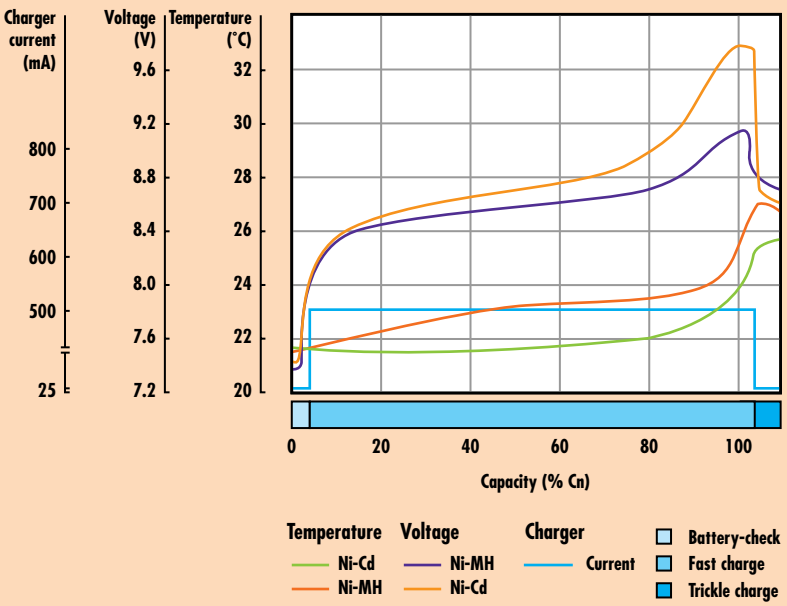
Charging methods

Correct charge and discharge are critical to the cycle life of rechargeable cells and batteries.

Charge for a six-cell battery pack



The typical changes of cell voltage, temperature and internal pressure during a charge performed at a constant current are given in this diagram.

Key parameters

There are key differences in behavior between the two battery technologies under charging. The following parameters must be taken into consideration in charger design:

• Internal pressure
Internal pressure is very low during the greater part of the charge and rises at the approach of full charge, when much of the charging energy is applied to producing oxygen. The pressure rises, and comes to equilibrium when the rate at which oxygen is produced and consumed is the same.

• Temperature
During charging, nickel-metal hydride cells release heat, unlike nickel-cadmium cells, which absorb it, their temperature remaining nearly constant during most of the charging period.

When the fully-charged state is reached and overcharge begins, the heat generated by the recombination reaction causes a rise in temperature, which if not controlled can adversely affect battery cycle life.

In addition, external conditions such as strong sunlight can increase the overall temperature of the battery, which means that fast-charge systems for Ni-MH batteries require time-out and thermal protection to avoid exceeding the battery's inherent temperature limit.

• Voltage
The voltage rises as the positive plate approaches full charge. Then, as the temperature rises during overcharge, voltage decreases. The voltage at end-of-charge is a function of rate of charge and cell temperature. This characteristic is used for controlling rapid charge.

Battery charging rates

Portable batteries can be charged at different rates. The application determines the time of charge and the complexity of the charger. The standard rate of charge for most cycling applications is between C/10 and C/20. With the vastly increased use of portable appliances, there is demand for chargers to provide much faster charging rates up to 4C (i.e., 15 minute ultra-fast charge). Whatever the rate, it is vital to design chargers to ensure secure operation without overcharging.

▼ Permanent charge

When the charge is continuously maintained, regardless of state of charge, the recommended charging rate is from C/20 to C/15.

▼ Standard charge*

The standard charge is 16 hours. Recommended rate is C/10, which may be applied to all sealed cells and batteries at temperatures between 0°C and +50°C, whatever the initial state of charge.

▼ Quick charge*

Applies only to cells designated as "quick chargeable" and at temperatures in the +5°C to +50°C range. Charge 4-5 hours at C/3 or 7-8 hours at C/5, depending on cell type. Appropriate cut-off method (timer or more sophisticated) is required.

▼ Fast charge*

Fast charge takes from 1 hour to 2 hours. This kind of charge is applicable only to cells designated as rechargeable at such a rate. One or preferably more than one control circuit to terminate the fast charge is necessary. The most suitable cut-off techniques are based on voltage or temperature detection.

* Trickle charge

Following standard and quick chargers, a "trickle charge", a continuous charge at a low rate (C/40 to C/20), is recommended in order to compensate for self-discharge, maintain the battery in a fully-charged state, and balance the cells. For fast and ultra-fast chargers, a trickle charge is mandatory.

Recommended cut-off methods:

Charge data

Charge time	Temperature range	VR/VE/VRE	VSE	VT	VH (b)	GB/HB	HP (b)
Permanent	See data sheet	Yes	Yes	Yes	Acceptable (c)	Yes	Acceptable (c)
Standard 16h	0°C to +50°C	Time	Time	Timer	Timer	Timer	Timer
Quick 7-8h	+5°C to +50°C	Timer	Timer (8 hours)	Timer (8 hours)	Timer		Timer (8 hours)
Quick 4-5h	+5°C to +50°C	Timer or dT / dt	Timer	dT / dt	-ΔV		-ΔV
	+5°C to +35°C	-ΔV or PKV	-ΔV or PKV				
Fast 1 to 2h (a)	+10°C to +40°C +10°C to +50°C	-ΔV or PKV dT / dt	-ΔV or PKV dT / dt		-ΔV dT / dt, PKV		-ΔV dT / dt

(a) If C > 4.5 Ah limited 2h
(b) Maximum recommended temperature limited at: +40°C, -ΔV recommended (-5 mV maximum per cell)
(c) With limited performances