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MIDTRONICS
Battery Management Innovation™

CONDUCTANCE TESTING QUESTIONS AND ANSWERS

Conductance testing has recently been added to the IEEE draft standard for testing sealed valve regulated lead acid batteries. Extensive field test results were presented to Bellcore's T1Y1 Group, a Bellcore symposium on passive battery monitoring and testing, the International Lead Zinc Research Organization and the Battery Council International conferences in May of 1992, and the International Telecommunications Energy Conference in October of 1992. Many battery manufacturers, every Regional Bell Operating Company, global telecommunications providers and manufacturers and users of Uninterruptible Power Supply (UPS) systems rely on Midtronics Conductance Testers.

This acceptance of conductance methodology has led to a series of questions about conductance testing. The following are answers to some of the most frequently asked questions:

Q. What is conductance?

A. Conductance describes the ability of a battery to conduct current. It is the real part of the complex admittance. Various test data have shown that at low frequencies, the conductance of a battery is an indicator of battery state-of-health showing a linear correlation to a battery's timed-discharge capacity test result. This can be used as a reliable predictor of battery end-of-life.

Q. What is Ohmic testing technology?

A. In simplest technical terms, Ohmic technology is based on Ohm's law, which expresses the relationship between volts, amperes and ohms in an electrical circuit. Ohm's law can be expressed as follows: Volts (E) = Amperes (I) x Ohms (R). If any two of the three values of voltage (volts), current (amperes) or Resistance (Ohms) are known, the third value can be calculated using the above expression of the law.

Thus, Ohmic technology attempts to use voltage and current to determine the resistive characteristic of a battery. Higher resistance equates to a reduced ability to produce current. This characteristic is translated into a measurement of resistance or impedance (Ohms) in some Ohmic technologies; more recent technology uses a converse measurement, called conductance.

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Q. Why test conductance?

A. Through years of laboratory and field-based research, conductance has been found to correlate directly with battery capacity as measured in a timed discharge test. This correlation is nearly linear, meaning that if conductance can be measured, timed-discharge capacity can be predicted. Since voltage and specific gravity testing are not predictive, timed discharge testing is very time-consuming and expensive, and impedance testing does not correlate directly and linearly with timed discharge capacity, conductance testing is a very effective and economical alternative.

Q. How is the conductance test performed?

A. Simply by connecting the two test set leads to the positive and negative posts of the cell or battery under test, a measurement is taken in a matter of seconds. There is no need for additional leads to be connected to the ends of the string, or for clamp-on current measurements. A conductance measurement is displayed in Mhos or Siemens, sometimes abbreviated with a "G".

Q. How can conductance readings be used?

A. A significant number of tests on a variety of valve regulated lead acid (VRLA) batteries demonstrate that conductance is predictive of battery state-of-health. Since conductance is directly related, and very nearly linear with timed-discharge capacity, a reading of the percentage of a known conductance reference value is a reliable predictor of a capacity test result. The conductance tester gives a quantitative measurement in Mhos (or Siemens), as well as a qualitative indication (percent of reference) of a battery as related to a standard.

Q. Are conductance readings difficult to interpret?

A. Unlike other testing techniques that require interpretation and mathematical calculation, conductance readings can be read instantly and can be related directly to the condition of the battery being tested.

Q. **Since the qualitative conductance test requires a standard, how can that standard be established?**

A. The most effective method for the establishment of a standard requires the performance of a timed discharge test to locate a cell or battery that performs to 100% of the rated discharge capacity. A conductance test can then be performed and a reference established. A sample of 30 or more new batteries can also be used to establish a standard. Without a set reference value, conductance testing can still be utilized to trend state of health, as batteries can be monitored through periodical conductance readings and the observation of deterioration over time.

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Q. **Can conductance testing be used to evaluate the quality of inter-cell connections?**

A Yes. Since a conductance reading of a cell plus an inter-cell connection can easily be related to the conductance of the cell alone, conductance provides a very simple and reliable indication of the system's inter-cell connection quality.

Q. **Can Midtronics conductance testers measure the condition of sealed valve-regulated batteries as well as flooded cells?**

A. Yes. Correlation studies have been performed on a significant number of valve regulated cells. These studies have shown that conductance test results are very predictive of battery timed discharge capacity, while voltage measurements are shown to be of little value. This data has been presented to a number of international organizations. Additionally, recent data includes gelled batteries, and Midtronics' testing will soon include NiCad batteries.

Q. **What kinds of batteries and cells can be tested utilizing conductance?**

A. Typically any 2 Volt to 12 Volt, lead-acid 5 to 2000 ampere-hour cells can be tested.

Q. **Can Nickel Cadmium (NiCad) batteries and cells be tested utilizing conductance?**

A. The Micro Celltron (CTM) from Midtronics will accurately measure the voltage and conductance of Nickel Cadmium batteries. Conductance will measure and identify gross failures of NiCad batteries. The Celltron will report hard shorts identified through low-voltage, and is a useful tool in testing the application of NiCad battery systems.

The feature of identifying the decline and forecasting the failure of battery cells, a superior feature of the Micro Celltron, is not as applicable when testing NiCads. Based upon their construction and chemistry, all NiCads will measure consistently (good) until there is a gross failure indicating the end of life. The Celltron will indicate this gross failure after the fact, a limitation that is true of all Ohmic measuring devices, including all existing impedance and resistance testers on the market.

As mentioned above, the Celltron contains a low voltage alarm, settable by the user to a minimum of 1.50 volts DC cell. The Celltron will report an audible alarm when testing single cell NiCads falling below the voltage benchmark. Additionally, the Micro Celltron will not test any battery or cell where the measured voltage is below 1.0 Volts DC, which would include any badly discharged or shorted NiCad cells.

For more information on the testing, trending and analysis of NiCad batteries, please contact Midtronics, Inc. directly.

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Q. Can a Midtronics conductance test be made while the battery is on float?

A. Yes. The current test technology enables successful testing of batteries while on float charge. In certain cases an excessive amount of electrical noise current can interfere with any test method.

Q. Does the Midtronics conductance tester need to be plugged in to AC power?

A. No. Midtronics Conductance testers require no external AC power. Midtronics testers derive test power by removing a small (less than 1 AH) load from the battery under test. Additionally, the testers are powered by an on-board 9-volt alkaline battery for the test data review, test configuration, portable printing and transfer to PC.

Q. Can the signal from the Midtronics conductance tester interfere with or damage electronic equipment or cause danger to a defective cell?

A. No. Midtronics conductance testers do not apply a large current to the battery under test, as does other test equipment. Midtronics testers apply a signal frequency less than one Amp; therefore, it is highly unlikely that over-current damage to sensitive electronic equipment could result in the event of a defective cell. Testing on communication systems shows that conductance testing does not interfere with telephone signals. Users should be aware that other types of battery test equipment (non-conductance methods) do use AC power to send a large current though the battery, which may affect sensitive electronic devices.

Q. How large are Midtronics conductance testers?

A. All Midtronics conductance testers are hand-held portable instruments. They are built to very rugged standards, yet weigh less than 2 pounds (1 kilogram) each. The testers are easily transportable and each includes some form of protective carrying case.

Q. How long has the Midtronics conductance test method been used for testing batteries?

A. The original technology was developed by Motorola in the 1970s for testing automotive batteries. Today's products are manufactured under license from Motorola, and include many new patents in North America, Europe and Japan. Midtronics has been developing and manufacturing conductance testers for more than ten years, and customers include the world's major battery manufacturers, major automotive manufacturers, telecommunications providers, electric power utilities, UPS manufacturers, and organizations in a variety of other industries. Midtronics has manufactured tens of thousands of battery conductance testers under the PowerSensor™, Midtron®, and Celltron® brands, as well as various private labels. Our products are manufactured and used extensively throughout the globe, making Midtronics the world leader in battery management technology.

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Q. Has conductance testing been proven and accepted by the international community?

A. Yes. Extensive data has been gathered by the global telecommunications industry, battery manufacturers worldwide, international rail and transportation providers, and the electric power industry. This data has been presented to the IEEE Standards Committee, which now includes conductance testing in its draft standard for testing sealed valve-regulated batteries. Additionally, The data has also been presented to the International Lead Zinc Research Organization, the Battery Council International, and the International Telecommunications Energy Conference.

Q. Is correlation data available for review?

A. Yes. Many papers have been presented which include correlation data. Midtronics will provide correlation data and customer references upon request. Many technical papers are currently posted on our website at www.midtronics.com.

Q. What is the optimal point of contact when making a conductance test?

A. Making direct contact with the lead post area is ideal for an accurate test result. In order to facilitate this contact (which can be difficult depending on the battery post design), Midtronics offers a variety of battery test interfaces, including clamps and contact probes of differing sizes. Contact with stainless steel post hardware will skew test results.

Q. What if I cannot test my batteries directly at the post because of physical constraints?

A. If battery and cabinet construction makes testing at the post or lead strap impossible, BE CONSISTENT with every test. If you must test on the hardware, test in the same spot for every cell, every time. If you are inconsistent with your probe or clamp placement, your reading will be inconsistent as well.

Q. What is a Kelvin Connection and why is it needed for accurate conductance measurement?

A. The Kelvin Connection is a four-point connection that is used in order to eliminate the resistance of the test interface material. It is necessary to ensure an accurate conductance measurement that is not affected by test interface resistance. All Midtronics testers and monitors utilize a Kelvin connection.

Q. Does battery temperature effect conductance measurement?

A. Yes. The actual temperature of the battery must be considered when making a conductance test. Battery conductance reference values (or baselines) assume the optimal battery operating temperature of 77° Fahrenheit (25 ° Celsius). A calculation can be made to

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compensate for temperature variation. The Micro Celltron can automatically calculate the change in percent of reference, or a chart detailing this calculation is available from Midtronics for other testers and monitors.

Additionally, an Infrared Temperature Sensor is available from Midtronics to accurately determine battery temperature.

Q. **Can the data collected by the Micro Celltron be manipulated by PC?**

A. Yes. The new Celltron inFORM™ software and data logger from Midtronics facilitates the downloading and manipulation of data collected with the Micro Celltron. Data is presented in a graphical format and can be utilized for trend analysis as well as historical archiving. An infrared strip printer is also available for on-site printing and record keeping. inFORM can be downloaded over the Internet FOR FREE at www.midtronics.com.

PRODUCT INFORMATION QUESTIONS

Q. **Can I get longer cables?**

A. The Micro Celltron cables are fixed at the current length to ensure that the cable wiring does not skew the electronic measurements. The DB9 connector contains a calibration shunt that "zeroes" out any interference in the conductance measurements. Any change or alteration to the cable assembly or length would interfere with the accuracy of the measurement.

Q. How can I test large amp batteries or batteries above 10,000 Siemens with the Micro Celltron?

A. For 2V, 4V or 6V batteries, there is a method to "trick" the Micro Celltron to test batteries with Siemens values above 10,000 and obtain an estimate of the conductance value of the cell. The procedure is not exact, and thus should not be used as a reference or absolute value. It simply represents a method for a customer who has a large battery to obtain a conductance value using the Micro Celltron:

1. Upon testing cells that reach the threshold of the CTM (over 9999 G), simply connect the tester across 2 consecutive cells in the string, as if they were one individual cell. Do NOT attempt this on 8V; 10V or 12V batteries as the 16V fuse will likely be blown!
2. The voltage of the test will be 2X the individual cell, and the conductance will be approximately 50%. Multiply the conductance by two to get the estimated conductance of the individual cell. Note that the voltage alarm will sound on the Micro Celltron during the test.

3. Continue through the string testing cells 1&2, 2&3, and so on. Note that you will not be able to tell a bad cell directly, but can interpret one from the string results. For instance:
Cell test 1&2 = 5500 Siemens
Cell test 2&3 = 3200 Siemens
Cell test 3&4 = 3700 Siemens
Cell test 4&5 = 5650 Siemens

Cell #3 is probably an issue!

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For information on other Midtronics products:

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