# Powering of Portable Products

## Integrating batteries into the design process

By Charles L. Snyder, Gates Energy Products, Inc.

Remember when "portable" TVs had to be plugged into the wall? So did portable drills, mixers, and vacuums. Now consumers increasingly expect their appliances, tools, and audio/video electronics to go everywhere they do. This revolution in portability extends to industrial products as well. Whether it is a dry-wall installer using a screwdriver to mount gypsum board, an engineer entering data in the field with his lap-top computer, or a paramedic using a defibrillator at the scene of a heart attack, portability is becoming a necessity rather than a luxury.

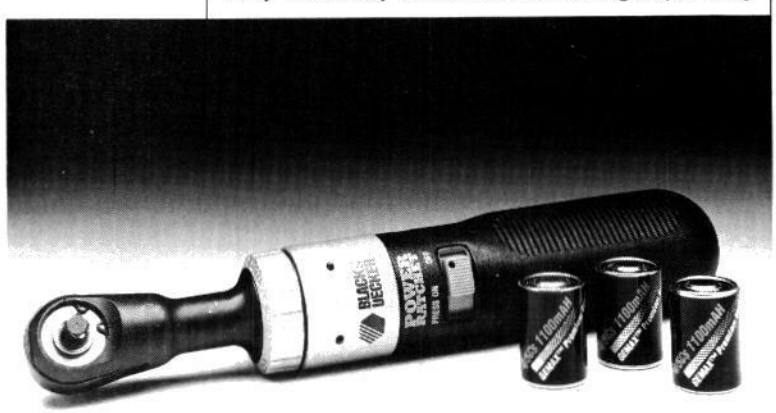
The boom in portable products, both consumer and industrial, has occurred because the old performance or cost penalties associated with portability have diminished or disappeared. Today's portable products represent convergence of two continuing trends: Improved energy efficiency within the end-product and increased battery performance. The result has been portables that run longer, weigh less and do more.

This means that the product designer who wants to capitalize on the competitive advantages that portability offers must understand how to apply both today's energy-efficient technologies and the new improvements in batteries. Here are some hints on integrating batteries into the design process for portable products.

Batteries fall into two groups; primary and secondary batteries. Primary batteries are the nonrechargeables that are the mainstay of the consumer business. But the cost of replacing primary batteries in repetitive heavy drain rate applications becomes prohibitive.

Secondary batteries are rechargeable batteries that can be charged and discharged many times with little or no drop in performance. While many forms of rechargeable batteries are available, only two, sealed nickel-cadmium and sealed-lead, are of major interest to the designer interested in portability. It is the recent improvements in secondary battery technology, especially sealed nickel-cadmium cells, that have created most of the opportunities for new portable products.

Designers using a rechargeable battery in their products typically first assure themselves that the battery will meet their performance requirements. Only when they are satisfied in this regard, do they worry about charging the battery. Then they move on to other concerns such as battery life, packaging and mounting requirements, and storage.



**4/5C cell designed for Black & Decker Power Ratchet. Photo Gates Energy Products**

On the performance side, the designer usually needs answers to some combination of these three questions–

How much current can I obtain from the battery?
How long will I be able to obtain this current?
At what voltage will this current be delivered?

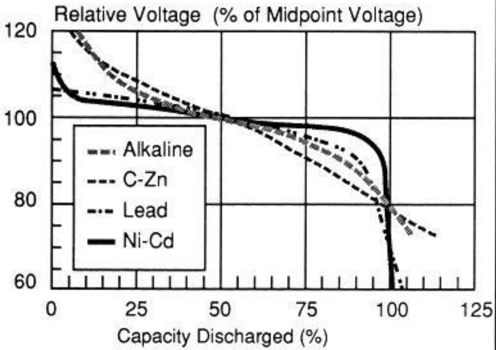
The product of current and time is capacity, normally measured in ampere-hours. This is the principal parameter used to rate or compare batteries. Capacity is essentially a function of size; the more active material in the battery, the more capacity that is available. Both sealed nickel-cadmium and sealed-lead batteries come in an extensive range of sizes allowing designers to select the capacity best suited to the product.

Choosing the battery size appropriate to a portable application involves tradeoffs. A bigger battery is more expensive, heavier and takes up more space. Conversely a larger battery may be able to supply more current and/or last longer.

The speed at which the capacity is removed also affects the amount of capacity available. Higher current discharges for a given cell size make less-efficient use of the cell's active materials resulting in a lower useful capacity. This may be a special concern for certain motor-driven portable appliances where higher currents are required.

Designers are concerned about the voltage at which the capacity will be supplied. The basic voltage available from a cell is fixed by its chemistry. Nickel-cadmium cells nominally provide 1.2 volts while lead-acid cells provide 2.0 volts. Batteries supplying multiples of the cell voltage can be created by connecting cells in series.

**Typical Voltage Drop During Discharge (Nominal Slow Discharges)**




## TAILORED CHARGING

All batteries decline in voltage as they discharge. In some, the drop is pronounced over the entire discharge. In other systems such as sealed nickel-cadmium, there is an initial voltage drop, then a long 'plateau' with minimal change in voltage through most of the discharge until a precipitous drop occurs at the end of the discharge. For most portable applications, the flat voltage profile provides better system performance.

Charging is the source of most battery problems. In charging a battery, more is generally better than less. Far more battery applications have had problems because they did not charge the battery sufficiently than have had problems attributable to overcharging. However, prolonged periods of charging at high rates once the battery is charged may have adverse effects on both battery behavior and life.

Charging needs to be tailored to the duty cycle of the battery. For most portable uses such as appliances or tools, the battery is used frequently and the charger has to restore the battery to service quickly. This goal can be met by either constant-current or constant-voltage charging.

## CONSTANT-CURRENT CHARGE

Constant-current charging is the preferred approach with sealed nickel-cadmium batteries. Two forms of constant-current chargers are in use: uniform and stepped. Uniform chargers supply the same current at all times, whether the battery is totally discharged or in overcharge after being fulli recharged. Stepped chargers use control circuitry to apply a high rate of charge initially and then drop down to a trickle charge when the battery has reached full charge. Modern sealed nickel-cadmium batteries are much better able to tolerate extended overcharge so that uniform chargers are finding greater application. Most uniform chargers used with standard sealed nickel-cadmium cells are designed to return charge to a fully discharged battery overnight. Uniform chargers can also be used with specially designed cells to return charge in about four hours. Faster recharge of sealed nickel-cadmium cells requires both specially designed cells and a stepped charger. With this combination, exceptionally fast recharges can be obtained with full charge being returned in as little as one hour.

## CONSTANT-VOLTAGE CHARGE

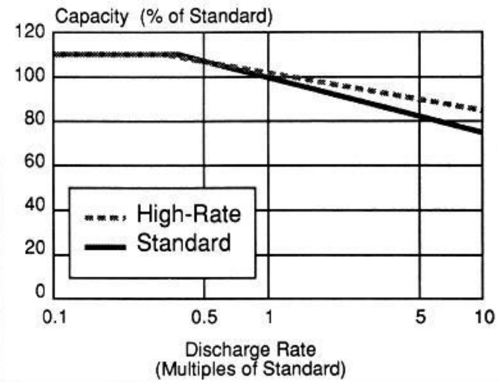
Constant-potential charging is generally used to charge sealed-lead batteries although stepped constant-current charging may be used with good effect. For portable applications, the charge voltage to be used in a constant-voltage charger must be selected to return the battery to service quickly after use.

## LOSS-OF-CHARGE

Charged batteries spontaneously lose some of their charge in a process called self-discharge. Because this process is slow, it rarely poses much of a problem with the end-product in use. Storage concerns are most pronounced in products with long distribution pipelines before the products are placed in service. Understanding the storage needs of a product is important because it may influence choice of a battery type. Sealed nickel-cadmium and sealed-lead have very different storage behavior.

Sealed nickel-cadmium batteries self-discharge relatively rapidly until the have no functional capacity remaining, but they may remain at that level for protracted periods of time. Sealed-lead batteries lose charge much more slowly than sealed nickel-cadmium, but can be damaged if left to

**Effect of Discharge Rate on Capacity**



self-discharge past the point of zero capacity for extended periods. Even with this limitation, acceptable storage periods for sealed-lead batteries are measured in years at room temperature.

Thus, requirements for long storage prior to use may favour sealed nickel-cadmium batteries while requirements for retention of some residual capacity after shorter storage periods may tilt the scale to sealed-lead batteries.

Storage time for either product is dramatically affected by temperature since self-discharge is a temperature-dependent reaction. Successful long-term storage of either battery type also requires that the batteries be stored in the open-circuit condition.

The only precaution necessary in packaging sealed batteries is to ensure that they are not mounted in a totally sealed container. In the event of a charger failure, even sealed batteries can emit sufficient quantities of hydrogen and oxygen to cause an explosion if the gases are not allowed to dissipate.

## IN GENERAL...

- Since sealed nickel-cadmium batteries have higher energy/densities, they are often chosen in portable applications where space or weight are critical.
- The fast charge capabilities and good cycle life of the sealed nickel-cadmium battery tend to reinforce its selection for tools and appliances.
- Sealed-lead batteries are often selected for applications where initial operational capability is a major consideration.
- Sealed nickel-cadmium batteries are often found in applications where performance demands are greatest and sealed-lead batteries are often used in products where the economic considerations and good performance are both major considerations.

Even these guidelines are by no means sacrosanct, many of the performance characteristics of sealed nickel-cadmium and sealed-lead are close enough that their uses often overlap. CEE