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# Guide to Maintaining Nickel-cadmium and Lithium-ion Batteries







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# Contents

Safety information . . . . .	1
Using the batteries . . . . .	1
Charging the batteries . . . . .	1
Non-rechargeable alkaline batteries . . . . .	1
Rechargeable alkaline batteries . . . . .	1
Disposing of the batteries. . . . .	2
Overview . . . . .	3
Battery basics . . . . .	4
Types of batteries . . . . .	4
Non-rechargeable alkaline batteries vs. nickel-cadmium/lithium-ion batteries . . . . .	4
Nickel-cadmium batteries vs. lithium-ion batteries . . . . .	5
Common terms . . . . .	5
Factors that can shorten battery life. . . . .	6
Temperature extremes . . . . .	7
Charging too quickly . . . . .	7
Unnecessary conditioning (nickel-cadmium batteries only) . . . . .	7
Short circuits. . . . .	8
Shelf life . . . . .	8
Charging the batteries. . . . .	9
General guidelines . . . . .	9
Routine charging . . . . .	9
When should routine charging be done? . . . . .	10
How long should the batteries be charged? . . . . .	10
Smart charging . . . . .	10
Fast charging. . . . .	11
Voltage detection (nickel-cadmium batteries only) . . . . .	11

Current detection (lithium-ion batteries only)	11
Conditioning (nickel-cadmium batteries only)	11
<b>Maintaining the batteries</b> . . . . .	<b>12</b>
Regular use . . . . .	12
Storing the batteries. . . . .	12
Nickel-cadmium batteries . . . . .	12
Lithium-ion batteries . . . . .	13
Transporting the batteries . . . . .	14
<b>Index</b> . . . . .	<b>15</b>

# Safety information 1

## Using the batteries

Follow these guidelines when handling nickel-cadmium or lithium-ion batteries:

- Do not expose the batteries to water, metal objects, direct sunlight, extreme heat, or fire.
- Do not attempt to disassemble the batteries.
- Do not handle a damaged or leaking battery.
- Treat batteries as live cells at all times.

## Charging the batteries

### Non-rechargeable alkaline batteries

Some Symbol products can be used with non-rechargeable alkaline batteries. Do not accidentally attempt to recharge non-rechargeable alkaline batteries. Doing so can cause the batteries to burst and damage your PTC or accessory.

### Rechargeable alkaline batteries

Rechargeable alkaline batteries may be used in some Symbol products. However, these batteries should be recharged using a charger recommended by the battery manufacturer.

## Disposing of the batteries

Nickel-cadmium and lithium-ion batteries contain chemically active materials that are hazardous to the environment; therefore, they must be disposed of properly. Never attempt to incinerate a nickel-cadmium or lithium-ion battery; doing so could cause it to explode. Symbol urges you to contact the Environmental Protection Agency, the Department of Natural Resources, a local hazardous waste disposal agency, or the Symbol Support Center at 1-800-653-5350 for assistance prior to disposing of your nickel-cadmium or lithium-ion batteries.

Because nickel-cadmium batteries may still have a significant charge, tape the terminals prior to disposal to prevent short circuits.

Although Symbol lithium-ion battery packs contain a protection circuit to prevent short circuits, lithium-ion battery pack terminals should also be taped prior to disposal. This is necessary because lithium-ion cells contain a flammable electrolyte solution that can be ignited by a spark if the solution is ever allowed to escape.



# Overview 2

Nickel-cadmium batteries and lithium-ion batteries are widely used in the portable electronics industry. They are found in common house-hold appliances such as electric razors, can openers, fire alarms, and a variety of power tools. Symbol uses nickel-cadmium or lithium-ion batteries in virtually all of its Portable Tele-Transaction Computers (PTCs). Both types of batteries are popular because they are rechargeable. With the proper care, the useful life of a nickel-cadmium or lithium-ion battery will greatly exceed that of a non-rechargeable alkaline battery.

The information presented in this manual can help you get the best possible service out of your nickel-cadmium or lithium-ion batteries. Topics discussed include

- safety information,
- battery types,
- extending battery life,
- charging the batteries, and
- maintaining the batteries.

Each topic is generic in nature and can be applied to any nickel-cadmium or lithium-ion battery.

# Battery basics 3

## Types of batteries

In today's world, many types of batteries perform a wide range of functions. *Physical* batteries, such as solar and thermal, are used to store energy from the sun and other heat sources. *Chemical* batteries, which are classified as either non-rechargeable or rechargeable, convert the energy released during chemical reactions into electrical current. Alkaline batteries, which are available as either rechargeable or non-rechargeable, are common in transistor radios, calculators, wristwatches, and many small electronic devices. Other rechargeable batteries include lead-acid, nickel-cadmium, and lithium-ion. Lead-acid batteries are used in automobiles. They are continuously recharged as you operate your car. Nickel-cadmium and lithium-ion batteries are very popular in the portable electronics industry, and one or the other can be used in virtually every Symbol PTC.

### Non-rechargeable alkaline batteries vs. nickel-cadmium/lithium-ion batteries

Nickel-cadmium and lithium-ion batteries have several advantages over non-rechargeable alkalines. The most obvious advantage is that nickel-cadmium and lithium-ion batteries can be used and recharged a number of times, allowing them to last much longer than non-rechargeable batteries. While in use, a nickel-cadmium or lithium-ion battery provides nearly constant discharge voltage though an alkaline's voltage continually decreases as the battery discharges.

Because of their sealed construction, nickel-cadmium and lithium-ion batteries will not leak or corrode under normal usage. In fact, other than routine

recharging, the advanced design of the rechargeable batteries used in Symbol products makes them completely maintenance free.

### Nickel-cadmium batteries vs. lithium-ion batteries

The advantage of lithium-ion batteries (over nickel-cadmium batteries) is their increased capacity in comparable weight and volume.

Lithium-ion batteries also differ from nickel-cadmium batteries in the following ways:

- Lithium-ion batteries do not suffer from memory effect and, therefore, do not need to be cycled or conditioned.
- While nickel-cadmium batteries can be stored for long periods of time without any deterioration in performance, lithium-ion batteries cannot be stored indefinitely. A lithium-ion battery pack's cells may fail if the pack is not kept routinely charged.

## Common terms

**Capacity** - The capacity, or rated capacity, of a battery is a measure of the available energy the battery is designed to provide when fully charged and in good working order.

**Cycle** (nickel-cadmium batteries only) - A nickel-cadmium battery is "cycled" when it is discharged, either fully or partially, and then completely recharged. Thus, one cycle consists of one discharge/charge event.

**Cycle charging** (nickel-cadmium batteries only) - Cycle charging is a type of charging in which nickel-cadmium batteries are forcibly cycled one time (i.e., a full discharge coupled with a complete recharge). Cycle chargers normally perform this operation automatically without any operator initiation.

**Conditioning** (nickel-cadmium batteries only) - Conditioning is a type of charging in which nickel-cadmium batteries are forcibly cycled three times. For most Symbol battery chargers, special steps must be taken to initiate conditioning.

**Service life** - The useful service life of a nickel-cadmium battery ends when the battery can no longer provide 80% of its rated capacity after being fully recharged or the cell fails. (Generally nickel-cadmium cells fail before reaching 80% capacity.) For example, if a nickel-cadmium battery can be cycled 600 times before it can no longer provide 80% of rated capacity, it has a service life of 600 cycles. A typical nickel-cadmium battery can be cycled approximately 500 to 1000 times before it will reach the end of its service life.

Similarly, lithium-ion batteries typically have a service life of 500 recharges, but the service life can be extended with more degradation in rated capacity.

Nickel-cadmium and lithium-ion batteries eventually wear out; they cannot be used forever.

Nickel-cadmium

batteries can undergo a finite number of cycles and lithium-ion batteries can be recharged a set number of times before they must be replaced.

**Memory effect** (nickel-cadmium batteries only) - This adverse condition occurs when nickel-cadmium batteries are only partially discharged before recharging. To prevent memory effect, users should occasionally (every 30 charge cycles) fully discharge the batteries before charging.

## Factors that can shorten battery life

The following factors can shorten the service life of a nickel-cadmium or lithium-ion battery.

### **Temperature extremes**

The temperature of the environment in which you use your nickel-cadmium or lithium-ion batteries will have the greatest impact on the service life of the batteries. Both types of batteries will last longer if they are operated and recharged at room temperature (70 degrees F/21 degrees C). Although you may not always be able to operate your batteries at room temperature, every attempt should be made to recharge them at room temperature. If the batteries are not operated at room temperature, allow them to reach this temperature before recharging.

### **Charging too quickly**

All battery chargers are not alike. Different chargers supply different amounts of current to a battery during recharging. To eliminate the risk of damage to your batteries, use only the Symbol battery charger designed for use with your batteries. See the user's guide for your Symbol product for recommended battery chargers.

### **Unnecessary conditioning (nickel-cadmium batteries only)**

Conditioning reduces the service life of a nickel-cadmium battery by three cycles each time it is performed. Therefore, conditioning should be done only when a battery is not providing its rated capacity after being fully recharged. Nickel-cadmium batteries do not need to be routinely reconditioned. The easiest way to avoid unnecessary or accidental conditioning is to use only a recommended Symbol battery charger with your nickel-cadmium batteries. If the batteries are routinely fully discharged, conditioning is not required.

### Short circuits

**CAUTION!** Take care to never short out any cells or battery packs.

A protection circuit within lithium-ion battery packs is designed to prevent the packs from experiencing short circuits. Recharge the batteries periodically using only the Symbol battery charger recommended for use with your batteries.

**Note:** If a lithium-ion battery pack is accidentally shorted out, the pack must be recharged in order for the protection circuit to be reset.

### Shelf life

A rechargeable alkaline or nickel-cadmium battery is deemed unfit for use if the age of the battery exceeds three years.

Lithium-ion batteries should be charged at least every six months.

# Charging the batteries 4

## General guidelines

When charging nickel-cadmium or lithium-ion batteries, follow these basic guidelines.

- When possible, allow the batteries to reach room temperature (70 degrees F/21 degrees C) before recharging. Avoid recharging in temperatures less than 40 degrees F (4 degrees C) or greater than 90 degrees F (32 degrees C). Recharging in cold temperatures will require more time or may not work at all.
- Recharge the batteries in an environment free of dust, dirt, and high humidity.
- Use only the Symbol battery charger designed for use with your particular batteries.
- Because recharging nickel-cadmium batteries produces heat, recharge these batteries in an open area.

## Routine charging

Routine charging is normally performed at the end of each day. Depending on the type of application you are running, you may have to recharge your batteries more or less frequently.

For a routine charge, simply attach a charge-only charger to your PTC and then plug it into a standard electrical outlet providing 110 volts AC in the U.S. and Canada. (**Note:** To charge the PTC's batteries outside of the U.S. or Canada, you need a charger designed for the country's AC voltage supply; for example, 220 volts). A charge-only charger has no means of determining when the batteries are fully charged. The batteries are charged at a predetermined rate until the charger is disconnected from the electrical outlet.

## When should routine charging be done?

Many factors influence the length of time a PTC can be operated before its batteries need to be recharged. Applications that require radio transmission of data can result in a shorter battery support time. Less demanding applications will lead to a significantly longer support time. To maximize the cycle life of nickel-cadmium batteries, you should try to fully utilize the capacity of the batteries before recharging them. Lithium-ion batteries, on the other hand, do not need to be discharged before being recharged. In fact, the service life of lithium-ion batteries can be extended by not fully utilizing their capacity prior to recharging.

Also, try to avoid prolonged charging for periods greater than 30 days. (**Note:** This guideline does not apply when using a smart charger as batteries can be left in a smart charger indefinitely.)

All Symbol PTCs provide a warning when the battery voltage is becoming low. This warning is normally indicated by a Low Battery LED and several short beeps. When the warning occurs, turn off the PTC and begin recharging the batteries. If you need to continue using the PTC, use a second set of batteries while the first set is being recharged.

**Note:** Some PTCs can be operated while their batteries are being recharged. Refer to your PTC's user's guide to determine if this applies to your unit.

## How long should the batteries be charged?

The amount of time required for recharging can vary. Please consult the user's guide for your PTC or accessory to obtain the proper recharge time.

## Smart charging

Smart chargers are available with new Symbol products. They offer several options not available with charge-only chargers.



**Note:** Consult the user's guide for your PTC or accessory to determine the type of charger with which it can be used.

### Fast charging

Smart chargers can fully charge a nickel-cadmium or lithium-ion battery pack in as little as 1.5 hours. Symbol battery packs are designed to allow this type of rapid charge without any adverse effects that would occur in older generation battery designs.

### Voltage detection (nickel-cadmium batteries only)

By monitoring battery voltage or temperature (Symbol uses voltage), smart chargers are able to detect when a nickel-cadmium battery is fully charged. They are then able to stop the fast charging process, thereby preventing overcharging, which can reduce battery life.

### Current detection (lithium-ion batteries only)

Smart battery chargers monitor battery current in order to determine when a lithium-ion battery pack has reached a full charge. When the battery current falls below 50 mA, the battery pack is fully charged. **Note:** Non-smart chargers determine a full charge using only time information.

### Conditioning (nickel-cadmium batteries only)

Conditioning is a type of charging in which a nickel-cadmium battery pack is completely discharged and fully recharged three times. This type of charging can recondition battery packs that are not holding a full charge but not battery packs that have reached the end of their service life. If a battery pack does not hold a full charge after being cycled, it is faulty and must be replaced.

Consult the user's guide for the recommended battery charger for more information.

# Maintaining the batteries 5

## Regular use

The nickel-cadmium and lithium-ion batteries used in Symbol products are designed to give you dependable, trouble-free service, provided you follow the guidelines below.

- Operate and recharge your batteries at or as near to room temperature (70 degrees F/21 degrees C) as possible.
- Do not charge batteries in areas where the temperature can go below 40 degrees F (4 degrees C) or above 90 degrees F (32 degrees C), such as garages and loading docks.
- Ensure that nickel-cadmium batteries left on a prolonged charge do not experience high temperatures.
- Use only the Symbol battery charger that is designed for use with your batteries.

Many applications require that batteries be operated at a temperature other than room temperature. This requirement will have a negligible impact on battery service life as long as the temperature is not extreme. Symbol does recommend, however, that the batteries be recharged at room temperature.

## Storing the batteries

### Nickel-cadmium batteries

Nickel-cadmium batteries can be stored for approximately three years without deterioration. Even if no capacity remains after prolonged storage, the batteries can be returned to full capacity with a maximum of three charge/discharge cycles.

If you plan to store nickel-cadmium batteries for more than three months, first completely discharge them. Your PTC will indicate when the batteries are low. Any remaining capacity will be dissipated through a gradual process known as *self-discharge*.

Store your batteries in a cool, dry place where the temperature will not be less than 32 degrees F (0 degrees C) or greater than 95 degrees F (35 degrees C).

Completely recharge your nickel-cadmium batteries after removing them from storage. Conditioning or cycle charging is not necessary. If the batteries are not defective, full capacity will return after a maximum of three charge/discharge cycles.

### Lithium-ion batteries

Lithium-ion batteries cannot be stored indefinitely as they will self discharge and eventually become inoperable. To prevent this, Symbol recommends recharging the batteries at least every six months.

Store your lithium-ion batteries in a cool, dry, well ventilated, and weatherproof location where the temperature is between 50 and 77 degrees F (10 to 25 degrees C). Avoid long-term storage of your batteries in temperatures above 104 degrees F (40 degrees C) or in environments with a relative humidity over 95% or below 40%.

Although the storage life of lithium-ion batteries is optimal at room temperature, storage is improved at lower temperatures (in cold rooms between 14 and 50 degrees F/-10 to 10 degrees C or in freezer environments below 14 degrees F/-10 degrees C), providing special precautions are taken. The batteries must be enclosed in special protective packing, such as sealed plastic bags, which should also be used to protect them from condensation during warm up to ambient temperature. Accelerated warming is harmful. Once the batteries return to ambient temperature, recharge them completely.

## Transporting the batteries

Symbol's nickel-cadmium and lithium-ion batteries are classed as "batteries, dry" under U.S. Department of Transport and Transport Canada rules and, therefore, are exempt from any special transportation requirements.

# Index

## A

Alkaline batteries, 4  
  charging, 1  
  compared to  
  nickel-cadmium/  
  lithium-ion batteries, 4-5

## C

Capacity, 5  
Chemical batteries, 4  
Conditioning, 6, 11  
Cycle, 5  
Cycle charging, 5

## F

Fast charging, 11

## L

Lead-acid batteries, 4  
Lithium-ion batteries  
  charging guidelines, 9  
  compared to alkalines, 4-5  
  compared to  
  nickel-cadmium  
  batteries, 5  
  disposing of, 2  
  maintaining, 12-14  
  routine charging, 9-10  
  service life, 6  
  storing, 13  
  transporting, 14

## M

Memory effect, 6

## N

Nickel-cadmium batteries  
  charging guidelines, 9  
  compared to alkalines, 4-5  
  compared to lithium-ion  
  batteries, 5  
  disposing of, 2  
  maintaining, 12-14  
  routine charging, 9-10  
  service life, 6  
  storing, 12-13  
  transporting, 14

## O

Overview, 3

## P

Physical batteries, 4  
PTC, 3

## R

Routine charging, 9-10  
  how long, 10  
  how often, 10

## S

- Safety information, 1-2
  - charging the batteries, 1
  - disposing of the batteries, 2
  - using the batteries, 1
- Service life, 6
  - charging too quickly, 7
  - shelf life, 8
  - short circuits, 8
  - shortened, 6-8
  - temperature extremes, 7
  - unnecessary conditioning, 7
- Smart charging, 10-11
- Storing lithium-ion batteries, 13
- Storing nickel-cadmium batteries, 12-13

## T

- Terms, 5-6
- Transporting the batteries, 14
- Types of batteries, 4-5





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