Testing manual for traction batteries
Objective

The presented manual aims to deliver a complete and comprehensive approach to application and testing of PowerBatt for traction batteries. It shall be interpreted using the support documents found on the intranet in order to present the client with end-to-end test execution, data analysis and presentation of PowerBatt effects and benefits.

1. Selecting the right product

PowerBatt traction battery treatment is intended to be used for wet "flooded" type traction batteries. Treatment is performed using the PowerBatt Prevent product. Application occurs typically every 12 months.

2. Battery selection

Do:

- Select 2-5 traction batteries for testing of different age (ideally batteries which are bellow 50% of the typical real-life-span, and have at least 50% of manufacture indicated capacity) depending on the climatic and usage conditions (e.g. batteries exposed warm climate or frequent power shortages tend to have shorter life).
- PowerBatt can also used in batteries 12 months old, however the increase in capacity will be lower (e.g. 5-10%).
- Notify the client not to add any distilled water at least 14 days before application of PowerBatt in order to have room in the battery for adding PowerBatt. However this shall not lead to electrolyte to be bellow the plate level.
- Take batteries from typical conditions (e.g. batteries which are used on day-to-day basis).
- Ideally, ask for batteries where there is not too much electrolyte, so that 60ml/100Ah of PowerBatt per cell can be added, but where the maximum levels will not be breached. It often happens that when technical team learns that PowerBatt testing will be performed they will fill the battery with distilled water making it hard to add PowerBatt to the battery.

Don’t:

- Don’t consider batteries with mechanical damage (holes, cracks etc.) or bended side walls, or where the positive plate is unusually raised from the battery, which is an indication of internal plate damage.
- If there is low electrolyte level – Electrolyte does not cover the entire plate, then add distilled water to just cover the plates. After you have added the distilled water then the battery has to be fully charged.
- Don’t consider batteries which have not been in use for month or more.
- Don’t apply PowerBatt to batteries which have been treated with pulse chargers (pulse levels above 30% of battery capacity).

3. Preparation for the test

Do:
• Ensure the electrolyte level allows for application of 60ml/100Ah of PowerBatt per cell can be added.
• Ask for the battery maintenance record if possible.

4. Test execution

**Ensure that the temperature of cells does not rise above 40 degrees Celsius during PowerBatt application.**

4.1 Before the test, make sure the battery is fully charged.
4.2 Remove the central distilled water distribution system.
4.3 Measure and record the voltage and acid density in the Test protocol A2 for each of the cells individually.
4.4 Perform the capacity testing in the following manner:
   4.4.1 Discharge the battery using standard discharger at a rate of C10 (current of 10% of battery nominal capacity until you reach 1.8V per cell eg. 43.2V for 48V battery) or otherwise if stated by the battery manufacturer.
   4.4.2 Record the temperature of battery during test.
   4.4.3 Record the capacity in the protocol.
4.5 For each cell add 60ml/100Ah of PowerBatt.
4.6 Apply PowerBatt slowly, in order to prevent the battery from sudden chemical overreaction. It is recommended to apply the quantity of PowerBatt in 3-4 instances with 20 minutes in between (In hot climate wait at least 30 minutes). Continuously observe the temperature of the electrolyte, do not add PowerBatt if the temperature of cells rises above 40 degrees Celsius.
4.7 Let the chemical reaction proceed and wait until its termination (bubbles are no longer formed violently, the electrolyte begins to be see-through) and the cell temperature begins to decrease.
4.8 Add back the central distilled water distribution system.
4.9 Charge the battery fully using a standard charger.
4.10 Put the battery into normal operation.
4.11 After 20 charging cycles (under typical conditions this relates to one month), then follow steps 4.1 – 4.4.
4.12 After the test charge the batter.
4.13 Then place the battery into normal operation.

Warnings:

**In hot climate, use thermometer to make sure that the battery is not put in operation before the temperature of cells goes bellow 40 degrees Celsius.**

5. Test results presentation

The test results shall be presented to the client in the format of PowerBatt performance report (please refer to a report guide available on the intranet).
Appendix 1 - *Interpretation of PowerBatt test results*

The essential question we are trying to find an answer for is what is the capacity of the battery to supply power, in minutes/hours, before and after application of PowerBatt.

From traction batteries we need them to be able to supply energy continuously for long time. The average current is about 10% to 20% of battery capacity with some short peaks not often exceeding 50-60% of battery capacity.

When finding the capacity before (and after) application of PowerBatt, we essentially discharge the previously fully charged battery by constant current to find how many minutes/hours it will take to discharge such battery. We do such exercise for twice, once before application and once after the application. Afterwards, we compare the time record before and after application and should find out that the time to discharge AFTER the application was longer than the time before application, meaning the battery has now the bigger capacity to hold and supply power. By creating the ratio of the time after application and before application, we can present such improvement in per cent.

In the data protocol we also indicate the change in **maximum difference between individual cell voltage levels** and **cell acid density levels** (difference between highest and lowest cell values). The difference is calculated automatically based on the data inputs prior and after the application of PowerBatt. Use of our product shall result in lower difference values indicating improved stability of the battery. Improvement in change of maximum differences in density and voltages of individual cells gives us information on increase of the battery lifespan. Smaller differences indicate longer battery life time, because all cells provide balanced energy levels.

It is very important to preserve and hold the same conditions of measurement on both cases before and after the same battery, the same measurement devices, the same surroundings conditions like temperature, humidity etc. Otherwise, the results could be strongly biased - altered and the interpretation of the results for your clients will not be persuasive.
Appendix 2 - **Q&A Traction batteries**

Q: **How should I decide what is the right current of charging and discharging?**

A: The battery has a sign from manufacturer which shows what is the construction current for charging and discharging. It is coded with battery capacity. For example 450Ah\(_{C5}\), 450Ah is the capacity to be measured during 5 hour discharge (C5). 450Ah\(_{C10}\) means 450Ah capacity to be measured during 10 hour discharge (C10). So in the first example, the charge / discharge current is 20% of the battery capacity (450 x 20% = 90A), for second example the charge / discharge current is 10% of the battery capacity (450 x 10% = 45A).

Note: It is OK to use a smaller charge current is used for charging. In this case the charging time will be longer. For discharging the discharge current is crucial, because different discharge currents shows different capacity of the same battery.

Q: **Some batteries have the level of 1,75V or 1,6V as discharge voltage. Which voltage should I use for discharging?**

A: To be on safe side, we recommend to use 1,8V per cell when discharging. This value will not destroy any battery.

Q: **Why shall we record acid densities and voltages of individual cells in the protocol?**

A: Voltages and densities of individual cells shows the differences of the quality between cells. The battery is so good as good is the weakest cell. Big differences between cells cause different charge level of cells when charged and different load during discharging. Some cells might be overheated. Overheating destroys the active mass of the electrodes. Finally the overheated cells will have a shorter lifetime.

Q: **What is the real improvement I can count with?**

A: The real improvement is the ratio between the achieved capacity after treatment and capacity before treatment. The achievement of 130% is already a good one, because this additional 30% will prolong the battery usage by 30% before it must be charged again.

Decrease in the maximum differences in density and voltages of individual cells after the use of PowerBatt should indicate the increase of the battery lifespan, since the battery is just as strong as its weakest cell. Smaller differences indicate longer battery life time, because all cells provide more balanced energy levels.