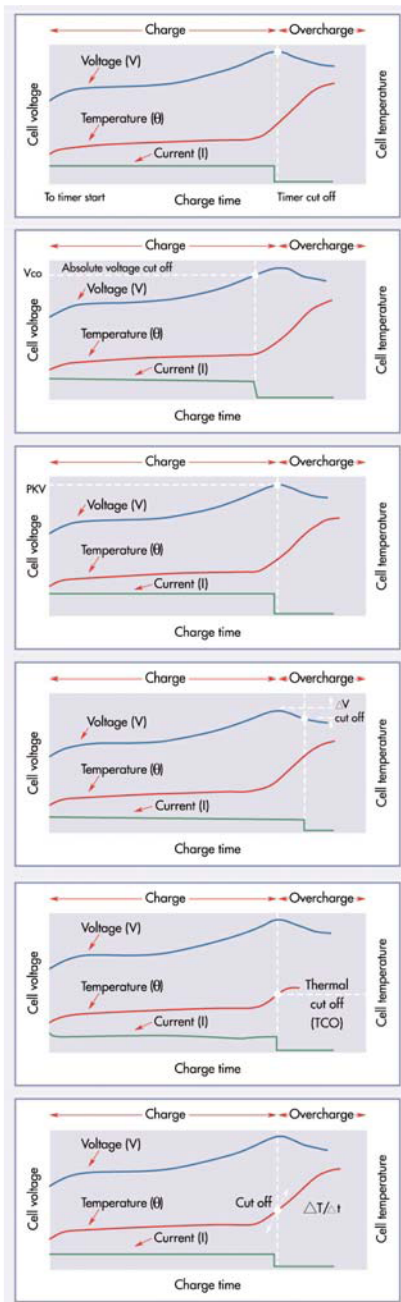


# Ni-Cd cut-off methods

The three main parameters to be controlled during the charge of, alkaline batteries are: temperature, voltage or time. The charge cut-off methods are based on the parameter changes.



- **Time cut-off techniques**

- **Control by timer**

For moderate charge rates (not higher than C/5 in general), a timer can be used to cut off the charge, or to reduce the charge current to the trickle charge. It can be used also as a back-up method associated to the main one.

- **Voltage cut-off techniques**

- **Cut-off based on voltage detection**

- **Absolute voltage detection:**

The detection level is difficult to manage due to charge voltage fluctuations related to current, temperature, electrode technologies, storage or cell ageing. This method is used only as an additional criteria to avoid hydrogen generation during charge at low temperature (below 0°C).

- **Peak voltage detection (PKV):**

The charge is stopped when the voltage reaches its highest point by detecting a singular point related to the variation of derivated value.

- **Detection of negative variation of battery voltage (-V)**

A constant current charge is stopped when the voltage curve inverts, giving a - 10 mV voltage drop for Ni-Cd, and a - 5 mV voltage drop for Ni-MH batteries.

- **Temperature cut-off techniques**

- **Cut-off based on temperature detection**

- **Absolute temperature detection (TCO):**

The charge is stopped when the battery reaches a predetermined temperature which is usually set at +45°C. However, this method is not very accurate as it may result in an insufficient charge or an excessive overcharging, according to high or low temperature respectively. TCO is more generally used as an additional back-up method.

- **Detection of positive variation of temperature (ΔT/Δt):**

The charge is stopped when the variation of temperature over time reaches a predetermined value (in general 0.5 to 1°C/minute) depending on the battery's thermal characteristics and design.

Charge time	Temperature range	VR/VE/VRE	VSE	VT
<b>Permanent</b>	See data sheet	Yes	Yes	Yes
<b>Standard 16 h</b>	0°C to + 50°C	Time	Timer	Timer
<b>Quick 7-8 h</b>	+5°C to +50°C	Timer	Timer (8 hours)	Timer (8 hours)
<b>Quick 4-5 h</b>	+5°C to +50°C	Timer or $\Delta\theta / dt$	Timer	
	+5°C to +35°C	- $\Delta V$ or PKV	- $\Delta V$ or PKV	
<b>Fast 1 to 2 h (a)</b>	+10°C to +40°C	- $\Delta V$ or PKV	- $\Delta V$ or PKV	
	+10°C to +50°C	$\Delta\theta / \Delta t$	$\Delta\theta / \Delta t$	

(a) If C > 4.5 Ah limited 2 h and maximum charging current 4.5 A