Battery Basics

By Bob Aberle

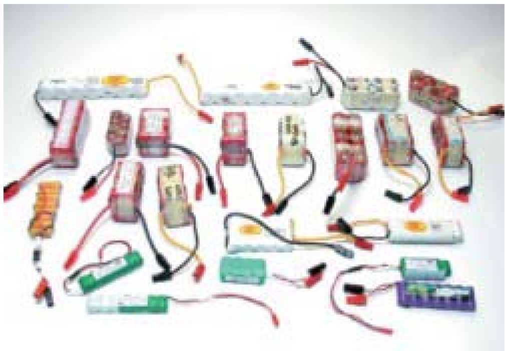
Many typical battery cells used in RC systems and electric flight look almost the same physical size; it's important to read labels. L-R: two typical Ni-Cd cells, NiMH cell, AA alkaline nonrechargeable battery cell, new Li-Poly cell.

My apologies. I had every intention this month of publishing my new Radio Control (RC) electric sailplane model that I hope beginners will build from scratch. (It's not a kit or an Almost Ready-to-Fly [ARF]/Ready-to-Fly [RTF] model!) As I learned, designing, building, flying, photographing, and writing about it takes more than four weeks. I promise to publish my "Scratch-One" design next month.

This month (the eighth installment I've written) will be devoted to the all-important battery basics. In the previous seven chapters I've referred to the RC-system batteries and the electric-motor batteries on many occasions. I will probably repeat some of those points to emphasize their importance.

The battery power to your RC system is like putting gas in your car; if you run out of gas, the car doesn't run. If your RC system runs out of electrical power, it doesn't work (fly)! During this presentation I will concentrate mostly on the RC-system batteries, but I will get into some aspects of the electric-motor batteries as they are used in electric-powered flight.

Typical RC system battery packs and charger. On left is RC transmitter with rear compartment cover removed, exposing eight-cell Ni-Cd battery pack (yellow). In center is dual-output battery charger normally supplied with RC system. On right are two typical four-cell Ni-Cd airborne battery packs (the ones that go in model).



Many of Bob's battery packs for electric flight. There are too many to keep on trickle charge at once, so he doesn't!

Types of Batteries: In the RC hobby today, modelers typically use Nickel Cadmium (Ni-Cd) or Nickel Metal Hydride (NiMH) cells. Both are rechargeable batteries. Under normal operation they can be recharged hundreds of times and have been known to last an average of three to five years and more.

From a beginner's perspective Ni-Cd and NiMH cells provide roughly the same kind of service, so you need not worry at the start about what kind of cells were supplied with your particular RC system.

The NiMH cell is the newer of the two. It can offer more capacity than the Ni-Cd cell of the same physical size. More capacity means that it can operate your system longer or fly your airplane longer. NiMH cells have a slightly lower characteristic voltage under load than Ni-Cd cells. From an RC-system standpoint, that difference is of little concern because the load is relatively low.

However, when using NiMH cells for electric-powered flight, the difference can be important. If you fly a model with a seven-cell Ni-Cd pack, then substitute a pack with NiMH cells, you might have to go up one more cell to a total of eight to achieve comparable performance. With every passing day, advancements in NiMH battery technology are removing this deficiency.

Some inexpensive (economy-type) RC systems are sold with no batteries included. If that is the case, you will have to purchase 12 AA-size alkaline (nonrechargeable) batteries (eight for the transmitter and four for the receiver or airborne side). Although these cells will last a long time (possibly 10 hours or more!), they must eventually be replaced since they can't be recharged.

Balsa Products sells a charger and eight individual NiMH cells which must be removed from the transmitter and placed in the charger. After charging is complete, the user inserts the cells back in the transmitter. The charger is $22.95 and a set of eight 1300 milliampere-hour (mAh) NiMH cells is $8.50. It's an interesting solution to what could become a costly long-term battery-replacement problem.

Balsa Products sells this eight-cell Ni-Cd or NiMH individual battery-cell charger which comes with a set of 1300 mAh NiMH cells, all for $22.95. You charge these cells by removing them from RC transmitter.

There is a new type of battery technology called Lithium Polymer (Li-Poly), which has emerged thanks to the cellular-telephone industry. There isn't much application for this type of battery cell for RC systems at this time, but you will be hearing and reading more about the great advantages of low weight and high capacity for electric-powered flight. There will be more about that in another installment.

Battery-Capacity Ratings: All batteries have a capacity or rating. The capacity can tell you how much power the battery can supply in a period of time, or how long the charge will last while powering your system, appliance, etc.

Battery capacity for our purposes is usually stated as mAh, and ampere-hours (Amp-hr) are used for larger-capacity cells. Most RC systems through the years have been powered by Ni-Cd cells of approximately 600 mAh capacity. Thanks to the newer NiMH technology, higher-capacity cells are being offered with some systems. I'll use that 600 mAh capacity for this discussion.

For most purposes, the Ni-Cd cell's nominal (average) voltage is 1.2 volts. If you applied a load of 600 milliamps (mA) to a fully charged Ni-Cd cell, it should take exactly one hour for that cell to reach 1.0 volt. At that 1.0-volt level, the cell, by definition, would be considered discharged. If you continued to load the cell, the voltage would rapidly head for 0.0.

We usually see RC transmitters with eight-cell battery packs. Using the nominal-voltage rule, eight of these cells in series would produce a total of 9.6 volts. If we used a commercially available battery tester, we would apply a load until that pack reached 8.0 volts (8 x 1.0 volts), at which point the testing device would cut off and the capacity in mAh could be read off of a monitor, meter, or Liquid Crystal Display (LCD) screen. I'll get into more specifics about battery testing later.

Charging: With respect to charging, you will hear the following terms: overnight charging, field fast charging, and trickle charging. The overnight charge rate is the one with which you should become most familiar.

A typical RC transmitter and airborne battery pack are charged at the same time using the supplied RC-system dual-output battery charger. It's left on overnight, or for at least 10 hours.

Bob holds the wall-plug dual-output charger. Green and red LEDs are lit, indicating that charge is taking place. If the indicators are not lit, it is not charging and you better figure out why!

All battery charging, regardless of the type, is done as a function of the battery's rated capacity. You want to know what a battery's capacity is before you put it on a charger because too small a battery charged at too high a charge rate will be "cooked." On the other end of the scale, too big a battery charged at too low a rate will never get to full charge.

The overnight charging rate has been established for many years as the *capacity* of the battery divided by 10 (usually written C/10). This is the rate most RC-system dual chargers use.

When employing a C/10 overnight rate, you are instructed to leave the batteries on charge for at least 10 hours. You could let them go for 16 or even 24 hours, and you would never hurt the batteries. This rule applies to Ni-Cd and NiMH cells.

ACE R/C Digipulse Multi-Charger can separately charge as many as six battery packs at currents ranging from almost 0 upward of 200 mA. After a 16-hour charge, the charge current reverts to pulsed trickle level which can remain indefinitely.

LED screen on ACE R/C DDVC indicates that current was set to 110 mA. This charger has two separate outputs.

As a beginner in the hobby, you shouldn't experience any problems if you use the unit that came with your new RC system to overnight-charge (the night before you intend to fly) the transmitter and airborne battery. As you progress in the hobby, you will learn the rest of what is necessary to maintain your battery packs.

I need to repeat several items I have already mentioned in this series because they are so important. First, when plugging your charger into a household 115VAC outlet, make sure that the outlet remains "live" during the overnight-charge period. If you plug your charger into an outlet that is connected to your shop lighting, you'll turn off your charger when you turn out the lights, and nothing will be charged.

Second, don't be tempted to restore only enough charge to cover what you took out at the flying field. When you return home, don't put the batteries on charge for only two hours if you flew for two hours that day. Ni-Cd and NiMH battery chemistry is such that it needs the C/10 charge current (rate) and a minimum of 10 hours of charging. Anything less than 10 hours can cause problems.

Third, *never charge a relatively high-capacity battery at a lower rate, then leave it on for a much longer period of time to compensate*. In the past couple of years, new NiMH cells of the same pen cell (or AA size) have come on the market with higher and higher capacity ratings. The AA Ni-Cd cells were usually rated at 500-700 mAh capacity. Now these same-size cells have capacity ratings upward of 1600 mAh.

Let's say you replace your original RC-system batteries with 1600 mAh cells. Apply the logic that the charge rate must be C/10, or 1600/10, which would require a 160 mA charge current, but your

RC-system charger produces only 50-60 mA charge current. Being smart, you use that RC-system charger and compensate by leaving the batteries on charge for 24 or 48 hours.

Don't do this! That battery will never achieve full capacity unless you get the current up to C/10. When using the higher-capacity cells, you must purchase a charger with increased output.

One of the best for this type of charging is the ACE R/C Digital Dual Variable Charger (DDVC). It has two outputs that can be adjusted continuously from 0 up to approximately 300 mA current and is capable of handling as many as 10-12 battery cells. In the preceding example you would attach your 1600 mAh eight-cell battery to the DDVC, dial up 160 mA current, and let it run overnight for at least 10 hours.

Popular field-type fast battery chargers. Clockwise from top left: AstroFlight 110 Deluxe, Watt-Age PF-12 Park Flyer AC/DC Peak Charger, tiny Dymond Modelsports four- to eight-cell mini-peak charger, FMA Direct Super Nova automatic peak-detect charger. All employ peak-detect-type circuitry—as it should be!

Watt-Age charger is capable of operating at home on 115VAC and at flying field off of 12-volt DC car battery. The 110 Deluxe requires separate 115VAC to 12VDC power supply (at rear) to operate from home shop.

FMA Direct Einstein XL dual-output battery discharge tester/cycler (at top) and 115VAC power supply for it.

Don't worry about how many times you charge your batteries overnight. At that rate, you could practically leave them on charge all the time. I've never gone quite that far, but on many occasions I've left batteries on the C/10 rate for 24 or 48 hours with no degradation in performance.

I generally put my battery packs on C/10 charge (such as the RC-system charger) the night before I plan on flying. If it is raining the next morning then several days go by before I have the opportunity to fly, I charge the batteries overnight again. There may have been only a few days between charging, but at this safe charge rate *more is always better*!

Trickle charging is done at a rate considerably lower than C/10. We generally refer to a trickle charge as C/50, so that a typical 500 mAh battery would be charged at only 10 mA (500/50 = 10). At that rate the battery can be left on trickle for an indefinite period.

All of my RC transmitters are left on constant trickle charge following overnight charging. I have four transmitters that have been on trickle charge for more than five years and still have close to their full rated capacity.

The advantage of trickle charging is that the batteries are available the moment you want to fly. However, you can only maintain a charge level at trickle; you *can't* recharge a battery that has been used at the trickle charge rate.

Photos show my shelf-mounted ACE R/C Digipulse Multi-Charger. It has six individual outputs, each of which can be adjusted for charge currents of roughly 5- to 200 mA. A charge current can be set up and will remain until you change it. After a timed 16-hour period, each output reverts back to a pulsed trickle charge that will keep the batteries at peak performance, ready when you are.

There is even a backup battery that protects the charger's memory in case of a power failure. With the variable-charge-current feature, you can set each output to produce exactly the C/10 rate for each battery capacity employed (up to approximately 2000 mAh).

As I stated, all of my RC transmitters stay on trickle charge. On the other hand, almost all of my airborne RC equipment is powered from the same cells that run my electric motors. For those packs, of which I must have more than 50 at any given time, I don't employ trickle charging because it could be a logistical nightmare of chargers and wiring.

Field fast charging is a high charge rate that allows Ni-Cd cells to be completely recharged in approximately 20 minutes and NiMH cells to be completely recharged in 30 minutes.

Close-up of Einstein XL. Note two separate outputs. You physically switch meter function between output 1 and 2. On each you can select charge current and number of battery cells. When discharging, load is fixed 300 mA. After charging, outputs revert to fixed 12 mA trickle-charge level.


Typical test of RC transmitter and receiver batteries using Einstein XL. It tests battery, saves capacity measurement, and does everything automatically, including recharging battery after discharge test is completed.

The specific rates are 3C for Ni-Cd and 2C for NiMH. If your Ni-Cd battery pack is rated at 300 mAh and you want to field fast charge it, you would select a 900 mA current (300 x 3 = 900). At that current, a totally depleted battery could be fully charged in roughly 20 minutes.

All field chargers operate from 12-volt DC expressly so that they can be conveniently connected to your car battery. The question is, Why would you want to field charge if you had charged your batteries overnight at home before you came to the flying field?

A person might resort to field fast charging to extend his/her flying time at the field. I get approximately two solid hours of operating time from a single RC transmitter; that is a lot of flying. Because of that, I have *never* resorted to field fast charging any of my RC transmitters.

There is a more compelling reason not to fast charge a transmitter. Most RC transmitters have a protective fuse in the primary power lead, which is sometimes rated at only 0.5 amp (500 mA). If you hit that circuit with a fast charge current of 1.5 amps (1500 mA) you will likely blow the fuse. In many cases that will require the unit to be returned to the factory for maintenance.

The only time I ever have the need for "extra power" at the flying field is when I compete in the AMA Nationals at Muncie, Indiana. Because of the possibility of a flyoff (in the event of a tie score) at the end of the day, I bring a second freshly charged battery pack and simply swap packs. My general rule is not to fast charge a transmitter battery pack at the field.

Four- and five-cell receiver (or airborne) battery packs tend to run out of power faster than the transmitter, so you might want to fast charge this type of battery pack. I prefer to substitute a freshly charged second pack rather than resort to fast charging. Many RC-system batteries were not intended for ever being field fast charged.

Because many RC transmitters use blocking diodes in power circuit, you may need to remove battery pack, as shown, to be able to discharge-test it.

If you are into electric-powered flight, as I am, you will have to resort to field fast charging for the second and all subsequent flights of the day. Most of my electric-powered models employ battery packs with 10 cells or less. This enables me to use an electronic (motor) speed controller that includes a Battery Eliminator Circuit (BEC).

The BEC allows me to share the single large airborne battery pack between the motor operation and the RC system. After each flight, that battery is field fast recharged in 20-30 minutes. After that, it is ready to run the motor and the RC system. Because of this "sharing" advantage, I rarely use the regular four- or five-cell RC-system airborne battery packs.

I've painted the picture of charging. Field fast charging, under most normal conditions, is unnecessary for the average fueled-powered-model enthusiast, but that capability is a must for electric-power modelers.

The only "fast" charger of choice is called a "peak detect" charger. The peak-detect circuit will permit fast charging up to the moment of full charge, at which point the battery will also be at peak voltage potential. Within a few seconds thereafter, the peak-detect circuit operates and turns off the charger. This feature provides for full charging (up to full capacity) and for automatic cutoff after full charge is reached. This is the only way to go!

Some inexpensive chargers simply employ a 15- to 20-minute timer. The problem with this is that it cannot sense the state of the battery's charge, so it is easy to undercharge or overcharge the battery—a bad idea!

There are several "automatic" peak-detect chargers on the market; two that come to mind are the FMA Direct Super Nova and the Dymond Modelsports Super Turbo. In automatic mode, these chargers sense the battery's cell count and capacity rating, and they automatically set the proper charging parameters. The concept involves averaging many of the parameters and applying conservative charging numbers, but it does work and is worth your extra attention if you become serious about electric-powered flight.

With regard to field fast charging, only peak-detect charge Ni-Cd or NiMH battery cells. Make sure your particular cells are rated for fast or elevated-level charging. Ask your battery dealer or distributor if you're in doubt.

Only fast charge your battery packs after they have had a chance to cool down; *never charge a hot battery pack*! (Warm to the touch is okay.) Never use a peak-detect charger to charge any Lithium-type battery, be it metal, ion, or polymer.

Testing: You know what capacity is and how to charge a battery; now you must learn how to monitor or test your batteries to determine when they are running out of power and when they must be replaced. Just because a battery is only a year old, you can't assume that it has to be good and not worry about it. Some batteries die after only a few months of service!

There are two places where you will want to test batteries: at home (in your shop!) and at the flying field. Generally the at-home testing is necessary on a regular basis to determine whether or not your battery continues to provide power at or close to its rated capacity. At the flying field you want to know when it is time to stop flying because you are running out of power. At that point your options are to go home, fast charge the battery, or swap with a freshly charged battery.

For at home there are probably close to a dozen popular battery discharge testers on the market. I use the FMA Direct Einstein XL, which costs slightly less than $100 with the power supply. This device might soon be out of production, but that decision was not final as I wrote this article.

However, I wouldn't want to disappoint readers by describing a product that is no longer available, so I'll use the Einstein for this discussion. At the end of this segment I will supply the names and sources for several other testing devices I know are still on the market.

The Einstein is convenient because it has two separate outputs, making it possible to charge and/or discharge test, or even trickle charge, two different battery packs. The basic idea is to be able to charge/test a transmitter and receiver battery, and at the same time keep the two totally separate. Many of these battery-testing devices have two separate outputs.

The Einstein is especially nice because it allows you to select discrete charging currents of 25-, 50-, 80-, 120-, and 140 mA. It also lets you select battery packs consisting of anything from two cells up to a total of 12. This applies to Ni-Cd and NiMH.

Another of the Einstein's features is the ability to overnight-charge battery packs up to 140 mA and 12 cells, then after a fixed 16-hour period have the charge level revert to a trickle. This can be accomplished without ever evoking the discharge test mode.

The basic use of any discharge battery tester begins by fully charging the battery at the overnight rate. If you're using the Einstein the next day, press the "Cycle Start" button, and a fixed 300 mA load will be placed on the battery. An LCD screen will begin to register your battery's capacity, expressed in mAh.

When a minimum voltage of 1.0 volt per cell is reached, the Einstein stops the discharge load and begins to recharge the battery at the rate you previously selected. The last mAh reading on the LCD screen is saved until you disconnect the battery from the output cable. Charging will continue for a timed 16-hour period, after which the battery will revert to a fixed 12 mA (nonadjustable) trickle-charge level.

The rest of this story depends on how you interpret the mAh reading. I generally discard a battery when the capacity drops 20% from its normal rated value. If I have a 600 mAh-rated pack, I will continue to use it until it gets down to 480 mAh (600 less 20%).

Keep a logbook containing capacity measurements made on each identified battery pack during a period of time. You'll usually observe that a pack will provide close to its rated capacity for two or three years, then all of a sudden the capacity will begin to drop off.

Testing battery packs often involves using adapter cables. Bob has been accumulating his for many years. You can make your own adapters or obtain them from RC or battery distributors.

Although I normally test-cycle my batteries only every three months or so, the minute I see the capacity start to drop I'll check it at least once a month. My experience is that a pack showing this characteristic will usually "go south" in a hurry. When it does, I discard the entire pack; I *never* "perform surgery" after locating the bad cell. It isn't worth it, and it can waste a great deal of time.

When discarding any battery pack, don't just put it in your garbage. Follow the manufacturer's recommendations and return it to a certified disposal organization (that goes for *any* type of battery cell).

Besides FMA Direct, there are several other sources of battery discharge testing devices that I recommend. Tower Hobbies and Great Planes Hobby Distributors sell the Hobbico Accu-Cycle. You can learn more about this unit at www.hobbico.com/chargers/hcap0260.html, and you can download its operating manual there too.

One of the nice things about the Accu-Cycle is that it has two separate monitoring meters—one for each output—so you don't have to keep remembering to switch the meter from output to output. The price is roughly $80, which is reasonable.

Horizon Hobby Inc. sells the Hangar 9 Sure Cycle Battery Cycler (tester). You can find information about it at http://horizon.hobbyshopnow.com/products/description.asp?prod=HAN9525. The Hangar 9 unit does the same job of battery discharge testing. It has a single output meter, as does the Einstein. At $60, it is a bargain.

I wish everything in this hobby was perfect and easy, but it is not. One major problem with battery testing is that almost all RC transmitters manufactured in the Far East come with a diode placed in the charging-jack circuit. It is done to prevent the main power source from accidentally shorting, but at the same time the diode essentially blocks your access to the battery pack. This means that when you hook up the transmitter, via an adapter cable, to any battery tester, you will not be able to discharge it.

To correct this problem, some clever modelers have gone inside the transmitter and shorted out the diode. In the process of doing this, they could cause problems to other circuits and they are canceling the factory warranty.

I prefer to simply remove the battery pack. Most transmitter battery packs can be accessed easily by removing a hatch cover, and the battery is usually attached with a connector. The trick is to unplug and remove the battery, then obtain an adapter cable that will allow you to connect the battery pack directly to the tester. The RC manufacturers usually sell these adapters, so try them first.

Trusting that your batteries are up to their rated capacity, it's time to address the next problem: How long can you fly at the field before charging or battery swapping is required? That answer is easy on the transmitter side of the RC system.

Most transmitters will have an analog voltmeter; better still, a digital voltmeter; sometimes an audible warning alarm; or on the less-expensive units, several colored LEDs that go from green (fully charged) to yellow or amber (as a caution) to red (when you are supposed to stop flying).

These transmitters usually consume 100-200 mA load current, which provides for a meaningful test. Never attempt to test a transmitter (or any) battery with only a simple voltmeter. Without a load, most batteries will always appear suitable for use, but if you place a load on those same batteries, they could quickly plunge below minimum.

For the receiver batteries (usually four or five cells), as used with fueled models or electric-powered models of more than 10 battery cells (where you can't use a BEC), the best quick field check is done with a "loaded" voltmeter.

Years ago we used an analog-type meter with an expanded scale for more resolution (and accuracy). We called these test units "expanded scale voltmeters," and the term "ESV" has stuck. But today we have modern digital-readout voltmeters, and expanding the scale is no longer necessary. All of these field-testing devices generally impose a load of 250-500 mA current.

I like using the Hobbico Digital Voltmeter Mk III (stock number HCAP0356) from Tower Hobbies. The special price was $21.99 at the time of this writing. When you purchase this voltmeter, the 9-volt supplied battery is wrapped in plastic inside its compartment. You must remove the battery, unwrap it, and plug the connector into it, then the LCD screen will light up.

The best way to use this field tester is to have a charging jack located on the side of the fuselage. That way you won't have to remove the wing to gain access to the airborne battery pack.

After every flight, plug in the tester and select it for the correct number of battery cells, with the load on. Wait approximately 10 seconds, then look at the LCD screen. The Hobbico unit has been thoughtfully set up to tell you when it is time to recharge. It will clue you in on a four-cell pack when the voltage gets to roughly 4.8 volts under load. That is somewhat conservative, but I support this choice.

There are more sophisticated field-type battery testers on the market. Rod Johnson of i4C Products has a Loaded Battery Tester that will let you select load currents of 500-, 1000-, and 1500 mA. This would be appropriate for larger-capacity batteries, as are used in larger model aircraft. The i4C unit is powered from the battery under test and needs no extra battery, so it is always available.

Rod has another interesting battery monitor called the C-Volt. It is a small LCD-readout digital voltmeter that you mount on the side of your model's fuselage. It goes on when you power up your airborne RC system. It doesn't contain a load since that would draw too much extra power.

You observe the C-Volt meter while you operate a few aircraft controls simultaneously, such as the rudder, elevator, and ailerons. By doing this you will load down the battery, providing a meaningful check of the remaining power. At 4.7 or 4.8 volts for a four-cell battery, it is time to recharge or replace it.

Testing batteries used for electric power is a slightly different story. If you are using a BEC and sharing power, the radio is using only a fraction of the battery's power (such as a few hundred mA), and the motor itself might be drawing a few amps or more power (much more significant). You are recharging this battery after each flight, so you know you start every flight at a full charge.

That being the case, there is no reason to really test the battery. When your model goes to take off, if it appears sluggish or wants to land after only a minute or two when it's in-flight, look into the possibility of a bad cell in the pack. In this instance, the way the model flies reflects on the battery's condition.

Replacing Batteries: I've written my opinions about the minimum capacity at which point it is time to replace your batteries. Then the choice becomes whether to buy the same battery pack direct from the RC manufacturer or from a reputable aftermarket battery-pack supplier.

Since most RC manufacturers supply only 500-700 mAh-capacity packs with their systems, your first choice for replacing batteries is to go to higher-capacity cells of the same physical size. I hate to suggest that you not go back to the manufacturer, but the aftermarket suppliers have some great stuff these days. I'll list as many as I can at the end of this article.

Keep in mind what I wrote about when you go from a 500 mAh-capacity battery to one that has 1600 mAh capacity; you won't be able to use that same charger that came with your system. You must get something such as the ACE DDVC or Digipulse Multi-Charger.

When you get some experience under your belt, and especially if you pursue electric-powered flight, you may want to make your own battery packs from individual cells. The aftermarket battery suppliers sell individual cells with solder tabs for your convenience. When you get into the higher-capacity cells which draw much more current, you will have to resort to copper bars or copper braid to make the intercell connections. But that's for a later article.

Charge Retention: If I'm unable to fly on a given day and several days or a week goes by before I get another chance, I recharge the night before that next flight attempt. Ni-Cd batteries do lose a certain amount of charge each day after they are fully charged.

Specifications indicate that charge retention depends on battery temperature. Ni-Cd cells stored at 32 degrees Fahrenheit can be expected to lose approximately 10% of their charge in 30 days. Those same cells stored at 68 degrees Fahrenheit will lose 30% of their charge in 30 days. At 104 degrees Fahrenheit, the loss will be almost 70% in a 30-day period! NiMH cells tend to lose charge at an even faster rate.

From this information you can probably understand why I instruct you to be safe and recharge at the C/10 overnight rate if a week goes by. The new Li-Poly cells exhibit excellent charge retention, losing only 1% or 2% of their charge in a six-month period.

The i4C Products Loaded Battery Tester operates much the same as Hobbico unit but offers choice of three load currents: 500-, 1000-, 1500 mA. This is valuable when checking capacity remaining in larger battery packs. This unit is self-powered, requires no extra battery.

The i4C C-VOLT is another neat testing device. This small digital voltmeter mounts flush on side of model fuselage; it goes for the ride. Moving controls (such as elevator and rudder at same time) will generate suitable load current to make accurate voltage readings.

Some RC transmitters have built-in voltmeter along with lowvoltage audible alarm or warning. This typical voltage reading remains on screen at all times.

Battery Storage: There are two schools of thought on this topic: to store the Ni-Cd or NiMH cells fully charged and to store them when fully discharged. Either way is okay, but experts tell us not to store cells at partial charge.

I find it easier to return from the flying field and put the cells on overnight charge. That way they go back on my battery shelf at full charge. If I don't use the battery in a month or two, I recharge it again. I have many battery packs, so some will be forgotten. However, most survive and provide three to five years (and more) of service.

Memory: Since Ni-Cd cells were first used in the early 1960s, we have been told that they can acquire a certain capacity memory. It was said that if a modeler made six flights each week, his/her batteries would get accustomed to supplying that level of energy. If that modeler made eight flights during a particular week, he or she might find the batteries incapable of supplying the extra power.

Why? The batteries supposedly developed a "memory" for that amount of power. This subject has been greatly debated through the years. The newer NiMH cells don't seem affected, and the even newer Li-Poly cells are not affected at all.

Regularly discharge testing (or cycling) your battery packs would eliminate the problem if it actually ever existed. RC-system batteries tend to be used at roughly the same rate, so periodic testing (cycling) can't hurt in that regard.

Batteries used for electric-powered flight are usually taken down to the minimum charge level on each flight; as such, they are essentially cycled on every flight. It would be difficult to conclude that batteries used in this manner require additional cycling in your shop. When your electric-powered model refuses to take off or support flight, then you know you have a battery problem and can investigate further. But don't bother to cycle these batteries; it's unnecessary.

Li-Poly cells will be the subject of a separate article sometime in the future. Progress in this area is being measured in weeks—not in months. Considerable recent development work is gradually producing cells that are capable of supplying more capacity at higher current (load) levels, with ever-decreasing weight. At the same time, the cost of Li-Poly cells is coming down.

Right now Li-Poly use is limited to roughly 10-amp loads, which can handle up through Speed 400 power (such as the Aero Craft Pogo in last month's article). However, these load-level limitations are constantly improving, so it is just a matter of time. Although I don't see the need right now, Li-Poly batteries may eventually be used to power our RC systems.

Don't *ever* attempt to charge Li-Poly batteries with peak-detect chargers; they have a completely different chemistry and should only be charged with their own chargers. You might be tempted to write in that there are chargers available—such as the Great Planes Triton—that can peak-detect charge Ni-Cd and NiMH cells and have a separate function for charging Li-Poly cells. That is correct; the Triton is new, and it works well. But don't leave it set on peak detect and try to charge Li-Poly cells.

I've written many articles about batteries throughout the years. No matter how basic and thorough I am, these articles generate the most inquiries. Readers have been relatively quiet to date when it comes to questions. Now is your chance! Please write in and let us know how we can continue to help you. What else would you like to see in this series? Address suggestions to Bob Hunt at Box 68, Stockertown PA 18083, or to bobhunt@mapisp.com.

Next month look for the Pogo follow-up: a new design which I hope you can build from basic materials without a kit. This will be your first scratch-built RC model. I think you can do it! *MA*