M/A-COM NiCd and NiMH Battery User's Guide

Introduction

This document provides information on the care and use of rechargeable battery packs for M/A-COM portable land mobile radios. Typically, M/A-COM portable radios use either high-capacity Nickel-Cadmium (NiCd) batteries or extra high-capacity Nickel Metal Hydride (NiMH) batteries. These battery packs are constructed from top quality materials to ensure high performance and a long life. Their best performance and useful life can be improved through proper care and maintenance, as explained in this document.

New Battery Packs

M/A-COM stores and ships battery packs in an uncharged state, so packs must be conditioned before use. Conditioning enables a battery to reach its full performance capability. This process involves fully charging and fully discharging the battery using either a battery analyzer/conditioner (recommended) or through normal use (not recommended).

Conditioning is most easily accomplished by using a battery conditioner/analyzer/charger such as the Cadex® C7400 or the Intelligent Technologies iTECH® iQ$^{five®}$. These units condition a battery pack by automatically charging and discharging (cycling) it 3 or more times. The units can also be used to test and charge battery packs. Refer to the manufacturer's technical data for instructions on using the conditioner/analyzer/charger and any required accessories.

Conditioning through normal use, that is charging the battery pack and using the radio until the battery pack is drained and then repeating the charge-discharge cycle, may require 25 to 50 full charge-discharge cycles to obtain optimal battery performance. This method, although optional for NiCd battery packs, is not recommended for NiMH battery packs. Failure to properly condition NiMH battery packs will result in initial short shift-life performance of the radio.

Charging Battery Packs

M/A-COM chargers are rapid chargers specifically designed for nickel-based battery packs. Rapid charging is a two-step process: rapid charge and trickle charge. During the rapid charge phase, the charger quickly replenishes about 90 to 92% of the battery's capacity. The charger then switches to the trickle charge mode to slowly fill the remaining capacity of the battery without causing excessive heat generation. This process enables the charger to recharge a NiCd battery pack in 1 to 2 hours and a NiMH battery pack in 1.5 to 2.5 hours.

When a battery pack is first placed in the charger, the charger checks the condition of the battery pack (as indicated by the red LED flashing). During this period, the charger is checking the temperature and voltage of the battery. By monitoring these parameters, the charger ensures that the battery pack is ready for charging. Batteries that are too cold or too hot will not charge properly, therefore the charger will not enter the rapid charge mode until the battery temperature is within the acceptable limits, usually between 32 to 113°F (0 to 45°C).

Next, the charger measures the voltage of the battery pack. If the voltage is below the rechargeable level (about 6 Volts), a trickle charge is applied to the battery to raise its voltage to an acceptable level. This may take a while if the battery pack is severely drained. When the

charger determines that the battery pack is ready, it begins the rapid charge. When the rapid charge phase is complete, about 90% of the capacity of the battery pack has been replenished, the charger switches to the trickle charge mode (green LED illuminates). The remaining 10% is restored using the trickle charge.

Charging Guidelines

Observe the following guidelines when charging a battery pack:

- Avoid high temperatures during charging, particularly when using vehicular chargers, where it is easy to exceed temperature limits due to the wide range of outdoor environments. M/A-COM chargers prevent charging when temperatures exceed cell manufacturer's recommendations. This is indicated by a flashing LED (the actual LED that flashes depends on the charger model being used. Refer to the charger's user manual for specifics).
- Battery packs normally become warm during charging. M/A-COM chargers continually monitor battery temperature and discontinue charging if temperature limits are exceeded.
- Only charge NiCd or NiMH battery packs using a rapid charger designed for this purpose. M/A-COM desk and multi-chargers differentiate between NiCd or NiMH battery packs and automatically adjust charging parameters.
- Do not leave batteries in the charger indefinitely. For best results leave the battery in the charger for 2 to 6 hours after the ready light (green LED) comes on. Then, place the battery pack in service and fully discharge it (as indicated by the radio "Low Batt" warning) before recharging.
- If any faults are encountered while charging the battery pack, consult the manual for the charger to determine the cause and possible corrective action.

Battery Pack Usage

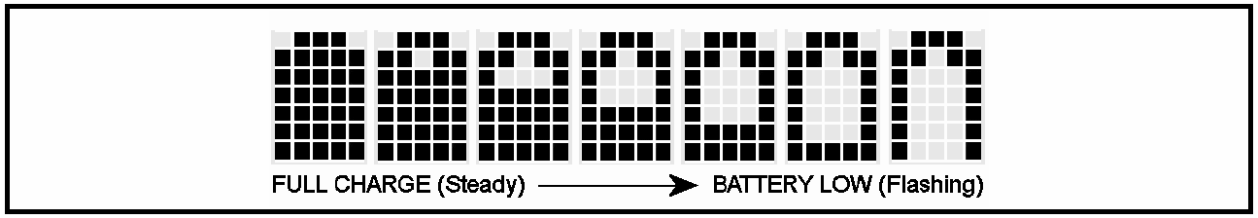
The runtime available for NiCd or NiMH battery packs can be influenced by many factors, the most important of which are duty cycle and battery capacity. Most two-way radio battery shift-life specifications assume a 5%-5%-90% duty cycle. This is further specified as transmitting for 3 seconds, receiving for 3 seconds, and sitting idle for 54 seconds. Adding extra receive time (actively receiving a signal) or transmit time changes the duty cycle and can reduce the runtime of the battery pack. Transmitting is especially taxing on the battery.

Battery capacity is affected by battery chemistry, battery age, and charging. NiMH batteries have a larger capacity and will have a longer shift life than NiCd battery packs. However, a NiCd battery pack has a longer life cycle; that is, with proper charging and battery cycling, a NiCd battery pack will allow more charge/discharge cycles than a NiMH battery pack operating under the same conditions.

Battery Fuel Gauge

Many M/A-COM radios use the battery pack voltage level to estimate remaining battery life. The radio software uses the voltage information to drive a visual display or "fuel gauge" that indicates the amount of charge remaining. However, due to the voltage discharge characteristics of NiCd and NiMH battery cells, the fuel gauge is only able to provide an

estimate of charge level remaining. Additionally, fuel gauge readings may prove inaccurate if the battery has not been properly conditioned, is being used at extreme temperatures, or is worn out.



Generally, the user should only view the fuel gauge as a relative indicator. The type of fuel gauge display depends on the radio. The image above is an example of the fuel gauge for the M/A-COM P7100^{IP} portable radio. The icon indicates the relative charge remaining in the battery. As the battery voltage decreases, so does the icon's indicated level. When the battery charge reaches the critical level, the radio will initiate the low-battery warning (flashing battery icon and audible alarm). At this time, the battery must be recharged.

Usage Guidelines

The following guidelines will increase the battery runtime or shift life:

- Ensure that the battery pack is fully discharged (as indicated by the radio "Low Batt" warning) before recharging.
- Condition battery packs in accordance with Table 1.
- Do not leave NiCd or NiMH batteries in a charger for more than a few days.
- Avoid storing batteries in hot environments (above 86°F (30°C)) – even for short periods.

Because of chemistry limitations, batteries removed from the charger immediately after the ready light (green LED) comes on will only perform to about 90% of capacity. To take advantage of its full potential, the battery must be allowed to trickle charge for 2 to 3 hours. Also, as a battery ages, its available capacity decreases. Older battery packs will not run as long as newer units. This is also true of battery packs that have been damaged by high-temperature exposure.

Servicing Battery Packs

To ensure that battery packs are readily available for radio operators (i.e., the user has a fully charged, long-running battery pack at the beginning of the work shift), M/A-COM recommends setting up a battery service program. The type of service program depends on the number of battery packs available and the importance of maintaining full-shift life. Either of the following methods may be used to keep a fleet of batteries in good condition. However, M/A-COM strongly recommends using the second method.

The first and simplest method is to ensure that all battery packs are fully discharged before starting the recharging cycle. Each day the battery pack should be discharged until the low-battery warning occurs. The battery pack can then be placed in the charger and will be available for use after recharging (about 2 hours). This method ensures that the battery pack is

kept in good running condition. Do not attempt to charge partially discharged battery packs; this will reduce the capacity of the battery pack.

The second method involves actively monitoring battery usage and periodically reconditioning the battery pack. The key to this method is maintaining accurate battery service records. Based on common usage patterns as described in Table 1, the service technician is able to monitor the performance of a battery pack and periodically recondition it. This practice alleviates some of the problems associated with reduced capacity resulting from partial discharge and enables the service technician to identify and dispose of any battery packs that are performing poorly. This method ensures that all battery packs available for use are healthy and capable.

Table 1 – Battery Pack Usage Patterns

Pattern	Description	Example	Need to Recondition
A	Battery is taken out of the charger, used for 8 to 12 hours (low-battery warning), and then recharged.	A police officer that carries the radio all day.	Annually, to track capacity
B	Battery is charged, used for over 8 hours, recharged, and then immediately used for the next shift.	A manufacturing plant that has three shifts a day.	Semiannually
C*	Battery is fully charged, used for 4 hours or less, and returned to the charger.	An administrator. May apply to a user that has two batteries.	Monthly
D*	Battery and radio reside in the desktop charger. Radio is turned ON waiting for a call.	Fireman or EMS	Monthly
E	Battery and radio are used with a vehicular charger.	Vehicle patrol officer	Monthly
F	Batteries are stored for more than 2 weeks at room temperature.		After 1 month of storage
G	Batteries are stored for more than 2 weeks at elevated temperatures (Around 30°C)		After 2 weeks of storage

*These patterns are the most demanding on a battery pack and may require more frequent conditioning.

Record Keeping Example

The most comprehensive method for tracking a fleet of battery packs is to assign an identification number to each battery pack, periodically check the condition of the packs, and record the data for each battery using a card file system or an electronic database. This process enables the service technician to easily identify individual battery packs that do not meet performance expectations.

To begin, individually number and mark all battery packs in the fleet (most M/A-COM battery packs are labeled with the part number and a unique bar coded serial number). Condition the battery pack using a conditioning charger and record the capacity of the battery. Next, based on the usage information in Table 1, determine when the battery pack will be due for reconditioning; this is the service due date. Mark the service due date on the battery pack using either an alphanumeric label or color-coded sticker. Finally, record the battery pack identification number, date conditioned, capacity, and service due date. The battery pack can now be placed in service.

When a battery pack reaches its service due date; remove the battery pack from service, recondition it, and record its capacity. If the capacity is unacceptable or the battery pack fails, properly dispose of the battery pack and replaced it with a new, conditioned battery pack. Battery packs that have an acceptable capacity can be relabeled and re-released into service. If a user complains about a battery pack loosing its capacity before its scheduled service due date, test and recondition the battery pack and either return it to service or replace it.

STORING BATTERY PACKS

If a battery pack is expected to be idle for a month or more, it should be properly prepared. Battery packs should not be stored fully charged. Before storing the battery pack, discharge it to its end-of-life voltage (about 6 Volts). If the battery is not discharged prior to storage, its overall capacity may be reduced. Although all battery packs experience some capacity loss during storage, the shelf life for NiMH battery packs is about 3 years and for NiCd battery packs about 5 years. However, note that any capacity drop which occurs during storage is permanent and cannot be reversed.

Storage Guidelines

While capacity loss cannot be totally prevented, the following guidelines will reduce the effect during storage:

- Keep battery packs in a cool, dry storage area (32 to 86°F (0 to 30°C)). Refrigeration is recommended, but freezers should be avoided. When refrigerated, the battery pack should be placed in a plastic bag to protect against condensation.
- Do not store charged battery packs. Ensure that the battery has been discharged.
- Never leave a nickel-based battery sitting in a charger for more than a few days.
- Recondition the battery pack before returning it to service.

DISCARDING BATTERIES:

All rechargeable batteries have a limited useful lifetime. After this, they must be properly disposed of. When a battery pack fails or is no longer able to retain an acceptable shift life, it should be replaced. For most users, the unacceptable level falls within 60 to 80% of the capacity provided by new batteries. The determination of the useful life of a battery should be based on the application.

NiCd batteries that fail to meet service requirements should be recycled. Disposal of NiCd batteries in the municipal waste system is prohibited by most state and municipality laws. Check with local solid waste officials for details concerning recycling options and proper disposal. In the United States, call toll free **1-800-8-BATTERY** for information and procedures for properly disposing of rechargeable batteries. Information regarding local NiCd drop-off locations may also be found on the Rechargeable Battery Recycling Corporation web site (http://www.rbrc.com).

Currently there are no specific disposal requirements for NiMH batteries in the U.S. However, the Rechargeable Battery Recycling Corporation web site may be able to offer alternate disposal recommendations.

For other countries, the rules for disposal of battery packs may vary from U.S. regulations. Please consult your local regulatory agency for proper disposal methods.