



**Operating and Component Maintenance Manual
For
Marathon Micro Maintenance (M³)
Nickel-Cadmium Aircraft Batteries**

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MARATHONNORCO AEROSPACE, INC.

OPERATING AND MAINTENANCE MANUAL

MARATHON MICRO MAINTENANCE (M³)

NICKEL-CADMIUM AIRCRAFT BATTERIES

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INTRODUCTION

This Micro Maintenance manual contains shop verified instructions for proper installation, operation and maintenance of MarathonNorco's Micro Maintenance Nickel-Cadmium batteries. These instructions are grouped in topics shown in the Table of Contents. They are for the operation, testing, and repair of MarathonNorco's Micro Maintenance battery products.

This manual is designed to service the Micro Maintenance batteries based on the cell type within the battery. Listings of the IPL's or Illustrated Parts Lists of the batteries covered by this manual are listed on page INTRO-4. This listing identifies the applicable cell type used within the battery to establish the servicing criteria listed in the various tables and charts within this manual. All IPL's listed herein are not included as part of this manual but can be requested in electronic format as a released document from MNAI by their applicable IPL number.

WARNING: SERIOUS INJURY CAN RESULT FROM CARELESSNESS WHILE HANDLING AND WORKING WITH NICKEL-CADMIUM BATTERIES. PLEASE OBSERVE THE FOLLOWING SAFETY RULES WHILE WORKING WITH THESE BATTERIES.

1. Remove all metal articles such as bracelets and rings.
2. Metal tools must be insulated.
3. Wear protective clothing and eye protection. The electrolyte can cause burns if in contact with skin or eyes.
4. Do not smoke or hold naked flames near batteries on charge. These batteries give off a mixture of oxygen and hydrogen during charge, which, if allowed to accumulate in a confined space, could cause an explosion. Do not charge the battery on the bench with the cover on.
5. Do not mix lead-acid and nickel-cadmium battery servicing in the same shop area.
6. Do not use petroleum spirits, trichloroethylene or other solvents.

READ AND UNDERSTAND THE CAUTIONS AND WARNINGS STATED THROUGHOUT THIS MANUAL BEFORE PROCEEDING WITH SERVICING PROCEDURES.

CARELESSNESS MAY RESULT IN THE RAPID AND UNCONTROLLED RELEASE OF ELECTRICAL, CHEMICAL OR HEAT ENERGY.



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DEFINITIONS OF COMMONLY USED BATTERY TERMS

Ampere Hours

A unit of electrical measurement used to describe the capacity of a cell or battery. The product of discharge current (in amperes) X the time of discharge (in hours). It is also used to describe the amount of electrical energy put back into a battery during the charging process. Abbreviated as Ah or Amp. hrs.

Capacity

A measure of the stored electrical energy that is available from a charged battery. Generally expressed in Ampere Hours, or as a % of the nominal (nameplate) capacity

Constant Current Charging

A method used to charge a battery in which a predetermined, fixed current is passed through it.

Constant Potential Charging (Constant Voltage)

This refers to a method in which a fixed voltage source is applied across the battery terminals. The charge current is variable and depends primarily upon the difference in voltage between the voltage source and that of the battery. The initial charge current is high and decreases as the battery accepts the charge and its voltage increases.

Trickle Charge

A continuous constant current, low-rate charge (slightly more than the self-discharge rate) suitable to maintain a battery in a fully charged condition.

Rated or Nominal Capacity

The nominal nameplate capacity rating of a nickel-cadmium battery generally refers to the number of Ampere-hours that the battery can deliver when discharged at the 1-hour rate to 1.0 volt per cell.

“C” Rate

That discharge rate, in nominal or nameplate amperes, at which a battery or cell will yield its capacity to a 1.0 volt per cell endpoint in one hour. Fractions or multiples of the C rates are also used. C/5 refers to the rate at which a battery will discharge its capacity in 5 hours. 2C is twice the C rate or that rate at which a battery will discharge its capacity in about 1/2 hour. Example: a 25

ampere-hour battery will have a C rate of 25 amperes, a C/5 rate of 5 amperes and a 2C rate of 50 amperes. This rating system helps to compare the performance of different sizes of cells and batteries.

State of Charge

The amount of stored energy (capacity) available in a rechargeable battery. Usually expressed as a percentage of its full capacity.

Electrolyte

The conductive medium that provides for the movement of ions (current flow) between the positive and negative plates of a cell; an alkaline solution of Potassium Hydroxide in nickel-cadmium aircraft cells.

End-of-Charge Voltage

The voltage of a battery at the conclusion of a charge measured while the battery is still on charge.

Fading

The loss of capacity that occurs when a battery is cycled with minimal overcharge. A correctable condition through re-conditioning

Separator

A material that is used to prevent the metallic contact between the positive and negative plates.

Gas Barrier

A membrane in the separator system that prohibits the recombination of oxygen (produced at the positive plate) on negative plate.

Nominal Voltage (Name Plate)

The voltage of a fully charged cell or battery while delivering current. The nominal voltage of a nickel-cadmium battery cell is 1.2 volts, therefore a 20-cell battery would have a nominal voltage of 24 volts, and a 19 cell is 22.8 volts. (Note: Older batteries use a different convention for nominal voltage).

Open Circuit Voltage

The voltage of a battery at rest, that is, with no charge or discharge current flowing.



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Micro Maintenance Cells

A vented nickel-cadmium cell whose plate technology results in a very low water consumption and long cycle life.

Deep Discharge (Cycle)

A discharge in which most or all of the available capacity is withdrawn from a battery and the cells are brought individually to a zero volt condition.

Reconditioning

A procedure consisting of a deep discharge and a constant current charge that is used to correct cell imbalance that may occur during continual cyclic use of a rechargeable battery.

Shorting Clip

A short length of wire (with or without a low value resistor) or a metal spring, used to "short" a cell to zero volts.



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MarathonNorco Micro Maintenance Aircraft Batteries

Battery Type	Cell Type	P/N	I.P.L. #		Battery Type	Cell Type	P/N	I.P.L. #
20-60M ³ X100	60M ³ X100	33006-001	1032		M ³ -44-9	44M ³ 120	32848-001	1016
7-75M ³ 120	75M ³ 120	32364-001	--		M ³ -44-12	44M ³ 120	32874-001	--
BTM3-179	17M ³ 100	33166-001	1043		M ³ -44-15	44M ³ 120	32890-001	1022
M ³ -17-2	17M ³ 100	32855-001	1002		M ³ -44-21	44M ³ 120	33008-001	--
M ³ -17-3	17M ³ 100	32871-001	--		M ³ -44-22	44M ³ 120	33204-001	1049
M ³ -1700L	17M ³ 100	32749-001	--		M ³ -44-24	44M ³ 120	33250-001	1050
M ³ -170AL	17M ³ 100	32752-001	--		M ³ -44-25	44M ³ 120	33275-001	1053
M ³ -1709L	17M ³ 100	33238-001	--		M ³ -44-26	44M ³ 120	32848-002	--
M ³ -1755	17M ³ 100	32761-001	--		M ³ -44-27	44M ³ 120	33204-002	1054
M ³ -1753	17M ³ 100	32766-001	--		M ³ -460L-1	44M ³ 120	31006-004	1041
M ³ -1760L-1	17M ³ 100	31918-003	1040		M ³ -460L-1A	44M ³ 120	31006-006	1038
M ³ X-23-1	23 M ³ X100	32955-002	1033		M ³ -460L-2	44M ³ 120	31006-005	1032
M ³ -25-1 MOD A	25M ³ 120	33082-001	1030		M ³ -54-1	54M ³ 120	32536-001	1028
M ³ -25-1	25M ³ 120	33082-002	1047		M ³ -54-2	54M ³ 120	33033-001	1029
M ³ -28-1	25M ³ 120	33206-001	1048		M ³ X-54-1	54M ³ X120	33183-001	1045
M ³ X-28-1	28M ³ X100	33103-001	--					
M ³ X-33-1	28M ³ X100	33181-001	1044		M81757/15-1	25M ³ 120	32744-001	--
M ³ X-33-2	28M ³ X100	33181-002	1055		M81757/15-2	25M ³ 120	32775-001	--
M ³ X-33-4	28M ³ X100	33181-004	1058		M81757/15-3	25M ³ 120	32764-001	--
M ³ -44-1	44M ³ 120	32663-001	1011		M81757/15-5	25M ³ 120	33261-001	--
TM ³ -44-4	44M ³ 120ST	32794-001	1013		M81757/16-1	44M ³ 120	32477-001	--
M ³ -44-7	44M ³ 120	32824-001	1031		M81757/18-1	60M ³ 120	33152-001	--
M ³ -44-8	44M ³ 120	32845-001	1015					



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DESCRIPTION AND OPERATION

General

The Micro Maintenance nickel-cadmium battery cell is an electrochemical system in which the active materials contained in the plates undergo changes in oxidation state with very little change in electrolyte concentration due to the production or consumption of water. These active materials are virtually insoluble in the alkaline (potassium hydroxide) electrolyte in any oxidation state. As a result the electrodes are very long-lived.

Some of the electrochemical mechanisms involved in the charge, discharge, and storage of the nickel-cadmium battery cell are rather complex. This is especially true of the positive plate. A brief simplified account of the essential reactions is offered in order to help initiate the reader into the theory and principles of this system and thus further the understanding of the operation of the battery and the role played by its main components.

GENERAL NICKEL-CADMIUM EQUATION,

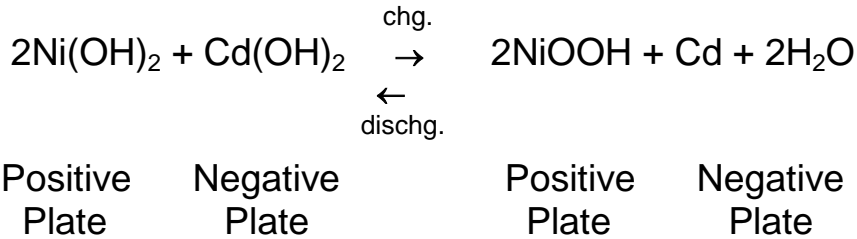
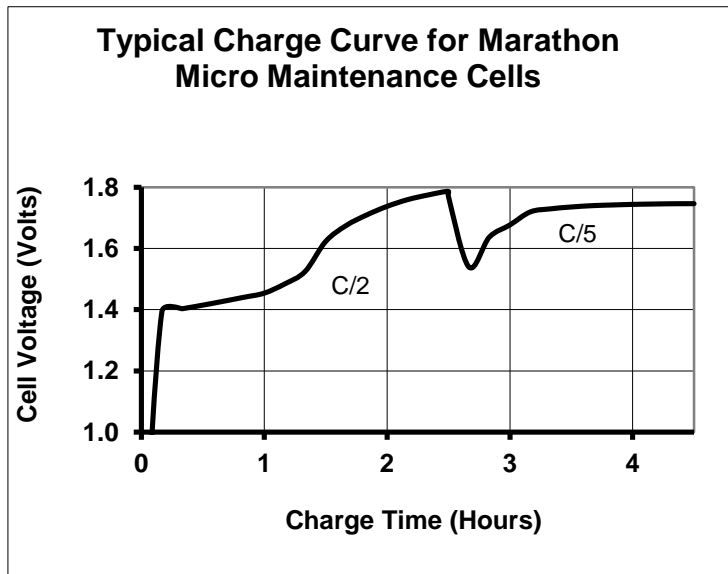


FIGURE 1





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Charge

Charging results in the conversion of electrical energy to stored chemical energy. The active materials, in a discharged condition, are cadmium hydroxide in the negative plates and nickel hydroxide in the positive plates. With the application of a charging current, these active materials undergo a chemical change. The negative material (cadmium hydroxide) gradually gains electrons and is converted to metallic cadmium (Cd); the positive material is gradually brought to a higher state of oxidation (loses electrons). As long as the charging current continues to flow through the battery, these changes will take place until the active materials in both electrodes are completely converted, at which point, overcharge commences.

Toward the end of the process (as the materials approach a full charge condition), and during overcharge, gas will be evolved and released through the cell vent. This gas results from the electrolysis of the water component of the electrolyte. The gas evolved at the negative plates is hydrogen and at the positive plates is oxygen. The amount of gas evolved depends upon the charge rate during the period in which the cells are being overcharged. After complete conversion of the active materials has occurred, the further application of charge current will only cause further electrolysis of the water and I^2R heating.

Discharge

Discharging results in the conversion of the chemical energy stored in the cell to electrical energy. During discharge, the chemical reactions which occurred in charging are reversed. The active material (Cd) in the negative plates gradually loses electrons and changes to cadmium hydroxide. The active material in the positive plates gains electrons and changes to nickel hydroxide. No gassing occurs during a normal discharge. The insolubility of the active materials and the fact that the potassium hydroxide does not participate in the cell reaction results in the very flat Ni-Cd discharge voltage curve.

The rate at which the conversions take place is primarily determined by the external resistance (load) introduced into the circuit in which the cell is connected. Due to its construction, the MarathonNorco Micro Maintenance cell has an extremely low internal resistance, and its ability to deliver high currents is due to this factor.



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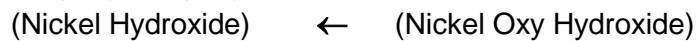
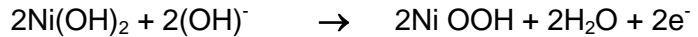
NICKEL-CADMIUM AIRCRAFT BATTERIES

Charge, Discharge and overcharge equations:

Positive plate

Charge →

Discharge ←



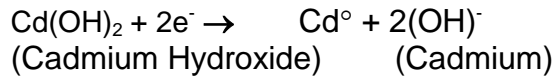
Overcharge



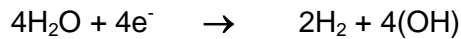
Negative Plate

Charge →

Discharge ←

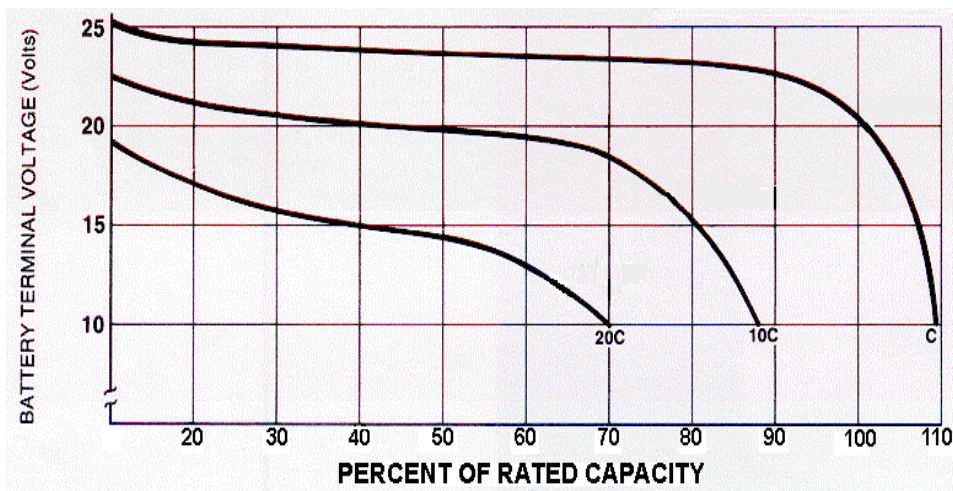


Overcharge



Overcharge (Net Cell Reaction)

$4e^-$



Constant Current Discharge For Typical Battery

Figure 2
TYPICAL CONSTANT CURRENT DISCHARGE CURVES
AT ROOM TEMPERATURE



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Capacity

Capacity is measured quantitatively in ampere-hours delivered at a specified discharge rate to a specified cut-off voltage at room temperature. The cut-off voltage is 1.0 volt per cell times the number of cells in the battery.

Battery available capacity depends upon several factors including such items as:

1. Cell design (cell geometry, plate thickness, hardware, and terminal design govern performance under specific usage conditions of temperature, discharge rate, etc.).
2. Discharge rate (high current rates yield less capacity than low rates).
3. Temperature (capacity and voltage levels decrease as battery temperature moves away from the 60°F (16°C) to 90°F (32°C) range toward the high and low extremes).
4. Charge rate (higher charge rates generally yield greater capacity).



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1.0 INSPECTION

1.1 Delivery Inspection

When the battery is unpacked, a thorough inspection should be made to ensure that no damage occurred during shipment. Inspect the shipping container as well as the battery. Before putting the battery into service, check the following points carefully.

1.1.1 Damage

See if any liquid has spilled into the shipping container. This may be a sign of a damaged cell. Check for dented battery container. **Check for cracked cell cases or covers. Do not place a damaged battery into service. Report any signs of improper handling to the shipping company.**

1.1.2 Shorting straps

Some batteries are shipped without shorting devices across the main power receptacle output terminals. Before subjecting battery to electrical service this device must be removed.

1.1.3 Electrical connections

Test all terminal hardware to ensure tightness. If necessary retorque them to the proper value. Poor electrical contact between mating surfaces may reduce discharge voltage, cause local overheating and damage the battery.

1.14 Liquid level - **Do not add water to a battery except near the end of a constant current charge. Some exceptions may be noted later.**

Additional of water, except at the proper time during the charge will cause spewing of electrolyte to take place during the subsequent charge. MarathonNorco batteries are shipped with the proper amounts of electrolyte. When a battery has been discharged or allowed to stand for a long period of time, the electrolyte becomes absorbed into the plates. Since the battery has been shipped in a discharged condition, the liquid of the cells may appear to be low. Charging the battery will cause the liquid level of the individual cells to rise to the proper operating level. If this does not happen, add sufficient distilled or demineralized water (using the proper syringe and nozzle) to the cells during the last 15 minutes of the topping charge, until the correct liquid level is reached.

BEFORE CHARGING THE BATTERY READ AND BECOME FAMILIAR WITH THE CHARGE PROCEDURE.



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WARNING: THE ELECTROLYTE USED IN NICKEL-CADMIUM BATTERIES IS A STRONG CAUSTIC SOLUTION OF POTASSIUM HYDROXIDE. USE RUBBER GLOVES, AN APRON AND A FACE SHIELD WHEN REPAIRING OR SERVICING THE BATTERY. IF ELECTROLYTE IS SPILLED OR SPRAYED ON CLOTHING OR OTHER MATERIALS, IT SHOULD BE BATHED IMMEDIATELY WITH LARGE QUANTITIES OF WATER AND NEUTRALIZED WITH A WEAK ACID SOLUTION SUCH AS VINEGAR. IF ELECTROLYTE GETS INTO THE EYES, FLUSH COPIOUSLY WITH WATER AND GET MEDICAL ATTENTION IMMEDIATELY.

1.2 INSPECTION IN THE AIRCRAFT

1.2.1 Vent Lines

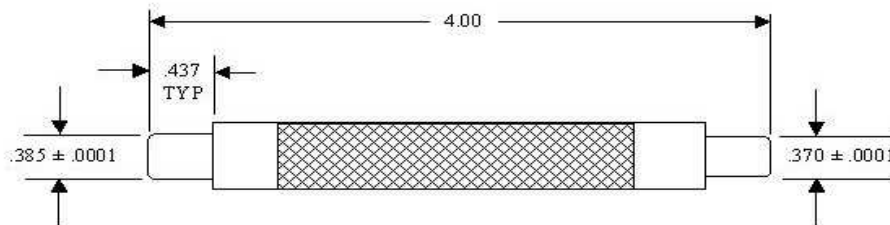
When installing a battery in the aircraft, check the event lines for obstructions, leaks or damage of any kind and repair or replace. Check battery box vents for obstructions or crack and repair.

1.2.1 Battery Disconnect

The following procedure defines an inspection program to field check the aircraft battery quick disconnect.

1.2.2 Equipment Required

Quick disconnect inspection gauge



Inspection Gauge
Figure 8

1.2.3 Procedure

Inspection of Battery Quick Disconnect: Remove all electrical loads from the battery then disengage the battery disconnect from the mating receptacle, and inspect for the following:

- A. Evidence of corrosion or pitting of the power contacts.
- B. Excessive free-play in the handwheel- worm assembly, or broken pins.
- C. Evidence of arcing or burn marks on the power contacts. This is caused when the disconnect is removed under electrical load.
- D. Insert the .385-inch diameter end of the inspection gauge into each power contact to a depth of .437 inches. The fit shall be snug with a force to remove greater than one (1) pound. This is to test the resiliency of the power contact to recover from an oversized pin.
- E. Insert the .370-inch diameter end of the inspection gauge into each power contact to a depth of .437 inches. The fit shall also be snug with a nominal force to remove one (1) pound. This will ensure proper contact to a worn or undersized contact pin.



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F. Replace if required.

1.3 Inspection - Received in for Service

When a Micro Maintenance battery is received in the shop for routine servicing, the following inspections should be performed:

- Visually inspect can and cover for dents, damage, epoxy coating separation, vent tube obstruction, latch function and cover seal condition.
- Remove the battery cover.
- Clean top of cells and connectors with a nylon brush. Blow out residue with oil-free compressed air using standard safety precautions. If cells are exceptionally dirty, connecting links, hardware, and cells may need to be removed, washed in warm water and dried. If this is required, discharge the battery before disassembly.
- Verify that the polarity of the cells and position of the internal connections are correct.
- Inspect intercell connectors for corrosion, burns or discoloration.
- Remove vent plugs and inspect "O" rings and vent sleeves for damage or hardening. Replace if defective. If necessary, wash vent plugs in warm water to remove the white powder (potassium carbonate) from vent holes. Dry with oil-free compressed air using standard safety precautions.

1.3.1 Inspection of Battery Power Connector

- Inspect for corrosion or pitting on the contact pins.
- Inspect for arcing or burn marks on the contact pins. This is caused when the disconnect is removed under electrical load.
- Inspect for battery electrolyte leakage through the receptacle body and/or the contact pins.

NOTE: Electrolyte leakage can be noticed by a discoloration of the receptacle body with the glass fibers exposed.

Gauge each contact pin diameter using dial calipers that are capable of reading to .001 inch.

The diameter shall be $.375 \pm .005$ inches.

Any evidence of the above shall be cause for rework or replacement of the parts.

1.3.2 Inspection of Sensor Receptacle (if so equipped)

Examine sensor connector for pin or locking mechanism damage.

CAUTION: The electrolyte used in the battery is a caustic solution of potassium hydroxide. Avoid contact with any part of the body.



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2.0 ELECTRICAL LEAKAGE

To determine if external leakage is of such a magnitude as to require a complete battery cleaning, set the range selector of a multimeter to the 500 milliampere range or higher.

Place the positive lead of the meter on the positive terminal of the battery receptacle and touch the negative lead of the meter to any exposed metal on the battery can.

NOTE: Many MarathonNorco Micro Maintenance batteries are supplied with epoxy coated battery cans and covers. Where epoxy coated cans are used, current flow may be measured between the battery terminals and the screws that are used to mount the main connector.

If the needle deflection is within the meter limits, connect the negative lead of the meter to the battery can. Now, decrease the meter current range until the current, if any, is readable. Record this current value.

Repeat the above, connecting the negative lead of the meter on the negative terminal of the battery receptacle and the positive meter lead to any exposed metal on the battery can. If either the above current measurement exceeds 50 milliamperes, flush the tops of the cells and dry. (Reference Paragraph 9.0)

Repeat the above current test on the positive and negative terminals. If the tops of the cells were cleaned properly and the current measurement is still greater than 50 milliamperes, one or more of the cells may be leaking. To isolate this cell or cells, proceed as follows:

- Using a voltmeter of 1000 ohms-per-volt, or greater, place one of the meter leads on either the negative or positive terminal of the battery and the other lead on any exposed metal of the battery can; note the meter reading. If the meter reads negative, reverse the positions of the meter leads.
- Keep one-meter lead on the exposed metal surface of the can and move the other lead systematically from one cell terminal to another, noting the voltage readings. Voltage readings will decrease and finally go negative indicating the location of the path and possibly a leaky cell.
- If the cell is leaking, replace the cell or cells. If no leaking cells are found, the leakage path may be due to electrolyte along the outside of the cells and at the bottom of the battery can, and the battery must be discharged, disassembled and cleaned. (Reference Paragraph 9.0 and 11.0)



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3.0 TORQUING REQUIREMENTS

Verify torque on every intercell connection starting with cell 1 (most positive) and working sequentially through the last (most negative) cell. Verify torque on cell connections to main battery connector.

TABLE 1

CELL TYPE	THREAD SIZE	SOCKET HEAD CAP SCREW	HEX NUT ACROSS FLATS	TORQUE (INCH LBS.) TO TIGHTEN
17M ³ 100	#10-32	5/32"		35-50
23M ³ X100	3/8"-16		9/16"	100-113
25M ³ 120	#10-32	5/32"		35-50
28M ³ X100	3/8"-16		9/16"	100-113
44M ³ 120	1/4"-28	3/16"		100-125
44M ³ X120	3/8"-16		9/16"	100-113
54M ³ 120	1/4"-28	3/16"		100-125
60M ³ X120	3/8"-16		9/16"	100-113
75M ³ 120	1/4"-28	3/16"		100-125
60M ³ 120	1/4"-28	3/16"		100-125
54M ³ X120	3/8"-16		9/16"	100-113

- All other hardware should be torqued in accordance with FAA document AC.43.13 (Aircraft Inspection and Repair)
- Torque not applicable for military non-repairable batteries.



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4.0 SENSOR ASSEMBLY INSPECTION

Refer to the applicable battery I.P.L. (Illustrated Parts List) for details.



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5.0 CHARGE

For batteries that are partially discharged, i.e., batteries received in for service, begin with STEP I

For batteries that are completely discharged, i.e., new batteries, or batteries following capacity test, begin with STEP IA.

CELL VENTS SHOULD BE UNLOCKED DURING CHARGE.

STEP I Connect battery to charging source and charge at the main constant current charge rate until all cells are 1.60 volts or better. This usually takes a short period of time.

IF CELL(S) ARE DRY, HIGH CELL VOLTAGE MAY OCCUR (2 VOLTS OR GREATER). FIVE TO TEN CC's OF DISTILLED OR DEMINERALIZED WATER MAY BE ADDED TO EACH CELL.

When all cells are at 1.60 volts minimum, reduce charge current to the topping charge rate and top charge constant current for two (2) hours. Adjust electrolyte during the final 15 minutes of the topping charge in accordance with Paragraph 6.0. Upon completion of the topping charge, while still on charge, all cell voltages must be from 1.60 volts minimum to 1.90 volts maximum.

- If cell voltages are 1.60 volts to 1.90, proceed to Paragraph 7.0.
- If any cell voltage is greater than 1.90 volts, the cell must be replaced, proceed to Paragraph 10.0.
- If any cell voltage rises to >1.75 volts and then decreases below 1.60 volts, the cell must be replaced, proceed to Paragraph 10.0.
- If any cell voltage fails to rise to above 1.60 volts, the cell must be replaced. See Paragraph 10.0



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STEP IA

Connect battery to charging source and charge at the main constant current charge rate (**MINIMUM** of two and one-half (2½) hours) ***and*** until ***all*** cells are 1.60 volts minimum.

IF CELL(S) ARE DRY, HIGH CELL VOLTAGE MAY OCCUR (2 VOLTS OR GREATER). FIVE TO TEN CC's OF DISTILLED OR DEMINERALIZED WATER MAY BE ADDED TO EACH CELL.

After completion of the main constant current charge with all cells at 1.60 volts minimum, reduce charge current to the topping charge rate and top charge for two (2) hours. Adjust electrolyte level during the final 15 minutes of the topping charge in accordance with Paragraph 6.0. Upon completion of the topping charge while still on charge, all cell voltages must be from 1.60 volts minimum to maximum of 1.90 volts.

OR

For charging with a reflex charger, charge per Table 2-B of this document. The reflex mode step is followed by a constant current mode. Adjust the electrolyte level during the final 15 minutes of the constant current topping charge.

- If cell voltages are 1.60 volts to 1.90, proceed to Paragraph 7.0.
- If any cell voltage is greater than 1.90 volts, the cell must be replaced, proceed to Paragraph 10.0.
- If any cell voltage rises to >1.75 volts and then decreases below 1.60 volts, the cell must be replaced, proceed to Paragraph 10.0.
- If any cell voltage fails to rise to above 1.60 volts, the cell must be replaced. See Paragraph 10.0



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TABLE 2-A
Battery Capacity and Constant Current Charge Rates

CELL TYPE	NOMINAL BATTERY CAPACITY (AH)	CONSTANT CURRENT CHARGING		
		Step 1 or 1 A MAIN CHARGE AMPS	TOPPING CHARGE AMPS	TRICKLE CHARGE RATE MILLIAMPS
17M ³ 100	17	9.0	3.6	34
23M ³ X100	23	12.5	5.0	46
25M ³ 120	25	14.0	5.6	50
28M ³ X100	28	15.0	6.0	56
44M ³ 120	44	24.0	9.6	88
44M ³ X120	44	24.0	9.6	88
54M ³ 120	54	30.0	12.0	108
54M ³ X120	54	30.0	12.0	108
60M ³ 120	60	33.0	13.2	120
60M ³ X100	60	33.0	13.2	120
75M ³ 120	75	41.0	16.4	150

TABLE 2-B
Battery Reflex Charge Procedures

Cell Type	Reflex Mode		Constant Current	
	Current (A)	Time (h)	Current (A)	Time (h)
17M ³ 100	34	1.0	3.6	2.0
23M ³ x100	46	1.0	5.0	2.0
25M ³ 120	50	1.0	5.6	2.0
28M ³ X100	56	1.0	6.0	2.0
44M ³ 120	80	1.0	9.6	2.0
44M ³ X120	80	1.0	9.6	2.0
54M ³ 120	80	1.0	12.0	2.0
54M ³ X120	80	1.0	12.0	2.0
60M ³ 120	80	1.0	13.2	2.0
60M ³ X100	80	1.0	13.2	2.0
75M ³ 120	80	1.5	16.4	2.0

For 19-cell Micro Maintenance batteries, set Reflex charger to 20-cell setting.
For 20-cell Micro Maintenance batteries, set Reflex charger to 21-cell setting.



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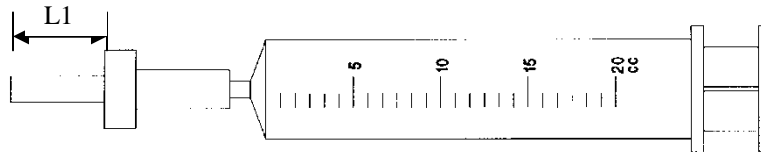
NICKEL-CADMIUM AIRCRAFT BATTERIES

6.0 ELECTROLYTE LEVEL ADJUSTMENT

During the last 15 minutes of the topping charge, and while the current is still flowing, the cells are at their most uniform electrolyte level, and it is at this time that the electrolyte level can be most accurately adjusted.

The electrolyte level should be adjusted using the syringe and appropriate nozzle (available in kit P/N 33178-001).

FIGURE 4



SYRINGE & NOZZLE ASSEMBLY

TABLE 3

SYRINGE P/N	NOZZLE P/N	NOZZLE LENGTH (L1)	NOZZLE COLOR	CELL TYPE
32415-001	32479-001	7/8" (22mm)	Green	23M ³ X100, 25M ³ 120, 28M ³ X100, 44M ³ 120, 44M ³ X120, 60M ³ 120, 75M ³ 120,
	32479-002	1-1/16" (27mm)	White	17M ³ 100, 54M ³ 120, 54M ³ X120, 60M ³ X100

Battery cells with aerobatic vents require special electrolyte adjustment procedures. Contact MarathonNorco for further information.



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6.1 Electrolyte Level Adjustment Procedure

Insert the syringe with the appropriate nozzle into the cell opening until the shoulder of the nozzle rests firmly on the "O" ring seat. Withdraw the plunger and check for any electrolyte in the syringe. If the level is too low the syringe will remain empty. If the level is too high any excess electrolyte will be drawn into the syringe until the level corresponds to the depth of the nozzles insertion into the cell. The depth of the nozzle into the cell is the correct electrolyte level.

If the electrolyte level is too low (the syringe remained empty) draw 10 cc's of distilled or demineralized water into the syringe and inject it into the cell. Withdraw the plunger. If the syringe remains empty continue injecting measured quantities of water into the cell to achieve the correct level.

At the point where some excess electrolyte is drawn into the syringe the correct electrolyte level for that cell has been achieved. Discharge any excess electrolyte

The amount of water required to fill the first cell should serve as an indication of the quantity required to fill the remaining cells. However, the electrolyte level must be independently adjusted in each cell.

Check to see that the quantity of water added per cell does not exceed the maximum allowable for that cell type in Table 4. If the water consumption is too high, the service interval may need to be reduced and/or check the charging system or voltage regulator setting.



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**TABLE 4
MAXIMUM ALLOWABLE WATER
CONSUMPTION**

CELL TYPE	VOLUME (cc)
17M ³ 100	21
23M ³ X100	28
25M ³ 120	29
28M ³ X100	28
44M ³ 120	68
44M ³ X120	68
54M ³ 120	82
54M ³ X100	82
60M ³ 120	142
60M ³ X100	82
75M ³ 120	89

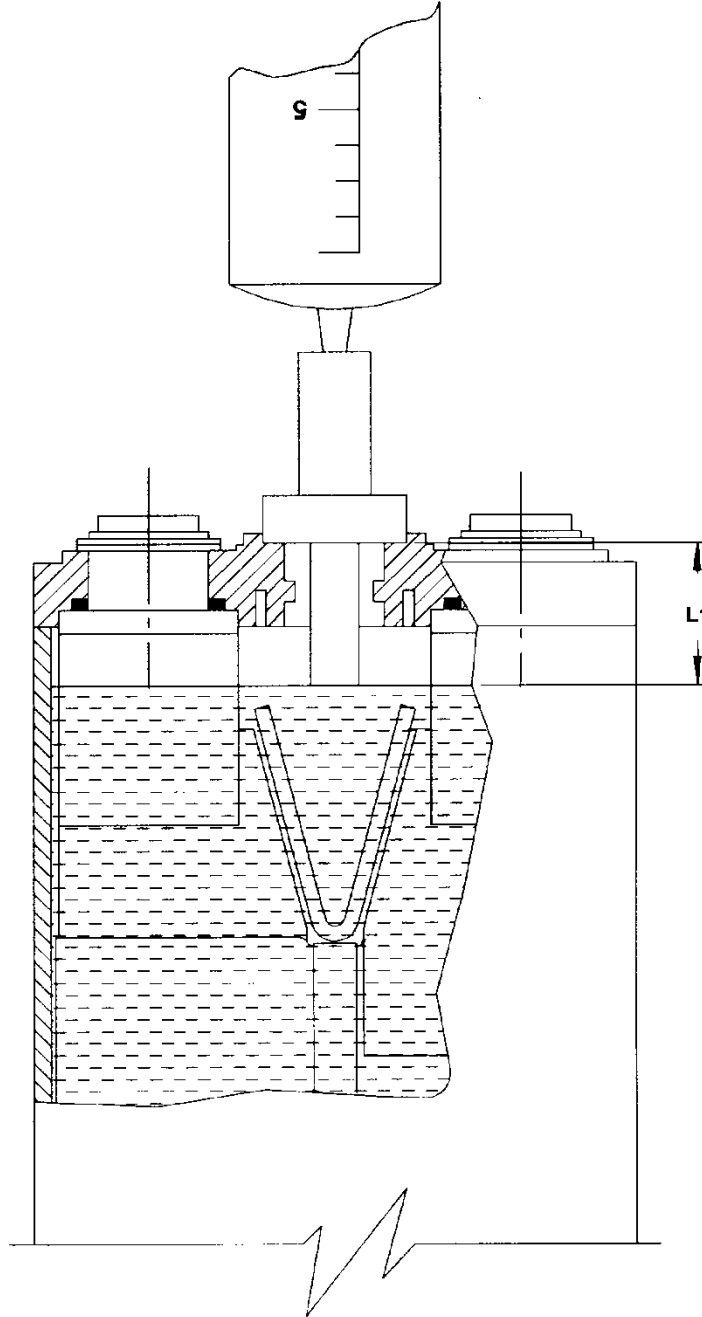


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**Proper Electrolyte Level Adjustment
FIGURE 5**



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7.0 CAPACITY TEST

If following a charge, a noticeable rise in battery temperature has occurred (warm to the hand) allow the battery to cool prior to proceeding with capacity test. When battery is cool proceed with capacity test (measure discharge versus time) using one of the following discharge rates:

- C-rate for 51 minutes - 85% capacity requirement to minimum acceptable end voltage of 1.0 volts per cell for in-service batteries.
- C-rate for 60 minutes minimum for new batteries.

OR

- C/2 rate for 103 minutes - 85% capacity requirements to minimum acceptable end voltage of 1.0 volts per cell for in-service batteries.
- C/2 rate for 120 minutes minimum for new batteries.

7.1 Interpretation of Capacity Test

If no cells have dropped below 1.0 volt before or at the end of the specified time, stop discharge. The battery has successfully completed the capacity test.

If cells have dropped below 1.0 volt before or at the end of the specified capacity test time, do not stop discharge. Battery must be reconditioned (deep cycled) according to Paragraph 8.0.

7.2 Cessna Battery 33206-001 must deliver 67 minutes to 19V at a 25 amp rate for new batteries.



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Table 5

CAPACITY TEST AMPERES		
Cell Type	"C" Rate	C/2 Rate
17M ³ 100	17	8.5
23M ³ X100	23	11.5
25M ³ 120	25	12.5
28M ³ X100	33	16.5
44M ³ 120	44	22.0
44M ³ X120	44	22.0
54M ³ 120	54	27.0
54M ³ X120	54	27.0
60M ³ 120	60	30.0
60M ³ X100	60	30.0
75M ³ 120	75	37.5



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8.0 RECONDITIONING

- 8.1 When reconditioning is required discharge the battery until individual cells reach 0.5 volts or less. Place a short-out clip across each cell once it has reached 0.5 volts or less.

When all cells have a short-out clip attached, turn off discharge unit.

For reconditioning, allow battery to stand in a shorted condition for a minimum of 4 hours, preferably overnight. See 8.2 below.

- 8.2 Remove short-out clips and return to Paragraphs 5.0, Step 1A.
- A severely unbalanced battery may need to be deep cycled as many as three times to restore its capacity.
 - If after three (3) deep cycles some cells still have not had their capacity restored, these cells should be replaced.
 - If twenty-five percent (25%) or more of the cells are found to be defective, either at one time or over a period of time, it is recommended that all cells be replaced.



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9.0 CLEANING

CAUTION: Exercise extreme care when working around the battery. Do not use metal brushes or metal brush supports. Remove rings and other metal jewelry from the hands. Any of these may cause an electrical short which may result in skin burns and damage to the battery.

The battery should be kept in a clean, dry state for optimum performance. The extent of the cleaning process depends upon the condition of the battery. Several procedures are described in the following paragraphs.

If heavy overcharging has occurred, gassing and spewing of electrolyte may cause a white powdery substance, potassium carbonate, to form on top of the cells. This may be removed by brushing the cells with a non-conductive stiff bristle brush or a clean cloth.

If necessary, the tops of the cells may be flushed with ordinary tap water. Make certain that all of the cell vent plugs are properly seated. Tip the battery at about a 45° angle with its receptacle (or power connector) facing upward. Flush with water from the top of the battery in a downward direction so as to prevent, as much as possible, any water from entering the battery can. It is permissible to use a non-conductive bristle brush to clean away stubborn dirt particles. Any excess liquid should be drained off and the battery permitted to dry. Drying may be accelerated by the use of oil-free compressed air.

WARNING: USE OF COMPRESSED AIR FOR CLEANING CAN CREATE AN ENVIRONMENT OF PROPELLED FOREIGN PARTICLES WHICH MAY ENTER THE EYES AND CAUSE SERIOUS INJURY. AIR PRESSURE FOR CLEANING SHALL NOT EXCEED 30 PSI. EFFECTIVE CHIP GUARDING INCLUDING EYE PROTECTION IS REQUIRED.

CAUTION: THE WATER USED TO WASH THE CELLS OR BATTERY WILL BECOME CAUSTIC; AVOID CONTACT WITH IT. DO NOT CLEAN THE TOPS OF THE CELLS WITH SOLVENTS, ACIDS OR ANY CHEMICAL SOLUTION. THESE MAY DAMAGE THE CELL CASE AND HARDWARE.



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If the battery has liquid electrolyte on the top of the cells, drain off as much as possible, wash with water, and air dry. If the electrolyte has overflowed to the extent that it has run down between the cells, the battery should be completely discharged, disassembled, and completely cleaned before reassembling.

1. Disassembly -- Disassemble the battery as described in Paragraph 11.0.
2. With the vent valves in place and locked, wash the cells under running water. Do not allow the wash water to enter the cell's interior.
3. Dry the cells with clean absorbent toweling or with an air hose.
4. Inspect each cell for cracks, holes or other defective condition. If any defects are found; replace with new cells.
5. Wash and clean all hardware to remove accumulated dirt and carbonate deposits. Heavy deposits may be removed by scrubbing with a stiff bristle brush. Corrosion preventive greases may be removed from connectors, screws, nuts, and washers by washing in alcohol or by degreasing after they are removed from the cells.
6. Allow all parts to dry thoroughly before reassembling.
7. Inspect all parts and replace those that are damaged or heavily corroded. Replace connecting straps that are burned, bent or have defective nickel plating. Polish tarnished connecting straps with a fine emery cloth being careful not to remove the plating.
8. Check the battery power receptacle for burns, cracks and bent or pitted terminals. Replace defective receptacles. They can overheat, arc, depress battery voltage and cause premature battery failure.
9. Repair or replace damaged battery cases and covers, loose or damaged cover gaskets and cell hold-down bars.
10. Reassemble battery (Paragraph 11.0)
11. Clean vent caps (vent plugs). Use hot water to thoroughly wash vent assemblies.



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10.0 REPLACEMENT OF CELLS AND BATTERY REPAIR

10.1 Replacement of Damaged or Defective Cells

If a cell becomes contaminated, physically damaged, or is defective and must be replaced, proceed as follows:

1. Discharge the entire battery as per Paragraphs 7.0 / 8.0, remove the shorting clips.
2. Clean the battery (Paragraph 9.0)
3. Remove enough intercell connectors to permit the cell to be withdrawn from the battery can.
4. Do not withdraw a cell from the battery unless a discharged or shorted replacement cell is immediately available.
5. Withdraw the cell, using a cell puller. Always tighten the puller to the cell and pull in a straight-up direction.
6. Insert the new (discharged) cell, making certain to insert the cell with the polarity symbols in the right direction. (Cells are connected plus to minus). If the cell is difficult to insert, apply a light coat of petroleum jelly or silicone grease to the sides of the cell case before inserting.
7. Replace the intercell connectors, assembling the hardware finger tight.

CAUTION:

MarathonNorco battery cells and other components are specifically designed to perform as an integral unit within the battery. Failure to use the proper replacement cells will change the batteries internal resistance and adversely affect the batteries charge and discharge capabilities.

8. Torque the terminal connection to the values indicated in Table 1 using a calibrated torque wrench.
9. Charge the battery in accordance with STEP IA.



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10.2 Replacement of Damaged Power Connectors

In some battery types, the battery is provided with a special quick disconnect receptacle, such as a type manufactured by Elcon or Cannon, or any of a number of MS type receptacles. Should one of these become damaged, it will be necessary to replace it with a replacement part obtained from your local MarathonNorco authorized distributor. Care should be taken in the removal of this connector to preserve all the hardware and gasketing, if possible, so that the new part may be installed properly.

To remove the connector, first remove those connections which go to the end cells in the battery, thus reducing the possibility of a short circuit when the connector body is removed from the battery can. All MarathonNorco batteries have the same hardware arrangement for attaching the power connector to the battery as is used on the intercell connectors. When installing the replacement part, it is necessary to consult Table 1 for the torque values.

CAUTION: Use only cells, intercell connectors, power connectors and all other battery components that are specified on the battery parts list for your battery. Failure to do so will result in imbalances between the cells within the battery and could create a safety of flight issue.



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11.0 BATTERY DISASSEMBLY AND REASSEMBLY

CAUTION: Exercise care when working around the battery. Avoid the use of uninsulated tools - severe arcing may result with possible harm to personnel and damage to the tools and a cell or cells in the battery.

Rings, metal watchbands and identification bracelets should be removed. Avoid contact between intercell connectors of opposite polarity, metal objects may fuse themselves to the connectors and cause severe skin burns. Keep flames away from the battery.

11.1 Battery Disassembly

Before disassembling the battery, make sure that all cells are completely discharged. This may be accomplished as follows:

1. Discharge the battery to approximately 0.5 volts per cell, and attach shorting clips (Refer to Paragraph 7.0 and Paragraph 8.0).
2. After all cells have been discharged, remove the shorting clips. Remove all intercell connecting links. The cells may now be removed. Use a cell puller if necessary. When removing cells from a battery. Always tighten the puller to the cell and use an even, straight-up pull.

11.2 Battery Reassembly

1. Lightly polish the cells' terminal surfaces with fine emery cloth and wipe clean.
2. Reassemble the cells into the battery can. Position the cells correctly with respect to polarity as shown on the illustrated parts list (IPL) applicable to the particular battery being serviced. **DO NOT HAMMER TIGHT CELLS INTO THE BATTERY CAN: USE A STEADY FORCE ON THE TERMINALS TO PRESS THEM INTO PLACE. FOR EASIEST ASSEMBLY, THE CELL AT THE MIDDLE OF A ROW SHOULD BE INSERTED LAST.**
3. Place intercell connectors in their correct position as shown on the Illustrated Parts List (IPL).
4. Install all hardware finger-tight.



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5. Starting at the positive terminal of the battery, tighten each terminal screw to the torque specified in Table 1.

CARE SHOULD BE TAKEN TO INSURE THAT THE TERMINAL SCREW IS NOT BINDING, DUE TO THREAD DAMAGE, OR BOTTOMING, BUT IS ACTUALLY TIGHTENING THE CONNECTOR. IMPROPER TORQUE MAY RESULT IN DAMAGE TO THE BATTERY.

Some batteries contain flat-sided washers as part of the terminal hardware. The flat side serves as a visual indicator during torquing. During initial thread engagement the washer rotates, and upon tightening, rotation stops. This indicates to the operator that the screw is tightened in the terminal and was not binding or bottoming when the proper torque was reached.

It is good practice to follow the battery assembly IPL during final retightening, as this is a good double check of the correct electrical order. Do not skip around over cells; do not leave the job partially completed and come back to it. Finish the complete battery reassembly once it is started. Forgetting where the tightening job was stopped is a good way to miss a screw or nut. One loose connection can permanently damage a battery and may cause an explosion.

CAUTION: Use only cells, intercell connectors, power connectors and all other battery components that are specified on the battery parts list for your battery. Failure to do so will result in imbalances between the cells within the battery and could create a safety of flight issue.

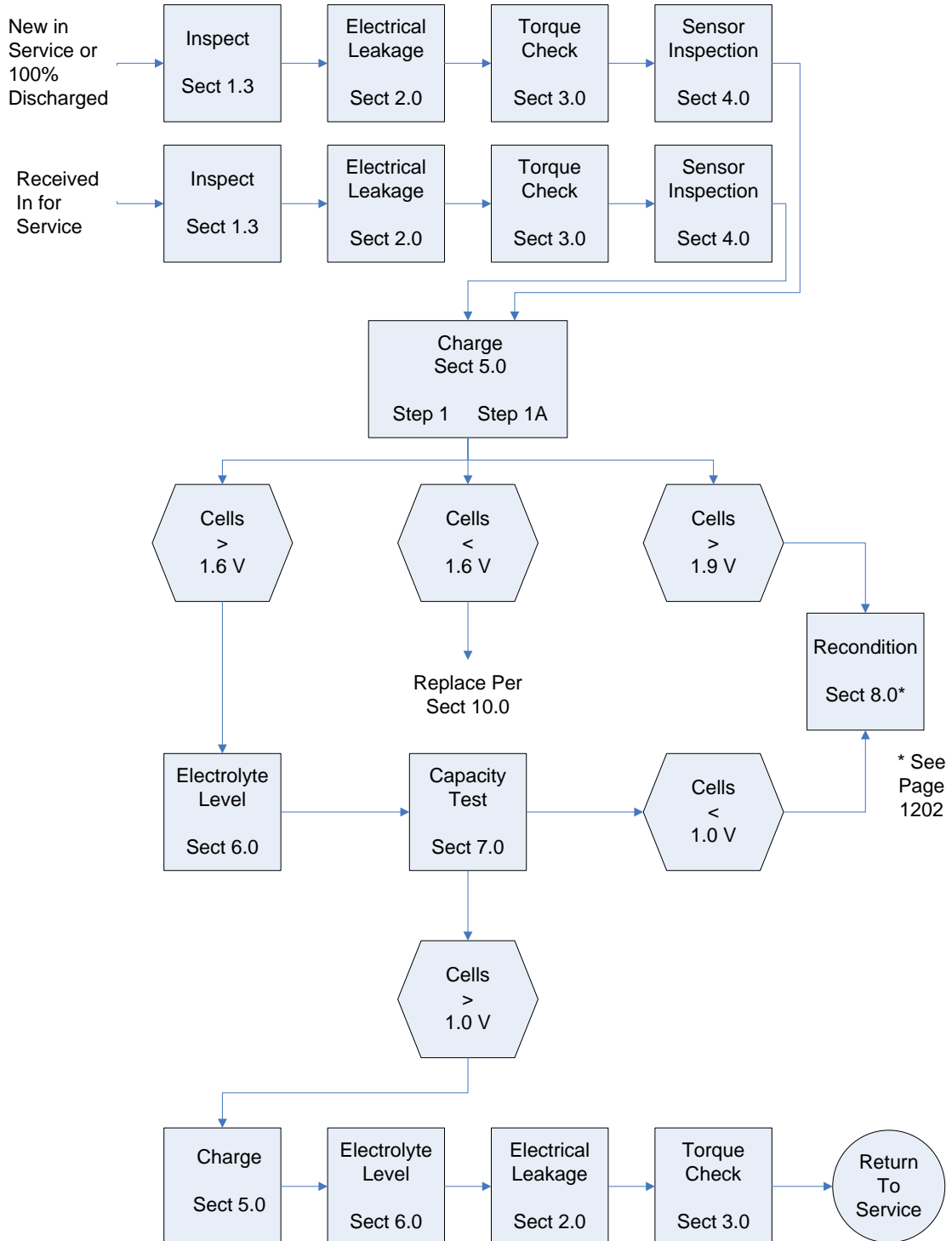
Corrosion Prevention:

MarathonNorco recommends a light spray of "LECTRO-TECH B SUPER-CORR" per Mil-C 87177A, type 1, grade B, as an effective corrosion inhibitor for the battery assembly. The use of this material is optional.



12.0 Battery Maintenance Flow Chart

**FIGURE 6
BATTERY MAINTENANCE FLOW CHART**





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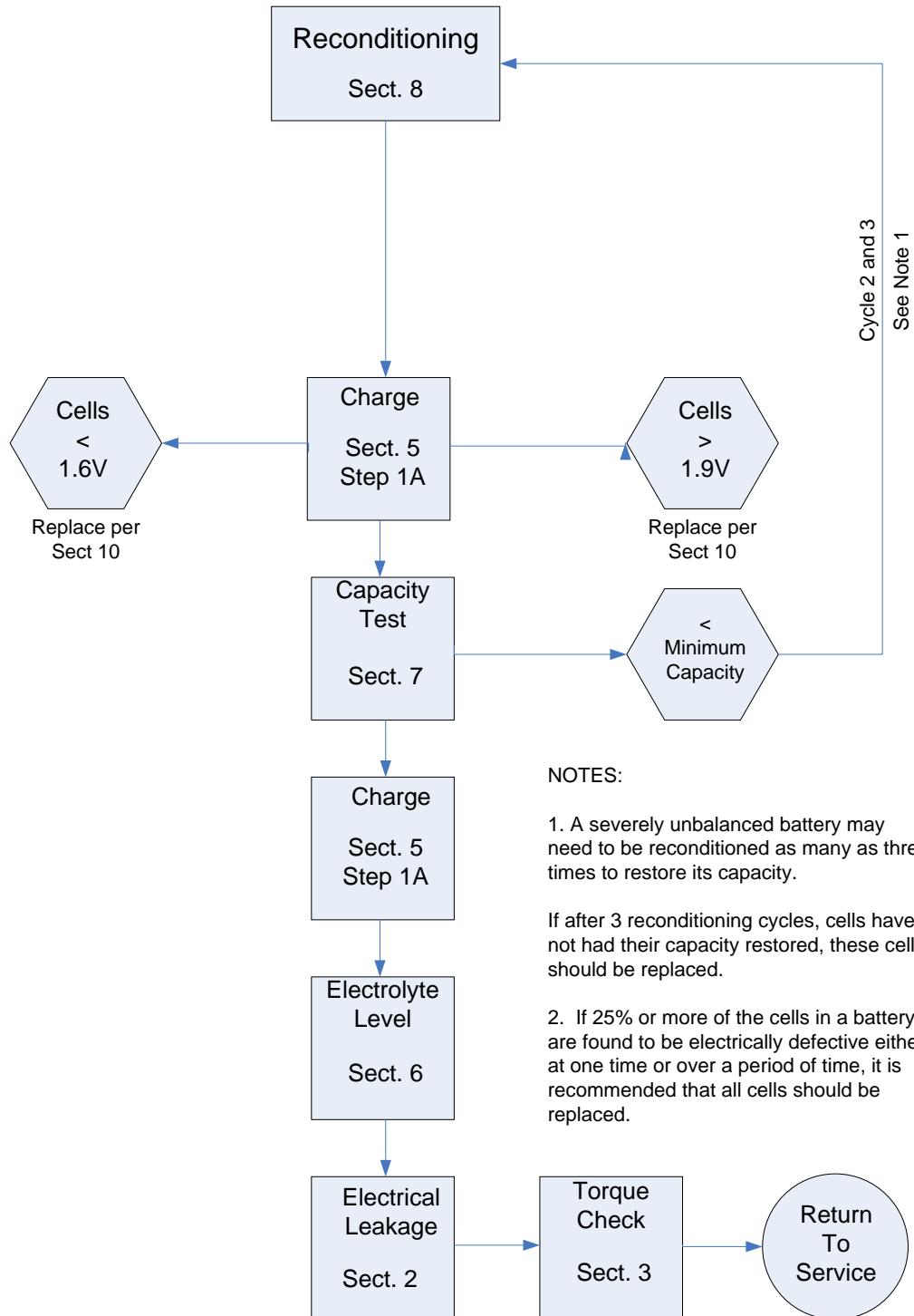
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BATTERY RECONDITIONING FLOW CHART

FIGURE 7



NOTES:

1. A severely unbalanced battery may need to be reconditioned as many as three times to restore its capacity.

If after 3 reconditioning cycles, cells have not had their capacity restored, these cells should be replaced.

2. If 25% or more of the cells in a battery are found to be electrically defective either at one time or over a period of time, it is recommended that all cells should be replaced.



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13.0 TROUBLE-SHOOTING

TROUBLE-SHOOTING HINTS

Table 6

TROUBLE	PROBABLE CAUSE	CORRECTIVE ACTION
Apparent loss of capacity	<p>Very common when recharging on a constant potential bus, as in aircraft. Usually indicates imbalance between cells because of difference in temperature, charge efficiency, self-discharge rate, etc., in the cells.</p> <p>Electrolyte level too low. Battery not fully charged.</p> <p>Use of unapproved cells and/or components.</p>	<p>Reconditioning and/or overhaul will alleviate this condition.</p> <p>Charge. Adjust electrolyte level. Check aircraft voltage regulator. If O.K., reduce maintenance interval.</p> <p>Replace with approved parts.</p>
Complete failure to operate	<p>Defective connection in equipment circuitry in which battery is installed - such as broken lead, inoperative relay or improper receptacle installation.</p> <p>End terminal connector loose or disengaged. Poor intercell connections.</p> <p>Open circuit or dry cell.</p> <p>Use of unapproved cells and/or components.</p>	<p>Check and correct external circuitry.</p> <p>Clean and retighten hardware using proper torque values.</p> <p>Replace defective cell</p> <p>Replace with approved parts.</p>
Excessive spewage of electrolyte	<p>High charge voltage High temperature during charge Electrolyte level too high</p> <p>Loose or damaged vent cap</p> <p>Damaged cell and seal</p>	<p>Clean battery, charge and adjust electrolyte level.</p> <p>Clean battery, tighten or replace cap, charge and adjust electrolyte level</p> <p>Short out all cells to 0 volts, clean battery, replace defective cell, charge and adjust electrolyte level.</p>



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Table 6 (Con't)

TROUBLE	PROBABLE CAUSE	CORRECTIVE ACTION
Failure of one or more cells to rise to the required 1.60 volts at the end of charge.	Negative Electrode not fully charged. Gas barrier damage.	Discharge battery and recharge. If the cell still fails to rise to 1.60 volts or if the cell's voltage rises to 1.60 volts or above and then drops, remove cell and replace.
Distortion of cell case to cover.	Overcharged, overdischarged, or overheated cell with internal short. Plugged vent cap Overheated battery	Discharge battery and disassemble. Replace defective cell. Recondition battery. Replace vent cap Check voltage regulator: treat battery as above, replacing battery case and cover and all other defective parts.
Foreign material within the cell case	Introduced into cell through addition of impure water or water contaminated with acid.	Discharge battery and disassemble, remove cell and replace, recondition battery.
Frequent addition of water	Cell out of balance Damaged "O" ring, vent cap Leaking cell Charge voltage too high	Recondition and/or overhaul battery Replace damaged parts. Discharge battery and disassemble. Replace defective cell, recondition battery. Adjust voltage regulator
Corrosion of top hardware	Acid fumes or spray or other corrosive atmosphere	Replace parts. Battery should be kept clean and kept away from such environments
Discolored or burned end connectors or intercell connectors	Dirty connections Loose connection Improper mating of parts	Clean parts: replace if necessary. Retighten hardware using proper torque values. Check to see that parts are properly mated.
Distortion of battery case and/or cover	Explosion caused by: Dry cells Charger failure High charge voltage Plugged vent Loose intercell connectors	Discharge battery and disassemble replace damaged parts and recondition.



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Table 6 (Con't)

TROUBLE	PROBABLE CAUSE	CORRECTIVE ACTION
Cell to battery can leakage to ground detected by testing	Excessive spewage Ruptured cell.	Clean battery, charge and adjust electrolyte level. Recheck for electrical leakage. Discharge battery and disassemble, replace defective cell, recondition battery.
Foaming of electrolyte during charge	Contaminant in electrolyte	Discharge battery and replace defective cell. Recondition battery. Replace cell that continues to foam
False or no battery high temperature indication	Dirty connections Loose connections Improper mating of parts Defective sensor assembly	Clean parts Inspect and retighten receptacle Replace sensor assembly



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14.0 STORAGE

14.1 Inactive Storage

Inactive storage is where the battery is stored for long periods of time. The battery should be stored in a completely discharged, shorted out condition. (See Section 8.1). Nickel-cadmium batteries may be stored in a non-corrosive atmosphere for an unlimited period at temperatures ranging from -65° to + 120°F; the upper limit may be extended to + 160°F for up to two weeks.

14.2 Active Storage

Active storage is where a fully charged battery is stored temporarily prior to going into service. Nickel-cadmium batteries will incur only a temporary loss of capacity during active storage. The charge retention depends largely on the ambient temperature in which the battery is stored and the length of time in storage. Charge retention is also affected by impurities in the electrolyte and electrical leakage from cells to battery case. Storage at higher temperatures will result in a greater loss of charge; at low temperatures, this loss will be much less.

Before placing a battery into active storage, the battery should be fully serviced and cleaned. Where operation is required immediately after removal from active storage, proper cleaning is even more important to avoid the possibility of contaminants creating conductive paths within the battery case and increasing the self-discharge rate.

A properly serviced battery can be stored at temperatures between 60°F and 80°F for up to 90 days. Beyond this time or temperature the battery should be serviced before being placed into service.

14.3 Extending Active Storage Shelf Life

If the battery is to be placed into an active storage condition, for longer periods, the battery should be serviced then maintained in a fully charged condition by trickle charging, thus compensating for the normal self discharge that occurs in the battery. Trickle charge rates are given in table 4 of this manual. Batteries stored under this condition must be kept at a temperature between 60°F and 80°F. Maximum trickle charge time prior to placement into service is one year. Beyond this time or temperature the battery should be serviced before being returned to active storage or being placed into service.

NOTE: Trickle charge rates are critical. Charging at a rate greater or less than the recommended rate can create significant problems.



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15.0 SHIPPING

Shipments must conform to current IATA regulations (UN2795 or UN2800 as applicable). Refer to the MSDS Document RS-95112 on the MNAI Website.



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16.0 WARRANTY INFORMATION

16.1 Product Warranty Registration

MarathonNorco Aerospace, Inc. includes a warranty registration card with the shipment of each new Micro Maintenance nickel-cadmium battery. The warranty registration card must be validated by a MarathonNorco Aerospace, Inc. authorized distributor/dealer, then filled out and mailed within 30 days of the date of purchase to MarathonNorco Aerospace, Inc.



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17.0 SPECIAL TOOLS

17.1 Nickel-cadmium Battery Maintenance Kit

MarathonNorco Aerospace, Inc. has made available through distributors, a battery maintenance kit (P/N 33178-001). Items contained within the kit are listed as follows:

TABLE 7

QTY REQUIRED	DESCRIPTION	DWG. SIZE	PART NO.
1	Case, Marked w/Pads	C	32535-001
5	Short Out Resistor	B	14000-001
22	Discharge Clip	B	31379-001
1	Stud Terminal Adapter	B	33177-001
1	Cell Puller, Universal	A	32515-001
1	Vent Wrench	C	25624-001
1	Hex Bit Socket 3/16" 3/8" Drive	A	33180-001
1	Adapter, Syringe Tip (Black)	A	32479-004
1	Adapter, Syringe Tip (Red)	A	32479-005
1	Adapter, Syringe Tip (White)	A	32479-002
1	Adapter, Syringe Tip (Green)	A	32479-001
1	Syringe, 20cc	A	32415-001

17.2 Recommended Equipment

For charging and discharging batteries, MarathonNorco Aerospace, Inc recommends a Christie RF80-M (123020-001) or RF80-K (121630-001 or -006) or equivalent:

Charge: 50 VDC MAX; 65 A recommended
Discharge: 50 A MIN recommended

CAUTION: It is not recommended to operate charging equipment capable of greater than 50 VDC output. The EU and other international safety organizations require a voltage limit of less than 50 VDC on battery chargers for operator safety.



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18.0 Record Keeping

Associated with good maintenance practices is the keeping of accurate records. These records serve as a verification of the maintenance procedure and provide information for establishing optimum servicing schedules in keeping with individual usage of the battery.

Documentation of battery servicing is not only required for warranty consideration, it is vital to the proper diagnosis of problems. Should a battery malfunction, its complete history will then be available to assist in the determination of the problem. It must be remembered that a battery is a collection of cells and that if only battery terminal voltages are observed, the problems with an individual cell may go undetected. A strong cell will compensate for a weak cell, therefore, individual cell voltages must be observed and recorded. The Battery Service Data Sheet on Page 1802 may be utilized for most nickel-cadmium service requirements.

NOTE: In some organizations cell number 1 is the most positive. In other organizations cell number 1 is the most negative. It is important that all people within an organization utilize the same system when referring to cell positions.



BATTERY SERVICE DATA SHEET

Page _____ of _____

Work Order _____ Battery S/N _____ Aircraft Type _____ Hours in Service _____
Date _____ Battery Type _____ Aircraft No _____ Service Performed by _____

Main Chg. Amps _____ Cap. Test Amps _____ Sensor _____
Top Chg. Amps _____ Torque in Lbs. _____

INSPECTIONS

Initial Visual _____ Torque _____ Vents _____ Deep Cycle No _____
Elect. Leakage _____ Connector(s) _____ Sensor _____ Final Inspection _____

TESTS

Table with 22 columns (1-22) and 4 rows (MAIN CHARGE, 30 Minutes, Time to 1.55V, Initial H2O CCs)

Table with 22 columns (1-22) and 6 rows (TOP CHARGE, 15 Minutes, 30 Minutes, 60 Minutes, 90 Minutes, 120 Minutes, Initial H2O CCs)

Table with 22 columns (1-22) and 4 rows (CAPACITY, 15/30 Minutes, 30/60 Minutes, 45/90 Minutes, 51/120 Minutes)

Approved for Service _____

Date _____