## Battery Pack Use

When charging and discharging a battery pack, the current and voltage applied to any cell in the pack shall not be exceeded for the given conditions under which the cell are exposed. Appendix A details the limits the cells must be kept within for a given cell's temperature and cell's state of charge. This section covers the following topics:

- Charger Limits

## Charger Limits

When charging or recharging Lithium Werks cells in a battery pack, the charger should limit its output current and voltage to match that of the battery pack configuration. During a recharge, the charger shall apply a constant current (CC) charge followed by a constant voltage (CV) charge. In addition, the **charger shall cease charging when either:**

- Any one cell in the series string, has exceeded its maximum recommended charge voltage, or
- The temperature measured in the pack has gone outside the recommended range for charging.

To achieve maximum life, reliability, and safety, Lithium Werks recommends using cell balancing circuitry to prevent an increasing spread between highest and lowest battery states of charge. Refer to Cell Balancing on page 43 for more information.

To determine the charge current for a parallel string of cells, multiply the number of parallel cells in the string by the recommended charge current for a single cell. Note that this calculation does not take into account limitations imposed by any protection electronics or any other features of the battery pack assembly.

*Eq 5.     Number of cells in parallel x Recommended Charge Current / cell = Charge Current / string*

To determine the end-of-charge voltage for a series string of cells multiply the number of series elements in the string by the recommended charge voltage of a single cell.

*Eq 6.     Number of cells in series x Recommended Charge Voltage / cell = Charge Voltage / string*

Table 11 provides examples of two  charge currents and voltage configurations.

**Table 11 – Charge current and voltage calculation examples**

| Example 1 | If a cell group has <u>3 cells in parallel </u>(3p), and the recommended charge current per cell is 20A, then the charge current for this group is <br> <u>60A</u>: (3 cells, parallel) x 20A = 60A |
|---|---|
| Example 2 | If a cell string has <u>10 cells in series </u>(10s), and the recommended charge voltage per cell is 3.6V, then the end of charge voltage for the string is <br> <u>36V</u>: (10 cells, series) x 3.6V = 36V |

Once the end of charge voltage has been reached, apply a constant voltage hold at this voltage until the current decays to near-zero. This process charges the cells to 100% state of charge (SOC). Refer to Figure 25 for an illustration.
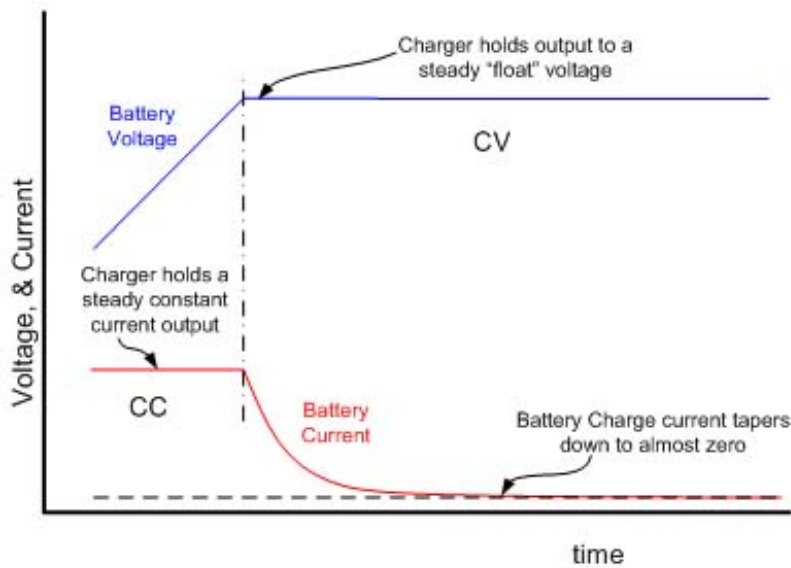


**Figure 25 – Battery voltage and current during recharge**