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January 5, 2007
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U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555-0001

Subject: **COLUMBIA GENERATING STATION, DOCKET NO. 50-397 RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION REGARDING LICENSE AMENDMENT REQUEST TO TECHNICAL SPECIFICATIONS ASSOCIATED WITH AC AND DC ELECTRICAL POWER**

Reference: Letter dated, May 31, 2005, WS Oxenford (Energy Northwest) to NRC, "License Amendment Request to Technical Specifications Associated with AC and DC Electrical Power"

Dear Sir or Madam:

On April 4, 2006, subsequent to discussions with the staff, Energy Northwest received a Request for Additional Information (RAI) related to the referenced submittal (TAC NO. MC7273). Attached herein are responses to the four questions detailed in the RAI. In order to resolve concerns with TSTF-360 raised by the NRC electrical branch, an industry task force was formed. The RAI responses herein reflect the resolution of these concerns as addressed in a meeting between NRC and the industry task force on July 12, 2006. Portions of Technical Specifications that are being revised will be relocated to the proposed Battery Maintenance & Monitoring Program of proposed Technical Specification 5.5.13.

If you have any questions or require additional information, please contact Mr. GV Cullen at (509) 377-6105.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the date of this letter.

Respectfully,

WS Oxenford (Mail Drop PE04)
Vice President, Technical Services

Attachments:
1. Response to Request for Additional Information
2. List of Commitments

cc: BS Mallett – NRC RIV
RF Kuntz – NRC NRR
NRC Senior Resident Inspector/988C
RN Sherman – BPA/1399
WA Horin – Winston & Strawn

A001

Response to Request for Additional Information

NRC Question 1

Specific gravity monitoring is used to measure the strength of a battery cell's electrolyte, which is an important component of the battery's chemical reaction, and provides an indication of the battery's State Of Charge (SOC). Whereas, float current monitoring may or may not provide an accurate indication of the battery's SOC. Float current monitoring is based on the following equation that is dependent on several variables.

$$I = (E - E_b) / R$$

Where:

I = Charging Current
E = Charging Voltage
E_b = Internal Cell Voltage
R = Cell Resistance

The staff has a concern with two variables of this calculation: the applied charging voltage and cell resistance. A change in either of these variables may provide a false indication of the battery's SOC. Provide assurance that float current monitoring will provide an accurate indication of the battery's SOC.

Energy Northwest Response To Question 1

Float current monitoring is the preferred method of determining battery SOC for the following reasons:

1. Battery SOC involves charge-discharge reactions related to electric current flow.
2. Float current monitoring is a more meaningful indicator of SOC because current is the primary means of discharging and charging the battery.
3. Specific gravity readings have an inherent time lag on both charge and discharge.

Note that the SOC is only one of many parameters used to determine battery condition in TSTF-360.

This concern deals with the fundamental question of which SOC indicator is best for surveillance purposes. The basic charge-discharge reactions for lead-acid batteries are associated with electric current flow internal and external to the battery/cells and lead-sulfate conversion internal to the cells. (See Reference 2 below for further discussion of float behavior.)

One of the first indications of a possible discharge is a charger failure alarm followed by a DC Bus under-voltage alarm. Once an unintended discharge is indicated, then battery condition including SOC must be determined. Measuring the specific gravity in one cell or even several cells at one level in the bulk electrolyte does not give a timely indication of SOC due to the inherent time lag associated with specific gravity readings.

Verifying adequate float voltage and then measuring float current provides a very quick indication of SOC. For example, if a discharge has occurred, there will be an immediate spike in the current entering the battery once the voltage is applied. Depending upon the degree of discharge, the subsequent recharge current may remain higher than the normal float current level for several minutes before it begins an exponential decay to normal. Therefore, float current monitoring provides a more timely indication of SOC than specific gravity.

The equation given in the NRC concern is one of two given in the 1994 INTELEC paper (Reference 1) to illustrate the cell voltage and current variations associated with the charge-discharge reactions of a lead-acid battery. However, in answer to the concerns, the charging voltage (E) is fixed by the battery charger float/equalize control setting. The internal cell resistance (R) is a very small value and varies inversely with the SOC, from a maximum when fully discharged to a minimum when fully charged. The dominant factor in the equation is the internal cell voltage (E_b), which is dependent upon the presence of lead sulfate ions within the cell. The quantity of lead sulfate ions is associated with the SOC. Even a small amount of lead sulfate reduces the internal cell voltage significantly, thus increasing the driving voltage given as ($E- E_b$) in the equation above. (This is why the current demand of a fully discharged battery can be thousands of Amperes even when the internal cell resistance is at its maximum value). The charge reaction (conversion of lead sulfate) is the preferred reaction electrochemically. Therefore, this reversible reaction proceeds to completion once adequate voltage is applied to the battery.

If there is no lead sulfate to be converted, the battery is fully charged and true float behavior takes place as described in the Paul C. Milner article published in the Bell System Technical Journal (Reference 2). Tafel line graphs are made by the battery manufacturer to document this behavior. These graphs depict the logarithm of the average expected float current versus the applied cell voltage for a given model series. Float current is made up of components associated with the electrolysis of water, grid corrosion at the positive plates, and oxygen recombination at the negative plates. In order for float current to flow, the voltage applied to the battery must be greater than its open circuit value. This is referred to as over-potential or sometimes an overcharge condition. This is not to be confused with the reversible charge-discharge reaction associated with battery capacity. The over-potential, measured in millivolts per cell, polarizes the plates in order to minimize grid corrosion and self-discharge.

The level of float current measured with the proper float voltage provides a clear indication of battery SOC at any time. If the current is higher than the established float current limit, then a recent discharge is indicated. The level and time response of the current indicates some characteristics of the discharge as described in the TSTF-360 Bases. If the current is at or below the established limit, there is reasonable assurance the battery is charged. This has been confirmed in technical papers, by consultation with the battery manufacturers, and by over 20 years of experience at one nuclear plant. (Even partial discharges in the order of 0.1% of rated Ampere-hour have been captured with continuous float current monitoring.)

References:

1. K. D. Floyd, "Assessment of Lead-Acid Battery State of Charge by Monitoring Float Charging Current," INTELEC'94, Vancouver, October 30-November 3, 1994.

2. P. C. Milner, "Float Behavior of the Lead-Acid Battery System," Bell System Technical Journal, pages 1321 through 1334, September 1970.

NRC Question 2

The battery pilot cell is representative of the average battery cell in the battery. Provide assurance that a battery with a battery pilot cell with a voltage of 2.07 volts or slightly greater will remain capable of performing its minimum designed function.

Energy Northwest Response to Question 2

Contrary to the assumption in the above question, the pilot cell is not representative of the average Individual Cell float Voltage (ICV) in the battery. Columbia selects the cell with the lowest ICV as the pilot cell. This method provides high assurance that the remainder of the battery cells are charging at a higher voltage than the pilot cell and that the battery is fully capable of performing its design function.

When pilot cell voltage is measured to be < 2.13 Volts, action will be taken to verify battery output terminal voltage is above the operability limit. Columbia's Battery Monitoring & Maintenance Program will describe additional actions to be taken when pilot cell voltage is measured to be < 2.13 Volts. These actions are described in the response to question 4.b below.

NRC Question 3

As mentioned in question 2, the battery pilot cell is representative of the average battery cell in the battery. Provide assurance that a battery with a battery pilot cell with an electrolyte temperature slightly greater than or equal to the minimum established design limit will remain capable of performing its minimum design function.

Energy Northwest Response to Question 3

With an electrolyte temperature slightly greater than or equal to the minimum established design limit (60° F) battery performance is improved and capability of performing designed function is ensured.

The battery rooms are maintained at a temperature above 74° F. Once per shift verification is made that room temperature is above this level.

Surveillance data demonstrates that cell temperatures deviate only slightly from the average (82.4° F) temperature and that minimum/maximum temperatures are well within a 5° F variance.

NRC Question 4

Consistency with the Institute of Electrical and Electronics Engineers (IEEE) Standard 450-2002, "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications," was used throughout your submittal as the justification for approval. The most recent version of IEEE Standard 450 that has been endorsed by the NRC through Regulatory Guides (RGs) is IEEE Standard 450-1975. The RGs of mention are: RG 1.128, "Installation, Design, and Installation of Large Lead Storage Batteries for Nuclear Power Plants," and RG 1.129, "Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Nuclear Power Plants."

Question 4.a

Provide a plant specific technical justification for each proposed change in lieu of referencing consistency with the IEEE Standard 450-2002.

Energy Northwest Response

Below are proposed excerpts from the Technical Specifications SR Bases that contained references to IEEE 450. They will be revised as described below to contain plant-specific justifications in lieu of referencing consistency with the IEEE Standard 450. References to IEEE 450 will be deleted from the reference sections of all of these SRs.

SR 3.8.4.1

The text containing the single reference to IEEE 450 will be revised to read as follows:

> The 7 day Frequency is conservative when compared with the manufacturer's recommendations.

SR 3.8.6.1

The text containing the single reference to IEEE 450 will be revised to read as follows:

> The charging current for a large station battery is highly reactive to a change in battery voltage. A charging current less than 2 amps is indicative of a fully charged battery when charging at normal float voltage. At a float voltage greater than minimum float voltage, the battery will be maintained in its fully charged state for an extended period of time. The 7 day frequency is adequate to ensure

the battery is capable of performing its design function. A measuring device accuracy of ± 10% of reading is adequate to verify float current to be within nominal values.

SR 3.8.6.2 & 3.8.6.5

The text containing the single reference to IEEE 450 will be revised to read as follows:

The verification of individual cell voltage readings every 31 days for the pilot cell and 92 days for all cells is consistent with the manufacturer's recommendations.

SR 3.8.6.3

The text containing the single reference to IEEE 450 will be revised to read as follows:

The verification of cell electrolyte level every 31 days is consistent with the manufacturer's recommendations.

SR 3.8.6.4

The text containing the single reference to IEEE 450 will be revised to read as follows:

The verification of the pilot cell temperature every 31 days is consistent with the manufacturer's recommendations.

SR 3.8.6.6

This SR contains four references to IEEE 450, they will be revised to read as follows:

The acceptance criteria for this surveillance are consistent with IEEE 485 (Reference 6) for the 125 Vdc batteries.

Degradation is indicated, when the battery capacity drops by more than 10% relative to its previous performance test or when it is below 90% of the manufacturer's rating. This is consistent with the normal aging curve for Lead-Acid batteries because at 90% (or a 10% change), the slope of the aging curve has started to increase.

The 12 month and 60 month Frequencies are consistent with the normal aging curve of Lead-Acid batteries. The 24 month Frequency is also derived from the aging curve.

NRC Question 4.b

Provide a copy of the proposed battery monitoring and maintenance program identified in TS 5.5.13.

Energy Northwest Response

Below is a draft of our proposed Battery Monitoring and Maintenance Program.

5.5.13 Battery Monitoring and Maintenance Program

A. Actions to restore battery cells with float voltage <2.13 Volts.

   1. Verify battery is in normal float condition.

      a. Float voltage within acceptable range (2.25 x number of cells ± 1.0 volts).
      b. Float current < 2.0 amps.

   2. If the pilot[1], or any individual cell voltage has made a step change, *perform the following actions:*

      a. Verify all connected cell voltages are above 2.07 Vdc within 24 hours.
      b. Consider placing the cell on equalize.
      c. Consider placing the battery on equalize.

   3. If the pilot cell voltage is not a step change, perform the following actions:

      a. Consider placing the cell(s) or battery on equalize.
      b. Monitor voltage and replace cell prior to any cell reaching 2.07 Vdc.

B. Actions to equalize and test battery cells with electrolyte level below the top of the plates.

   1. Check specific gravity and water to at least the low-level line.
   2. Perform visual inspection for evidence of leakage.
   3. Place battery or cell(s) on equalize.
   4. Inspect for sulfation near the top of the negative plate and for loss of active material on the positive plate.
   5. If there is evidence of leakage, sulfation or loss of active material, consider additional corrective actions to include replacement of the cell(s). The manufacturer should be contacted for further guidance on cell recovery or replacement.

[1] Columbia selects the cell with the lowest individual cell voltage as the pilot cell.

C. Ancillary Information

1. Battery float current

   a. Enersys and C&D batteries are installed in Columbia's Class 1E safety related applications. Both of these battery manufacturers recommend using float current monitoring as the primary indicator of state of charge.
   b. To ensure adequate monitoring of battery state of charge, float current is to be measured with instruments accurate to within 10% of the current reading.
   c. Calculation EI-02-91-01 provides the basis for the nominal 2 amp float current acceptance criteria.

2. Specific Gravity

   a. Specific gravity measurements are performed as part of the Battery Maintenance & Monitoring Program. Trending specific gravity measurements is useful when evaluating battery health particularly when analyzing anomalous indications of other parameters.

3. Battery aging

   a. Lead-Calcium batteries are employed in Class 1E safety related applications at Columbia. An attribute of this type of battery is a "low and stable" float current throughout the life of the battery [2].

4. Electrolyte level

   a. The minimum design electrolyte level corresponds to the low level mark on the side of the battery jar.

[2] EPRI TR100246, "Stationary Battery Guide."

List of Commitments

1. Portions of Technical Specifications that are being revised will be relocated to the proposed Battery Maintenance & Monitoring Program of proposed Technical Specification 5.5.13.

2. The specific gravity of all cells will be measured periodically at Columbia as part of the Battery Maintenance and Monitoring Program.

3. The Battery Maintenance & Monitoring Program document will describe the capability of the monitoring equipment that will be used to monitor float current to be within 10% of the float current reading. The Battery Maintenance & Monitoring Program document will also contain a discussion regarding the significance of SG measurements to support troubleshooting.

4. Columbia's Battery Monitoring & Maintenance Program will describe additional actions to be taken when pilot cell voltage is measured to be < 2.13 Volts.

5. The Technical Specifications Bases for SRs 3.8.4.1 and SRs 3.8.6.1 through 3.8.6.6 will be revised as described in the response to question 4.a in Attachment 1 to contain plant-specific justifications in lieu of referencing consistency with the IEEE Standard 450.