

Technical Tips for NiCd/NiMH Battery Pack Users

Why is it so confusing?

Most high quality NiCd/NiMH cells will take a lot of abuse before their performance drops or they become damaged. This is great for most users, but not for those who want to get the absolute best performance from their cells or extend their life as much as possible.

The problem is that you can't have both maximum performance and the longest cell life. You can however balance the two, choosing which is more important to you. But, this makes it hard to sort out the often conflicting advice you can get regarding cell care.

Whether you're a R/C racer, backyard basher, fighting robot builder, or robotic-vehicle designer, we'll help you understand what can affect NiCd/NiMH cell life and performance so you can get the most out your battery packs.

What shortens NiCd and NiMH cell life?

Eventually, no matter how carefully you charge, discharge and store your packs, the cells will wear out. There are two main reasons for this; failure of the separator and failure of the plates. Internally, NiCd or NiMH cells basically consist of the following:

- Positive nickel-hydroxide plate electrodes.
- Negative nickel-cadmium (NiCd) or nickel-metal hydride (NiMH) plate electrodes.
- A separator, often made of nylon fibers, that keeps the positive and negative plates from touching.
- An alkaline electrolyte. This electrolyte is not conductive (for electrons) but merely facilitates the transfer of ions between the plates. If did conduct electrons, the cell would quickly self-discharge.

The multiple, sandwiched electrodes (for increased surface area) and separator are spooled together and placed into a metal can that is sealed after filling the cell with a small amount of electrolyte.

The life of a cell is limited and is typically rated as the number of charge/discharge cycles a cell can perform before its discharge capacity drops to below 80% of its initial rating. For example, a 2400mAH cell would be considered to be at the

end of its life when its capacity drops to 80% of 2400 = 1920mAH.

But, these capacity ratings are typically done at a low discharge rate, 0.2C-1C (e.g., 480mA-2400mA for our 2400mAH cell). If you discharge at a higher rate, the cells will be less efficient and you will see a greater drop in the capacity of the cells.

NiCd and NiMH cells won't just "fail" at this 80% capacity point, their capacity will continue to fall as they continue to be cycled. When your battery packs have dropped in capacity to a point where they no longer deliver the performance you need (run time or a high enough voltage under load), it's time to recycle the pack. The Rechargeable Battery Recycling Corporation (RBRC) has a list of drop-off points for your "dead" battery packs. See our [Recycling](#) page or visit the RBRC at www.rbrc.org for more information.

Cell life is limited due to unwanted physical and chemical changes that occur in the cell. These changes are usually permanent and they affect all aspects of the cell's performance. Some of the causes of these changes are:

- *High temperature* – Though higher temperatures can increase the performance of NiCd and NiMH cells, we can't over-emphasize how much the life of these cells is shortened by charging, discharging, or storing cells at high temperatures. Electro-chemical reactions in a cell speed up as the temperature increases. This can increase performance as more current can be supplied at higher voltages, but unfortunately the higher temperatures cause physical and chemical changes in the cell that shorten its life.

Using peak-detecting chargers, tray/pack dischargers with known loads and the proper cutoff voltage point for the number of cells you're discharging, and properly storing your packs will go a long way in not only maximizing the performance of your cells, but their life expectancy too.

- *Crystalline growth* – Under certain conditions (overcharging, repeated partial charging) the electrodes can grow large crystals that

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reduce a cell's capacity, increase its internal resistance and possibly damage the separator.

- *Passivation* – This is a chemical reaction in the cell that causes a high-resistance layer to form on the electrodes in a cell. It increases the cell's internal resistance and interferes with necessary electro-chemical reactions.
- *Venting or rupture* – These changes will obviously impact both the performance and life of a cell. Venting typically occurs when a cell is overcharged and excess gas is produced faster than it can be electro-chemically combined with compounds in the cell. A safety vent allows this excess gas (and water vapor) to escape before the cell ruptures. Since this gas and water vapor can no longer be used by the cell, its capacity decreases and its internal resistance increases. The conditions that caused the venting to occur can also physically damage the cell, further affecting its performance and life.

Rupture is the physical failure of the seals of the cell or the metal can itself. It's typically caused by discharging at much too high a rate, overheating the cell and causing it to expand until the seals fail.

- *Overvoltage and reverse-voltage* – Overvoltage of the cell can be caused by a charger set to charge a higher number of cells or using the wrong "wall-wart" to charge a pack. Reverse-voltage can occur if a pack is connected the wrong way to a charger or a pack is over-discharged and one or more of the cells is discharged down to zero volts and is actually forced into a reversed-polarity situation if the discharging continues. Both of these situations may not cause immediate failure of the cell, but they will decrease its life.

To maximize the performance and life of your cells, it is critical to minimize or completely prevent these changes from ever occurring.

Conditioning new cells and packs

This is often overlooked but most cells, particularly NiMH, will perform best if they are conditioned properly before using them, especially in high discharge-current situations. The initial conditioning of new cells is typically done at the factory and is called "forming" or the

"formation" step. But, these new cells can sit for months before being used and will need to be properly conditioned to bring their capacity and voltage under load back up to their rated values. This conditioning causes microscopic changes in the electrodes and electrolyte and helps them to work as efficiently as possible.

- If the cells were stored charged (not a good thing to do as this encourages voltage depression, higher internal resistance and loss of capacity), then discharge them first (at a 1C rate or less) to 0.9V/cell using a pack or tray discharger.
- Charge them slowly, at a rate about 1/10 of the capacity of the cell (1/10C.). For example, use a 300mA charge for 3000mAh cells. Let them cool.
- Discharge at about a 1C rate (e.g., about 3A for 3AH cells) and let the pack cool. We recommend the use of a pack discharger with a known load and known cutoff voltage so you can track the performance of your packs as they become conditioned.
- Repeat this charge/discharge cycle 2-3 times, being sure the cells are cool before continuing any the steps. But, at this low rate they'll probably only be a bit warm.
- If you have an AH-meter like the Astroflight, Inc. Super Whattmeter or Medusa Research, Inc. Power Analyzer, use it during the discharge to track the ampere-hours (AH) of capacity you're getting out of the cells. When the value stops increasing for each cycle, the cells are conditioned and can be used as you wish.

If the charger "false-peaks" and ends the charge before the cells are full, just write down the AH put into the pack and keep restarting the charger until the pack is charged. The first charge may reach over 20% past the rated capacity of the cells since they are discharged more than usual. Just let the charge continue. Our 3AH NiCd packs can reach up to 3.5AH when charged after a month of storage. Let the temperature of the cells guide you. If they are getting very warm, the cells are charged.

After these 2-3 cycles, the packs should false-peak a lot less (NiMH cells can keep false peaking for a few more cycles). Your pack is now ready for use.

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CamLight Systems' [2-Stage Pack Dischargers](#) and [Auto-Cutoff Modules](#) were designed to make this new-pack conditioning both safe and easy. They feature adjustable loads and adjustable per-cell cutoffs for 4-10, 10-20, and 15-30 cell packs.

Keeping cells conditioned

Critical to proper maintenance of your NiCd and NiMH battery packs is an occasional slow charge to help balance the voltages of the cells and regular discharging down to 0.9V/cell to allow a full charge to break up any large crystals forming in the cells that can affect performance.

We recommend a monthly 2-stage charge and 2-stage discharge.

As the cells in your packs are used, they can become unbalanced and have differing voltages. As the pack is used further, these voltage differences between the cells continues to increase. This can become a problem because the pack is only as good as the lowest-voltage cell. Once that cell is discharged, you need to stop discharging the pack to prevent the cell from undergoing "cell-reversal" which essentially reverse-charges the cell and can damage it. There are 2 ways to help rebalance the cells. Once a month:

1. Use a tray discharger to individually bring each cell down to exactly the same voltage (balancing them)....

and/or...

2. Slowly charge the pack at a rate that prevents the already charged cells from over-heating but allows the other cells to become fully charged too (balancing them).

If your packs have the cells assembled in a way that fits a tray discharger (side-by-side), and have the right number of cells, you're all set. If the tray discharger requires that your cells be mostly discharged first, consider the use of a pack discharger to quickly discharge the cells down to a level that the tray discharger can handle. Even if the tray discharger can handle fully charged packs, you might want to consider a discharger like our [Pack Dischargers](#) to very quickly bring the pack down to 0.9V/cell so the tray discharge goes much faster.

If your packs don't fit into a tray discharger, use a pack discharger to bring the pack down to

approximately 0.9V/cell (not below 0.8V/cell and not above 1.0V/cell). Then rebalance the cells by doing a slow charge, 1/20C-1/10C, or a 2-stage charge.

To perform a 2-stage charge, first charge the packs to 80%-90% of capacity (or a full charge at a lower-than-normal rate), then restart the charge at the 1/20C-1/10C rate. This slow charge fills the cells that are still not fully charged without overheating the cells that are "full". Allow the cells to overcharge at this low rate approximately 10%-20% past their rated capacity.

If you'd like, you can use both balancing methods, tray discharging and slow-charging or 2-stage charging.

No matter what type of pack you have, bring the cells down to 0.9V/cell every month or so at a 1C rate or less. This full discharge allows a complete charge which breaks up any large crystals that might have formed in the cell. This increases the active surface area of the cell, lowers its internal resistance and increases the voltage under load of the cell.

You don't want to do a high-current discharge (greater than 1C) for this step because the internal resistance of the cells will cause a voltage drop that will make the cells seem discharged before they really are. But, a slow discharge can take forever.

To speed up the process, perform a 2-stage discharge; a fast, high-current discharge down to 0.9V/cell followed by a slow discharge again down to 0.9V/cell. This speeds up the discharge significantly but still ensures that it's complete. All of our [Pack Dischargers](#) feature 2-Stage discharging.

You often see recommendations to do these discharges at the same discharge current rate you typically use the cells at. That is, if you draw 20A while driving your R/C car, you would discharge them at 20A too. We feel this isn't needed. It unnecessarily heats up the cells, doesn't have any electro-chemical benefit (increased capacity and voltage under load) that we've been able to consistently measure and causes the discharger to turn off early. If done as part of a 2-stage discharge this premature ending of the discharge can be compensated for, but the packs are still running unnecessarily hot. We recommend a 1C-3C

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discharge rate as a balance between the possible benefits of high-current discharging and the possible slight, but cumulative, damage due to overheating of the cells.

Of course, if you are testing the capacity of the cells, you might need to use very high discharge current levels.

A couple of warnings:

- Don't discharge your packs in your R/C car, robot, or robotic vehicle until it stops running! There's no way to know what voltage level the pack was brought down to and cell damage is possible.
- And don't use bulbs (or another type of load) to discharge your packs unless you have a voltmeter to monitor the packs or a cutoff switch like our [Auto-Cutoff Modules](#) to stop the discharge at the right voltage. If you just keep discharging the pack until the bulbs go out, there's a risk of over-discharge and possible cell damage.

It's more work, but proper maintenance of your cells will significantly increase their life and easily pay for the equipment you need to perform this maintenance properly.

Measuring cell temperature

Most NiCd and NiMH cell manufacturers recommend that you don't exceed 130°F.-150°F. (55°C.-66°C.) when discharging or charging the cells (check the data sheets for your cells for the recommended maximum temperature).

You often don't have much choice when it comes to minimizing overheating of your cells during use, but at other times anything you can do to prevent this will extend the life of your packs.

There are several ways to measure the temperature of your cells, each with its own advantages and disadvantages:

- *Infrared Temperature "Gun"* – this is a very convenient method but the gun can have a very wide "view" of what it's aimed at and can be fooled by reflective surfaces. Read the instructions carefully, you might need to use a black marker on the cells to get an accurate reading. And pay close attention to the angle-of-view of the gun. If it has a 4:1 view, it sees a 1" spot from 4" away...wider

than a lot of cells. Get up close and take readings from several angles/directions.

- *Thermocouple* – Available with certain digital multimeters or dedicated temperature meters, it is fast and can be extremely accurate. But, be sure you carefully place the thermocouple directly on the cell, away from breezes and anything else touching the bare wires leading from the thermocouple. We use Omega's HH308 dual-channel, dual display thermometer, costing approximately \$85 (www.omega.com).
- *By Hand* – though quick and convenient, it's the worst method possible. It's good for a rough idea of whether a cell is way too hot or only warm, but it's useless for anything in between. If you want the most from your cells, you need a method that allows you to push them as hard as possible without overheating and using your hand just won't be accurate enough.

Be sure to take into account the insulating effects of shrink wrap, foam, or cardboard tubes that might be around your cells. If you measure a cell's temperature at 130°F. (55°C.), the internal temperature might be much higher and the cell could already be damaged.

Also remember that any heat generated inside the cell takes a couple of minutes to migrate to the outside of the cell (particularly with larger cells or cells in cardboard tubes). Be sure to measure the temperature a minute or two later to make sure it hasn't risen anymore.

And lastly, we don't recommend letting the outside of a cell ever reach the rated temperature, typically 130°F.-150°F. (55°C.-66°C.). The inside of the cell can be a lot hotter than this and can start damaging the cell. Performance might not suffer at first, but the damage is cumulative and the capacity and voltage under load of the cell will be reduced as time goes on. Even worse, the cell might vent or rupture.

Cooling your packs

The best way to cool your packs is with air. Using water can be dangerous and can short out a pack very quickly. Using your refrigerator or freezer isn't very efficient since air isn't blowing across the packs (drawing heat out of the pack) and the cells can be damaged due to the

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extreme difference in temperature between the cells and the part of the fridge or freezer they are touching.

A fan, blowing across all the cells, is a safe and very effective method of cooling. If you use a "cooling tube", placing the battery pack and the fan within a large cardboard or plastic tube, the cooling will be even more effective.

Using AH-meters

We highly recommend using an AH-meter like Medusa Research, Inc.'s Power Analyzer (www.medusaproducts.com) or Astroflight, Inc.'s Super Whattmeter (www.astroflight.com). With one of these meters you can:

- Monitor the voltage of your packs when they're being discharged or tested with different loads.
- Monitor and/or confirm the charging current.
- Monitor the charge (ampere-hours) put in or taken out of your packs.
- Test the efficiency of your packs at various discharge current levels.
- Test different cells/packs to determine which best fits your needs.
- Test the capacity of used cells that you are purchasing from someone else.
- Track the capacity of new cells as they are being conditioned to know when they are ready for high discharge-current use.

If you're interested in maximizing performance or cell life, don't rely on "feel", take measurements. You've bought the best cells, don't stop there when it comes to making sure those expensive battery packs keep working at their best year after year.

If you accidentally over-discharge your pack

Cells that have been over-discharged should immediately be slow-charged to minimize any damage from possible cell-reversal.

This damage occurs when one or more cells in a pack has a lower voltage level than the others during a discharge. If these lower-voltage cells reach zero volts, continued discharging actually reverses their polarity and they are force fed a reversed-polarity charging current. This can damage them. You can help to avoid this by occasionally rebalancing the cells in your packs.

Over-discharging can still accidentally occur though and immediately slow-charging the cells (at a 1/20C-1/10C rate) can help to minimize any damage. No need to fully charge the packs at this low rate. Just a 10%-20% charge to bring any cells out of reversal and then you can finish the charge normally and either use the pack or discharge it to 0.9V/cell and store it.

If your pack has been stored for a long time

If your pack has been stored for months without an occasional cycling (charge/discharge), certain changes can occur internally that increase the cells' internal resistance and reduces their capacity and voltage under load. Before using the pack, slow-charge it at a 1/20C-1/10C rate and discharge at 1C or less. Repeat this cycle 1 or 2 more times until the capacity of the pack has been brought back up again. You can verify this by using an AH-meter during the discharge or by the display on your charger. When the capacity is no longer increasing each time you cycle the pack, it's ready to be used normally.

Sensitive peak-voltage detecting chargers can often "false-peak" when charging packs that haven't been used for a long time, either new or stored for a while. This false-peaking causes the charger to think that the cells are fully charged and the charger turns off too soon. You can confirm this by checking the AH reading on the charger's display or by feeling the pack. If the pack isn't warm when the charger turns off (and you're charging at a decent rate, not trickle charging), then the pack isn't fully charged. Just write down the charge (in AH) already put into the pack and restart the charger. If you don't have a charger with a display of the AH going into the cells, restart the charger and check the cells every few minutes. When they start getting warm, they're charged. An AH-meter (described in an earlier section) is invaluable here if you don't have an AH-displaying charger.

Buying someone else's used cells

There are some great deals out there on eBay and other places. But, you should be aware that the only way you can tell if the cells or packs you're buying are any good is to test them before committing to the purchase.

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You can charge them up and use your car/plane/boat/robot to give them a good run-through, but this is very subjective and won't give you much information other than "they seem to work".

It's much better to use a discharger or auto-cutoff switch with a known load and known cutoff voltage, along with an AH-meter, to test the packs with. This way you can measure the AH the cells can deliver at a specific discharge current and know if they're damaged (from abuse or plate/separator failure due to old age) or not.

If you don't have this equipment (which we recommend for lots of other reasons too), at least measure the run time and repeat the discharging in your car/plane/boat/robot at least once more to make sure the performance doesn't drop off radically after cycling the pack a couple of times.

Other tips:

- Before testing the pack, cycle it the same way you would a brand new pack. This conditions the cells in case they haven't been used in a while.
- After conditioning, you'll start using higher charging currents when testing the cells. After charging is complete, carefully feel each cell in the pack. Is one or more of them a lot hotter than the others? If so, this cell is probably damaged and you'll need to replace it if you purchase the pack.
- Carefully check around the vents on the positive end of each of the cells. Do you see any "goop" or deposits there? If so, that cell might have vented or ruptured and is no longer any good. Be aware that if the cells use soldered tabs or battery bars to connect each cell to the next one, the cells might have solder resin around the bars/tabs. If it is resin, it would probably be on both the positive and negative ends of the cells where the bars/tabs are attached. Though unsightly, this resin isn't a problem. If you're soldering your own packs though, don't use plumber's flux. Though extremely effective, it's corrosive. Use solder and flux specifically made for electrical purposes.
- Check for split or melted shrink wrap. It might have accidentally happened when the shrink wrap was installed (if done by the

pack's owner) but it can also indicate that the pack was overheated enough to damage the cells.

- Make sure the pack reaches at least 80% of its rated capacity at a 1C discharge rate, preferably close to 100%. If it doesn't, one or more cells may be bad or the pack is at the end of its life. This is another situation where an AH-meter is invaluable.

Discharging and the "memory effect"

Briefly, the "memory effect" doesn't exist.

At least, not as a true memory of how the pack was previously used. The apparent loss of capacity (often attributed to "memory") is really just a reduced cell voltage typically caused by overcharging. The full capacity of the pack is still available, just at a lower voltage.

Overcharging causes the formation of a different compound that has a lower voltage level and higher internal resistance. This results in a lower pack voltage and the appearance of reduced capacity as the pack will appear "empty" sooner.

When the pack is only partially discharged, only a part of the lower-voltage compound is converted back to the higher-voltage, "normal" compound. After charging the pack and using it again, the pack will begin to discharge this higher-voltage compound first and everything will appear normal. But, as soon as the higher-voltage part of the cell is discharged, the cell's voltage will rapidly drop to the lower-voltage compound's level. This lower voltage makes the cell appear to be discharged, especially if a low-voltage cutoff circuit exists in whatever device the pack is being used in. This cutoff might shut off current from the pack thinking that it is discharged.

Since the switch over to the lower-voltage compound occurs at the same place as the previous use of the battery pack, it appears to have a memory of that previous use.

Continuing to charge the pack and then using it only down to where the switchover to the lower-voltage compound occurs will only reinforce this switchover by encouraging the growth of ever larger (higher resistance) crystals of the lower-voltage compound.

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This happens most often with NiCd cells, but it can occur with NiMH cells too (via a different electro-chemical process).

Regular discharging of your packs down to approximately 0.9V/cell helps to break up this lower-voltage compound, converting it back to the normal higher-voltage compound when charged, and increases the pack's voltage level and useful capacity. Our [2-Stage Pack Dischargers](#) and [Auto-Cutoff Modules](#) make this easy.

Cell zapping – worth it?

In our opinion, for reviving a “dead” or “tired” cell, no.

For achieving a very small increase in the cell's voltage under load, yes. But, only you can determine whether the possible damage to the cell caused by zapping it is worth the small performance gain.

When a cell's crystals have grown large enough (or have formed dendrites long enough) to poke through the separator and short out the cell (increasing the cell's self-discharge rate), “zapping” can provide a temporary fix. The high-current pulse vaporizes the part of the crystal that's shorting out the cell and the cell appears to be “revived”. The problem is that the vaporized crystal material has now contaminated the separator, leading to a higher than normal self-discharge rate, and additional crystal or dendrite growth will soon follow the material just blown out.

If your cells are only reaching about 80% of their rated capacity at a 1C discharge rate, then it's time to start considering the replacement of that pack. Proper charging, discharging, and storage will make sure your packs last as long as possible.

NOTE: It's normal to for the pack to suffer a loss of efficiency when discharging at a rate higher than 1C and not be able to deliver 80% of capacity.

Storing your cells

NiCd and NiMH cells can be safely stored for very long periods of time if you follow these procedures:

- **Always** remove a NiCd or NiMH battery pack from the device that uses it before storing the pack.
- Occasionally discharge your packs down to 0.9V/cell or, if possible, individually down to zero volts per cell (anything below 0.8V is essentially completely discharged). A charged pack that is allowed to self-discharge is subject to large crystal formation and voltage depression when used again.
- Do not exceed 85°F. (30°C.) during storage. Keeping the temperature a lot lower is preferable, but do not go below 32°F. (0°C.). A lot of NiCd/NiMH battery pack users have very successfully stored their packs in the refrigerator or freezer but we feel that the need for air-tight wrapping and the inconvenience when thawing out the packs isn't worth the trouble. Lower temperatures slow down the self-discharge rate of the cells but we recommend cycling the cells every few weeks anyway. Balance the possible benefits of long-term storage (without worrying about self-discharge) against any possible inconvenience when thawing out the packs and choose the storage method that works for you. You'll be fine either way.
- Store the cells in an air-tight container or other packaging to prevent condensation if the cells need to come up to room temperature after storage (and before using them). Some cells can be stored and used at very low temperatures, down to -40°F. (-40°C.). Check the data sheet of the manufacturer of your cells to be sure.
- To use the cells after they've been stored, perform a slow 0.1C-rate charge and 1C-rate discharge before charging again normally and using them. If the cells have not been conditioned every 3-4 weeks during storage, you may need to cycle them this way up to 3-4 times before the cells regain their rated capacity.

You'll often see advice to store NiMH cells partially charged. But, we've been storing all of our NiMH packs discharged to 0.9V/cell between uses and haven't damaged any cells or measured any loss in capacity or reduced voltage under load. In addition, none of the major cell manufacturers that

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discuss storage of their NiMH cells say that a partial charge is needed. In fact, most state that they can be stored discharged.

The only sure reason we know of for storing NiMH packs partially charged is that certain chargers won't start if the voltage of the cells is below a certain level. Since NiMH cells self-discharge faster than NiCd cells, there's a chance that these chargers might not charge a NiMH pack that hasn't been used or cycled in a while. We don't recommend buying one of these chargers as they prevent you from slowly charging over-discharged packs or packs that haven't been used in a long time.

But, with all of the conflicting information available on the Web, we decided to do a test. After charging and 2-stage discharging three different 10-cell NiMH battery packs to 0.9V/cell (cycled 3 times), we stored all three packs for 8 weeks at room temperature. After 8 weeks had elapsed, the following pack voltages (no load) were measured; 11.71V, 11.79V, 12.32V. No individual cell had dropped below 1.0V.

Based on these tests, cell manufacturer recommendations and our experience over the years using various NiMH battery packs here at CamLight Systems (and always discharging them to 0.9V/cell before storage), we have the following recommendations:

- If you're storing a NiMH battery pack for a month or less, discharge it to 0.9V/cell. No need to partially charge it before storing it.
- If you're storing a NiMH battery pack for longer than a month and you own a charger that will not start if the voltage of the cells has dropped too far, and you don't want to cycle the pack every month or so, discharge the pack to 0.9V/cell and partially charge it (about 10%). When you're ready to use the pack again, you will probably need to cycle it at least once to restore its capacity and voltage under load.
- If you're storing a NiMH battery pack for longer than a month and you have a charger that won't prevent

you from charging when the pack is below a certain voltage, just cycle the packs every 4 weeks or so. This helps to condition the cells and makes it easier to bring the packs back up to their rated capacity and voltage under load when you're ready to use them.

Maximizing NiCd/NiMH cell life

The life of your cells can be increased by following these tips:

- Condition your new packs by gently cycling them, at least twice. Charge at a 0.1C rate (or less) and then discharge at a 1C rate. If you're using a sensitive peak-detecting charger, you may have to restart the charge several times due to false peak detection by the charger.
- Don't overcharge the pack or trickle charge for more than 24 hours. This helps to prevent large crystal growth and voltage depression. Use a peak-detecting charger at a moderate to high rate, but avoid overheating the pack, over 130°F.-150°F. (55°C.-66°C.) depending on the cell manufacturer.
- Don't needlessly cycle your packs but do regularly discharge them to approximately 0.9V/cell to condition the cells and allow the charging to break up any large crystals that may have formed. This is the perfect time to measure their capacity with an AH-meter.
- Don't overheat your cells during charging or discharging, over 130°F.-150°F. (55°C.-66°C.), depending on the manufacturer.
- Remember that the cell's temperature is much higher internally, especially if your pack is shrink-wrapped or the cells have cardboard tubes around them.
- Keep the discharge current level low enough to prevent overheating whenever you can. Let the temperature of the cells tell you how high a discharge current level they can safely handle. If the cells are too hot to grab firmly and hold, they're too hot.
- As much as possible, cool the cells with fast moving air as they are being used and afterwards. Add space between the cells to allow for better air flow.

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- If the packs are not being used, cycle (charge/discharge) them 1-2 times every 3-4 weeks.
- Whenever possible, don't store, charge, or discharge the cells above 85°F. (29°C.) or below 32°F. (0°C.).
- To use the cells after they've been stored, perform a slow 0.1C-rate charge and 1C-rate discharge before charging again normally and using them. If the cells have not been conditioned every 4 weeks or so during storage, you may need to cycle them this way up to 3-4 times before the cells regain their rated capacity.

High-quality NiCd cells are rated by their manufacturers for up to 1,000 charge/discharge cycles and high-quality NiMH cells for up to 500 cycles (check the data sheets of your cell's manufacturer to be sure). Unfortunately, these ratings are often based on tests which use charge and discharge currents that are a lot lower than what are typically found in R/C cars/plane/boats and robots/robotic vehicles.

This means that you might get significantly fewer charge/discharge cycles from your battery packs depending on how hard they are used and how well they are maintained. But, following these tips will help you to get the longest life possible out of your packs for the performance level you're seeking.

Check our web site at

www.camlight.com

for our list of dealers and the latest information on our current and upcoming products.