Cell Failure: An Insidious Problem

Four Key Points About Cell Failure

1. Cells can fail in any battery at any time. Cell failure can affect the battery in several ways, ranging from gradual decreases in battery capacity and driving range, to inability to drive the vehicle, and (in a worst case scenario) to catastrophic failure such as battery fire.

2. Cell failure is a particularly notable problem in EVs. EV batteries are subjected to use conditions that are uncontrolled and sometimes are extreme. Some drivers treat their vehicles very gently. Other drivers abuse and/or neglect the vehicle. When vehicles are abused or neglected, cells can experience failure very early in the life of the vehicle.

3. Cell failure is insidious. Quite often cell failure occurs gradually, starting slowly and then accelerating. Detecting cell failure is like detecting disease in your body – it's best to detect it early when it's easier to treat and before it does significant damage. If you don't detect it early the consequences could be expensive and in some cases life threatening (for cell failure and for disease).

4. Today's battery management systems are very ineffective at detecting cell failure in early stages.

Cell Impedance: An Indicator of Health

Rising or Falling Impedances Can Tell You a Lot

Many modes of cell failure are characterized by changes in cell impedances. As cells age and degrade their impedance rises. If the internal impedance of a specific cell is significantly higher than the other cells in the pack, that's an indication that the cell is going bad. If the impedance of a cell is rising at an unusually fast rate, that could be an indication of a cell that is going bad quickly.

There are some failure modes that can cause cell impedance to drop. This happens infrequently, but when it happens it can indicate a potentially severe condition such as a breach of the separator.

If the vehicle is in a minor collision there may be no visible damage to the battery, but there might be internal damage to some of the cells or modules that could be detected by checking the impedance of each cell in the pack. This could trigger an alert to the driver to bring the vehicle in for service before a hidden condition of the battery becomes worse.

True Balancing continually monitors impedance on a cell-by-cell basis, collecting data on the state of cell impedance and on rate of change in cell impedance. This can provide early warnings of cells that are going bad and can give indications of the severity of the condition.

Early Detection of Cell Failure ➟ Safer EVs

Failures on the road can be averted

When the vehicle is brought in for regular maintenance, True Balancing can provide the service technician with a report on cell condition. If one or more cells are starting to go bad, the technician will be notified and the affected battery module(s) can be replaced.

If one or more cells start going bad in between maintenance checks, True Balancing can send a message to the OBD system, which will notify the driver that the vehicle should be brought in for service. This could be the difference between preventive maintenance and a vehicle failure on the road.

At the service center, the technician can query the OBD system to get a report on the specific modules that should be replaced and the specific cells that are going bad. The technician immediately knows which module(s) to replace, which reduces service time.

Battery modules that are removed can be labeled to indicate specific cells that are bad. The defective modules can then be sent to a secondary service facility for refurbishing and second life – such as in an energy storage system. This extends battery life and reduces the environmental impact of the battery.

How True Balancing Monitors Impedance

More Than Just DC Resistance

True Balancing can monitor all of the forms of impedance shown in the table to the right.

True Balancing Can Monitor…	Static Impedance (V/I)	Dynamic Impedance (dV/dI)
DC Resistance	✓	✓
AC Impedance (1Hz to 10kHz)	✓	✓

True Balancing can monitor these forms of impedance on a cell-by-cell basis in the vehicle, in real-time.

True Balancing can monitor these forms of impedance during charging, or when the battery is under load, or when the battery is idle.

True Balancing can monitor cell impedance under all of these conditions using known and selectable test currents.

True Balancing does this by modulating the input signals to the switch mode dividers and sensing values from the current sensors (on the balancing legs) and from the voltage sensors (in parallel with each cell in the battery).

As noted, these impedance measurements can provide early warnings of cells that are starting to fail. Additionally, these impedance measurements can provide valuable data on cell aging and cell health. This can be used to detect trends in battery performance and to help develop better battery technologies.

Conclusion

Early detection of cell failure: One of the most powerful benefits of True Balancing

True Balancing brings a wealth of benefits to the entire battery system. Early detection of cell failure and real-time data on cell impedances are added bonuses that are an integral part of any True Balancing system.

You can see a list of all of the benefits of True Balancing at www.truebalancing.com