EAGLE EYE TECHNICAL NOTE

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Title: Establishing Compliance with NERC Standards PRC-005-6 an TPL-001-5 using the Vigilant Battery Monitor

Revision History

Date	Revision	Description of Change	Author(s)
3/2/20	1	Added TPL-001-5 information	GP

PRC-005-6 is the latest version of the Protection System, Automatic Reclosing, and Sudden Pressure Relaying Maintenance Document. This standard defines the maintenance and reporting requirements for all network components identified in the document. This Includes the Protection System Station DC Supply using, Vented Lead-Acid (VLA), Valve Regulated Lead Acid (VRLA), and Nickel Cadmium (NiCd) Batteries. The DC Power Supply and associated batteries listed above, are subject to an abbreviated version of the calendar-based maintenance program outlined in IEEE Recommended Practices 450, 1188, and 1106. The parameters to be measured and analyzed are detailed in tables 1-4 (a-e) of the Standard.

To reduce the number of site visits required for compliance. Table 1-4(f) identifies those calendar-based maintenance functions which can be eliminated if the parameters are remotely monitored and any alarms are communicated to a location where corrective action can be initiated. These alarms must be transmitted within 24 hrs. of the alarm occurrence, as detailed in table 2 of the specification.

The Vigilant Battery Monitor is a next generation battery monitor that expands on the capabilities of the previous generation of monitors to more accurately meet the evolving standards of the Smart Grid and the associated cyber security risks.

As with many standards, compliance with PRC 005-6 can be subject to different interpretations. It is important that selected monitor can demonstrate that all the parameters listed in Table 1-4(f) are monitored and interpreted in a manner that will meet the most stringent audit. The following will outline how the Vigilant monitor meets or exceeds that requirement.

> ***"Any station dc supply with high and low voltage monitoring and alarming of the battery charger voltage to detect charger overvoltage and charger failure"***

As the required voltage setting of the charger is determined by the installed batter specifications and the battery distance from the charger, the DC bus voltage can be measured and verified at the battery terminals. The Vigilant monitor measures the actual voltage at the battery terminals and does not use a voltage generated by the addition of the measured individual cell/unit voltages.

Both the upper and lower limits for the warning and critical alarms on the DC Bus are preset in the monitor for the model of battery on which the monitor will be installed. These alarm limits are based on the battery manufacturers specifications but can be reset to meet the user requirements.

In the event of a charger or utility failure the bus voltage will drop below that critical alarm point and the monitor will show that the battery is in discharge. In order to differentiate a charger failure from utility failure the Vigilant monitor external alarm inputs can use the charger fail alarm to differentiate the conditions.

> ***"Any battery based station dc supply with electrolyte level monitoring and alarming in every cell"***

Each Vigilant sensor can accept an input from an associated Electrolyte Level Monitoring (ELM) sensor. This sensor will identify when the level of any cell drops below the low level line inscribed in the cell. Two levels of alarm are provided the first when a single unit goes into alarm and a second when five or more units are in alarm.

Because the alarms are recorded against a specific cell, any cell that is continually the first in alarm can be checked to identify possible problems that could be linked to premature failure.

"Any station dc supply with unintentional dc ground monitoring and alarming"

In order to prevent interaction between ground fault detectors using similar ground reference methods of detection. It is important that the ground fault detection circuits can be isolated from the DC bus. While the Vigilant does not use a ground, reference-based detection circuit, the ability to isolate the circuit is included.

"Any station dc supply with charger float voltage monitoring and alarming to ensure correct float voltage is being applied on the station dc supply"

Because the charger output voltage monitoring is based on the float voltage being measured at the battery, the monitoring and alarm conditions being reported for that parameter are also valid for this one.

"Any battery based station dc supply with monitoring and alarming of the intercell and/or terminal connection detail resistance of the entire battery"

Many of the battery monitors measure the internal ohmic value of the cell/unit, and the interconnect resistance to the next cell or unit, as a single measurement. PRC 005-6 Requires that these interconnection resistances and terminal connection resistance be measured and reported as separate values. The Vigilant achieves this by measuring the values as part of the perturbation cycle and using isolated Kelvin connections on the battery posts to achieve the level of accuracy required.

"Any battery based station dc supply with monitoring and alarming of battery string continuity"

Battery continuity can only be measured by measuring the float current within the battery under normal operating conditions. As this current is typically in the milliamp range dependent on battery capacity. A hall effect sensor intended to measure charge / discharge currents will not have the accuracy required to measure the float current accurately. A third-party specialized sensor is often used by other vendors to satisfy this requirement. But because the Vigilant accurately measures the intercell resistances as part of the ohmic value measurement each interconnect becomes a calibrated shunt which can be used to measure the float current.

In addition to meeting the continuity requirement the float current can be used to establish the battery state of charge, identify conditions leading to potential Thermal Runaway and as the float current will increase as the battery ages it is a parameter that can be used with other factors to indicate the rate at which the battery is aging.

"Any Valve Regulated Lead-Acid (VRLA) or Vented Lead-Acid (VLA) station battery with internal ohmic value or float current monitoring and alarming and evaluating present values relative to baseline internal ohmic values for every cell/unit"

This exclusion in Table 1-4(f) states, that if a monitor is installed then a human review of the data collected is no longer required to establish if the battery can perform as manufactured. In reality the

requirement to establish the viability of the battery still exists but the analysis is now considered to be a function of the monitor firmware or a separate analysis program.

In addition to determining the risk associated with the alarm and trend information derived from the collected data, the analysis will need to include the impact of the operational and environmental conditions in which the battery operates.

The Vigilant battery monitor using the historical data stored within the monitor will implement a first generation algorithm to provide a determination of battery State of Health and a level of Risk Analysis to identify those batteries that may need further analysis or possibly a discharge test. As the volume of stored data increases the Vigilant has been designed to eventually implement advanced Artificial Intelligence algorithms to further improve this analysis.

There is a second NERC standard for which a battery monitor can provide compliance. In the Reliability Standard TPL-001-5 – Transmission System Planning Performance Requirements the objective is to identify and eliminate all single points of failure. In the latest -5 issue of the standard the DC power system has been added to the list of sub systems identified as potential single points of failure. In many of the existing physical transmission infrastructure there is no way that the DC power system can be upgraded to provide the level of redundancy required. In recognition of this, the Standard Drafting team allowed for compliance with the monitoring and reporting of the DC voltage and battery continuity to a manned control center where corrective action can be initiated. Any Vigilant battery monitor installed and in compliance with PRC-005-6 will also meet the regulatory requirements of TPL-001-5.