



## LITHIUM ION BATTERY STORAGE & MAINTENANCE CHARGING

The following applies to the storage/shelf life of Lithium Ion cells and batteries.

The storage temperature range for Lithium Ion cells and batteries is -20°C to +60°C (-4°F to 140°F).

The recommended storage temperature range is 0°C to 30°C (32°F to 86°F). At this storage temperature range, the battery will require a maintenance charge within a nine (9) to twelve (12) month period. **A detailed maintenance charge schedule, based on storage temperature, is located at the end of this white paper.**

Lithium Ion rechargeable batteries should be stored at 50% to 60% state-of-charge (SOC).

The shelf life of a lithium ion cell/battery is a function of the self discharge, temperature, battery age and state-of-charge (SOC) conditions imposed upon the cell/battery. As the storage temperature and SOC increase, the resultant capacity upon discharge decreases and the impedance of the cell(s) increases. The shelf life is almost cut in half by holding the cell/battery at 100% SOC at temperatures between 30C and 60C as opposed to 50% SOC at the same temperature range. The effect is not as pronounced at room temperature, with the shelf life roughly 75% at a 100% SOC condition as opposed to 50% at elevated temperatures.

In other words, the shelf life would be approximately four months (at 100% SOC) to nine months (at 50% SOC) at a storage temperature of -20°C to 30°C (-4°F to 86°F), provided that the cell/battery has been operated under recommended charge, discharge and storage conditions. After that point, the cell/battery would need a maintenance charge to return it back to its recommended original storage voltage (SOC).

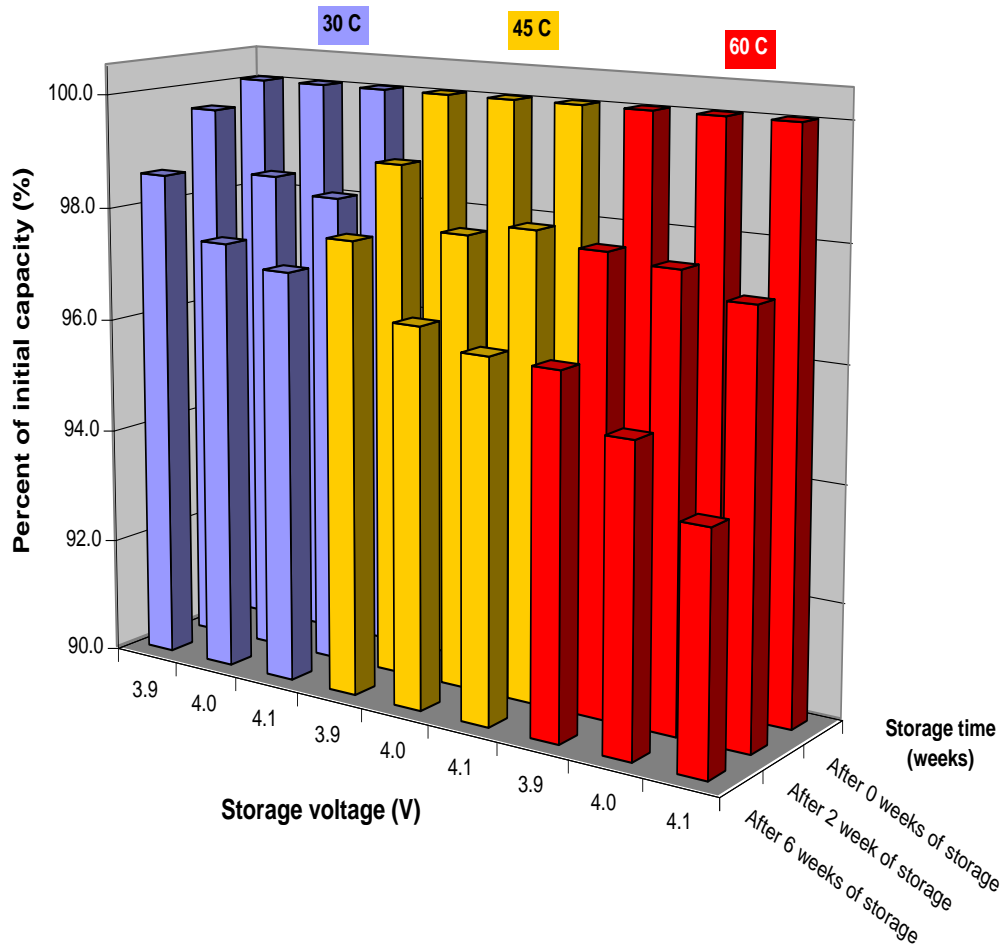
We do not recommend float charging lithium ion batteries, since the current will eventually decay the surface films on the electrode and electrolyte, shortening cycle life significantly. Float charging can harm lithium ion chemistry and is not recommended. **The recommended and preferred charging method for rechargeable Lithium Ion batteries is a modified constant current / constant potential charger.**

Please see **Figure 1** below, showing independent testing performed by Motorola for the Lithium Ion 18650 cell. The Lithium Ion 18650 cell is the cell that is used by battery manufacturers for manufacture of the rechargeable Land Warrior (PB-LW, PB-LWH & LI Series) and BB-2590/U (XX90 format) batteries and other battery configurations.

**The following data is what has been observed specific to the lithium ion 18650 cells used in the rechargeable Land Warrior and BB-2590/U (XX90 format) batteries and other battery configurations at an elevated storage temperature of 60°C (140°F).**

### % CAPACITY REMAINING

<u>Storage Time</u>	<u>100% SOC</u>		<u>50% SOC</u>	
	<u>C/5 Rate</u>	<u>C Rate</u>	<u>C/5 Rate</u>	<u>C Rate</u>
2 Wks.	90%	90%	98%	98%
1 Month	87%	87%	90%	90%
2 Months	83%	83%	88%	88%
3 Months	80%	80%	85%	83%
6 Months			80%	80%
9 Months			80%	80%



**Figure 1**

**High Temperature & High State-of Charge (SOC) Degradation Performance**



**STORAGE MAINTENANCE RECHARGE SCHEDULE  
WHEN STORED AT RECOMMENDED 50% to 60% STATE-OF-CHARGE (SOC)**

<u>Storage Temperature</u>	<u>Relative Humidity</u>	<u>Freshening Recharge</u>
-20°C to 30°C (-4°F to 86°F)	45% to 85%	within 1 year
-20°C to 35°C (-4°F to 95°F)	45% to 85%	within 9 months
-20°C to 40°C (-4°F to 104°F)	45% to 85%	within 6 months
-20°C to 45°C (-4°F to 113°F)	45% to 85%	within 1 month
-20°C to 50°C (-4°F to 122°F)	45% to 85%	within 1 week
-20°C to 55°C (-4°F to 137°F)	45% to 85%	within 1 week
-20°C to 60°C (-4°F to 140°F)	45% to 85%	within 1 week

**In Summary:**

- 1. As storage temperature and stat-of-charge (SOC) increases, retained capacity decreases.**
- 2. The lost capacity is due to degradation reactions in the cell that are accelerated by temperature and consume lithium ions on the anode surface.**
- 3. Recommended storage is at 50% to 60% state-of-charge (SOC) and 0°C to 30°C (32°F to 86°F).**
- 4. Maintenance charge at a temperature range of 0° C to +45° C (32°F to +113°F).**
- 5. Maintenance charge using a modified constant current / constant potential charger.**

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