.25 SG (open circuit voltage = .845V). Solving for x:

$$(.849 - .845) / (1.2 - 1.25) = (.849 - x) / (1.2 - 1.215)$$
$$x = .848$$
$$.848 + 1.215 = 2.063\text{V (approximately 2.06V)}$$

The plates are charging above 2.06V. The plates have discharged when below 2.06V. The cell is fully charged at 2.06V. Therefore, the 2.07V TS limit was conservatively chosen as a result of this calculation.

Optimal long term performance is obtained by maintaining a float voltage of 2.20 to 2.25 Vpc (as specified by the manufacturer). This provides adequate over-potential, which limits the formation of lead sulfate and self discharge. In response to a staff request for additional information (RAI) dated March 3, 2004, the licensee stated that the original vendor manual provided a recommended ‘Nominal’ float voltage of 2.20 - 2.25V but did not specify a ‘recommended operating range.’ The current vendor manual provides ‘Recommended’ and ‘Allowable’ float voltage Vpc Min/Max limits as follows:

Recommended:	2.21 - 2.22V
Allowable:	2.20 - 2.25V

In its response to the staff RAI dated April 16, 2004, the licensee stated that based on historical performance of their batteries ANO will follow the guidance provided in the original vendor manual. This is acceptable, however, the licensee should be aware that operating their battery in the recommended float voltage range (2.21 - 2.22V) will prolong the life of the battery. Operating the battery at a higher float voltage increases the probability of (1) mossing on the negative plates, (2) corrosion of the positive plates, (3) increased cell temperature, and (4) increased electrical resistance. High cell temperature will cause an acceleration of positive plate corrosion, increase the capacity, and decrease the life of that cell, these signs of degradation should be included in the visual inspections section of the licensee’s predictive maintenance program.

In general, the TS voltage limit of 2.13V is a maintenance limit that was provided by the battery manufacturers. This limit was put in place to alert licensees to take action (i.e., equalized charge) before their batteries degraded any further.

The 2.07V TS limit is an absolute value and does not change with fluctuations in float voltage. Annex C of IEEE Standard 450-1995, Section C.2, “High-voltage cells,” states that normally there is no detrimental effect associated with a cell that has a float voltage slightly higher than the average of the other cells in the battery. However, when a cell’s voltage is significantly higher [0.1V for a pure-lead/lead-calcium cell or 0.05V for a lead-antimony/lead-selenium cell] than the average, the cause should be investigated and corrected if necessary. Therefore, if the licensee operates the battery at a higher float voltage (outside the allowable range specified in the vendor manual) an effect may be seen in the form of cell voltage differential/deviation from the average of the other cells in the battery.

A positive attribute of operating at a higher float voltage is stated in IEEE Standard 485-1983, “IEEE Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations,” Section 6.1.3, “Float Voltage as Limiting Factor.” IEEE Standard 485-1983 states, in part, that in order to eliminate the need for frequent equalizing charges (refer to ANSI/IEEE Std. 450-1980[2]), it may be desirable to establish a float voltage at the high end of the manufacturer’s recommended range. The float voltage must, however, be consistent with the maximum system voltage.

The licensee is required to meet the individual cell voltage limits in their TSs and should maintain a float voltage bounded by the specified float voltage range provided in the vendor manual. The licensee may operate the battery at a higher float voltage (i.e., higher than the vendor’s specified range), if the results of an engineering analysis (usually completed by the vendor) provides assurance that the battery will be capable of providing its intended safety function when called upon.

Request 2 We request assistance in determining whether we should impose this new requirement on the licensee in order to provide adequate assurance that the batteries will perform acceptably if called upon to function. If you agree, we will propose a plant specific backfit.

A new requirement is not necessary to provide adequate assurance that the batteries will perform acceptably if called upon to function.

However, there are no industry standards or accepted practices for successfully determining battery capacity by extrapolating test data. In order to accurately track the health of a battery, trending of successful performance test data is necessary. The accurate documentation of successful battery test data allows for comparison analysis which can be used to help determine the health of the battery.

With respect to experiencing problems during performance testing, IEEE Standard 450-2002 states the following:

> In the event of problems with the load bank that interrupts the test, the test should be continued in order to determine the capacity of the remaining cells. The time of the interruption shall not exceed 10% of the total test duration or 6 minutes, whichever is shorter. This “downtime” shall not be included in the test discharge period. No more than one “downtime” period should be allowed when a battery is being tested. The battery may supply higher than its normal capacity (especially during short duration testing) if the battery is subjected to more than one “downtime” period.

Request 3 We request assistance in determining whether it is a new requirement to expect a performance discharge test to confirm the acceptability of installing cells that are not like-for-like replacements. We would also appreciate assistance in developing criteria for determining which cells are like-for-like replacements.

With respect to complete battery or individual cell replacements, IEEE Standard 450-2002 describes the physical characteristics in Section 8, “Battery Replacement Criteria” as follows:

> Replacement cells, if used, should be compatible with existing cells and should be tested in accordance with 6.1 of this recommended practice and installed in accordance with IEEE Std 484-1996. The capacity of the replacement cell(s) should not degrade the battery’s existing ability to meet its duty cycle. Replacement cells are not usually recommended as the battery nears its end of life. Due to material and/or design changes, cells of different vintages may have different operating characteristics. Identical model numbers do not guarantee compatibility. Before mixing cells of different vintages, the manufacturer should be contacted.

When cells are connected in series, they should be from the same manufacturer; made of the same lead-alloy (or pure lead if the original cells are pure lead); of the same nominal full charge electrolyte SG; and approximately the same rating (e.g., Ampere-hours) on the same base (e.g., discharge rate, end voltage, electrolyte density, and temperature). It is also desirable that the replacement cell be of the same age/vintage, however, a replacement cell of the same age is not a requirement. The licensee may deviate from the above recommended practices if the results of an engineering analysis provides assurance that the battery will be capable of providing its intended safety function when called upon.

Prior to replacing a cell within a battery, it is expected that the licensee would perform an acceptance test (performance/modified performance test) on the replacement cell to verify that the cell has adequate capacity. Increased monitoring of the replacement cell should be performed until the cell has stabilized within the battery.

CONCLUSION

The licensee's most recent performance test on battery 2D11 (October 10, 2003) was completed successfully and the battery was found to have a capacity greater than 100%, however, the staff recommends increased monitoring by the licensee to monitor key parameters of battery 2D11 (e.g., cell voltage, SG, temperature, electrolyte level, etc.) to provide further assurance that the battery will be available to provide its safety function when called upon. Specifically, our recommendation is to increase the licensee's monthly monitoring frequency to bi-weekly, until battery 2D11 is replaced, so as to provide additional data points for more accurate trending of the battery's performance. Our recommendation is based on the uncertainty that exists due to past battery test equipment failures and because of the battery nearing its expected end-of-life. Based on our review of the February 9, 2004, request for technical assistance and its supporting documentation, the staff finds that there is adequate assurance that ANO-2 battery 2D11 will perform its designed safety function when called upon provided that the licensee increases its battery monitoring frequency, as prescribed above. The above evaluation concludes this review under TAC No. MC1994.

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