Comparing Conductance data to discharge test results

While a conductance test provides a reliable, efficient and effective method for evaluating battery state-of-health, conductance data can not be directly correlated to a capacity test because there are many variables at work during a discharge that may influence the test results.

As an illustration of this point, it is possible that a battery with a conductance reading that is low in comparison to others in a string will maintain an acceptable voltage longer during a discharge than other batteries in this string with comparatively higher conductance readings. This can be caused by any of the following factors:

- A poorly executed conductance test on the battery—this can be caused by poor contact with the lead post material due to the presence of steel connection hardware or other impediments
- A phenomenon where other "stronger" batteries within the string more fully support the discharge load, in essence compensating for the degraded battery (that has been identified with a lower conductance reading). This can cause a false sense of security with the string as on a subsequent discharge this phenomenon may not occur and the load will be dropped because of the degraded battery
- Erratic measurements due to an abnormally high level of AC current from the DC charging system, often caused by a malfunctioning charging system. This can be identified using the DMM function of the Celltron ULTRA or by taking repeated readings from a battery that is significant disparate from the others in the string. To counteract this situation, the batteries can be tested off-line.
- All of the batteries in the string are significantly degraded. In this case, since all are significantly below rated capacity (or conductance reference value), the direct correlation to full capacity is lessened; it is clear that none of the batteries will make their full run time.

Other factors affecting system performance/battery discharge that may not be found through a conductance test:

- Intercell connection integrity: it is critical to system performance that the intercell connectors are properly torqued. IEEE maintenance regimes require that connection torque levels are checked and recorded as loose connections will alter discharge performance.
- The rate of discharge: battery systems should be sized appropriately to the load expected from the site equipment and a load or discharge test should simulate this load or the specified load found in the battery specifications document. However, often times load/discharge tests are conducted at much higher rates in order to shorten the duration of these tests. Such a practice can adversely affect the battery by causing premature degradation as well as other failure mechanisms like shorts that often only become evident after the discharge test has been performed.

Reference Value Quick Tips

1. **The best baseline is one established for that specific battery installed at that site for 90 - 180 days.**
2. **Generic values should only be used as a broad guide when no other data is available.**
3. **If no value is available variation among batteries in a string can also be an indicator of degradation. Review this brochure or contact Midtronics for assistance.**

Use of Conductance reference values

Key to the effective application of conductance technology is the appropriate trending of test results over time. However, when historical conductance results are not available for a given battery system, a generic reference value can be established or employed. This value can be found in the test equipment memory, from the battery manufacturer or at www.midtronics.com.

In some instances this value must be developed using the battery system being analyzed. In order to establish a value for a system, refer to the test equipment operator's manual, but it must be noted that a value can ONLY be established within the first years after the deployment of a battery system and when it has been determined by way of an appropriate discharge test that the battery system maintains its rated capacity.

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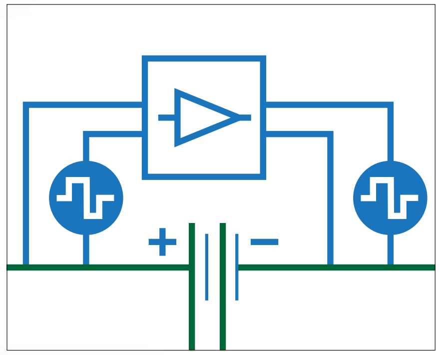
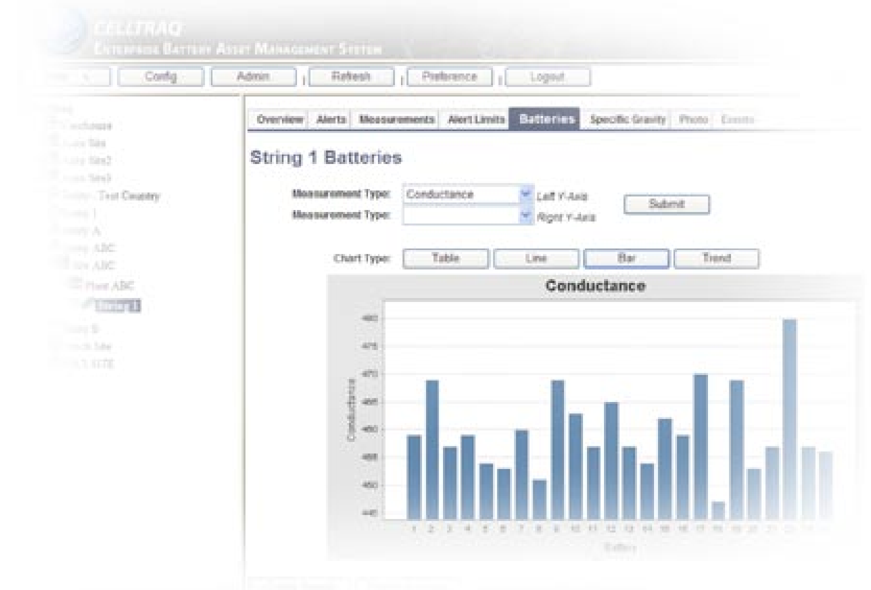
Battery Conductance Training

Conductance defined.

Conductance is an indication of a battery's ability to conduct or produce energy. Using conductance and trending the results will provide you with the battery's state of health and help plan the replacement of batteries before they reach end of life. The unit of measure for conductance is Mhos or Siemens.





MIDTRONICS

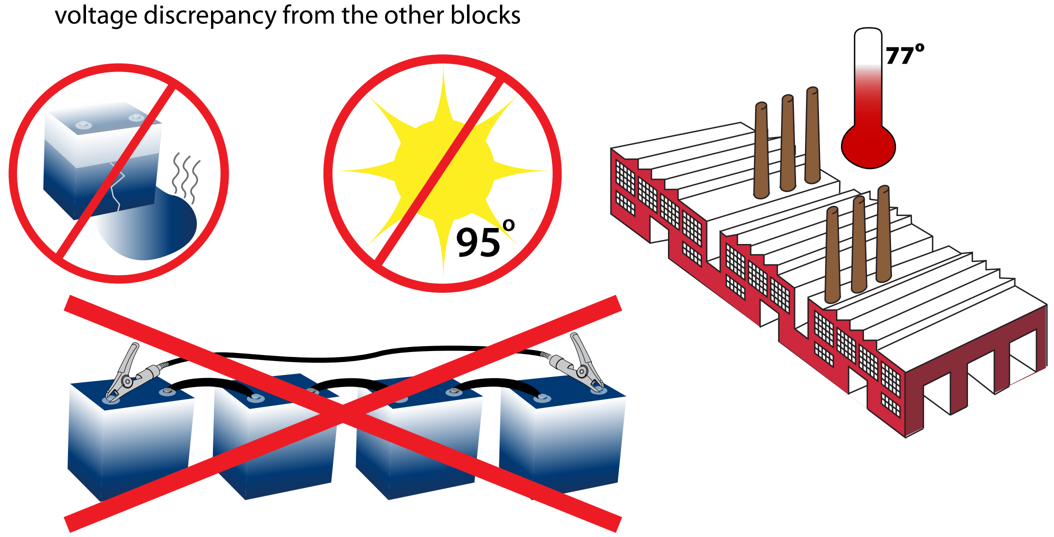
Advancing Battery Management

Do

- **Follow safety regulations:** eye protection, remove metal jewelry, etc. prior to working with batteries.
- Conduct a **visual inspection** prior to testing. A **cracked case, leaking post** or **bulging battery** should be **replaced**, not tested.
- Check the battery charging current prior to test. The **charging current should be stable** and the within the normal float current recommendations of the battery model (**or approximately 50mA per 100 Ah of capacity as recommended by IEEE**). If it is not, it is likely that the batteries have recently been discharged and a test is not appropriate until this stabilizes.
- Measure **battery temperature for each jar prior to test** using the infra-red temperature sensor provided in this kit and input this temperature into the conductance tester where appropriate.
- Set appropriate conductance and voltage thresholds in the conductance tester prior to beginning the test process. This will alert you to any deviations from manufacturer's specifications for float voltage (usually printed on battery label).
- Be certain to make **contact** with the battery on the **lead post or copper sleeve** with the **probes or clamps** as appropriate and use this contact point consistently when testing the batteries (if possible, mark the battery where the test contact has been made with a permanent marker for future reference). Stainless steel bolts or connectors will influence test results!
- Establish a **baseline measurement** for **each battery block 90 days after installation** if possible. This ensures the best trend relationship.
- Consult the section on "Reference Values" on the reverse side if a site/battery specific baseline is unavailable.
- **Review previous conductance test results** for the batteries/string if available and compare to your results. Variation from previous results, if one year or less, should be less than 5%. **Greater variation may indicate imminent battery decline.** Variation of more than 30% from the baseline suggests battery degradation and near term replacement. Variation of more than 40% suggests that the battery will likely not meet rated capacity.
- Review battery voltage results to ensure general consistency among the string and against manufacturer's specifications. Variation among batteries within a string can indicate a battery problem. Variation from manufacturer's specification can indicate a charger problem that can impact battery life or an already present battery problem.

Don't

- Forget to review the reverse of this card prior to beginning your test process.
- **Begin testing a battery that exhibits any physical damage.**
- **Apply the tester across an entire string, it is design** for individual battery block testing
- Skip any component of the tester setup menu/process. This ensures proper test results.
- Use input ambient temperature into the analyzer; measure battery temperature with the included infra-red temperature sensor.
- Condemn a battery based upon a single snapshot test without any trend history or an established baseline for that specific block unless the conductance varies more than 10% from the other block in the string, measures 0 mhos, or has a significant (more than 0.5V) voltage discrepancy from the other blocks



General battery replacement conditions

1. Any battery that displays 0 conductance (rated in Siemens or MHOs)
2. Any battery that displays 0 voltage
3. Any battery with physical deformities, such as a cracked or bulging case, post or vent
4. Any battery that is currently or has previously leaked electrolyte
5. Any battery that has lost 50% or more of its rated conductance while on float charge

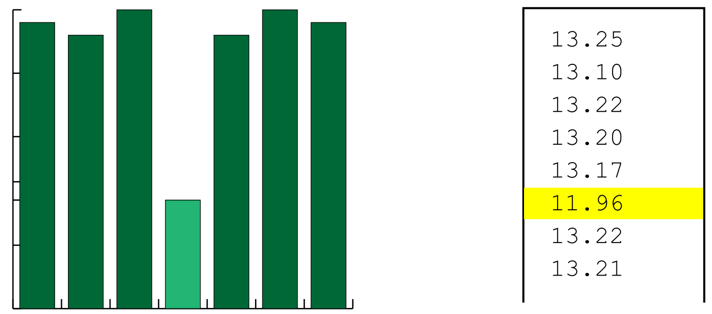
Should any of the above mentioned conditions exist, there is an extremely high probability that the entire battery string will fail (and the site load lost) should it be called into service given a loss of commercial power.

Other conditions that should be strongly considered as indication for immediate replacement

1. A battery that has lost 40% or more of its rated conductance as established for that specific battery in that specific site.

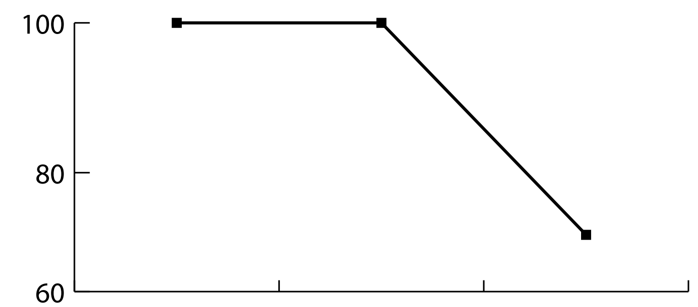
2. A battery that while on float charge, exhibits a voltage reading that varies more than 5% of the manufacturer's specification for float voltage

Should any of these conditions exist, it is possible that the battery string will perform if called into service if the condition exists in only one or two of batteries in the string because other, known good batteries in this string will overcompensate for the failing battery. However, this will affect the long-term life of all of the batteries and could result in premature aging.



A condition that merits strong consideration for near term scheduled replacement

1. A battery that has lost more than 25% but less than 35% of its rated conductance as established for that specific battery in that specific site.



Projecting battery capacity/run time using conductance data results

No known technology can measure exact battery capacity/run time with 100% accuracy with the exception of the actual full load test. Since the load or capacity test is often impractical and can create other undesired affects on the battery plant, some techniques can be combined with conductance and voltage data to estimate the "drop out" of battery jars under load.

1. See the General battery relacement conditions section. Any battery with these conditions will provide nearly 0 capacity and in fact can create a dangerous condition if loaded.

2. Batteries in a string with similar conductance and voltage readings that are at or above 100% of their baseline measurements will perform well and will meet site demands. If there is a significant variation among the jars in a string, there is a high likelihood that the string will not perform as designed and those batteries with lowest conductance will drop out first (although not necessarily in exact succession, lowest to highest).

1 Safety First

- Glasses
- Jewlery
- Visual Inspection

2 Proper Setup

- Review Past Results (if available)
- Measure & Input Battery Temperature

3 Consistent Use

- Review Past Results (if available)
- Measure & Input Battery Temperature