

Battery test part 1 – NiMH rechargeables

This is an article for those who use battery lights – I hope someone else will write a bit about dynamo setups before long – a Schmidt or Shimano hub with the Solidlights 1203D LED front light seems to be generating a lot of favourable vibes – I don't use this stuff so someone who does, please step forward!

I tested various brands of battery cells suitable for bicycle lights, for *Arrivée* back in 1999. The results are rather out of date now, and with PBP looming on the horizon, I decided to revisit the theme. Alkalines (non-rechargeable types such as Duracell etc) will be surveyed in depth in the next issue but at the same time I've checked out some NiMH rechargeables.

The main message of Part 1 of this test is this: Quite simply, good modern NiMH cells are currently the best option for a single all-night ride (eg a 400 or 600) or for commuting in UK conditions. They are cost-effective and relatively environmentally-friendly compared with other options, and by most measures they easily out-perform the best alkalines in a typical halogen bike light.

However, there is a bit more to say on the subject – NiMHs have come a long way in recent years but they still have several 'issues' which I'll cover below. The crossover from halogen to LED front lighting also affects the equation, LED lights being more favourable to alkaline batteries. And with PBP in mind, rechargeables obviously have problems when there are a possible four long nights in prospect.

I test batteries by running 4x

AA cells in a good old Cateye Micro HL500-II front light, monitoring voltage and time from switch-on to brown-out. In a basic unregulated light like this, higher voltage equates to brighter light, its very simple. Above 4.8V, the Micro is a good light. Below 4.8V, its not. Below 4V, it's pathetic. Below 3V, it's dead. The test does not imply any particular endorsement of the Cateye Micro as a bike light – it was a good light in its day, but that day is long gone – it just happens to be a 'standard' that is quick and easy for me to work with, and which gives AA cells a hard time (runtime to brown-out using alkaline cells is around 3h30).

I test AA cells because they are much quicker to run down than the bigger C or D cells – to do a similar test on D's would be a year's work! Although D cells are a much more economical way to buy power in your local supermarket, AAs are generally more highly developed these days, and if bought in bulk online the price differential disappears. I have seen drum-shaped converters that allow you to mount 3x AAs in parallel in such a way as to replace a single D cell, and with the best AAs this arrangement would easily outperform any D cells on the market. You could thus feed an old NeverReady with six AAs and get a humungous runtime – if it lasts that long without breaking down.

Graph 1 shows a typical alkaline battery in a Cateye Micro (Boots Extra Long Life – good, but not best in test) vs a typical NiMH battery (HFE 2500mAh – again good but not best) vs Energizer Lithiums as a benchmark. The Cateye is a 2.4W light. The higher the line, the brighter the light. Below the 4.8V line the light is getting increasingly yellow. Below 4V its not really worth having. The longer the line, the longer the runtime. The NiMHs (green line) had to be stopped when they dropped below 4V. Had they been run down to 3V (risking damage to the rechargeable cells) it would only have added about five minutes to the runtime anyway.

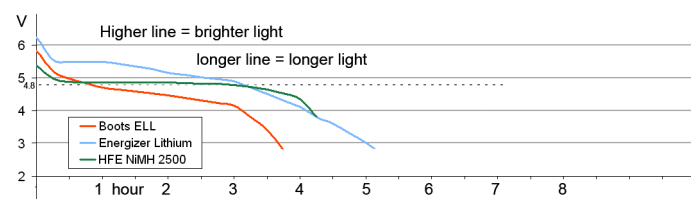
I hope you can see that alkalines (orange line) are really non-starters in this contest – good light for less than one hour, dismal light after three hours. The NiMHs give good light for nearly three hours, and run for over four before the 'dismal' stage (when you have to switch the light off anyway). The lithiums come out best – they really do give noticeably brighter whiter light than any other battery in a Cateye Micro, and runtime to brownout is 30 minutes longer than the best of any other cells I've tested.

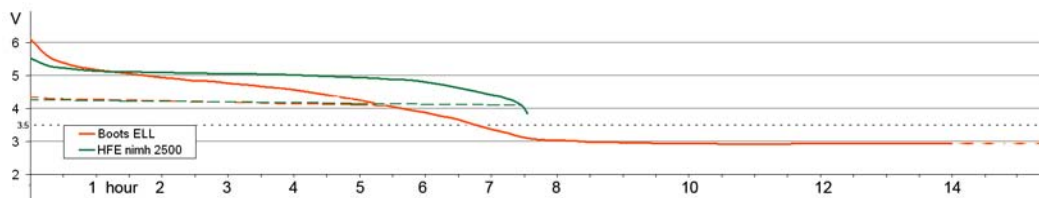
The Cateye Micro is a bit old hat these days (though it may still have a place for PBP '07 if the ACP attitude to LED lights is unchanged). Even the 1W LED lights (the type that use a single 1W led and some fancy optics) will outperform it easily, while the newer 3W types are surely set to take bike lights into a new era. LEDs behave quite differently to halogen bulbs, as the battery ages and the voltage runs down

– where bulbs lose their efficiency and their ability to convert power into light, LEDs actually become more efficient. Although they do become dimmer, this trend is partially counterbalanced by the LEDs working better and eventually running practically on thin air. You can end up with the familiar very long runtime in 'visibility' mode. Modern LED lights typically incorporate some form of regulation as well, which means you can only really compare batteries for runtime, not for brightness.

Graph 2 shows the same information as graph 1, at the same scale, but for a Halfords 1W LED light. The NiMHs were the same set, the alkalines were another four from the same bargain bin of 24. I've marked the 3.5V line, as the point where I judged the light stopped being useful as a beam-throwing light, and became merely a 'visibility' light. Of course with NiMHs you should never get to this point – you'd be in battery-damage territory – so once again the line on the graph stops short to illustrate this. The additional dotted lines are an attempt to show how the regulation works in this light, in terms of perceived brightness. There's no line for Lithiums as a) my budget doesn't run to it and b) neither would my patience. This test was much like watching paint dry. After 13 hours the condition of the Boots alkalines was actually showing measurable improvement – the light was still an acceptable visibility light and the voltage was actually increasing, presumably because the current drain was now so low that the cells were actually resting while they worked. At 14 hours, I gave up and went to bed.

Graph 1. Cateye Micro Halogen





Graph 2. Halfords 1W LED'

Graph 2 clearly shows the alkalines giving seven hours of useful beam – long enough for summer 400s and 600s – plus at least another seven as a visibility light. The NiMHs give 7.5 hours of beam but must then be switched off, and with very little warning (note the sharp downturn from regulation to sudden death). In terms of alkaline vs NiMH performance, there is no clear advantage either way, in this type of light. On a typical 6-hour summer night you'd never spot the difference. The alkalines can be used for a whole 2nd night in visibility mode – but this is a very dubious advantage, if I were using the light like this I would surely replace them before the second night anyway, to get my beam back. The alkalines would definitely score on a longer, 10-hour night such as you get on PBP.

I wanted to do the same comparison using a 3W LED light. For this I used a Topeak WhiteLite

3W, which can accept power from an external 6V supply. This light gives a useful beam all the way down to the 3V point, where it suddenly switches off. The alkalines gave a predictably pathetic runtime of 2h40 to switch-off – but this was actually a decent light all the way, in practical terms a better result than in the Cateye. I couldn't get this light to run with NiMHs at all (its internal cells are 2x 3V lithiums).

Issues with NiMHs

1. NiMHs have a lower voltage than alkalines – 1.2V vs 1.5V – in practical use this is far less of a problem than you might expect. You can see from the graph that in a Cateye Micro the extra brightness from alkalines is very short-lived indeed, and more than outweighed by the brightness advantage of NiMHs over the long haul.

2. They don't like deep discharge and if you see your light visibly yellowing you need to

switch it off. Run it right down and you risk damaging at least one of your cells for good and all. Many 'smart' devices such as cameras and GPS units which monitor battery usage will shut down at this point – not because they can't run but to protect the batteries from deep discharge – bike lights are not so smart and you have to be aware of this.

3. Then there is the NiMH tendency to self-discharge – to get the best out of them you should charge them as close as possible to time of use – this is another good reason why they may be unsuitable for PBP, you could well leave home some four days before the start of the event, and in this time the cells could lose maybe 20 per cent of their capacity. In my tests I tried to simulate best 'real world' practice by resting the cells for 12 hours between charging and testing.

4. A minor point – the highest-capacity NiMHs are a bit heavier than other cells – four weigh about

120gm, as opposed to about 95gm for alkalines and 60gm for lithiums. No big deal, until you remember how much those titanium chainring bolts cost you!

NiMHs have come a long way in the last six years but they do seem to feature rather fanciful labelling on an ever-upward spiral.



From my tests, the ratings do seem to be optimistic, but there is a good correlation between the comparative ratings and the actual relative capacities. In other words, with the best charging regime a cell marked 2500mAh is very likely to have more capacity than one marked 2300mAh. In fact I have to say that I tested several different makes of 2300mAh cells, and, to be frank, compared with the higher-rated ones none of them were remotely worth having. If you are using 2300mAh cells in your lights, give or throw them away and get some with a bigger number printed on the tin.

As I write the highest-rated AA NiMHs are labeled 2700mAh and these can be bought quite cheaply enough for there to be absolutely no point in buying anything else (as I write, £5.39 for four from 7dayshop). If you already have last year's model, then a difference of 100mAh – which in theory represents about 12 minutes of runtime in the Cateye Micro – is small enough to be masked by several other factors – the efficiency of your charger, how frequently they are cycled, and sample variation between cells in the same packet.

Sample variation is very significant. A typical set of four NiMH cells can be assumed to vary by 100mAh between best and worst. Many vary by much more. My worst set (in this respect) shows a variation of 450mAh, which really indicates a faulty cell, and my best set (same brand, as it happens) varies by just 50mAh – but you

Charger efficiency is obviously very important

NiMH chargers vary greatly in just how fully they charge the cells before the little green 'charged' light comes on, and they also vary in what they do after that point. All chargers protect the cells from overcharge – some do this just by charging very slowly – others by switching off after a set time – others by deliberately undercharging – others by heat detection (one feels by that time its probably too late) – others are so-called 'smart' chargers which is taken to imply some kind of Voltage trend detection. So what do you look for in a charger?

1. It should be specifically designed to handle NiMH cells. Most are marked NiCad/NiMH which in theory is OK but all too often simply masks the fact that it is a NiCad charger which can also charge NiMHs. Really, its almost impossible to tell what you are getting, from the blur. A big switch on the top of the charger marked NiCad – NiMH is reassuring, even though it may very well not be connected to

anything inside the case. Cynic, moi?

2. It must use Voltage trend detection to determine when to end the charge – this is often referred to as 'negative delta V'.

3. It should then drop back to a 'trickle' state, and not switch off entirely.

4. Best if it treats each cell individually, rather than as a set of four (or maybe two sets of 2). This might be apparent from the layout of the charger – eg if it has individual 'charged' leds for each bay I would take this as an indication (but not a guarantee) that each bay is treated separately.

Speed of charge is not that important and is a matter of personal taste – I like a charger that takes several hours, so that I can leave it overnight. Most 'smart' chargers are also fast – some are very fast indeed – this is because it is actually easier for the 'full' detection circuitry to work reliably if the cell is charging quickly. Cells do get quite warm

but this is OK, in moderation. All things considered, a smart charger – provided it also drops back to a slow trickle and doesn't just switch off – is the best type to get – they combine reasonably effective charging with the best possible battery cycle life. Although they used to cost around £30, I have recently seen decent-seeming NiMH chargers that tick all the right boxes for £12 which is good value. If you have the patience, then you will get better charge capacity using a very, very slow trickle charge – but such ultra-slow chargers are specialist items and not generally easily available – and this is not kind to batteries in the long run, cycle life will be greatly reduced. Its probably safe to assume that the inflated capacities printed on the cells are obtained in this way, under virtually laboratory conditions of charge and discharge – one reason why they don't tally with the real world.



have to count yourself lucky to get a well-matched set of four straight out of the bubble-pack.

This is important because the weakest cell in the set is always prone to get damaged during a deep discharge (such as brown-out). None of these sets were conditioned before testing, because in the real world I know they wouldn't be. With a very careful and patient trickle charging regime, it should be possible to reduce these variations. If you have the ability to measure capacity (like the digital readout on my charger) then its probably well worth buying two similar sets of 4x NiMHs and doing some cell-matching to get the best possible set. I mark my 4x sets into two pairs, with a spot of magic marker, so I can match the best two and the other two, for use in things like cameras or GPS that only use two cells – even the weaker pair benefits from matching.

Cycle frequency is very important. Although dis-use doesn't actually damage NiMHs, they definitely give best results with regular, almost constant, use. Don't have too many sets of NiMH on the go at once – pick your best two or three sets (or however many you think you need) and throw or give the rest away. The ones you keep will work much better for you,

in consequence. After about 300 cycles each they will need to be replaced, because they'll be losing capacity – but 300 cycles is many years use, most people will replace them long before that just because newer better ones have come to market.

Charger efficiency and a good charging regime is an article in itself – without optimal charging you won't get even close to the best possible results from your NiMHs, either in terms of capacity or cycle life.

Test Results

In the table below I include a couple of the better alkalines, for comparison, and also the Energizer Lithiums (as tested in 1999) – still the best AA batteries you can buy regardless of cost. A fuller survey of alkalines will be in the next Arrivee.

I've highlighted good results in green, and poor ones in red. The table doesn't tell the whole story of course – for example the Sanyo and Panasonic batteries settled to a voltage just slightly below my 4.8V benchmark but performed very well in every other respect – a graph would have shown them in a better light. I've especially marked good or bad results in the 'worst measured capacity' column – because it is the worst single cell in a set of four that limits the

performance of the set overall.

The **cheapest** set in the test was **Vapex** – £4.25 for four including a useful rigid case – unfortunately they didn't measure well and they were slightly oversize, which prevented them from working at all in the Cateye Micro. Next cheapest were the two **7dayshop** sets, and these tested well. I didn't test any expensive brands – you can spend up to £15 for a set of four NiMHs (**Ansmann** brand) – since the best in test were only just over £5, there didn't seem much point.

My clear best in test were the 7dayshop 2700mAh.



They were a well-matched set, the capacity measured well on my charger, and the run-time tests confirmed the good measurements. As I write, the price (from 7dayshop.com) is £5.39 for four including rigid case. My choice as runner-up is the HFE 2500mAh – these measured and performed well all round, and as it happens this is a set I've used regularly for over two years now, without problems. Currently these are available labelled as 2550mAh, £5.95 inc p&p, from www.batterysave.co.uk

Economy

Value for money – is traditionally the main reason to use rechargeables, and yes they are cost-effective in the long haul but the figures don't actually stack up quite as you'd expect. NiMH cells themselves aren't very expensive any more, but you do have to factor in the cost of a very good charger – without one, you won't get all the performance benefits shown in these graphs. Good chargers can be found for under £15 but I wouldn't hesitate to pay £40 for the best. Cycle life is often quoted as 1000, but realistically its more like 300 even with the best care, and battery care is not something most people are good at. In practice most people will never even approach this figure – the cells will get damaged, or newer higher-capacity ones will be bought to replace them, probably before 50 cycles are up. Also, alkalines can be bought in bulk very cheaply indeed – even in Boots you can buy a bin of 24 AAs for £7.99, go online and you can get 48 for a similar price. So I would say that performance is the compelling reason to use NiMHs, not price.

Sanyo Saga

I borrowed two sets of Sanyo cells from a friend. One set was marked 2500mAh, the other was 2700mAh, otherwise they looked identical. Sanyos have a good reputation in the anorak-clad world of battery freaks, they are known to be the OEM for several other brands, you can spot Sanyo-made cells even if they've been rebadged because they have the letters HR stamped into the metal at the -ve end. The 2500s tested well, similar to other 2500 and 2600 cells I tested. The 2700s were remarkably light in weight, and despite repeated attempts to charge them, could not be made to last more than about 25 minutes. They were, it seems, complete forgeries, probably some old low-capacity NiCad stock with new labels wrapped on – even the HR on the baseplate had been forged to complete the illusion.



| | measured capacity worst | measured capacity best | run time to 4.8V | run time to 4V | run time to 3V |
|-----------------------|-------------------------|------------------------|-------------------------------|----------------|----------------|
| Vanson NiMH 2300mAh | - | - | 1h45 | 2h20 | n/a |
| Uniross NiMH 2300mAh | 1380 | 1750 | 1h40 | 2h40 | n/a |
| Technoline 2300mAh | 2100 | 2420 | 3h00 | 3h40 | n/a |
| 7Day NiMH 2500mAh | 1940 | 2390 | 1h55 | 3h25 | n/a |
| Sanyo 2500mAh | 2430 | 2510 | 0h45 | 4h06 | n/a |
| HFE NiMH 2500mAh | 2420 | 2500 | 2h50 | 4h06 | n/a |
| Hama NiMH 2600 mAh | 2230 | 2370 | 2h45 | 3h52 | n/a |
| Panasonic 2600 mAh | 2390 | 2440 | 0h30 | 4h17 | n/a |
| 7Day NiMH 2700mAh | 2470 | 2520 | 2h42 | 4h25 | n/a |
| Vapex 2700mAh | 2170 | 2550 | *** Cateye test not completed | | |
| Sanyo 2700 | 0323 | 0359 | *** forgeries, useless cells | | |
| Boots Extra Long Life | n/a | n/a | 0h45 | 2h53 | 3h54 |
| Duracell Ultra M3 | n/a | n/a | 0h22 | 3h15 | 4h16 |
| Energizer Lithium | n/a | n/a | 3h12 | 4h05 | 5h00 |

Other mainstream rechargeable chemistries

NiCad still have their place, in some very heavy-duty situations, but don't offer the high capacities of the latest NiMH. Li-ion perform very well but don't like repeated deep discharge – eg, running a

light right down – and have the reputation of a short life, only about two years before serious deterioration sets in, regardless of usage. SLA or gel-cell still have a place on workhorse commuter

bikes, but weight is very much against them. Emerging technologies such as Li-pol and fuel cells are, well, still emerging.

