



Battery Management Guide

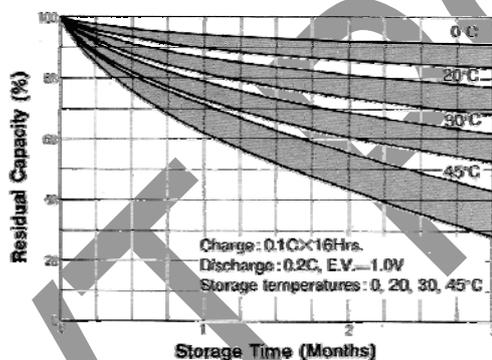
Batteries are perishable products that start deteriorating as soon as they are produced. Many failures of batteries are actually caused by improper handling, usage, and storage. In order to ensure all batteries are properly treated and maintained, we provide the following basic guidelines for our customers as these simple preventive measures can significantly improve battery's performance and service life.

Ni-Cd & Ni-MH Batteries

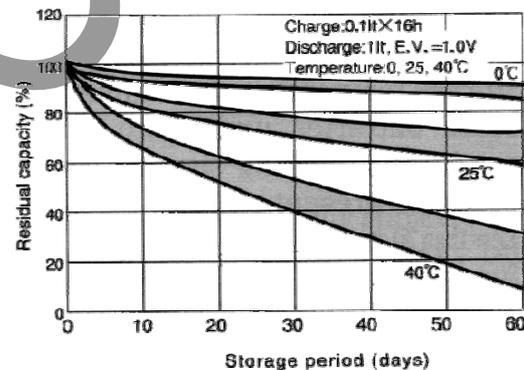
Storage

- Keep batteries in a cool and dry storage area free of corrosive gas. Recommended storage temperature range and humidity is -20°C ~ 30°C and $65\pm 20\%$ respectively.
- Avoid storing batteries for prolonged period of time without cycling. Typical shelf life for a Ni-Cd battery is 2-3 years with self-discharge rate of 10% per month. Typical shelf life for a Ni-MH battery is 1~1.5 years but its self-discharge rate is about 1.5~2 times greater than that of a Ni-Cd battery. Self discharge rate will increase with higher temperatures.

Residual capacity after self-discharge under various storage temperature



Ni-Cd Batteries



Ni-MH Batteries

- Avoid fully charge before storage; keep batteries partially charged and apply a full charge before use.
- Ni-Cd batteries can be stored up to two years and Ni-MH batteries can be stored up to one year without suffering from significant cycle loss. If you plan to store batteries for longer than 90 days, charging your batteries every 90 days is highly recommended to maintain maximum capacity.
- When battery voltage drops below 0.8V/cell after prolonged storage, normal desktop chargers (rapid and trickle) may not be able to activate the battery and complete a successful charge. These batteries must be cycled by specialized charging equipment/analyzer.
- Avoid connecting the batteries to the host (equipment) when they are stored for a prolonged period of time; it may result in cell leakage.
- Avoid dust piling on batteries during storage, especially on the battery terminal area.



Operation

- Never leave a nickel-based battery sitting on a charger for more than a few days, even on a trickle charger. Prolonged trickle charge causes crystalline formation (memory effect).
- Recharge your battery when your equipment signals “low battery”. Failure to “deep cycle” batteries will result in “memory” build-up. This can significantly reduce a battery’s run time as well as shorten the battery’s overall cycle life. Periodic discharge (recommended once per month) on a battery analyzer or run down on the equipment to 1V/cell is essential.
- Let your batteries charge fully. Never interrupt a charge cycle.
- Charge within specified current range and charging time; repeated overcharging will cause battery performance to deteriorate.
- Do not charge a Ni-MH battery in a charger designed for Ni-Cd batteries, such Ni-Cd charger could overcharge the Ni-MH battery. However, a charger designed for Ni-MH battery can also accommodate Ni-Cd batteries.
- Recommended ambient temperature for charging Ni-Cd and Ni-MH batteries:

Chemistry	Slow Charge (Below 0.5C)	Fast Charge (0.5~1.0C)
NI-CD	0 °C ~ 45 °C (32 °F~113 °F)	5 °C ~ 45 °C (41 °F~113 °F)
NI-MH	0 °C ~ 45 °C (32 °F~113 °F)	10 °C ~ 45 °C (50 °F~113 °F)

- **Cycling (Priming)** is recommended to regain lost capacity after a battery has been stored for 6 months or longer. Cycling can be achieved by applying a slow charge followed by one or several discharge/charge cycles. The recovery rate is governed by the condition under which the battery was stored. The longer the storage time and the warmer the storage temperature, the more cycles will be required. *Excessive cycling should be avoided because of wear-down effect.*
- **Forming** - Nickel-based batteries are not always fully-formed upon delivery. Applying several charge/discharge cycles through normal use or with a battery analyzer completes the forming. The number of cycles needed to attain full capacity differs between cell manufacturers. Batteries assembled with high-quality cells from Japanese manufacturers perform to specification after 5-7 cycles. Others may need 50-100 cycles to reach acceptable capacity levels. The forming process is only required when the battery is new.
- **Initializing** - Initial batteries before placing into service for the first time. Let your battery stay in the charger approximately 50% longer than a normal charge (normal charge is approximately 2-4 hours for a rapid charger and 14-16 hours for a slow charger).
- Do not expose battery packs to mechanical shock.
- Always try to keep your battery pack dry.
- To prevent an accident from a short circuit, do not allow metal objects to come into contact with the battery terminals.
- Keep battery packs away from high heat (temperatures above 60°C/140°F), fire and direct rays from the sun.
- Do not disassemble or try to modify the battery pack.



Li-ion & Li-Polymer Batteries

Storage

- Recommended storage temperature for Li-based battery is 15°C.
- Do not fully charge or fully discharge a Li-based battery before storage. Keep it partially charged and apply a full charge before use. Recommended state-of-charge is about 40% (or 3.75-3.80V/cell open terminal for Li-ion batteries).

Temperature	40% Charge Level Recommended Recoverable Capacity After 1 year storage	100% Charge Level Recoverable Capacity After 1 year storage
0 °C	98%	94%
25 °C	96%	80%
40 °C	85%	65%
60 °C	75%	60% (after 3 months)

- If a Li-ion battery is left discharged after use, the self-discharge will further drain the pack and eventually trip the protection circuit at about 2.5 volts per cell. At this point, the charger will no longer recognize the battery and the pack appears dead. Only specialized equipment or advanced battery analyzer will be able to re-activate the protection circuit and recharge the battery. Charge for about 30 minutes before storage if the Li-ion battery is depleted.
- Do not stockpile lithium-ion batteries; and avoid buying dated stock. The aging process cannot be reversed and cycling will not improve.
- The self-discharge of the lithium-ion battery is 5% in the first 24 hours after charge, and then reduces to 1% to 2% per month thereafter. The safety circuit adds about 3%. No scheduled cycling is required to prolong the battery's life.
- Avoid connecting the batteries to the host (equipment) when they are stored for a prolonged period of time.
- Avoid dust piling on batteries during storage, especially on the battery terminal area.

Operation

- Do not attempt to recharge a Li-ion battery below 1.5V/cell for safety reason.
- Charge Li-ion batteries often, except before a long storage.
- There is no memory effect when unscheduled charges are applied. Avoid repeated deep discharges and excessive charge/discharge cycles to obtain higher cycle counts.
- Recommended ambient temperature for charging Li-based battery is 0 °C ~ 45 °C (32 °F~113 °F) for slow charge; and 5 °C ~ 45 °C (41 °F~113 °F) for fast charge.
- Charge only on Li-ion charger or approved tri-chemistry charger.
- If the Li-ion battery is used on a laptop that is capable of running without a battery and fixed power is used most of the time, remove the battery and store it in a cool place.



- Li-ion batteries do not have memory effect; however, batteries with *fuel gauges* may suffer “digital memory effect” that is caused by frequent short discharge and charge pattern. In order to achieve higher-accuracy of the fuel gauge over time, a deliberate full discharge and charge is recommended every 30 charges.
- Do not expose battery packs to mechanical shock.
- Always try to keep your battery pack dry.
- Make sure that the battery pack is attached to the host (equipment) securely.
- To prevent an accident from a short circuit, do not allow metal objects to come into contact with the battery terminals.
- Keep battery packs away from high heat (temperatures above 60°C/140°F), fire and direct rays from the sun.
- Do not disassemble or try to modify the battery pack.

It is distributors' and end users' responsibility to ensure that their battery packs are handled, charged, and stored with proper manner. Multiple factors can affect the overall reliability of a battery pack, so it is impossible to give an accurate prediction on battery's life. If the above procedures are followed and implemented precisely, then a battery will most likely to achieve its optimal cycle counts and give best performance during its service life.

Addvantech is more than happy to answer your questions on how to maintain your battery properly. For more information, please e-mail to sales@advantech.com or fax to 886-2-25239961.