CHAPTER 11

CONTENTS — NICKEL-CADMIUM HELICOPTER STORAGE BATTERY

Paragraph Number	Title	Chapter/Section Number	Page Number
11-1	Nickel-cadmium helicopter storage battery	11-00-00	5
11-2	Construction	11-00-00	5
11-3	Principal parts and material	11-00-00	5
11-6	Cylindrical Sealed cell	11-00-00	7
11-7	Electrolyte	11-00-00	8
11-8	Principles of operation	11-00-00	8
11-9	Electrochemical action	11-00-00	8
11-12	Capacity	11-00-00	10
11-13	Factors affecting capacity	11-00-00	10
11-16	Discharge characteristics	11-00-00	10
11-17	Charging characteristics	11-00-00	11
11-18	Charging efficiency	11-00-00	12
11-19	Charge/discharge techniques	11-00-00	12
11-20	Charge techniques	11-00-00	12
11-23	Discharge techniques	11-00-00	13
11-29	Operation of battery shop	11-00-00	15
11-30	Training of personnel	11-00-00	15
11-31	Separation of nickel-cadmium and lead-acid battery facilities	11-00-00	16
11-32	Separation of lead-acid and alkaline battery facilities	11-00-00	16
11-33	Battery records	11-00-00	17
11-36	Special equipment and tools	11-00-00	18
11-37	Calibration of equipment	11-00-00	18
11-38	Battery shop safety procedures	11-00-00	18
11-39	General warnings	11-00-00	18
11-40	Factors affecting service life	11-00-00	21
11-41	Adjustment of electrolyte level	11-00-00	21
11-45	Overheated nickel-cadmium batteries	11-00-00	22
11-46	General warnings	11-00-00	22
11-47	Temporary loss of capacity	11-00-00	23
11-51	Storage/shipping	11-00-00	24
11-52	Electrolyte requirements and adjustments	11-00-00	24
11-55	Battery servicing procedures using model RF8OH automatic reflex charger/analyzer	11-00-00	26
11-56	RF8OH automatic charger/analyzer	11-00-00	26
11-57	Operational characteristics	11-00-00	26
11-61	Battery analysis and acceptance criteria	11-00-00	27
11-62	Battery acceptance or rejection criteria	11-00-00	29
11-66	GO/NO-GO decision in discharge cycle	11-00-00	29
11-68	Electrolyte level check	11-00-00	37
11-69	Optional procedures	11-00-00	37
11-71	Electrolyte level check during charge	11-00-00	38
11-72	Cell voltage balance test during constant current charge	11-00-00	38
11-73	Cell fatigue (cellophane barrier) test	11-00-00	38
11-74	Charging only	11-00-00	39

CONTENTS — NICKEL-CADMIUM HELICOPTER STORAGE BATTERY (CONT)

Paragraph Number	Title	Chapter/Section Number	Page Number
11-77	Manual selection of discharge mode	11-00-00	39
11-78	Automatic stop after discharge	11-00-00	39
11-79	Operating procedure after power failure	11-00-00	39
11-80	Inspection, charging, and analysis procedures	11-00-00	40
11-81	Battery inspection	11-00-00	40
11-82	Visual inspection	11-00-00	40
11-83	Electrical inspection	11-00-00	40
11-84	Standard setup and operation	11-00-00	40
11-88	Marathon aircraft battery, model PCA-131/PCA-131, 50/60 series charger/analyzer	11-00-00	41
11-89	Battery servicing procedures using model PCA-131 series to charge and analyze aircraft nickel-cadmium batteries automatically	11-00-00	41
11-90	Operational characteristics	11-00-00	41
11-93	Maintenance and reconditioning schedules	11-00-00	41
11-94	Inspection and maintenance check	11-00-00	43
11-98	Reconditioning nickel-cadmium batteries	11-00-00	46
11-102	Eagle-pitcher recommended procedure	11-00-00	50
11-103	Operation and maintenance	11-00-00	50
11-104	Operations	11-00-00	51
11-105	Maintenance	11-00-00	51
11-107	Storage	11-00-00	54
11-108	Charging the batteries	11-00-00	56
11-110	Electrolyte adjustment	11-00-00	58
11-111	Electrolyte adjustment procedures	11-00-00	58

FIGURES

Figure Number	Title	Page Number
11-1	Battery container	5
11-2	Battery construction	6
11-3	"Stack-up" is prepared	7
11-4	Terminals are welded to "Stack-up"	8
11-5	Entire unit is inserted in cell case and sealed	9
11-6	Cylindrical sealed cell	10
11-7	Comparison of discharge voltage for typical lead-acid and nickel-cadmium helicopter storage batteries	11
11-8	Constant current power supply used as discharge unit	14
11-9	0.5 to 1.0 OHM workaid	15
11-10	Cell shorting clips workaid	16
11-11	Battery history card	17
11-12	Battery service record	19
11-13	Battery service record	20
11-14	Electrolyte level and removal syringe	26
11-15	Reading a hydrometer	27
11-16	RF80H Automatic ReFLEX charger/analyzer controls and indicators	30
11-17	Marathon model PCA-131/PCA-131, 50/60 series charger/analyzer controls and indicators	42
11-18	Cell shorting clips	47
11-19	1.0 ohm, 2 watts resistor	48
11-20	Cell construction	52
11-21	Cell puller	53
11-22	Battery schematic	55
11-23	Power connector torquing guide	56
11-24	Temperature sensor test harness	56
11-25	Temperature sensor conversion chart	57
11-26	Charging voltage requirement	58
11-27	Electrolyte level adjustment	59
11-28	Syringe needle modification	60

TABLES

Table Number	Title	Page Number
11-1	Charge and overcharge equations	9
11-2	Discharge equations	10
11-3	Internal resistance - typical values	11
11-4	Nickel-cadmium special equipment and tools	18
11-5	Battery data	28
11-6	Initial setting before turn on and adjustments	33

NICKEL-CADMIUM HELICOPTER STORAGE BATTERY

11-1. NICKEL-CADMIUM HELICOPTER STORAGE BATTERY.

11-2. CONSTRUCTION.

11-3. PRINCIPAL PARTS AND MATERIALS.

The fundamental unit of the nickel-cadmium aircraft storage battery is the cell. The sintered-plate, nickel-cadmium cells used in the battery consist of two basic types: vented and sealed. Most helicopter nickel-cadmium storage batteries employ rectangular vented-type cells. Sealed cells, of both rectangular and cylindrical types, are used in some applications for standby power requirements.

11-4. Battery container.

The battery container is a rectangular metal case enclosing the cells. The container has a removable top to permit access for routine maintenance. Plastic liners are used to insulate the inner sides of the container. Plastic shims are used to firm up the cell pack within the container. Refer to figure 11-1.

11-5. Vented cell. The principal parts and materials used in vented cells of the nickel-cadmium battery are as follows:

1. **Plate.** A plate is made from powder in a metallurgy process. Nickel carbonyl powder is lightly compressed in a mold and then either subjected to a temperature of about 1600°F (871°C) in a sintering furnace or to a heavy electric current. These processes cause the individual grains of nickel to weld to their points of contact, resulting in a porous plaque that is approximately 80 percent open holes and 20 percent solid nickel. The plaque is then impregnated with active material by being soaked in a solution of nickel salts to make a positive plate or in a solution of cadmium salts to make a negative plate. Refer to figure 11-2, detail A. Soaking is repeated until the plaque contains the necessary amount of active material to give it the desired capacity. Refer to detail B. After impregnation, the negative and positive plaques are submerged in electrolyte and subjected to an electric current which converts the nickel and cadmium salts to final form. Refer to detail C. The plaque is then washed and dried and cut into plates. When the cell is assembled, a nickel tab is welded to a corner of each plate for connection purposes. Refer to detail D.

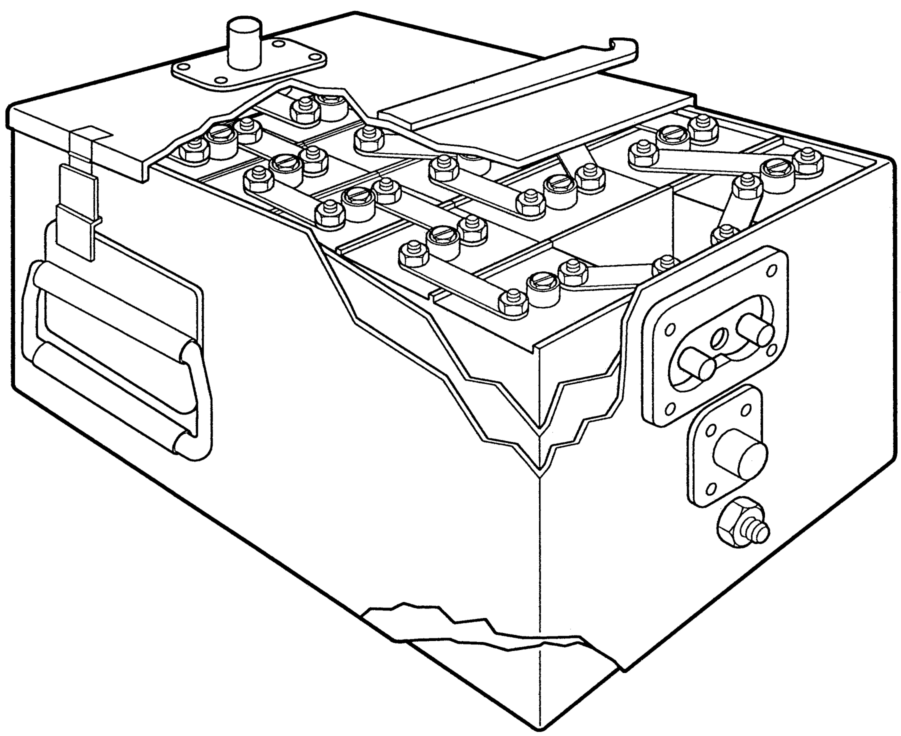

Figure 11-1. Battery container

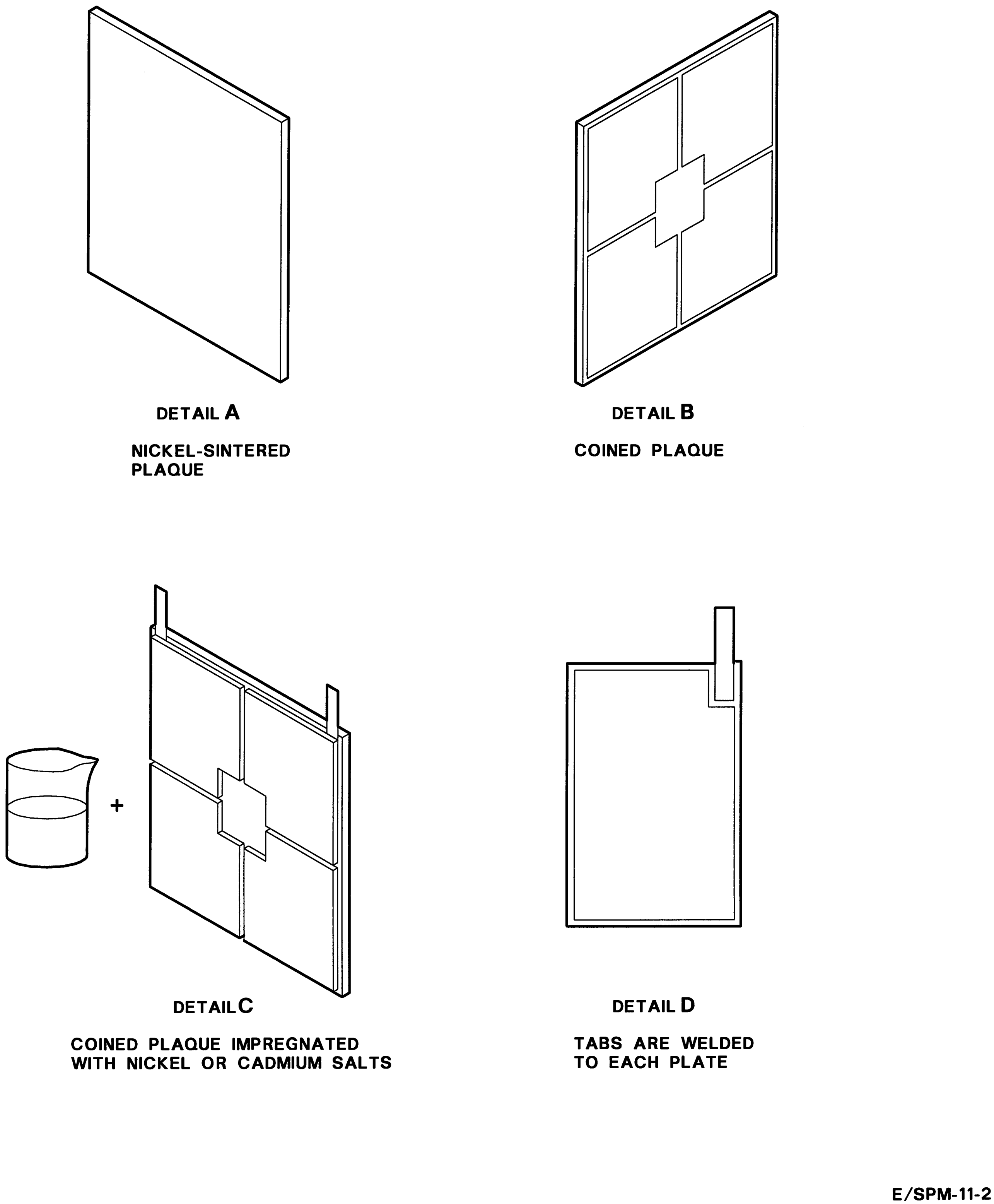

Figure 11-2. Battery construction

2. **Separator.** The separator (figure 11-3) is a continuous thin porous multilaminate of nylon and cellophane, or some other gas barrier material such as Permion or Celgard, that keeps negative and positive plates from coming into contact with each other. In preparing the cell assembly, the continuous separator is interposed between plates as each successive plate is added to form a stackup. Refer to figure 10-3.

3. **Cell.** The cell is assembled into its final form by welding tabs of the negative plates to one terminal post and tabs of the positive plates to a second terminal post. Refer to figure 11-4. Once assembled, it is inserted into a plastic case and fitted with a cover-and-vent assembly that permits the terminal posts to project through the top of the case. The complete unit is then sealed. The venting system allows excess gasses to escape. A typical cell assembly is shown in figure 11-5. The exact number of cells required for a specific battery assembly is determined by the voltage rating of the equipment to be operated. The nominal voltage of a single nickel-cadmium cell ranges between 1.2 and 1.3 volts. For a 24-volt battery, 19 vented sintered-plate cells are connected in series.

4. **Vent plug.** The vent plug on the top of the cell is usually constructed of nylon. It can be removed for the addition of distilled water or for adjustment of the electrolyte. When excessive gasses develop in the cell during charge, they escape through the vent hole, which opens when a certain pressure is reached. Except when releasing gas, the vent automatically seals the cell to prevent electrolyte leakage and entry of foreign material into the cell.

11-6. CYLINDRICAL SEALED CELL.

The cylindrical sealed cell is rechargeable and free of the usual maintenance routines such as adjusting and checking the electrolyte. Refer to figure 11-6. Its electrolyte, a viscous solution of potassium hydroxide, does not take part in the chemical reaction. The active materials are contained in molded screens or sintered plates that are spirally rolled with a separator to form a core. The core is then jacketed in a metal case, which provides a rigid unit. Generally, the negative plate is welded to the case, and the positive plate is welded to the cell cover. The cover is attached to the case by a plastic sealing gasket. A cutaway view of a cylindrical sealed cell is shown in figure 11-6.

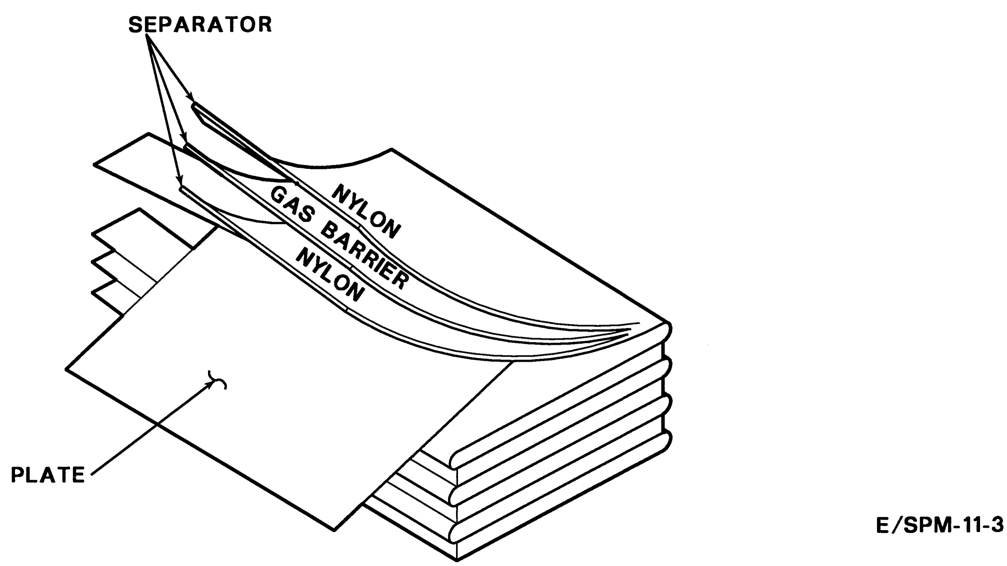

Figure 11-3. "Stack-up" is prepared

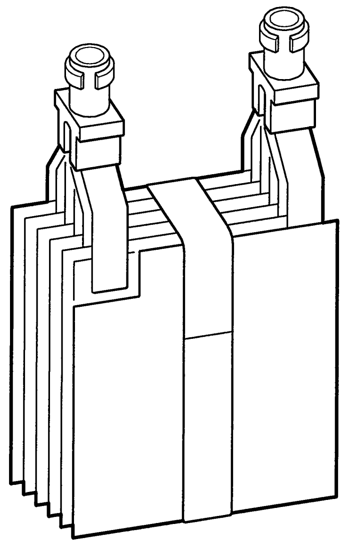

Figure 11-4. Terminals are welded to "Stack-up"

11-7. ELECTROLYTE.

The electrolyte is normally, by weight, a 30 percent solution of potassium hydroxide (KOH) in 70 percent distilled water, see following formula. It provides a path for current that flows between positive and negative plates. The electrolyte does not take part in the chemical reaction in nickel-cadmium batteries, but acts as an ion carrier. The specific gravity remains the same whether the batter is in a charged or discharged condition.

ELECTROLYTE II
30% KOH + 70% H_2O

11-8. PRINCIPLES OF OPERATION.

11-9. ELECTROCHEMICAL ACTION.

The exact chemical reactions that occur within a cell of the nickel-cadmium battery during charge and discharge are open to question, particularly with regard to the oxidized states of the active materials. However, the essential operation can be described.

11-10. Charge.

1. When charging current is applied to the cell, cadmium-oxide material of the negative plates gradually loses oxygen and becomes metallic cadmium, and the nickel-oxide active material of positive plates is brought to a higher state of oxidation. Refer to **table 11-1**. These changes continue in both sets of plates as long as charging current is applied, or until active materials of plates have been completely converted. The cell emits gas toward the end of this process because of decomposition of water components of electrolyte into hydrogen at negative plates and oxygen at positive plates. The electrolyte conducts current between plates of opposite polarity and reacts to produce electrochemical changes without producing any significant changes in its own overall chemical composition. Thus, the measurement of specific gravity of the electrolyte gives no indication of the state of charge in a nickel-cadmium cell.

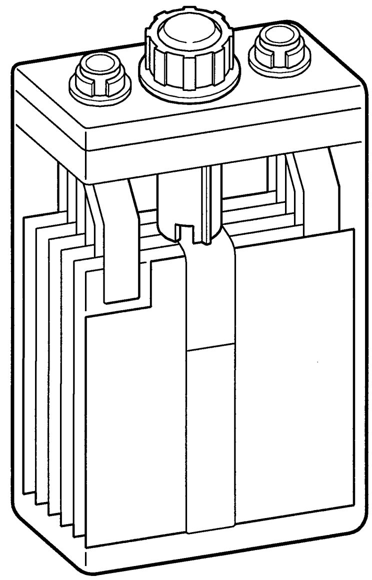

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Figure 11-5. Entire unit is inserted in cell case and sealed

Table 11-1. Charge and overcharge equations

POSITIVE PLATE		**NEGATIVE PLATE**	
Charge:		Charge:	
$2Ni(OH)_2 + 2(OH)$	$2NiOOH + 2H_2O + 2e$	$Cd(OH)_2 + 2e$	$Cd + 2(OH)$
(Nickel Hydroxide)	(Nickel Oxy Hydroxide)	(Cadmium Hydroxide)	(Cadmium)
Overcharge:		Overcharge:	
$2(OH)$	$_{1/2}O_2 + H_2O + 2e$	$2H_2\ O + 2e$	$H_2 + 2(OH)$

2. The rectangular type of nickel-cadmium cells are provided with vented cell caps to allow escape of excessive gasses generated during the latter part of the charge cycle. In the cylindrical type of cell, which is hermetically sealed, it is necessary to dissipate these gasses within the cell. This dissipation is achieved by constructing negative plates that have greater ampere-hours capacity than positive plates. The positive plate will thus achieve full charge before the negative plate and begin to liberate oxygen into the cell dead space while the negative plate is still charging, but not liberating hydrogen. However, the negative plate reacts with oxygen given off by the positive plate to form cadmium-oxide. Therefore, in overcharge, the negative plate is oxidized at a rate that offsets the charging energy and holds the cell in equilibrium. The length of time this process can continue depends on cell construction; but excessive overcharging will result in cell rupture.

11-11. Discharge.

During discharge the chemical reaction is reversed. Refer to table 11-2. Positive plates gradually return to a state of lower oxidation, while negative plates simultaneously regain lost oxygen. During discharge process, chemical energy is released as electrical current through the discharge load. The rate at which chemical energy is converted in determined principally by resistance of load to current flow.

Table 11-2. Discharge equations

POSITIVE PLATE		NEGATIVE PLATE	
$2NiOOH+2H_2O+2e$ (Nickel Oxy Hydroxide)	$2Ni(OH)_2+2(OH)$ (Nickel Hydroxide)	$Cd+2(OH)$ (Cadmium)	$Cd(OH)_2+2e$ (Cadmium Hydroxide)

11-12. CAPACITY.

Battery capacity can be determined only by making a constant current-time measured discharge. Current is normally held at the 1/2 C rate until the voltage per cell drops to one volt with ambient temperature between 70°F and 80°F. The "C" rate is defined as the amount of current a battery will deliver if discharged in 1 hour. For example, a 34 ampere hour battery has a C rate of 34.

11-13. FACTORS AFFECTING CAPACITY.

The primary factors that influence battery capacity are discharge rate and temperature.

11-14. Discharge rate.

Sustained high current and extreme temperature have a degrading effect on cell capacity. A capacity measurement is therefore made at the 1/2 C rate.

11-15. Temperature.

The optimum operating temperature for typical rectangular and cylindrical nickel-cadmium cells is 7.5 to 77.5°F (-13.61 to 25.27°C) and an increase or decrease in temperature from that range causes a corresponding reduction in cell capacity and charge efficiency.

11-16. DISCHARGE CHARACTERISTICS.

1. The nickel-cadmium battery is capable of delivering very high discharge currents relative to its size. If battery is discharged at currents higher than the one-hour rate, a noticeable temperature rise may result. After battery has been discharged in the shop, it shall be allowed to cool to 77.5°F (25.27°C) before being recharged.

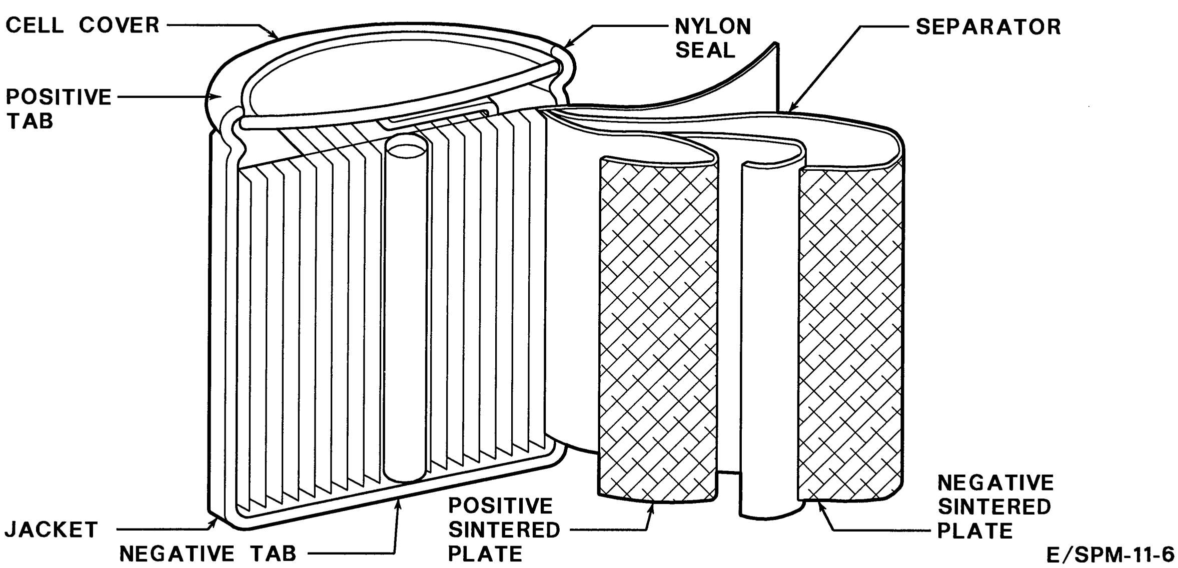

Figure 11-6. Cylindrical sealed cell

2. A comparison of voltage discharge characteristics for three types of aircraft storage batteries rated at 24 volts and 31 ampere-hours is presented in figure 11-7. Two of these batteries were nickel-cadmium types, (one of 20 cells and one of 19 cells). The remaining battery was a lead-acid type. The batteries were discharged at the 1-hour rate of 31 amperes. The voltage levels of the nickel-cadmium batteries dropped initially and then remained somewhat constant almost until they had reached a state of complete discharge. Voltage level of the lead-acid unit dropped initially and then tended to stabilize. An important characteristic of a nickel-cadmium battery is that voltage remains almost constant under normal operating conditions until approximately 95 percent of capacity has been delivered. Refer to figure 11-7.

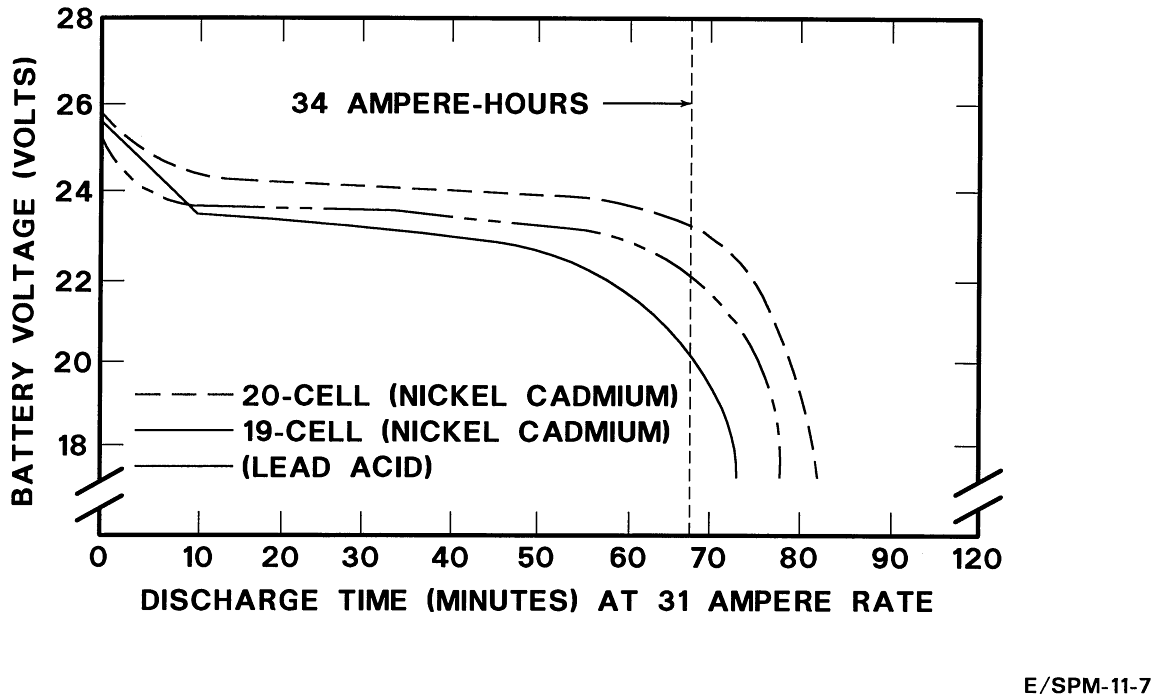

Figure 11-7. Comparison of discharge voltage for typical lead-acid and nickel-cadmium helicopter storage batteries

11-17. CHARGING CHARACTERISTICS.

Since nickel-cadmium cells have extremely low internal resistance (table 11-3). A severely discharged battery will initially draw very high currents if charged by the constant potential method. Because of high current initially drawn by a discharged battery, and when using the constant potential method of charging, it is advisable to use charging equipment with built-in protective circuitry. Constant potential charging equipment should be capable of delivering current of at least three times the capacity rating of the battery.

Table 11-3. Internal resistance - typical values

Cell Size Ampere Hours	Plate Type	Milliohms Per Cell
40	H	0.6
36	H	0.8
36	M	0.85
24	H	0.90
24	M	1.1
17	H	0.95
10	H	1.1
5	H	2.0
3	H	4.0

11-18. CHARGING EFFICIENCY.

Charging efficiency is the ratio of ampere-hours attained on discharging to ampere-hours returned to a battery during charge; this ratio is always less than 1-to-1. Therefore, an excess of charge must always be returned to the battery after discharge to restore full capacity. The total charge necessary may be as low as 110 percent depending on temperature and cell characteristics. It is generally recommended that the nickel-cadmium aircraft battery be charged for a time that will give 140 percent of the previously discharged ampere-hours. For example, a battery having been discharged 18 ampere-hours would be recharged until 1.4 x 18 ampere hours are returned to the battery.

11-19. CHARGE/DISCHARGE TECHNIQUES.

WARNING

IF TEMPERATURE OF A NICKEL-CADMIUM BATTERY EXCEEDS 100°F (37.8°C) WHILE BEING CHARGED ON NON-AUTOMATIC TYPE OF CHARGING EQUIPMENT, THE CHARGE SHALL BE TERMINATED. THERE IS NO REQUIREMENT TO MONITOR THE TEMPERATURE OF A NICKEL-CADMIUM BATTERY THAT IS BEING CHARGED ON AUTOMATIC TYPE OF CHARGING EQUIPMENT UNLESS SPECIFIED BY OTHER AUTHORITY.

11-20. CHARGE TECHNIQUES.

The three charge techniques currently used are constant current, pulsed current, and constant potential.

11-21. Constant current charging.

1. The constant current method is the preferred method of charging nickel-cadmium batteries. As the name implies, the charge current remains at the constant rate regardless of the voltage of the battery. The constant current method is effective in correcting cell imbalance and temporary loss of capacity, and it permits easy computation of charge capacity in ampere-hours.

2. Time required to charge a nickel-cadmium battery by constant current methods depends on the state of charge of the battery, charging current, and actual capacity of the battery. On average, a nickel-cadmium battery will require a recharge of 140 percent of the previous discharge.

3. Any constant current charge or power supply may be used to charge a nickel-cadmium battery if current and voltage ratings of the unit are adequate. Generally, a C/10 charging rate (rated capacity, C, of the battery divided by ten) is a safe charging rate. A voltage limit is not necessary as the charging rate will not overcharge cells to any great extent. This rate will require approximately 16 hours of charging to fully charge a completely discharged battery. Refer to the battery manufacturer's service manual for recommended charging instructions.

4. When a vented or sealed nickel-cadmium battery is constant current charged on non-automatic type of equipment, the battery voltage, charging current, and battery temperature should be monitored frequently to minimize any damage that can occur from excessive charging or equipment malfunction. The temperature of vented batteries may be monitored by placing a suitable thermometer (liquid-in-glass, thermocouple, thermistor) in, or adjacent to a centrally located cell. A deterioration of potassium hydroxide electrolyte can take place when vent caps of vented nickel-cadmium cells are removed and electrolyte is exposed to the atmosphere. Vented nickel-cadmium batteries shall be charged with vent caps loose but in place. Vent caps may be removed to allow for the inspection of the interior of the cell, inspection of vent caps, adjustment of the electrolyte levels, or measurement of the electrolyte temperature. The temperature of sealed batteries may be monitored by placing thermometer adjacent to the battery case in the area of greatest heat concentration.

5. Constant potential charging. The constant potential charging method is the fastest method of charging a nickel-cadmium battery, however, a disadvantage of constant potential charging is that full capacity cannot normally be restored if a battery suffers from temporary loss of capacity.

6. Vented 19-cell 24-volt nickel-cadmium batteries will normally be charged in the shop at 28.5 volts when charging with a constant potential voltage. Note that charging a 19-cell battery at 28.5 volts is equivalent to charging each cell at 1.50 volts. Initial charging current may be as high as 10 times the ampere-hour rating of the battery, depending on the state of charge of the battery. High initial current will not damage the battery, but charging equipment should have an inherent current-limiting capability or be provided with overload protection; a generator capable of delivering at least 300 amperes provides an adequate constant potential charging source.

7. Time required to charge will depend primarily on the current delivery capability of the charging source. The lower the charging current, the longer the time required to charge. Near full charge may be restored within one hour at 28.5 volts charging potential, provided the charging source is also capable of delivering current equal to two-to-three times the ampere-hour rating of battery. For monitoring purposes, an ammeter should be connected in series with the battery and power source.

CAUTION

INTRODUCTION OF MONITORING AMMETER INTO THE CHARGE CIRCUIT MUST BE DELAYED FOR APPROXIMATELY 5 MINUTES TO PROTECT METER FROM POSSIBLE DAMAGE DUE TO CHARACTERISTIC HIGH CURRENT IN THE EARLY CONSTANT-POTENTIAL CHARGING STAGE.

8. Charging should continue until ammeter indicates a current flow of 1 ampere or less, or until a maximum time of four hours has elapsed. Should a battery be severely discharged, charging by the constant potential method may produce a slight imbalance in cell capacity. Imbalance can be detected by a periodic check of cell terminal voltages with a precision voltmeter after charging current levels off and while battery is charging. Should voltage spread between the highest and lowest cell exceed 0.35 volt, the battery shall be subjected to an equalization discharge. Refer to paragraph 11-28.

11-22. Trickle charging.

Trickle charging may be used to maintain the battery in a fully charged condition. The charged battery is connected to a constant current or constant potential DC source for charging at a rate sufficient to compensate for the internal losses. The constant current used is 0.4 to 1.0 milliamperes/ampere hour, and the corresponding potential is 1.35 to 1.36 volts/cell. When a trickle charged battery has been discharged it must be recharged by means of a separate charger/analyzer.

CAUTION

DUE TO THE POSSIBILITY OF A CELL SHORTING WHILE ON TRICKLE CHARGE, THE CHARGING CIRCUIT MUST BE LIMITED AS TO THE CURRENT IT WILL SUPPLY. THE ELECTROLYTE LEVEL MUST BE MONITORED AND ADJUSTED TO COMPENSATE FOR WATER LOSS.

11-23. DISCHARGE TECHNIQUES.

The amount of electrical energy available from a fully charged nickel-cadmium battery is defined by the rating of the battery and is stated in terms of ampere hours. A reduction in the capacity of a nickel-cadmium battery occurs at high discharge rates, and an improvement in capacity occurs at low discharge rates.

NOTE

The nominal rated capacity used throughout this manual is the one-hour capacity at 80°F (26.7°C).

11-24. Discharge rates for capacity tests.

The ampere-hour rating for batteries used in helicopters is based on a one-hour discharge rate. Example, the capacity test of a 19-cell, 18-ampere hour battery would consist of discharging the battery at a rate of 18 amperes (after it has been charged) until the terminal voltage drops to 18.0 volts (0.95 volt per cell). This point will be reached at the end of one hour, or later, if the battery is capable of delivering its rated ampere-hour capacity. Some battery manufacturers recommend a discharge rate of C/2.

11-25. Constant current discharge.

The most accurate and repeatable methods of measuring capacity is to discharge the battery at a constant current rate. The load resistance in the method is varied to maintain a constant discharge current as the battery voltage decreases. At the end of discharge, the calculation of ampere-hour capacity is the product of the discharge current times the elapsed discharge time.

11-26. Discharge with constant current power supply.

1. Any constant current power supply can be used to constant-current discharge a battery provided the voltage range and current range of the power supply are adequate. Figure 11-8 shows the proper method for using a constant current power supply to discharge a battery. The values of components used in figure 11-8 are as follows:

a. Storage Battery. Battery that is to be discharged.

b. A. Ammeter of proper value to measure discharge current.

c. V. Voltmeter of proper value to measure battery voltage.

d. R_L. Load resistor whose resistance value is determined by dividing open circuit voltage of the battery by discharge current; e.g., 25.0 volts divided by 18.0 amperes equals 1.39 ohms. A resistance of 1.5 ohms or 2.0 ohms could be used in this example as they are of a more common value. The wattage of the resistor is determined by $P = I_2R$.

e. Power Supply. The power supply must be a constant-current device with adequate voltage and current range. Voltage output of the power supply must be as great as the decline in voltage of the battery during discharge; e.g., a battery with an open circuit voltage of 25.0 volts is to be discharged to 18.0 volts. This is a voltage drop of 7.0 volts, therefore, the power supply must have a voltage range of 7.0 volts. The power supply can have a voltage range that is greater than the voltage drop of the battery, but not less.

2. During the discharge, the current through the circuit is controlled by the current control device in the power supply. The power supply and battery are connected in series and total voltage of both items is impressed across the load resistor. Refer to figure 11-8, view A. The output voltage of the power supply increases as the battery voltage decreases thereby keeping voltage constant across the load resistor.

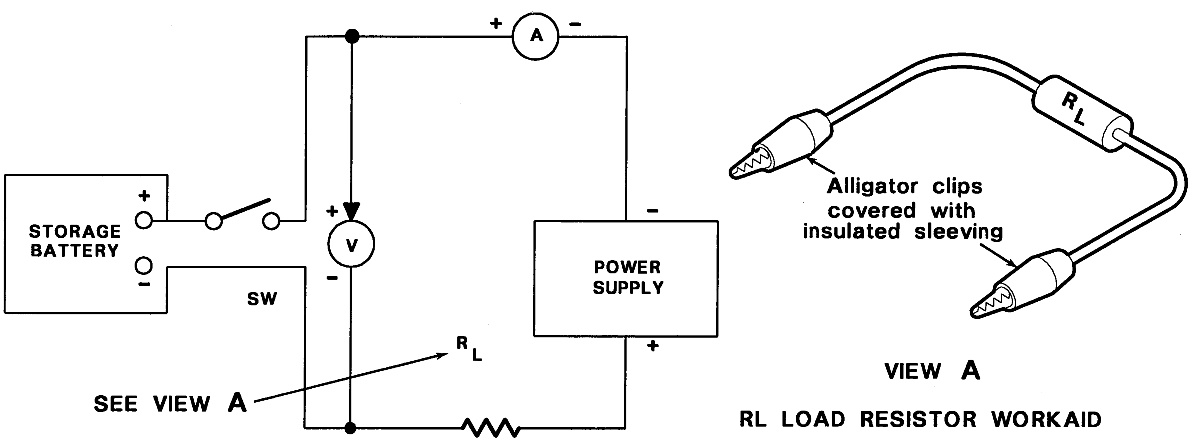

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Figure 11-8. Constant current power supply used as discharge unit

11-27. Fixed resistance discharge (approximating capacity).

A method of approximating capacity is to place a fixed resistor across the battery terminals and monitor the current and time as the battery discharges. As the battery discharges, the current drops as the battery voltage decreases. To calculate capacity, multiply the average discharge current by the discharge time. Refer to figure 11-9.

11-28. Equalization discharge.

1. Part of the task of reconditioning is an equalization discharge or deep cycle. Nickel-cadmium battery capacity does not decrease appreciably with age. However, there can be a temporary loss of capacity under certain duty cycles. A temporary loss of capacity is normally an indication of imbalance between cells. Imbalance can be caused by differences in temperature, charge efficiency, self discharge rate, etc. The purpose of deep cycling is to restore a battery to its full capacity and to prevent premature damage and failure.

2. A battery may be equalized by placing individual shorting clips across each cell in the battery when voltage is less than 1 volt. A shorting clip is shown in figure 11-10. The shorting clip should remain on the cells at least 14 hours after the cell voltages reach zero potential, to ensure a complete discharge. A battery shall not be discharged by placing a resistor across the entire battery as this will cause imbalance of the individual cells within the battery.

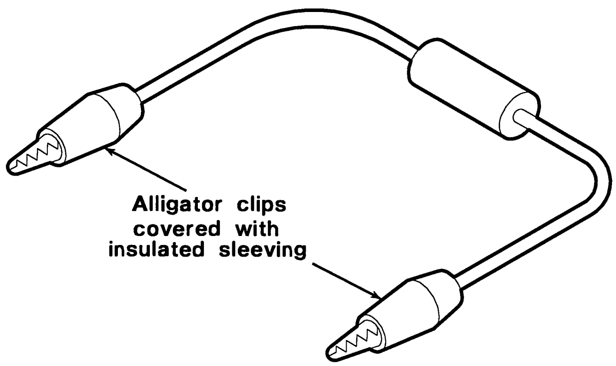


Figure 11-9. 0.5 to 1.0 OHM workaid

NOTE

After an individual cell has been determined to be defective, it should be removed from the battery and identified so as never to be installed in a battery. One method is to spray paint the entire cell “red”. A better method is to destroy the cell in accordance with a locally approved procedure.

11-29. OPERATION OF BATTERY SHOP.

11-30. TRAINING OF PERSONNEL.

Servicing of a nickel-cadmium battery requires highly skilled personnel. It is recommended that personnel engaged in servicing these batteries receive a minimum of 40 hours of specialized training in the care and servicing of nickel-cadmium batteries. Use of properly trained personnel in maintenance and servicing of the batteries cannot be overemphasized. the official or individuals responsible for the avionics shop shall ensure that all personnel concerned with battery servicing and handling are qualified and are fully aware of proper safety precautions. Personnel training records should show that these qualifications were authenticated. Normally, personnel with aviation electrician ratings will be assigned to the battery shop.

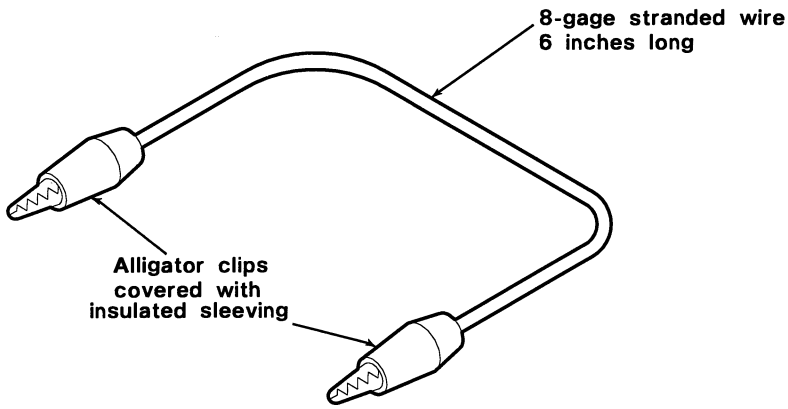


Figure 11-10. Cell shorting clips workaid

11-31. SEPARATION OF NICKEL-CADMIUM AND LEAD-ACID BATTERY FACILITIES.

1. Nickel-cadmium batteries use potassium hydroxide and distilled water as an electrolyte. Chemically, this electrolyte is the opposite of an acid.

CAUTION

SINCE THE ELECTROLYTE USED IN LEAD-ACID BATTERIES IS A STRONG SOLUTION OF SULFURIC ACID AND DISTILLED WATER, IT IS IMPERATIVE THAT NICKEL-CADMIUM BATTERIES BE SEPARATED FROM THE LEAD-ACID TYPES.

2. Anything associated with the lead-acid batteries (acid fumes included) should never come in contact with a nickel-cadmium battery or its electrolyte. Even traces of sulfuric acid from lead-acid batteries entering the electrolyte of a nickel-cadmium battery will result in damage. Acid fumes can damage the hardware of the nickel-cadmium battery.

11-32. SEPARATION OF LEAD-ACID AND ALKALINE BATTERY FACILITIES.

MATERIALS REQUIRED

NUMBER	NOMENCLATURE
EC074	Sodium Bicarbonate
EC075	Boric Acid Solution

Separate battery shops, or at least separate rooms shall be used. The usual battery shop benches, tools, and other equipment used with lead-acid batteries are contaminated by sulfuric acid which will damage nickel-cadmium batteries. Potassium hydroxide electrolyte of nickel-cadmium batteries will also damage lead-acid batteries.

1. Tools and equipment used for the different battery types should also be color-coded so that they will not be used interchangeably. If the use of paint to color-code tools is contrary to the tool control program because of foreign object damage (FOD), the use of hand-dipped insulation should be considered. Ideally, the color-code should be red (pink) for the lead-acid shop and blue for the nickel-cadmium shop. The color-coding or tools and the color-codes used shall be as directed by the local tool control.

2. If there is a shortage of tools and it becomes necessary to use the same tools for both the nickel-cadmium and lead-acid batteries, neutralize the tools of any acid contamination prior to use on nickel-cadmium batteries.

3. Tools can be neutralized for acid by rinsing them in clean water, preferably hot water and then immersing them in a solution of sodium bicarbonate (EC-074), followed by an additional rinse with clean tap or distilled water.

4. A three percent by weight boric acid solution boric (EC-075) may be used as a neutralizing agent for cleaning tools contaminated with potassium hydroxide solution. In this case, also, use water freely to rinse.

NOTE

Ensure that a premixed container of 3 percent by weight boric acid solution (EC-075) is readily available to clean tools and neutralize spills on skin. Do not use to flush eyes.

11-33. BATTERY RECORDS.

Proper maintenance is essential if the battery is to achieve maximum life and performance. Associated with good maintenance practices is the keeping of accurate records. These records serve as a verification of maintenance accomplished, provide information for determining usage rates, establish optimum servicing procedures, and determine cause for removal of battery from helicopter.

NICKEL-CADMIUM HELICOPTER BATTERY HISTORY CARD

<table>
<tr><td colspan="2">SERIAL NO.</td><td>CELL MFR</td><td colspan="2">BATTERY TYPE</td><td>HELICOPTER TYPE</td><td>RATED CAPACITY
AH</td><td>MAINT INT
DAYS</td></tr>
<tr><td colspan="6">BATTERY SERVICING</td><td colspan="2">HELICOPTER INSTALLATION</td></tr>
<tr><td rowspan="2">NEXT SERVICE DUE DATE</td><td colspan="5">BATTERY ISSUED</td><td rowspan="2">HELICOPTER NUMBER</td><td rowspan="2">INITIALS</td></tr>
<tr><td colspan="2">DATE</td><td colspan="3">ACTIVITY</td></tr>
<tr><td></td><td colspan="2"></td><td colspan="3"></td><td></td><td></td></tr>
<tr><td></td><td colspan="2"></td><td colspan="3"></td><td></td><td></td></tr>
<tr><td></td><td colspan="2"></td><td colspan="3"></td><td></td><td></td></tr>
<tr><td></td><td colspan="2"></td><td colspan="3"></td><td></td><td></td></tr>
</table>

NOTE: Post where visible when installed in helicopter

E/SPM-11-11

Figure 11-11. Battery history card

11-34. Shop and helicopter record of battery service.

A form similar to that shown in figure 11-11 shall be affixed to each main and spare nickel-cadmium aircraft battery as a record of battery service. The use of the form on avionics batteries is optional. The form shall be completed as follows:

CAUTION

THE DECAL MUST BE POSTED WHERE IT IS VISIBLE TO INSPECTORS. IT SHOULD BE PLACED ON THE MAIN BODY OF THE BATTERY WHENEVER POSSIBLE.

1. **Serial number.** Manufacturers serial number of the battery, or serial number assigned by the user.

2. **Cell manufacturer.** The manufacturer of the cells that make up the battery. This may be different from the manufacturer of the battery case.

3. **Battery type.** The standard number of the battery.

4. **Helicopter type.** The type helicopter in which the battery is installed.

5. **Rated capacity.** The rated capacity of the battery as determined by the AH standard for the battery.

6. **Maintenance interval days.** The maintenance interval for the battery as established by the user.

7. **Next service due date.** Date battery is due for servicing as determined by the user, figured from the date of issue.

8. **Battery issued date/activity.** Date the battery leaves battery shop and activity performing maintenance.

9. **Helicopter number.** Registered number of helicopter.

10. **Initials.** The initials of the individual that installed the battery on the helicopter.

11-35. Nickel-cadmium helicopter battery service record.

The form shown in figure 11-12 and 11-13 shall be used and retained for each nickel-cadmium battery serviced in the battery shop.

11-36. SPECIAL EQUIPMENT AND TOOLS.

In addition to the charger/analyzer, the materials and tools listed in table 11-4 shall be available for servicing nickel-cadmium batteries.

Table 11-4. Nickel-cadmium special equipment and tools

EQUIPMENT	TOOLS
Apron, rubber/plastic	Applicator, retaining ring
Charger/analyzer	Brushes, acid, artist, paint
Gloves, rubber	Flashlight
Goggles, chemical	Gauge, receptacle pin
Multimeter, digital or analog	Needle, hypodermic
Shield, face	Puller, cell
Thermometer	Syringe, battery filler
Stop watch	Syringe, disposable
Torque wrench	Shorting clips (1 per cell)

11-37. CALIBRATION OF EQUIPMENT.

All meters and test equipment used to service the nickel-cadmium batteries shall be calibrated periodically.

11-38. BATTERY SHOP SAFETY PROCEDURES.

The following safety precautions shall be observed at all times when working in a nickel-cadmium battery shop.

11-39. GENERAL WARNINGS.

1. ONLY AUTHORIZED PERSONNEL INSTRUCTED IN MAINTENANCE PRECAUTIONS AND ASSOCIATED HAZARDS SHOULD BE ASSIGNED.

2. NO METAL JEWELRY SHALL BE WORN; IF A SHORT OCCURS ACCOMPANYING HEAT WOULD RESULT IN A SERIOUS BURN.

NICKEL – CADMIUM BATTERY SERVICE RECORD

ORGANIZATION	DATE	HELICOPTER NO.	HELICOPTER TYPE

BATTERY MANUFACTURER	BATTERY TYPE	SERIAL NO.	DATE LAST ISSUED

A–Inspect for:	yes	no	Clean:
CASE AND/COVER DAMAGE			☐ BATTERY CASE AND COVER
CELLS: LEAKING			
VENT CAPS (MISSING/BROKEN)			
DETERIORATION			☐ CONNECTORS, LINKS, CELL TOPS
DAMAGE			
CORROSION: LINKS, CONNECTORS			

B–Electric leakage test:

LEAKAGE CURRENT:______ MILLIAMPS/+ TERM. TO CASE ______ MILLIAMPS/– TERM. TO CASE

NOTE: LESS THAN 1.0 MA/RATED A/H ALLOWED. IF EXCESSIVE PERFORM STEP __C.__ THEN __F.__

C–Capacity determination charge: TIME: start_____ finish_____

1 – FIVE TO TEN MINUTES AFTER TURNING ON CHARGER, MONITOR THE ON–CHARGE VOLTAGE OF EACH CELL.
A. LOW VOLTAGE (LESS THAN 1.0 VOLT, SHORTED CELLS, REVERSE POLARITY).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

INDICATE DISCREPANT CELLS

STOP CHARGING OPERATION IF ANY CELL IS SHORTED, MEASURES LESS THAN 1.0 VOLT, OR HAS REVERSE POLARITY. PERFORM STEP __F.__, THEN STEP __G.__ .

2 – DURING THE LAST TEN MINUTES OF INITIAL ON–CHARGE, MEASURE THE VOLTAGE OF EACH CELL.
A. CELL VOLTAGE BELOW AVERAGE (0.1 VOLT LESS THAN AVERAGE OF ALL CELLS).
B. CELL VOLTAGE ABOVE ANY MINIMUM CELL VOLTAGE (VOLTAGE OF 0.1 VOLTS OR GREATER THAN CELLS ABOVE MINIMUM (1.4 VOLTS) CELL VOLTAGE).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

INDICATE DISCREPANT CELLS

A VOLTAGE LESS THAN 1.4 VOLTS INDICATES DAMAGED CELL. PERFORM STEP __F.__, THEN STEP __G.__ .
HIGH VOLTAGE INDICATES CELL LOW IN ELECTROLYTE. (ADD ONE (1)/TWO (2) DROPS OF DISTILLED WATER TO LOWER HIGH VOLTAGE.

3 – AFTER 54 MINUTES OF DISCHARGE (1–HOUR RATE) OR 1 HOUR 48 MINUTES (2.0 HOUR RATE) CHECK THAT EACH CELL IS AT LEAST 1.0 VOLT.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

INDICATE DISCREPANT CELLS

A. IF ALL CELLS MEASURE OVER 1.0 VOLT, ALLOW THE DISCHARGE TO CONTINUE. *
B. IF ANY CELL MEASURES LESS THAN 1.0 VOLT, PERFORM STEP __D.__ , AND __E.__, THEN __C.__ .

* THE CHARGER/ANALIZER AUTOMATICALLY MAKES A GO/NO-GO DECISION AS TO BATTERY CAPACITY AT THE END OF THE DISCHARGE CYCLE.
C. CAPACITY TEST YIELD____ AMPERE–HOURS.

SIDE 1

E/SPM-11-12

Figure 11-12. Battery service record

NICKEL – CADMIUM BATTERY SERVICE RECORD

D–Cell equalization (Deep discharge)

1. ☐ USING CHARGER/ANALYZER, DEEP DISCHARGE FUNCTION, ALLOW BATTERY TO DISCHARGE UNTIL INDIVIDUAL CELLS DROP BELOW 0.50 VOLT.
2. ☐ SHORT OUT INDIVIDUAL CELLS (BELOW 0.50 VOLT). CONTINUE THIS PROCESS UNTIL OVERALL BATTERY VOLTAGE DROPS BELOW 10 VOLTS. CONNECT INDIVIDUAL 5 WATT 1/2 OHM SHORTING RESISTORS ACROSS ALL REMAINING BATTERY CELLS.
3. ☐ BATTERY SHORTED MINIMUM OF 16 HOURS.
4. ☐ REPLACE DAMAGED CELLS (LEAKING, SHORTED). CELLS THAT FAIL TO CHARGE ABOVE MINIMUM VOLTAGE SHOULD BE DEEP CYCLED TWO/THREE TIMES BEFORE BEING DISCARDED.

E–Charge after equalization — TIME: start______ finish______

1. ☐ REMOVE ALL SHORTING STRAPS AND PREPARE BATTERY FOR CHARGING.
2. ☐ PERFORM CAPACITY DETERMINATION CHARGE PER STEP C.
3. ☐ CAPACITY TEST YIELD ________ AMPERE–HOURS.

F–Cell discharge and disassembly (Cells marked for replacement and cleaning)

1. ☐ CELLS EQUALIZED (DISCHARGED) MINIMUM FOUR HOURS. STEP D.
2. ☐ DISASSEMBLE BATTERY FOR REPAIR
3. ☐ REMOVE DEFECTIVE CELLS, REPLACE WITH NEW/SERVICEABLE CELLS (DISCHARGED TO ZERO VOLTS)
4. ☐ REPLACE DEFECTIVE PARTS, VENT CAPS, CONNECTORS, ETC.
5. ☐ CLEAN AND DRY ALL PARTS.
6. ☐ REASSEMBLE BATTERY USING PROPER TORQUE VALUES.
7. ☐ IF CELLS REPLACED, PROCEED TO STEP E, THEN STEP C.
8. ☐ IF NO CELLS REPLACED, PROCEED TO STEP G.

G–Final charge (No cells marked for replacement)

1. ☐ CELL VENT CAPS CLEANED AND CONTAINER VENTS CHECKED FOR OBSTRUCTIONS.
2. ☐ CHARGE COMPLETED TIME ________
3. ☐ ELECTROLYTE ADJUSTED TIME ________
4. ☐ INTERCELL AND TERMINAL CONNECTIONS TORQUED TO PROPER VALUES.
5. ☐ BATTERY CONTAINER AND COVER PROPERLY MARKED.
6. ☐ ELECTRICAL LEAKAGE WITHIN LIMITS AS PER STEP B.
7. ☐ INTERCELL CONNECTORS COATED WITH CORROSION PREVENTIVE.
8. ☐ CELL VOLTAGE BALANCED WITHIN LIMITS.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

ACTUAL READINGS OPTIONAL

REMARKS

DATE SERVICING COMPLETED ___________ BOOST CHARGED OR TRICKLE ___________ CHARGED BEFORE ISSUED _________ DATE ISSUE FOR INSTALLATION ___________

CERTIFIED BY (SIGNATURE AND TITLE) ______________________ DATE ______________

SIDE 2

E/SPM-11-13

Figure 11-13. Battery service record

3. THE GASSES EVOLVED FROM A CHARGING BATTERY ARE A MIXTURE OF HYDROGEN AND OXYGEN GASSES THAT WOULD PRESENT AN EXPLOSIVE HAZARD IF A SPARK OR FLAME OCCURS NEAR THEM. THEREFORE, THE AREA WHERE TESTING IS PERFORMED SHALL BE WELL VENTILATED AND NO SMOKING OR OTHER ACTIVITY THAT MAY GENERATE SPARKING SHALL BE PERMITTED IN THE IMMEDIATE AREA.

4. WHEN NECESSARY TO MOVE OR ALTER AN EXISTING TEST SETUP, CONNECTIONS SHALL BE REMOVED FIRST FROM THE BATTERY OR POWER SUPPLY AND THEN FROM THE MEASURE EQUIPMENT. THIS WILL ELIMINATE THE CHANCE OF SHORTING AND SPARKING WHICH COULD RESULT IN AN EXPLOSION OR INJURY FROM EXCESSIVE HEAT.

5. ALL ACTUATING SWITCHES ON CONTROL UNIT SHALL BE IN THE OFF POSITION PRIOR TO CONNECTING OR DISCONNECTING A BATTERY.

6. WHEN NECESSARY TO REMOVE THE CONNECTORS OR CABLES FROM THE CHARGE UNIT PANEL, EXTREME CAUTION MUST BE EXERCISED WHEN INSTALLING THEM TO ENSURE PROPER POLARITY AND FIT.

7. CAUTION MUST BE OBSERVED WHEN HANDLING BATTERIES. SERIOUS INJURY COULD OCCUR BY LIFTING AND HANDLING INCORRECTLY. ALL PERSONNEL INVOLVED SHALL BE PROPERLY INSTRUCTED IN CORRECT LIFTING AND HANDLING TECHNIQUES.

8. CLOTHING AND EQUIPMENT WORN OR USED WHILE WORKING WITH BATTERIES SHOULD BE OF A TYPE NOT LIKELY TO STORE A STATIC ELECTRICAL CHARGE.

9. BATTERIES, EQUIPMENT, AND SPACES MUST BE KEPT CLEAN. POTABLE TAP WATER IS ADEQUATE FOR CLEANING BATTERY SURFACES.

10. DELUGE SHOWER AND EYE WASH SHALL BE PROVIDED.

11. DO NOT MAKE REPAIRS TO BATTERY CONNECTIONS WHILE CIRCUIT IS ENERGIZED.

12. ENSURE THAT BATTERY SHOP IS EQUIPPED AT ALL TIMES WITH FIRST AID MATERIAL, PROPERLY LABELED, FOR NEUTRALIZATION OF ELECTROLYTE THAT MIGHT COME IN CONTACT WITH THE SKIN. WASH EYES WITH WATER ONLY.

13. DO NOT CARRY ELECTROLYTE IN OPEN-TOP CONTAINERS. KEEP GLASS CONTAINERS PROTECTED AGAINST BREAKAGE.

14. CONTAINERS OF ELECTROLYTE SHOULD NEVER BE PLACED NEAR HEATING PIPES OR ALLOWED TO STAND IN DIRECT SUNLIGHT.

15. WEAR CHEMICAL GOGGLES, APRON, AND RUBBER GLOVES WHEN ADJUSTING OR HANDLING ELECTROLYTE.

16. ANY NICKEL-CADMIUM BATTERY EQUIPMENT WITH AN MS3509 RECEPTACLE, THAT LEAVES THE BATTERY SHOP, SHALL HAVE A PROTECTIVE PLASTIC COVER(S) OVER THE RECEPTACLE PINS.

11-40. FACTORS AFFECTING SERVICE LIFE.

11-41. ADJUSTMENT OF ELECTROLYTE LEVEL.

The electrolyte level of cells in a nickel-cadmium battery shall not be adjusted when the state of charge is unknown.

11-42. Adjusting electrolyte level.

1. The level of the electrolyte shall be adjusted, in most cases, during the last 15 minutes of the topping charge. Adjust to a level of 1/8 - 1/4 inch above the cell baffle. In instances where the battery is subjected to severe vibration and/or overcharging, the electrolyte level may be adjusted to the bottom of the cell baffle immediately prior to the end of charge. This may be necessary to prevent flooding of the battery case with electrolyte during flight. Ideally, electrolyte level should be adjusted to maximum level allowed by existing conditions. Consult the battery manufacturer service manual for more details.

2. An inherent characteristic of nickel-cadmium cells is that when they are in a low or discharged condition, the electrolyte is absorbed within the plates and separators to a point where it is not visible from the top fo the cells. When the battery is recharged, the electrolyte level rises. The electrolyte is at its maximum during the final stages of charging when cells are producing gas bubbles.

CAUTION

DO NOT ADD WATER TO A NICKEL-CADMIUM BATTERY WHEN INSTALLED IN THE HELICOPTER.

11-43. Adding water.

Water should not be added to nickel-cadmium cells while the battery is in the helicopter and the state of charge is unknown. As the battery receives its charge from the helicopter bus, electrolyte may boil or spew through cell vent caps if excessive water is present. Potassium carbonate may eventually plug the vents of the cell caps. Should vents become plugged, pressure immediately builds up in cells as gas accumulates. When sufficient pressure builds up, electrolyte will be forced from the cells. It may then flow over the top of cells and down into the case bottom between cells. The overflow of electrolyte eventually starts corrosion and may cause a short circuit between cell connectors. The chain of events, particularly the accumulation of hydrogen, can lead to an explosion. An igniting spark could be caused by a loose cell connection or a short circuit between cell connectors resulting from the spewed electrolyte.

11-44. Thermal runaway.

1. Thermal runaway is a condition in which current for a charged nickel-cadmium battery rises out of all proportion to the charging voltage.

2. Thermal runaway occurs in an overcharged state. After the battery is fully charged, excess charging energy is dissipated as heat. Continued overcharging under certain conditions has the effect of reducing internal battery resistance so that it draws a higher current from the charging voltage. As temperature of the battery increases, the effective internal resistance continues to decrease, and current becomes progressively greater. This process continues and eventually destroys the battery.

3. Thermal runaway may be detected by the following signs:

a. Battery temperature shows a significant rise at the end of charge above 100°F (37.8°C).

b. Current gradually rises rather than gradually decreasing.

c. If constant current charging method is used, runaway will be indicated by a decrease of battery voltage rather than an increase.

11-45. OVERHEATED NICKEL-CADMIUM BATTERIES.

Overheated nickel-cadmium batteries shall be handled as follows:

11-46. GENERAL WARNINGS.

1. WHEN A NICKEL-CADMIUM AIRCRAFT BATTERY IS BEING SERVICED IN THE BATTERY SHOP ON A CHARGER/ANALYZER, IT IS HIGHLY UNLIKELY THAT THE ENTIRE BATTERY WILL OVERHEAT TO THE DANGEROUS LEVELS SOMETIMES EXPERIENCED ABOARD A HELICOPTER. THIS IS BECAUSE OF VOLTAGE AND CURRENT CONTROL OFFERED BY THE CHARGER. A TRUE "THERMAL RUNAWAY" DOES NOT OCCUR WHEN THE BATTERY IS ON THE CHARGER/ANALYZER AS, BY DEFINITION, IN A "THERMAL RUNAWAY" THE CHARGE CURRENT INCREASES AS BATTERY IMPEDANCE DECREASES, THE CHARGE CURRENT OF THE CHARGER/ANALYZER IS PRESENT AND FIXED.

2. IT IS POSSIBLE, HOWEVER, FOR INDIVIDUAL CELLS WITHIN A BATTERY TO OVERHEAT TO DANGEROUS LEVELS. THIS OCCURS WHEN SEPARATOR MATERIAL WITHIN A CELL BREAKS DOWN AND ALLOWS A NEGATIVE AND A POSITIVE PLATE TO MAKE CONTACT WITH EACH OTHER. THIS ACTION CREATES A "HOT SPOT" THAT IS CHARACTERIZED BY INCREASED PRESSURE WITHIN THE CELL WHICH FORCES HOT ELECTROLYTE, STEAM, AND SMOKE FROM THE CELL VENT CAP. THIS "HOT SPOT" CAN PROGRESSIVELY BURN ITSELF FROM ONE CELL TO THE NEXT UNLESS THE CELL PACK CAN BE COOLED DOWN.

3. ALTHOUGH EXPLOSIVE GASSES CAN BE DISCHARGED FROM AN OVERHEATED NICKEL-CADMIUM BATTERY, THE GREATEST HAZARD TO BATTERY SHOP PERSONNEL IS SPEWING OF HOT ELECTROLYTE.

4. IF THE BATTERY IS ON FIRE AND FLAMES ARE PRESENT, A CO_2 FIRE EXTINGUISHER SHALL BE USED TO EXTINGUISH THE FIRE. DO NOT USE A CO_2 FIRE EXTINGUISHER IF FLAMES ARE NOT PRESENT AS THE STATIC DISCHARGE FROM THE

FIRE EXTINGUISHER NOZZLE MAY IGNITE ANY EXPLOSIVE GASSES THAT ARE PRESENT WITHIN THE BATTERY SHOP.

5. IF THE BATTERY IS NOT ON FIRE OR FIRE HAS BEEN EXTINGUISHED, PERSON(S) REQUIRED TO HANDLE THE BATTERY SHALL DRESS WITH PROTECTIVE GEAR TO COMPLEMENT THEIR STANDARD WORK CLOTHES. AS A MINIMUM THIS SHALL CONSIST OF A FULL FACE SHIELD, A LONG SLEEVE SHIRT OR JACKET, FULL-LENGTH RUBBER OR PLASTIC APRON, AND LONG RUBBER GLOVES.

6. TURN OFF THE CHARGER/ANALYZER AND DISCONNECT THE CHARGE/DISCHARGE CABLE FROM THE BATTERY. THE FIXTURE SHOULD BE REMOVED IN SUCH A MANNER AS TO DIRECT ANY ELECTROLYTE SPEWAGE AWAY FROM THE PERSON(S) INVOLVED.

7. PLACE A BATTERY COVER ON THE BATTERY. QUICKLY TRANSPORT THE BATTERY TO A LOCATION WHERE THE BATTERY CASE CAN BE FLOODED WITH COLD WATER. A DEEP SINK, WATER SPIGOT, GARDEN HOSE, ETC., WILL SUFFICE.

8. REMOVE THE COVER AND FILL BATTERY CASE WITH COLD WATER. THE WATER SHOULD COVER THE CELL PACK COMPLETELY AND IT SHOULD BE ALLOWED TO RUN TO DISSIPATE HEAT WITHIN THE CELLS. DROPPING THE BATTERY INTO A CONTAINER OF SUFFICIENT SIZE THAT IS FULL OF WATER MAY ALSO BE USED AS AN ALTERNATE METHOD OF COOLING THE BATTERY.

9. AFTER THE BATTERY COOLS TO THE POINT WHERE GAS BUBBLES ARE NO LONGER VISIBLE, WATER MAY BE DUMPED FROM THE CASE AND THE BATTERY DISASSEMBLED AND REPAIRED.

10. THE ABOVE PROCEDURE IS ALSO THE PROCEDURE FOR HANDLING OVERHEATED NICKEL-CADMIUM BATTERIES ABOARD THE HELICOPTER.

11-47. TEMPORARY LOSS OF CAPACITY.

1. An important characteristic observed in nickel-cadmium batteries is temporary loss of capacity of sleepiness (also referred to as memory fading). When this temporary loss occurs, the battery is unable to delivery full capacity. The loss of capacity is a result, in part, of shallow discharge cycles and recharging with a constant potential voltage, such as might occur under moderate usage in a helicopter.

2. Loss-of-capacity effect is more common when recharging a battery across a constant potential bus, such as in helicopter, then when recharging with constant current. Loss of capacity is usually an indication of imbalance between the cells because of differences between individual cells in temperature, charge efficiency, and self-discharge rate. Full capacity is regained when the battery is deep cycled.

3. In order to minimuze the loss-of-capacity problem, nickel-cadmium helicopter batteries shall be removed from the helicopter for servicing in accordance with the maintenance requirement cards.

11-48. Cell gassing.

The tendency of nickel-cadmium cells to gas during the charge increase with cell temperature for a given cell voltage. Cell gassing characteristics will vary somewhat among manufacturers and cell types. A certain amount of gassing is necessary for a battery to become fully charged. The danger is in excessive or violent gassing, which might occur under abnormal conditions in a helicopter, leading to possible explosion or damage to the battery.

11-49. Shock and vibration.

Nickel-cadmium batteries are capable of withstanding unusual shock and vibration. However, vibration should be kept to a minimum or electrolyte in cells will tend to bubble and may overflow through vent caps.

11-50. Extreme temperature operation.

1. Nickel-cadmium batteries display significantly greater low-temperature operation capability than the lead-acid battery. Its capacity will be somewhat degraded at high temperatures.

2. In general, the lower the battery temperature, the longer the time required for charging. Charging with constant current at low temperature will usually result in higher battery voltage than is experienced at recommended ambient temperatures. The voltage decreases with an increase in discharge rate and/or a decrease in temperature. Nickel-cadmium batteries seem to charge better at room temperature between 70 to 80°F.

11-51. STORAGE/SHIPPING.

1. Nickel-cadmium batteries can be stored in any state-of-charge. However, long-term storage in a charged condition at elevated temperature is not recommended. The rate of self-discharge is approximately 0.7 percent per day in storage at 80°F (26.7°). At this rate, a battery would deliver about 90 percent of its actual capacity two weeks after charge.

2. Any nickel-cadmium helicopter battery, other than the sealed-cell type, that is to be stored in excess of thirty days, shall be discharged to zero volt per cell, battery terminals shorted with bus wire, vent caps in place and electrolyte in cells. Under no circumstances shall the electrolyte be dumped or vent caps removed for storage.

3. Dumping of electrolyte and removal of vent caps results in oxidation of plate materials and contamination of electrolyte. Both actions are extremely detrimental to cells, and will probably render them inoperable.

4. Nickel-cadmium batteries should be stored at temperatures not exceeding 130°F (54°C). Any nickel-cadmium battery, other than the sealed-cell type, that is to be shipped to a distance user, should be discharged to zero volt per cell and the battery terminals shorted with bus wire. Shipping of the batteries shall be in accordance with manufacturers shipping instructions. Batteries that have to be transported in a charged condition for installation into a helicopter shall be packaged in accordance with existing shipping regulations.

5. Any nickel-cadmium battery equipped with a MS3509 receptacle, that leaves the battery shop, shall have a protective plastic cover(s) (item 12, table 11-4, Materials) over the receptacle pins.

11-52. ELECTROLYTE REQUIREMENTS AND ADJUSTMENTS.

11-53. Mixing electrolyte.

WARNING

THE ELECTROLYTE USED IN NICKEL-CADMIUM BATTERIES IS A STRONG SOLUTION OF POTASSIUM HYDROXIDE THAT IS ALKALINE AND CORROSIVE. SERIOUS BURNS WILL RESULT IF THE ELECTROLYTE COMES IN CONTACT WITH ANY PART OF THE BODY. USE RUBBER GLOVES, RUBBER APRON, AND PROTECTIVE GOGGLES WHEN HANDLING THE ELECTROLYTE.

IF THE ELECTROLYTE GETS ON THE SKIN, WASH AFFECTED AREAS WITH LARGE QUANTITIES OF WATER OR TAKE A SHOWER IMMEDIATELY. NEUTRALIZE WITH 3 PERCENT BORIC ACID SOLUTION AND WASH WITH WATER.

IF THE ELECTROLYTE GETS INTO THE EYES, WASH EYES WITH LARGE QUANTITIES OF WATER AND SEEK IMMEDIATE MEDICAL ATTENTION.

IF ELECTROLYTE HAS BEEN TAKEN INTERNALLY, DRINK LARGE QUANTITIES OF WATER AND A WEAK SOLUTION OF LEMON JUICE, ORANGE JUICE, OR VINEGAR: FOLLOW WITH WHITE OF EGG, OLIVE OIL, MELTED BUTTER, STARCH WATER, OR MINERAL OIL. SEEK IMMEDIATE MEDICAL ATTENTION.

DURING PREPARATION OF THE ELECTROLYTE, ALWAYS POUR THE POTASSIUM HYDROXIDE INTO THE WATER SLOWLY AND ALLOW IT TO DISSOLVE; OTHERWISE, VIOLENT BOILING WILL OCCUR, AND THE RESULTANT MIXTURE MAY SPLATTER ON THE PERSON PREPARING THE ELECTROLYTE.

CAUTION

POTASSIUM HYDROXIDE IS SOMEWHAT CORROSIVE TO GLASS. ALL GLASS CONTAINERS, HYDROMETERS, OR OTHER DEVICES USED THAT CONTAIN GLASS SHOULD BE THOROUGHLY WASHED AFTER CONTACT WITH ELECTROLYTE.

1. The electrolyte used for the nickel-cadmium battery is a solution of 70 percent, by weight, of distilled water and 30 percent potassium hydroxide. The specific gravity of this mixture is 1.300. When these liquids are mixed, heat is generated, raising the temperature of the mixture. After a battery has been in use for some time, specific gravity may change slightly. Unless it falls outside the range of 1.240 to 1.320, the effect of the change on battery performance is usually insignificant.

2. Due to the hazards involved in mixing electrolyte, it is recommended that only premixed electrolyte be used.

11-54. Adjustment of electrolyte level.

CAUTION

THE ELECTROLYTE LEVEL OF THE NICKEL-CADMIUM BATTERY SHALL NOT BE ADJUSTED ON THE HELICOPTER. SUCH AN ADJUSTMENT WOULD CREATE RISK OF OVERFILLING AND RESULT IN OVERFLOW AND POSSIBLE DAMAGE DURING CHARGING.

1. The electrolyte level should be adjusted in the shop during the topping charge and according to manufacturers recommendations. When the battery is in a discharged condition, the electrolyte is absorbed within the plates and separators. Immediately after charge electrolyte is at maximum height but settled somewhat after the battery stands for a few hours. Unless spillage has occurred, the electrolyte level is adjusted by adding distilled water.

2. The electrolyte level should be adjusted 0.125 to 0.250 inch above the cell baffle. In instances where the battery is subjected to severe vibration and/or overcharging, the electrolyte level may be adjusted to the bottom of the cell baffle immediately prior to the end of charge. This may be necessary to prevent flooding of the battery case with electrolyte during flight.

3. Use of level checker. The electrolyte level checker and the electrolyte removal tool (figure 11-14) are useful in checking the electrolyte level. Use as follows:

a. Insert the electrolyte level checker into the filler opening deep enough to touch the bottom of the baffle. Place a finger over top open end of tube and remove tube from filler well. Electrolyte level in the tube is a measure of electrolyte level in the cell.

b. The electrolyte removal tool automatically removes excess electrolyte from the cell. Wash each tool after use.

4. Cell cap. To ensure that the electrolyte settled properly before adjustment, it is advisable to unlock but not remove the cell cap during charge.

5. Foam. Although foam will sometimes be noticed in cells during charge, it does not indicate a defect and is harmful only if it results in overflow and causes shorts or corrosion. If there is enough foam to spill, it may be floated off during end of charge by filling cell to the brim with electrolyte. After most of the foam has been eliminated, reduce electrolyte to proper level, clean vents and gaskets in water, and reinstall. If required, discharge battery, disassemble, and clean with water, but do not get water into cells. Dry all parts thoroughly, reassemble, charge, and then return the battery to service. Foaming is more likely to occur after water has been added. It will usually disappear after a few cycles of operation. Petroleum based contaminates are a possible cause of foaming.

6. Specific gravity measurement and temperature correction of electrolyte. A hydrometer is used to determine the specific gravity of the electrolyte. The type of hydrometer commonly used consists of a small sealed glass tube that is weighted on one end so that it will float upright. Within the narrow stem of the tube is a scale for reading the specific gravity of the electrolyte (uncorrected for temperature).

7. Reading hydrometer (figure 11-15). Place rubber nozzle of hydrometer into vent opening of battery and draw enough liquid into barrel to permit the float to ride free. The float must not touch side, top, or bottom of barrel. Hold vertical and at eye level. If hydrometer has to be removed from the vent, pinch nozzle tightly or place gloved finger against opening to prevent dripping of electrolyte. Read float scale at electrolyte level. Disregard curvature of liquid.

8. No hydrometer reading is to be considered correct until a temperature correction has been applied. Some hydrometers have built-in small thermometers and correction scales to that temperature correction can be readily made. If a temperature-correcting hydrometer is not available, any hydrometer may be used and temperature corrections made from existing electrolyte temperature as indicated by some other thermometer.

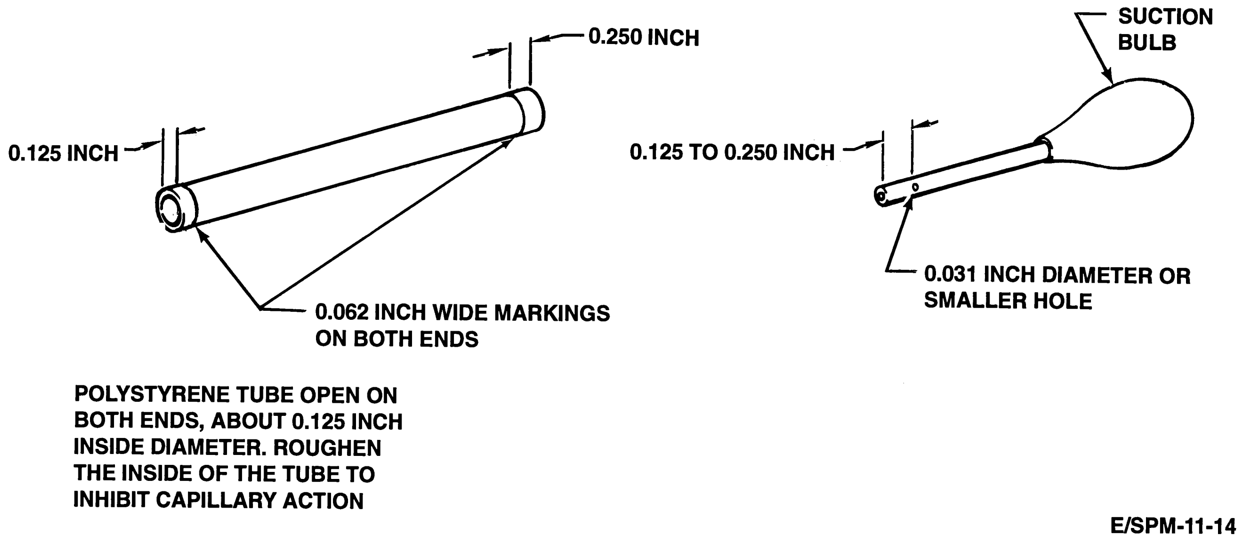


Figure 11-14. Electrolyte level and removal syringe

11-55. BATTERY SERVICING PROCEDURES USING MODEL RF80H AUTOMATIC REFLEX CHARGER/ANALYZER.

11-56. RF80H AUTOMATIC CHARGER/ANALYZER.

Paragraphs 11-56 through 11-85 detail procedures for testing nickel-cadmium aircraft batteries using the RF80H charger/analyzer. Table 11-5 lists the test parameters for the batteries used on Bell helicopters that may be tested on the RF80H charger/analyzer. For a more complete listing, reference Christie Electric Corp. (02294) manual TD-A6 Operating Instructions.

The controls and indicators for (02294) Model RF80H charger/analyzer are shown in figure 11-16.

CAUTION

BEFORE SERVICING THE BATTERY, MAINTENANCE PERSONNEL SHOULD BE THOROUGHLY FAMILIAR WITH THE EQUIPMENT TO BE USED AND THE PROPER TEST PROCEDURES, CHARGING, AND DISCHARGING RATES. THE NICKEL-CADMIUM AIRCRAFT BATTERY SERVICING RECORD, FIGURE 11-12 AND 11-13 SHALL BE USED WHEN SERVICING BATTERY.

11-57. OPERATIONAL CHARACTERISTICS.

11-58. General.

The charger/analyzer allows automatic rapid charging and analysis of nickel-cadmium batteries. This section includes instructions for standard charging and analysis procedures using the CHRISTIE RF80H and the instructions for various optional procedures.

11-59. Standard automatic operation.

The charger/analyzer provides an automatic three/cyclic for battery charging and analysis. During the first cycle the battery is ReFLEX for a specified time period, and then automatically switched to the second cycle. The second cycle is a constant-current discharge analysis cycle in which actual ampere-hour capacity (LONG CYCLE) or pre-programmed capacity (SHORT CYCLE) of the battery is established. If the battery fails this test, the red BATTERY REJECT indicator will illuminate and the battery will not recharge. If the battery passes the analysis cycle tests, it is automatically switched to the final recharge cycle in which it is again ReFLEX charged to full capacity and the green CYCLE COMPLETE indicator will illuminate.

11-60. Digi-flex operation.

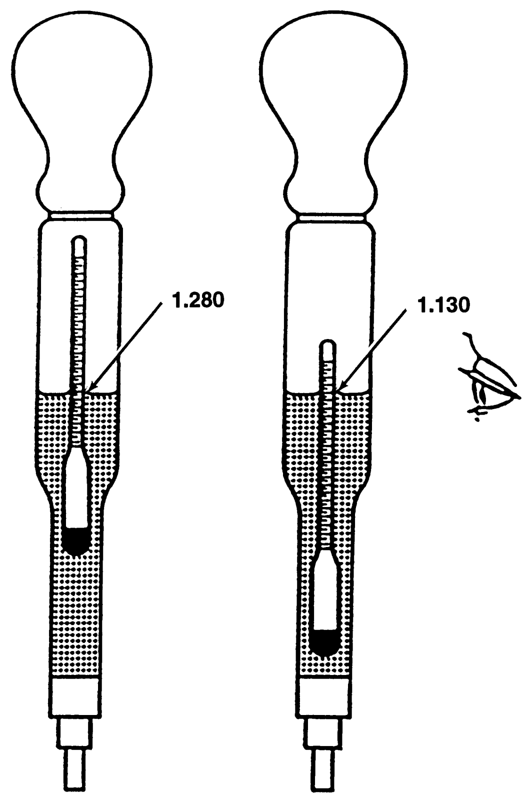
The green bar display, during the last few minutes of CHARGE, gives an indication of relative state-of-charge and state-of-health of the battery connected to the charger/analyzer. Green bars start to appear at about 90 percent of attainable battery capacity. Ni-Cad battery characteristics differ by brand, type, service history, etc. Thus, one battery may be fully charged when eight green light up, yet another battery may produce eight bars and not yet be fully charged.

NOTE

> Some batteries may have higher ampere-hour capacity than stated. In such cases continue charging until maximum number of green bars are obtained.

11-61. BATTERY ANALYSIS AND ACCEPTANCE CRITERIA.

After the charger/analyzer has set up, refer to table 11-6. Observe the red pulses of the Bar Display. Also observe its green pulses depending upon the battery state-of-charge. Red pulses show the magnitude of the charging current. Green pulses show the approximate state-of-charge of the battery when ReFLEX charging. In addition, green identifies whether the charger/analyzer is set to ReFLEX or Constant Current charging. A non-pulsing green display identifies the discharge (analyze) mode.



E/SPM-11-15

Figure 11-15. Reading a hydrometer

Table 11-5. Battery data

USAGE HELICOPTER MODEL	BHT PART NO.	VENDOR PART NO.	VENDOR	MFG RATING VOLTS	C RATING	CELLS
204B		MS24498-1	SONOTONE			
205A	214-175-380	24535-10	MARATHON	24.0	30	19
205A1	214-175-380	24535-10	MARATHON	24.0	30	19
206A	206-075-742	27662	MARATHON	24.0	13	19
	206-075-742	27662-21 11218 (alternate)	MARATHON	24.0	13	19
206B	206-074-742-103	19230	SAFT	25.2	17	20
	206-075-742	27622-21 11218 (alternate)	MARATHON	24.0	13	19
	206-075-742	29365-01C	MARATHON	25.2	17	20
206B (250-C20B Engine)	206-075-742	27662-21	MARATHON	24.0	13	19
206B3		(SAME)				
206L	206-075-742-101	30450-001	MARATHON	25.2	17	20
206L1	206-075-742-101	16205	SAFT	24.0	17	20
	Replaced by					
	206-075-742-103	19230	SAFT	25.2	17	20
206L3	206-075-742-103	19230	SAFT	25.2	17	20
206L4	206-075-742-103	19230	SAFT	25.2	17	20
212	214-175-380	24535-10	MARATHON	24.0	30	19
214B	214-175-153-007	MAR1811-23	EPI	24.0	20	20
214ST	214-175-380-101	18164-3	EPI	24.0	20	20
222A/B	214-175-380	TMA5-20	MARATHON	25.2	40	20
222U	214-175-380	TMA5-20	MARATHON	25.2	40	20
230		31908-001	MARATHON	25.2	40	20

11-62. BATTERY ACCEPTANCE OR REJECTION CRITERIA.

There are four points in the automatic cycle at which the battery is subjected to pass-fail tests. The first two consists of cell scanning during initial charge cycle, the third test is at the end of the discharging cycle, and the fourth is at the end of the recharge cycle.

11-63. Cell scanning method.

Cell scanning is performed using the red (+) and black (–) probes to measure individual cell voltages. Each cell shall be measured across the positive (+) and negative (–) terminal using the following method:

1. Set DPM switch to the CELL VOLT position.

a. Cell Reading #1: Use this position only after flashing green bars appear during charging. Reading on the digital meter then stands for relative ampere-hours.

b. Cell Reading #2: Use this position only before flashing green bars appear during charging e.g., to detect low electrolyte or shorted cell at beginning of charge, and during discharge. The dampened reading on the digital meter in this position is cell voltage.

NOTE

The voltage fluctuates during damping due to the ReFLEX positive and negative pulses.

2. Start with the cell connected to the red positive (+) terminal of the battery. This is usually considered cell number 1. Measure across cell terminals with probes and observe the cell voltage on the DPM. Record voltage of each cell for future reference.

3. Repeat step 2 for each of the remaining cells.

11-64. Cell scanning during initial charge cycle and recharge cycle.

Cell scanning is performed twice during the initial charge cycle and once during the final recharge cycle. The basic requirements shall be as follows:

1. Cell Voltage Scanning Upon Turn-on. 5 to 10 minutes after turning on the charger, measure voltage of each cell in cell reading position 2. Reject battery if any cell is shorted, measures less than 1.0 volt, or has reverse polarity. Also review step 2.

2. Cell Capacity Scanning During Last 10 Minutes of Charge. During the last 10 minutes of the initial charge and final recharge, use scanning probes, in cell reading position 1, to check whether one or more cell readings are substantially higher or lower than the others. See step 3 in case of abnormal readings.

3. Cell Evaluation Scanning. If a cell voltage is at least 0.1 volt less than the average of all the individual cell voltages, it could be weak and shall be monitored closely for signs of failure throughout the discharge cycle. If any minimum cell voltage is greater by at least 0.1 volt than the other cells, it could have too low an electrolyte level. Add one or two drops of distilled water to lower the voltage. If a cell is obviously defective, such as having a 0 to 1.4 volts total charge, the battery is unsuitable and shall be rejected without further testing.

11-65. Cell voltage scanning during discharge cycle using cell reading position 2.

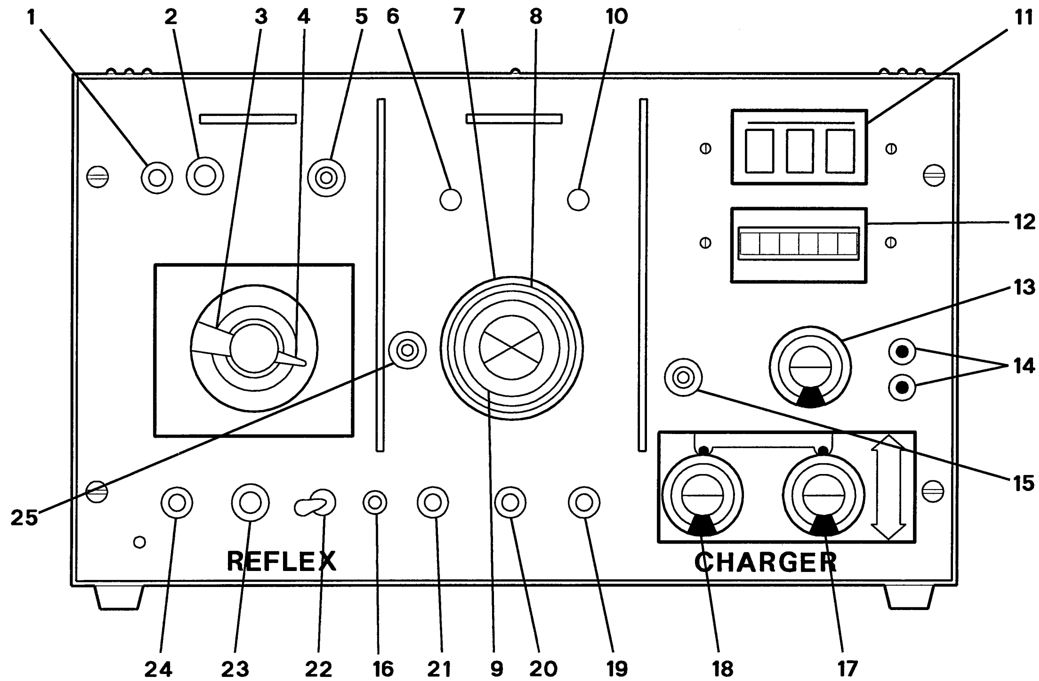
1. After 54 minutes (0.9 on HOURS DISCHARGED dial) of a one-hour discharge cycle or after 1 hour and 48 minutes (1.8 on HOURS DISCHARGE dial) of a two-hour discharge cycle, scan the individual cell voltage a second time. If all cells measure over 1.0 volt, allow discharge cycle to continue.

2. If any cell measures less than 1.0 volt, battery (deep discharge) reconditioning is required as described in paragraph 11-70 regardless of whether the battery passes the battery capacity GO/NO-GO test described in paragraph 11-66.

11-66. GO/NO-GO DECISION IN DISCHARGE CYCLE.

The charger/analyzer automatically makes a GO/NO-GO decision as to battery capacity at the end of the discharge cycle. This decision is predicated upon an average cell voltage of 0.95 volt defining the discharge state. For example, a decision would be made at approximately 18 volts for a 19-cell battery. The GO/NO-GO decisions are as follows:

1. Long cycle. With the discharge cycle selector in the LONG CYCLE, if the HOURS DISCHARGE pointer, which moves clockwise, is past the white GO arrow (at the 12 o'clock position on the panel) when the battery voltage reaches the discharge state decision point, the battery has demonstrated its rated ampere-hour capacity. The charger/analyzer will automatically switch to the final recharge cycle but not until it reaches the voltage corresponding to the number of cells listed in table 11-5 and then will recharge the battery and shut off.



INDEX NO.	NOMENCLATURE	FUNCTION
1	Start Switch (Momentary)	When momentarily operated, supplies power to control circuits and starts operation of unit. The BLOWN FUSE INDICATOR (5) will light as this switch is held down. This verifies that power is present to the unit and that the blown fuse indicator light is good. The switch may be operated at any time during operation to check the fuse.
2	A. C. Switch	Applies primary power to all circuits in the ON position. The OFF position removes power from the unit; however, certain internal circuits will still be at line voltage. Therefore, always remove power from the power cord before opening the cabinet.
3	Hours Charge White Pointer (Center Knob)	Indicates remaining charging time. The white pointer automatically moves counterclockwise from the black pointer position to zero, with the time indicated in 0.1 hour increments by the dial plate on the panel. This pointer automatically resets to the black pointer position when commanded in the automatic cycle and also whenever the CYCLE RESET switch (16) is operated. Rotation counterclockwise to the 0 position automatically places the unit in the discharge mode if the ANALYZER switch (6) is set to ON and the CHG MODE switch (22) is set to ReFLEX.
4	Hours Charge Black Pointer	Sets the total charge time. A range of zero to 3.0 hours (3.6 hours for 50 Hz operation) is provided with increments of 0.1 hour marked on panel dial plate.

E/SPM-11-16-1

Figure 11-16. RF80H Automatic ReFLEX charger/analyzer controls and indicators (Sheet 1 of 3)

INDEX NO.	NOMENCLATURE	FUNCTION
5	Blown Fuse Indicator (Indicator and Fuse Holder)	Lights if abnormal conditions cause panel-mounted 5 ampere fuse F4 to open. If lighted, no ReFLEX charging action takes place even though panel meters indicate charging. Also lights when START switch (1) is operated to verify power to unit and that indicator is good. Fuse F4 is replaced by setting AC switch (2) to OFF and unscrewing cover to indicator. The fuse may then be grasped with two fingers and withdrawn. Fuse F4 is installed by aligning the two fuse prongs with the holder holes and pushing into place.
6	Analyzer Switch	Controls the analyzer (discharge) functions. The OFF position makes the automatic and manual discharge functions inoperative. The ON position enables all analyzer functions.
7	Go/No-Go Dial	Movable dial which sets the GO/NO-GO level for the battery under analysis and indicates discharge time in increments of 0.1 hour over a range of zero to 3.0 hours. The small knob at bottom of dial secures it in place. During use, this dial is set to a time specified by table 11-5 for the particular battery by aligning the specified dial indication with the GO/NO-GO arrow (8).
8	Go/No-Go Arrow	This arrow is the GO/NO-GO point for battery analysis. If the discharge pointer (9) has passed the GO/NO-GO arrow by the time the battery reaches the discharged state, the automatic cycle continues. If the pointer has not reached the arrow by that time, the BATTERY REJECT indicator (20) lights and the charge/analyzer will not start automatic recharging.
9	Hours Discharge Pointer	Timer pointer indicates elapsed discharge time. During use this pointer must be set to zero on GO/NO-GO dial (7) before unit is turned on. When discharge automatically begins, the pointer travels in a clockwise direction. When the battery reaches battery discharge voltage (i.e., 0.95 volts per cell) the pointer movement stops. The elapsed discharged time multiplied by the discharge current equals the actual ampere-hour capacity of the battery in LONG CYCLE. SHORT CYCLE will indicate rated capacity, or less.
10	Discharge Switch	Selects discharge mode for the battery under analysis. The NORMAL position provides a controlled, constant current discharge rate with programmed cycle. The DEEP position provides discharge until manually stopped.
11	Digital Meter Panel (DPM)	Provides value of parameter selected by Meter Switch (13).
12	Bar Display	The red display shows the magnitude of the charging current. When pulsing, the red display identifies the RF80H as being in the ReFLEX charging mode. The green display shows the approximate state-of-charge of the battery when ReFLEX charging. When not pulsing, the green display identifies the discharge (analyze) mode.
13	Meter Switch	Selects parameter to be displayed on DPM (11), e.g.,: charge or discharge current (AMPS), battery voltage (BATTERY VOLTS), or cell voltage (CELL VOLTS). The BATTERY VOLT position automatically applies the overall voltage of the battery under test to the meter. The CELL VOLTS position applies the battery cell voltages monitored with the scanning probes connected to panel jacks (14). Refer to paragraph 11-61.

E/SPM-11-16-2

Figure 11-16. RF80H Automatic ReFLEX charger/analyzer controls and indicators (Sheet 2)

INDEX NO.	NOMENCLATURE	FUNCTION
14	Cell Volts Jacks	Two panel jacks, one red (+) and one black (-), for connection to the cell voltage measurement probes. The signal monitored here is applied to the meter if the meter switch (13) is in the CELL VOLTS position.
15	Battery Type Switch	Selects proper ReFLEX charge for battery type under analysis. Proper setting for each battery type is listed in table 11-5.
16	Cycle Reset Switch	Momentary switch which resets the automatic cycle to the initial charge mode. This switch can be operated at any time to reset the unit to charge mode when CHG MODE switch (22) is in the ReFLEX position.
17	Battery Rating Switch	Selects internal circuit functions compatible with six different battery ampere-hour capacity categories. The battery cable type (twin or yellow band) used with each position is also shown. The switch is set according to battery type to the position as provided in table 11-5.
18	Cells in Series Switch	Selects internal circuit functions compatible with the number of cells (11, 19, 20, or 22) actually in the battery.
19	Discharge Current Adjust Control	Adjustable multi-turn control which sets the constant discharge current rate as indicated on meter (11).
20	Battery Reject Indicator	Red indicator which lights if the battery under analysis fails to have rated ampere-hour capacity as indicated by HOURS DISCHARGE pointer failing to pass the GO arrow (8).
21	Cycle Complete Indicator	Green indicator which lights at the end of the full automatic cycle if the battery has at least "GO" capacity.
22	Charge Mode Switch	Selects charging mode of unit. The ReFLEX position provides normal ReFLEX charging and also allows full automatic operation. The CONST CURRENT position provides constant current charging, at greatly reduced rate, for use in certain types of special tests or applications. No automatic cycle is provided in this mode.
23	Charge Current Adjust Control	Adjustable multi-turn control which sets the charging current rate as indicated on meter (11).
24	Charge Current Adjust Switch	Momentary switch which, when operated, places the unit in the constant current mode. This allows the adjustment of charging current in the ReFLEX mode by CHG CURRENT ADJUST control (23) to be read directly on DPM (11). Refer to table 11-6, Step 15.
25	Short/Long Discharge Cycle Selector	LONG CYCLE allows discharge to continue for actual capacity. SHORT CYCLE will stop discharge at the 12 o'clock position.

E/SPM-11-16-3

Figure 11-16. RF80H Automatic ReFLEX charger/analyzer controls and indicators (Sheet 3)

Table 11-6. Initial setting before turn on and adjustments

STEP	CONTROL OR FUNCTION	NORMAL SETTING	COMMENTS
1.	CELLS IN SERIES Switch	See comments at right. Refer to index 18, figure 11-16.	COUNT ACTUAL NUMBER OF CELLS IN BATTERY. DO NOT RELY ON BATTERY PLATE as cells are sometimes added. Then set to position exactly equal to number of cells in battery. DO NOT, for example, operate a 20 cell battery at 19 cell position.
2.	BATTERY RATING Switch	Set. Refer to index No. 17, figure 11-16.	Battery rating should be based on the one-hour rating. IF CELLS IN SERIES switch or BATTERY RATING switch are in wrong position when unit is turned on, fuse F4 in front panel may blow (amber BLOWN FUSE INDICATOR lighted or flashing) and prevent depolarizing reverse pulses from flowing. This results in increased battery heating and reducing battery capacity. Fuse F4 also may blow if unit is turned on with no battery connected.
3.	BAT TYPE Switch	Set to a position.	Refer to paragraph 11-67. **CAUTION** ALL CELLS MUST BE OF SAME TYPE AND MANUFACTURER.
4.	BATTERY CABLE	Use cable as follows:	**NOTE** A positive interlock system results in no charge output if wrong cable or wrong BATTERY RATING switch position is used. Be sure to remove the yellow covers from the Elcon connector when used. Connect and screw proper cable completely onto connector on right side of unit. Then connect to battery, (+) to (+) and (–) to (–).
	<u>Battery</u>	<u>Battery Cable</u>	
	MARA 30450-001	Yellow	
	MARA 27662-221	Yellow	
	MARA 29365-01C	Yellow	
	SAFT 16205	Yellow	
	SAFT 19230	Yellow	
	GE 43B010RB03	Yellow	
	EP MAR18112-3 MS24498-1		
	EP 18164-3	Twin	
	MARA 24535	Twin	
	MARA TMA5-20	Twin	
5.	HOURS CHARGE Timer	Set as described, under index 4, figure 11-16.	Set charging time by turning black pointer on charge timer. Use proper Hz dial.
6.	GO/NO-GO HOURS DISCHARGE Dial	Set. Refer to index 7 and 9, figure 11-16.	To make GO/NO-GO dial setting, loosen small black locking knob retaining dial position and rotate dial until required number lines up with white arrow on panel. Then tighten locking knob. Other discharge rates between 5 and 50 amps can sometimes be used.

Table 11-6. Initial setting before turn on and adjustments (Cont)

STEP	CONTROL OR FUNCTION	NORMAL SETTING	COMMENTS
7.	HOURS DISCHARGE Pointer	Set to 0 position. Refer to index 19, figure 11-16.	This is at 8 o'clock position for one hour discharge, or the 4 o'clock position for two hour discharge, on 60 Hz dial. During discharge, the discharge pointer will move clockwise toward the white arrow, which is the "GO" capacity point. Use proper Hz dial.
8.	CHG MODE Switch	ReFLEX position. Refer to index 22, figure 11-167.	Always set CHG MODE switch to ReFLEX, except for the optional procedures described in paragraphs 11-67, 11-72, and 11-73. Observe special operating directions.
9.	ANALYZER Switch	On position. Refer to index 6, figure 11-16.	Set to OFF if battery is to be charged only and not analyzed. Refer to paragraph 11-70 for DEEP discharge setting.
10.	DISCHARGE Switch	NORMAL position.	
11.	LONG CYCLE SHORT CYCLE Switch	LONG CYCLE SHORT CYCLE, SHORT CYCLE	Refer to paragraph 11-66, steps 1 and 2 for use of this switch.
12.	AC Switch	ON. Refer to index 2, figure 11-16.	Nothing visible will occur.
13.	START Switch	Press momentarily. Refer to index 1, figure 11-16.	Fan should start. Blown FUSE INDICATOR should light up momentarily while switch is depressed. If it does not come on, check light again by depressing START switch 30 seconds after charge current has been adjusted. If it still does not come on, replace light before proceeding. If light stays on or continues to flash, check BATTERY RATING and CELLS IN SERIES switch position and replace fuse. Status indicator should show red pulses, unless cable is not connected to battery, wrong cable is used, CHG MODE switch is set to CONST CURRENT position, BATTERY RATING switch is set wrong, or CHG CURRENT ADJUST control is turned completely counterclockwise.
14.	Meter Selector Switch	AMPS. Refer to index 13, figure 11-16.	In order to obtain a display of current on the DPM, this switch must be set to AMPS. If ReFLEX charging, the CHG CURRENT ADJUST switch (Step 15), which puts the RF80H into the constant current charging mode, must also be depressed. Otherwise an error signal indication will be displayed.
15.	CHG CURRENT ADJUST Switch	Press momentarily. Refer to index 24, figure 11-16.	Simultaneously, press the CHG CURRENT ADJUST switch and set the charge current by turning the multi-turn CHG CURRENT ADJUST control.
	CHG CURRENT ADJUST Control	Set per step 14 and 15 of this table.	

Table 11-6. Initial setting before turn on and adjustments (Cont)

STEP	CONTROL OR FUNCTION	NORMAL SETTING	COMMENTS
16.	DISCH CURRENT ADJUST Control	Set per step 15 of this table.	Start discharge by moving only white pointer of HOURS CHARGE timer gently counterclockwise back through zero. Then set discharge current by turning multi-turn DISCH CURRENT ADJUST control. In rare cases, mechanical movement of white pointer may not result in termination of charge cycle and initiation of discharge cycle. The reason relates to mechanical alignment of Charge Timer components. Should your repetitive gentle counterclockwise movement of white pointer through zero not result in the discharge mode, then mechanically move white pointer close to zero and let it move electrically the remaining few moments until zero contact closure initiates discharge cycle.
17.	CYCLE RESET Switch	Press momentarily. Refer to index 16, figure 11-16.	Press CYCLE RESET switch to start new fully programmed automatic charge-discharge-recharge cycle.
18.	Cell voltage balance check at start of charge (Meter switch)	CELL VOLT position. Refer to indexes 13 and 14, figure 11-16.	5 to 10 minutes after start of charge: Use scanning probes to check voltage of each cell. Stop charging operation and reject battery if any cell is shorted, measures less than 1.0 volt, or has reversed polarity. Review. If any cell voltage is unusually high, check electrolyte level. **NOTE** Steps 19 through 22 are for battery acceptance or rejection.
19.	Cell capacity balance check during charge	CELL VOLT position.	DURING CHARGE: At least during the last 10 minutes of charge, use scanning probes to check whether one or more cell readings are substantially higher or lower than the others. Refer to paragraph 11-62, step 2. in case of abnormal readings.
20.	Cell voltage balance check during discharge (Meter switch)	CELL VOLT position.	DURING DISCHARGE: After 54 minutes of discharge if discharging at the one-hour rate (or after one hour and 48 minutes if discharging at the two-hour rate), use scanning probes to check that each cell voltage is at least one volt.
21.	Cell capacity balance check during recharge (Meter switch)	CELL VOLT position.	DURING RECHARGE: At least during the last 10 minutes of recharge, use scanning probes to check whether one or more cell readings are substantially higher or lower than the others. Refer to paragraph 11-62, step 2. in case of abnormal readings.

Table 11-6. Initial setting before turn on and adjustments (Cont)

STEP	CONTROL OR FUNCTION	NORMAL SETTING	COMMENTS
22.	Acceptance or rejection		**NOTE** For battery to be acceptable, the following four conditions must all hold true at end of recharge: **a.** Green CYCLE COMPLETE indicator is illuminated. **b.** There were no abnormal readings in step 19 and 21 for which corrections have not been made. **c.** There were no cells with less than 1 volt in step 20. **d.** Electrolyte level satisfies battery manufacturers requirements.

The green CYCLE COMPLETE indicator will light. In summary, the operator is told not only whether the battery is good or bad, but also how good or how bad - i.e., total ampere-hour capacity. Since the battery is always fully discharged (to 0.95 volt average per cell) at the end of the LONG CYCLE, it takes, for example, one hour, 15 minutes in lieu of one hour (or two hours 30 minutes, in lieu of two hours) for a battery with 25% more than rated capacity.

2. Short cycle. With the discharge cycle selector in SHORT CYCLE, the analyzer will automatically switch to the final recharge cycle when the ampere-hour capacity set by the operator is met (i.e., the discharge timer reaches the 12 o'clock position). In summary, the SHORT CYCLE tells the operator whether the battery is good or bad, and how bad. It does not tell how good it is. The SHORT CYCLE never takes more than one hour if the one-hour discharge rate is used, or two hours if the two-hour rate is used.

NOTE

If the electrolyte temperature of a particular type battery exceeds 120.2°F (49°C) at the end of the discharge cycle, set the AC switch to OFF and allow the battery to cool to within 41.0°F (5°C) of ambient temperature before recharging. In such cases, future discharging of this battery should be performed at a two-hour (C/2) discharge rate.

3. If the HOURS DISCHARGE pointer has not passed the white GO arrow when the battery voltage reaches the decision voltage, the battery has less than the rated ampere-hour capacity. When this occurs the programmed cycle will be interrupted. The red BATTERY REJECT indicator will light and the charger/analyzer will continue to discharge the battery at approximately the 10-hour rate (C/10) for the time set by the black HRS CHARGE pointer. If this occurs, perform a deep cycle in accordance with paragraph 11-70 and strap out the individual cells prior to charging.

NOTE

In the LONG CYCLE the actual ampere-hour (amperes x hours) capacity will be displayed regardless of whether predialed capacity is reached (green light) or not (red light). Read and record time and current. In the SHORT CYCLE, only predialed capacity (green light) or less (red light) will be displayed.

11-67. Attainable capacity/greater than rated capacity.

If the time between pulses does exceed one second at the end of charge with the BATTERY TYPE in the A position, and the battery did not heat or gas excessively during the charger cycle, it may be an indication that the battery has a substantially greater attainable capacity than its rated capacity. In this case:

1. Continue charging for an additional 0.5 hour by selecting the CYCLE RESET switch and advancing only the white HOURS CHARGE pointer on the charger timer to the 0.5 hour point (leaving the black pointer undisturbed). If the time between pulses exceeds 1 second toward the end of charge, continue using the BATTERY TYPE switch in the A position. In subsequent battery tests, use this actually attainable ampere-hour value for step 3 when setting the charging current.

2. For maximum life, maximum reliability, and minimum memory effect, the battery should be charged to the maximum attainable capacity whenever possible.

3. With the BATTERY TYPE switch in the A position, if the time between pulses fails to exceed one second just occasionally on a certain type battery, and the current setting is properly based on attainable capacity, it may be an indication of one or more weak cells. In this case, the cell voltages should be checked at regular intervals during the capacity test.

4. The BATTERY TYPE switch B setting is used whenever the A position does not provide sufficient depolarization. Depolarization is usually sufficient when the battery temperature during charge rises less than 50.9°F (15°C) and gassing is not excessive.

5. Some batteries requiring the BATTERY TYPE switch A setting will require B setting only when new or immediately after reconditioning. In this case the A setting should be used after one or more discharge cycles.

11-68. ELECTROLYTE LEVEL CHECK.

Once the full charging program has been successfully completed, let the battery rest for two to four hour. Then check the electrolyte level of each cell and add pure distilled water if necessary. For SAFT batteries, perform the optional electrolyte level checking procedures in paragraph 11-71.

11-69. OPTIONAL PROCEDURES.

The charger/analyzer has several capabilities in addition to the standard automatic charge and analysis operating mode. These capabilities assist in the recondtiioning of batteries which have been rejected during analysis. They also allow the performance of special procedures required by some battery manufacturers.

11-70. Deep discharge cell equalizing.

Deep discharge cell equalizing is a process which discharges each cell individually in a controlled manner to zero volts. Perform procedures as follows:

1. With the AC switch set to OFF, connect the battery to the charger/analyzer. Set the CELLS IN SERIES switch, BATTERY RATING switch, and BATTERY TYPE switch to the positions listed in table 11-6 for the battery.

2. Set the HOURS DISCHARGE dial to the two-hour position and the pointer to 0. Set the ANALYZER swtich to ON, DISCHARGE switch to DEEP, and AC switch to ON.

3. Operate momentarily the START switch and the CYCLE RESET switch. Rotate the white HOURS CHARGE pointer clockwise through zero (leaving black pointer undisturbed) to start discharging.

4. Refer to table 11-5 and determine the C/2 ampere-hour rating for the battery.

NOTE

The C/2 ampere-hour rating is determined by dividing the battery ampere hour rating (C rating column of table 11-5) by 2.

5. Set the DISCH CURRENT ADJUST control to obtain the two-hour discharge current on the panel meter.

6. Allow battery to discharge and use the charger/analyzer probes (with meter swtich at CELL VOLT position) to scan cell voltages.

7. As the voltage of an individual cell drops below 0.50 volt, short out that cell individually by connecting a shorting strap between the (+) and the (–) terminals. Continue this process until the overall battery voltage drops below ten volts.

8. Shut off charger/analyzer and disconnect battery. Connect individual five watt 1/2 ohm shorting resistors across all remaining battery cells.

9. Monitor cell voltage and allow cells to remain shorted out for at least three hours (overnight is recommended if possible) after all cells have dropped to zero.

10. Remove shorting straps and resistors and charge battery using to full standard automatic charging and analysis cycle of the charger/analyzer.

11-71. ELECTROLYTE LEVEL CHECK DURING CHARGE.

SHAFT batteries require checking of electrolyte level during (not after) charge. This shall be performed immediately after the battery has been fully analyzed and ReFLEX recharged as described in table 11-6. Perform the electrolyte level check as follows:

1. Refer to table 11-5 and determine the C/10 ampere-hour rating of the battery.

NOTE

The C/10 ampere-hour rating is determined by dividing the battery ampere-hour rating (C rating column of table 11-5 by 10).

2. Momentarily operate the CYCLE RESET switch to start the charge cycle in the ReFLEX mode. Set CHG MODE switch to CONST CURRENT, IMMEDIATELY (within 10 seconds) adjust the CHG CURRENT ADJUST control for the C/10 current value, as indicated on panel meter.

3. Allow battery to charge for one hour at the C/10 constant current rate. During the last 10 minutes of this charging period, check and adjust the electrolyte level.

CAUTION

BATTERY MUST BE FULLY CHARGED OR CHARGE STATUS BEFORE WATER IS ADDED. WATER MUST NEVER BE ADDED TO A BATTERY IF THE CHARGE STATE IS UNKNOWN.

11-72. CELL VOLTAGE BALANCE TEST DURING CONSTANT CURRENT CHARGE.

General Electric batteries require checking cell balance while the battery is being charged at a constant current. This shall be performed immediately after the battery has been fully analyzed and ReFLEX recharged as described in table 11-6. Perform the cell balance test as follows:

NOTE

Check individual battery cell temperature. If any cell temperature exceeds 120.2°F (49°C), let the battery cells cool to that temperature before proceeding.

1. Refer to table 11-5 and determine the C/10 ampere-hour rating of the battery.

2. Momentarily operate the CYCLE RESET switch to start the charge cycle. Set CHG MODE switch to CONST CURRENT. IMMEDIATELY (within ten seconds) adjust the CHG CURRENT ADJUST control for the C/10 current value, as indicated on the DPM.

3. Set the white HOURS CHARGE pointer for 30 minutes (0.5 on dial) of charging. During the last ten minutes of the charging period, use the charger/analyzer probes with meter switch set to CELL VOLT position to measure individual cell voltage. Record each cell number and voltage for use during cell fatigue tests.

4. If the cell fatique (cellophane barrier) test is to be performed, retain control setting and proceed directly to paragraph 11-73.

11-73. CELL FATIGUE (CELLOPHANE BARRIER) TEST.

General Electric batteries require checks for separator gas barrier (cellophane) condition. This is accomplished directly after and essentially as part of the cell balance tests of paragraph 11-72. Perform the cell fatigue test by continuing the cell test as follows:

1. Retain the charger/analyzer control settings from paragraph 11-72, step 4, including the C/10 current adjustment.

2. Continue charging at a C/10 constant current for an additional four hours. To facilitate timing, the black HOURS CHARGE pointer can be set to the two-hour position and then reset for a second two-hour period. Operate CYCLE RESET swtich to start charging cycle as needed. Total charge time including the cell balance test is four and one-half hours. Battery should be monitored, as time allows, throughout charging period.

3. During the last 10 minutes of 4-hour charging, measure each individual cell voltage using charger/analyzer probes. Reject battery if any cell voltage has decreased, in the 4-hour period, by 0.04 volt or more from voltage measured and recorded in paragraph 11-72, step 3. Reject battery if any cell voltage measures below 1.50 volts. Measure individual cell electrolyte temperature and reject battery if any cell electrolyte temperature exceeds 104°F (40°C).

11-74. CHARGING ONLY.

When required to charge a battery without using automatic feature, proceed as follows:

1. Perform procedures of table 11 -6 except in step 9; set ANALYZER switch to OFF, and do not perform steps 6, 10, 11, 15, and 19 through 21.

2. Charger/analyzer will not charge battery for the specified period and automatically stop. At end of charging period, green CYCLE COMPLETE indicator will light.

11-75. Lengthening charging time.

To lengthen charging time while charging is in progress, operate CYCLE RESET switch and rotate the white HOURS CHARGE pointer (do not move black pointer) counterclockwise to position which provides additional charging time required. To increase charging time, set ANALYZER switch to OFF before operating CYCLE RESET switch.

11-76. Shortening charging time.

To shorten charging time while charging is in progress, rotate white HOURS CHARGE pointer (do not move black pointer) counterclockwise to position which provides additional charging time required.

11-77. MANUAL SELECTION OF DISCHARGE MODE.

Discharge mode can be manually selected at any time in the automatic cycle if CHG MODE switch is at ReFLEX, ANALYZER switch is at ON, and the HOUR DISCHARGE pointer is counterclockwise from white GO/NO-GO arrow. To select discharge mode while in a charge mode, rotate white HOURS CHARGE pointer counterclockwise slightly past zero (without changing black pointer position) and then release. Unit will then automatically switch to discharge mode.

11-78. AUTOMATIC STOP AFTER DISCHARGE.

1. Charger/analyzer can be set to automatically stop when discharged to full discharge point and, therefore, not continue automatically into recharge mode. This is easily accomplished by setting HOURS DISCHARGE white GO/NO-GO dial to a higher discharge time setting than the ampere-hour capacity of battery will allow it to attain. For example, a GO/NO-GO dial setting of 2.9, with pointer set to zero, and normal discharge rate will cause a battery to reach discharge point before GO arrow is reached. High discharge will then automatically stop, dropping to approximate battery 10-hour rate (C/10) for the additional time equal to black pointer setting of charge timer.

2. Red BATTERY REJECT indicator will light under these conditions, but will not be indicative of a rejected battery.

11-79. OPERATING PROCEDURE AFTER POWER FAILURE.

As a safety feature, in case of power failure during any part of the cycle, the unit will turn off. Discharge timer pointer, however, will allow determination of battery status at time of power failure. There are three possible pointer positions:

1. If discharge pointer is at zero, it means that battery was still charging. Once power becomes available operate START switch, and charge timer. As soon as time between pulses is approximately one second (ten pulses in 10 seconds), move white HRS CHARGE pointer to the 0.25 to 0.5 hour pointer, leaving black pointer undisturbed.

2. If discharge pointer is between zero on dial and white GO arrow, that means that battery was discharging. Once power becomes available, operate START switch and then CYCLE RESET switch. Then slowly rotate white pointer of HOURS CHARGE timer counterclockwise lightly through zero (leaving black pointer undisturbed), and discharge operation will continue from its status when power failed.

3. If discharge pointer is past white GO arrow on LONG CYCLE or at 12 o'clock position on SHORT CYCLE, it means that battery has passed GO point during discharge, and is conditionally acceptable for use when fully charged. Once power becomes available, operate START switch to complete charge with ANALYZER switch OFF.

11-80. INSPECTION, CHARGING, AND ANALYSIS PROCEDURES.

The following includes procedures for battery inspection prior to charging, charger/analyzer preliminary set up procedures, and standard charging and battery analysis procedures.

11-81. BATTERY INSPECTION.

Carefully inspect battery visually and electrolyte before starting to charge it. Always follow closely battery manufacturers recommended procedures for both inspection and any necessary corrections.

11-82. VISUAL INSPECTION.

Examine battery case and cover for damage and make sure that all hardware is present and secure. Refer to figure 11-12, step A. Remove cover and inspect cells for damage, deterioration, missing or broken vent caps, and similar problems. Verify that cells are properly interconnected with positive (+) terminals connected to negative (–) terminals and interconnecting links properly installed and tightened. Check insulation, electrical receptacle, and its connections for damage.

11-83. ELECTRICAL INSPECTION.

Inspect battery for cell-to-case current leakage (figure 11-12, step B). A simple method for this electrical leakage check is as follows:

1. Use a 500 milliampere meter and a typical 0.25 amp fuse for leakage checks.

2. Measure current leakage between battery case and positive terminal, and battery case and negative terminal of each cell in battery. Momentarily touch each positive and negative terminal to avoid damage to test meter in event of excessive leakage.

3. Individual cell-to-case leakage should be less than one millampere per ampere-hour of battery rating. For example, maximum single cell leakage current should be 34 milliamperes for a 34 ampere-hour battery.

11-84. STANDARD SETUP AND OPERATION.

Become fully familiar with use of operating controls of charge/analyzer which, for convenience, are illustrated and completely described by figure 11-16.

WARNING

NEVER OPEN OR REMOVE CABINET TOP WITH POWER APPLIED TO POWER CORD. HIGH VOLTAGES WHICH COULD BE DANGEROUS TO OPERATORS LIFE ARE PRESENT IN EXPOSED CIRCUIT EVEN WITH CHARGER/ANALYZER AC SWITCH IN OFF POSITION. ALSO, DAMAGE TO CHARGER/ANALYZER FROM OVERHEATING CAN RESULT FROM OPERATION WITH COVER OPEN OR REMOVED.

11-85. Preliminary setup.

Perform following preliminary setup procedures prior to charging a battery:

1. Position AC switch on charger/analyzer to OFF.

2. Position battery for charging and check that cables for connection to battery are available for use.

3. Remove battery cover.

4. To monitor electrolyte temperature, insert a clean alcohol-type thermometer into a cell located in center of battery.

WARNING

CHARGER/ANALYZER AC POWER SWITCH MUST BE OFF WHENEVER BATTERY IS BEING CONNECTED OR DISCONNECTED.

11-86. Charging procedure.

Specific parameters and charger/analyzer control settings for battery makes and types used at BHTI are provided in tables 11-5 and 11-6. Table 11-6 provides specific procedures for battery charging, analysis, acceptance, and rejection.

11-87. Battery charging and analysis procedure.

After completion of battery inspection (paragraph 11-79), perform the step-by-step charging and analysis procedures provided in table 11-6. The following precautions should be considered during these operations.

1. Read and understand the battery manufacturers battery manual before starting (TD-A6 Operating Instruction).

2. Periodically monitor battery and charger/analyzer throughout automatic cycling.

CAUTION

NEVER OPERATE WITH CHARGE MODE SWITCH IN CONST CURRENT (CONSTANT CURRENT) POSITION WHILE USING REFLEX CHARGING CURRENT LEVELS IN TABLE 11-5 OF OPERATING INSTRUCTIONS TD-A6. SEVERE BATTERY DAMAGE WILL RESULT.

3. If at any time during operation the BLOWN FUSE INDICATOR illuminates (except briefly at turn-on) and remains illuminated, fuse F4 has blown and ReFLEX charging action is not taking place regardless of seemingly correct charging action and meter indications. Stop operation immediately and call the Equipment Repair Section to correct the problem.

11-88. MARATHON AIRCRAFT BATTERY, MODEL PCA-131/PCA-131, 50/60 SERIES CHARGER/ANALYZER.

11-89. BATTERY SERVICING PROCEDURES USING MODEL PCA-131 SERIES TO CHARGE AND ANALYZE AIRCRAFT NICKEL-CADMIUM BATTERIES AUTOMATICALLY.

1. PCA-131/PAC-131, 50/60 series charger/analyzer. Paragraphs 11-95 through 11-96 detail procedures for testing nickel-cadmium aircraft batteries using Model PCA-131/PCA-131, 50/60 series charger/analyzer.

2. Controls and indicators for Model PCA-131/PCA-131, 50/60 series charger/analyzer are shown in figure 11-17.

11-90. OPERATIONAL CHARACTERISTICS.

11-91. General.

Marathon Model PCA-131 series battery analyzer is a portable unit designed to charge and analyze aircraft batteries of nickel-cadmium type automatically.

11-92. Standard automatic operation.

1. Before providing a service charge, model PCA-131, 50/60 series analyzes the capacity of the battery. Through a discharge test cycle, the battery is first discharged to a predetermined end capacity of 90 percent of its rating. If the end voltage is reached before the discharge cycle is completed, the red light indicates NO-GO, and the operation stops. Battery can then be checked for cause of substandard capacity, and then put on succeeding charge mode.

2. The timer-programmer is the controlling component of the battery charger/analyzer. For battery testing, it provides a timed discharge during which 90 percent of the rated battery capacity is removed. If battery capacity is below normal, an appropriate indicating lamp lights, and the timer-programmer automatically halts programmed test-charge operation until operator performs necessary operation.

3. If battery capacity is normal, the timer-programmer commences the pulsed constant average current battery charge. Charging portion of the operation takes four hours for all nickel-cadmium battery types.

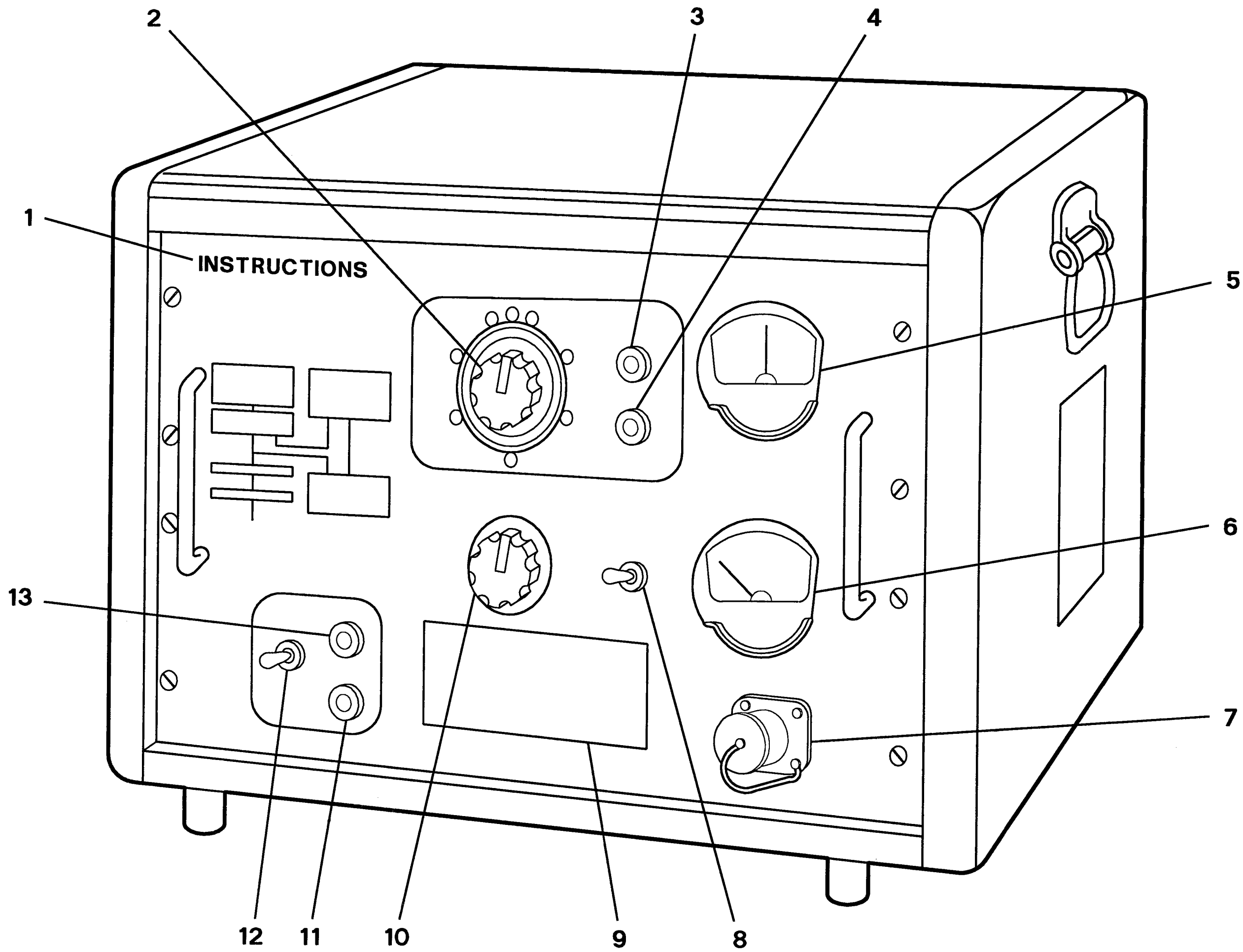
4. During the first two hours, charging current consists of a high rate main charge. For the subsequent two hours, the timer-programmer switches to produce shorter duration pulses which constitute lower rate topping rate.

11-93. MAINTENANCE AND RECONDITIONING SCHEDULES.

1. At no time should a battery be allowed to deteriorate to a point where its performance affects the mission or the operation of the helicopter. A proper maintenance program is required to prevent battery failures. Such a program requires trained, knowledgeable personnel familiar with proper battery maintenance and reconditioning procedures, and keeping of accurate records.

2. The frequency of adding water or reconditioning cycles is directly dependent upon the following:

- **a.** Type of starting service
- **b.** Battery duty cycle
- **c.** Operating temperature
- **d.** Generator voltage regulator setting.



INDEX NO.	NOMENCLATURE	FUNCTION
1	Instruction Guide: Lettering	Provides outline of operating instructions.
2	Timer: Motor Driven Rotary Switch	Selects the mode of operation of the battery charge analyzer cycle and times the cycle.
3	End of Cycle: Yellow Lamp	Indicates battery in good condition after programmed charge.
4	Battery Low: Red Lamp	Indicates battery in NO-GO condition after programmed discharge. Battery must be reconditioned.
5	Ammeter: 20-0-20 ADC	Indicates charge current to right of zero and discharge current to left of zero.
6	Voltmeter: 0-40 VDC	Indicates battery terminal voltage.

E/SPM-11-17-1

Figure 11-17. Marathon model PCA-131/PCA-131, 50/60 series charger/analyzer controls and indicators (Sheet 1 of 2)

INDEX NO.	NOMENCLATURE	FUNCTION
7	D. C. Output: Connector	Connects battery under test to charger/analyzer by means of supplied cables.
8	Automatic Cycle Manual Discharge: Toggle Switch	Enables charger/analyzer to cycle automatically or operate for manual discharge.
9	Battery Chart: Lettering	Provides charge and discharge data on batteries to be tested with charger/analyzer (current values listed are 20% of stated value).
10	Selector: 5 Position Switch	Selects battery to be tested.
11	A. C. Power Fuse: 3AG Fuse	Fuses power to charger/analyzer.
12	A. C. Power ON-OFF: Toggle Switch	Applies A. C. power to charger/analyzer.
13	A. C. Power Indicator: Red Lamp	Indicates A. C. power applied.

E/SPM-11-17-2

Figure 11-17. Marathon model PCA-131/PCA-131, 50/60 series charger/analyzer controls and indicators (Sheet 2)

3. Because of widely varied flight profiles encountered in individual helicopter use, no fixed maintenance and recondition period can be specified. These periods can only be approximated. The user must eventually apply experience and information gained during the first few maintenance and reconditioning periods to determine a schedule that is best suited to his particular type of battery usage.

11-94. INSPECTION AND MAINTENANCE CHECK.

CAUTION

BATTERY MUST BE DISCHARGED PRIOR TO REPAIRING CONTAINER OR CONNECTORS.

1. When a battery is received in the shop for routine servicing, it should first be inspected visually for damage to the container, cover, and external battery connectors. Repair or replace these as necessary.

2. Check inside of battery for such things as cleanliness, loose or corroded connectors, leaking cells, and damaged hardware. Inspect cell vent assemblies. Tighten loose vent plugs and replace damaged or missing vent plugs or vent rubbers to prevent contamination of the electrolyte.

WARNING

BECAUSE SERIOUS INJURY CAN RESULT FROM CARELESSNESS WHILE HANDLING AND WORKING WITH NICKEL-CADMIUM BATTERIES, CERTAIN PRECAUTIONS MUST BE OBSERVED. ALL METAL ARTICLES, SUCH AS WATCH BANDS, BRACELETS AND RINGS SHOULD BE REMOVED BEFORE WORKING WITH NICKEL-CADMIUM BATTERIES. INADVERTENT CONTACT OF THESE METALLIC OBJECTS WITH CURRENT CARRYING PARTS OF THE BATTERY WOULD RESULT IN THE FUSING OF THE METAL, VERY HIGH TEMPERATURE, AND SEVERE BURNS TO THE WEARER.

TOOLS USED TO SERVICE NICKEL-CADMIUM BATTERIES SHOULD

BE COVERED WITH INSULATING MATERIAL. METAL TOOLS DROPPED INTO THE BATTERY WILL SHORT-CIRCUIT CONNECTOR BARS AND CAUSE ARCING WHICH CAN DAMAGE THE BATTERY AND CAUSE INJURY TO THE TECHNICIAN.

11-95. Cleaning procedures.

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

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

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

CAUTION

WATER USED TO WASH CELLS OR BATTERY WILL BECOME CAUSTIC; AVOID CONTACT WITH IT. DO NOT USE A METAL BRUSH; THIS MAY RESULT IN A SHORT CIRCUIT WHICH MAY CAUSE SKIN BURNS OR DAMAGE TO THE BATTERY. DO NOT CLEAN TOP OF CELLS WITH SOLVENTS, ACIDS OR ANY CHEMICAL SOLUTION. THESE MAY DAMAGE CELL CASES AND HARDWARE.

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

a. Disassemble battery in accordance with manufacturers maintenance manual instructions.

b. Wash cells under running water. Do not allow wash water to enter interior of the cells.

c. Dry cells with clean absorbent toweling or with an air hose.

d. Inspect each cell for cracks, holes, or other defective condition. If any defects are found, replace with new or rebuilt cells.

e. 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 grease may be removed from connectors, screws, nuts, and washers by washing in alcohol or by degreasing after they are removed from the cells. Use hot water to thoroughly wash vent assemblies.

f. If the rubber liner used on some of the older batteries has deteriorated, replace it. If it has pulled away from the container, cement it using rubber-to-metal, cement, G.C. Electronics Type 35-2 (EC-050) or equivalent. Replacement of the liner itself can be made by cutting to require neoprene sheet, 40 to 60 durometer, 1 1/16 inch to 1/32 inch thick.

g. Allow all parts to dry thoroughly before assembling.

h. 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 emory cloth being careful not to remove the plating.

i. Check the battery power receptacle for burns, cracks, and bent or pitted terminals. Replace defective receptacles. Receptacles can overheat, arc, reduce battery voltage, and cause premature battery failure.

j. Repair or replace bent battery cases and covers, loose or damaged cover gaskets, and cell hold-down bars.

k. Reassemble battery in accordance with manufacturers maintenance manual instructions.

l. Clean vent caps (vent plugs).

11-96. Electrical leak check.

NOTE

Voltage reading between terminals and battery must not be used as a criteria for rejection; current flow is the determining factor.

1. General. This refers to external electrical leakage between a cell terminal or connector and battery container caused by electrolyte collecting around the cell usually as a result of spewing from vent caps. It may also be caused by a damaged cell case-to-cover seal. A leakage path greater than about 50 millamperes between battery container and either positive or negative terminals of battery, is considered to be excessive.

CAUTION

DEPENDING UPON CONDITIONS, A POTENTIAL SHOCK HAZARD MAY EXIST ACROSS EITHER BATTERY TERMINAL AND THE CONTAINER ON A BATTERY ASSEMBLY HAVING A VOLTAGE OF 50 VOLTS OR GREATER AND A LEAKAGE CURRENT GREATER THAN 2 MILLIAMPERES. KEEPING THE LEAKAGE CURRENT BELOW 2 MILLIAMPERES BY THOROUGH CLEANING AND INCREASED MAINTENANCE WILL REDUCE OR ELIMINATE THIS POTENTIAL SHOCK HAZARD.

2. Procedure. To determine if external leakage is of such a magnitude as to require a complete battery cleaning, set the range selector of a multimeter, such as a Simpson 261 or equivalent, to 500 milliampere range higher.

NOTE

Most batteries are supplied with epoxy coated battery containers and covers in order to completely insulate the cells from the containers. Where epoxy coated containers are used, current flow may be measured between battery terminals and screws that are used to mount the main connector.

a. Place positive lead of meter on positive terminal of battery receptacle and momentarily touch negative lead of the meter to any exposed metal on the battery container. If needle deflection is within meter limits, connect negative lead of meter to battery container. Now, decrease meter current range until the current, if any current flow exists, is readable. Record this current value.

b. Repeat the above, connecting negative lead of meter on negative terminal of battery receptacle and positive meter lead to any exposed metal on battery container.

c. If either of above current measurements exceed 50 milliamperes, flush tops of cells and dry (paragraph 11-95).

d. Repeat the above current test on both postiive and negative terminals. If tops of the cells were cleaned properly and current measurements are still greater than 50 milliamperes, one or more of the cells may be leaking. To isolate this cell or cells, proceed to steps e. through g.

e. Using a voltmeter of 1000 ohms-per-volt or greater, place one of the meter leads on either the negative or positive terminals of the battery and the other lead on any exposed metal of the battery container; note the meter reading. If the meter reads left of zero, reverse the positions of the meter leads.

f. Keep one meter lead on the exposed metal surface of the container and move the other lead systematically from one cell terminal to another, noting the voltage reading. Voltage reading will decrease and finally go negative indicating the location of the path and possible a leaky cell.

g. If the cell is leaking, replace the cell or cells following the procedure in accordance with manufacturers maintenance manual. If no leaking cells are found, leakage path may be due to electrolyte along outside of cells and at bottom of battery container. Perform procedures in paragraph.

11-97. Adjustment of electrolyte.

NOTE

Additional information for adjustment of electrolyte may also be found in paragraph 11-54.

1. Water additions to adjust liquid level should be made after charging. Electrolyte levels decrease after termination of a charge because of the porosity of the plates.

2. In general, an electrolyte level should be adjusted to 0.125 inch (3.175 mm) above the visible insert after allowing battery to stand 2 to 4 hours following a charge. If time does not permit the four-hour waiting period, an approximate level would be about 0.25 inch (6.35 mm) above the visible insert immediately after charge.

3. In some batteries, it is possible to see the liquid level through ports in the side of the battery container. In batteries where these ports are not provided, such as certain helicopter types it is necessary to determine this liquid level by looking down into the vent well after filler cap has been removed.

4. If it is not possible to determine the liquid level in this manner, we recommend the use of a 6-inch length of polystyrene tube, open at both ends, and having an inner diameter of about 0.125 inch (3.175 mm). Refer to **figure 11-14.**

NOTE

Make electrolyte adjustments with distilled deionized (EC-076), or demineralized water (EC-077) only.

Do not use tap water.

Do not overfill. Overfilling will result in spewing of electrolyte from the cell during charging or overcharging, and may dilute electrolyte, causing additional cleanup and poor low temperature performance.

Do not add water when battery is in a discharged state unless an abnormally high cell voltage reading (greater than 1.5 volts) is encountered immediately after placing battery on charge. Cell may be dry. If so, add about 1 cc of water per ampere-hour of capacity (about 10 cc for a 10 ampere-hour cell) to cell or cells displaying this high voltage.

Do not add electrolyte.

WARNING

DO NOT USE TOOLS WHICH HAVE ANY ACID ON THEM. PERSONAL INJURY AND EQUIPMENT DAMAGE MAY RESULT.

5. This tube is inserted into filler opening deep enough to touch top of plates or plastic insert. Grasping tube between thumb and middle finger of right hand, place index finger over top end of tube and remove tube from filler well. If the level in lower end of tube is as stated above, liquid level is adjusted properly. If no liquid is withdrawn, add distilled or demineralized water until proper level is reached in polystyrene tube, using perviously described method. Adjustments in liquid level may be made by a syringe of type shown in **figure 11-14.**

11-98. RECONDITIONING NICKEL-CADMIUM BATTERIES.

11-99. General.

Under certain conditions of usage, nickel-cadmium batteries may show a temporary loss of capacity. Usually this loss is due to an imbalance in individual cell capacities as may result from differences in self-discharge rates, charge efficient, etc.

Reconditioning is recommended to restore a battery to full capacity and to prevent premature damage and failure. Batteries may be capacity reconditioned using either a constant-current charger, or a Marathon PCA-131 charger/analyzer. Refer to paragraph **11-100** and **11-101**.

Data obtained during reconditioning of a battery is invaluable for determining maximum flight hours between reconditioning services.

More frequent reconditioning is recommended whenever possible.

In helicopters where more than one battery is used, either in series or parallel starting, care should be taken that the batteries are not allowed to become unbalanced. Perform the conditioning service on both batteries during the same inspection period.

11-100. Reconditioning procedure using constant current charger.

A battery may be received in the service shop in an unknown state of charge. The cells may look as if they are dry and need water. It may be a discharged battery, or one that has been allowed to run dry. Proceed as follows:

1. **Inspection.** Inspect battery (paragraph 11-94). If necessary, clean battery. Refer to paragraph 11-95.

2. **Leak Check.** Perform an electrical leak check in accordance with paragraph 11-96.

3. **Charge.** Charge battery on a constant current charge at five-hour charge rate until total battery voltage reaches a minimum of 29.5 volts for a standard 19-cell battery (an average of 1.55 volts per cell) or 29.1 for a low impedance 19-cell battery. If battery voltage does not rise to specified voltage within 30 minutes, check voltage of each cell to see that there are no shorted cells. If a shorted cell is found, replace it as described in the vendor battery maintenance manual. The 5-hour charge rate should take about seven hours to completely charge the battery. If some other rate is used, care should be taken to see that the total ampere-hour charge is at least 140 percent of the 5-hour rated capacity.

NOTE

Additional information for adjustment of electrolyte may also be found in paragraph 11-52.

4. **Adjustment of Electrolyte.** Check electrolyte levels in cells. Refer to paragraph 11-97. If adjustment is required, refer to paragraph 11-54.

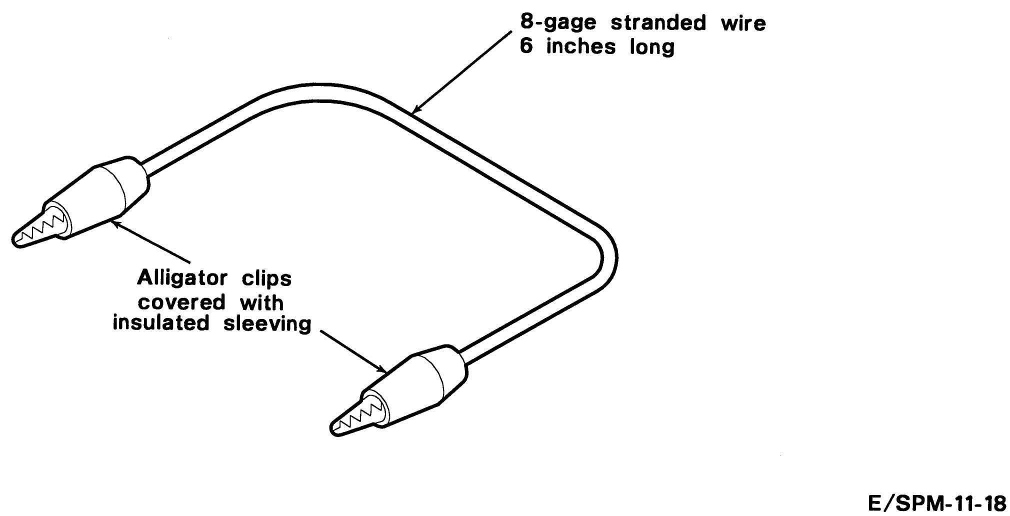


Figure 11-18. Cell shorting clips

11-101. Reconditioning procedure using Marathon PCA-131, or PCA-131, 50/60 Series charger/analyzer.

1. General. The Marathon PCA-131 charger/analyzer was designed to charge and analyze nickel-cadmium batteries automatically and thus simplify the reconditioning procedure. The charger/analyzer features a GO, NO-GO indication of battery condition. Correct charge and discharge current is pre-selected with setting of switch position. Battery can be left unattended during charge, and automatically adjusts for change in line voltage. It will automatically terminate discharge if average battery voltage falls below a pre-selected end voltage. Actual discharge time can be determined from running timer.

2. Procedure.

a. Inspect battery in accordance with paragraph 11-94.

b. Clean battery, if necessary in accordance with paragraph 11-95.

c. Perform electrical leak check in accordance with paragraph 11-96.

d. Preliminary instructions:

(1) The PCA-131 series charger/analyzer is connected as follows.

(2) PCA-131, 50/60 series. This instrument operates on 115 volts 60 Hertz, 10 percent.

(3) PCA-131, 50/60 series. This instrument is connected to operate on a line voltage of 220 volts. For other line voltages, refer to instructions in table on inside tip lid of charger/analyzer. If instrument is to be operated on a 110-120 voltage line, a 12 amp fuse must be used.

(4) Set the SELECTOR switch to the nickel-cadmium battery type to be tested. Turn off the AC POWER SWITCH.

(5) Insert AC power cord plug into power source. Be sure vents are not obstructed.

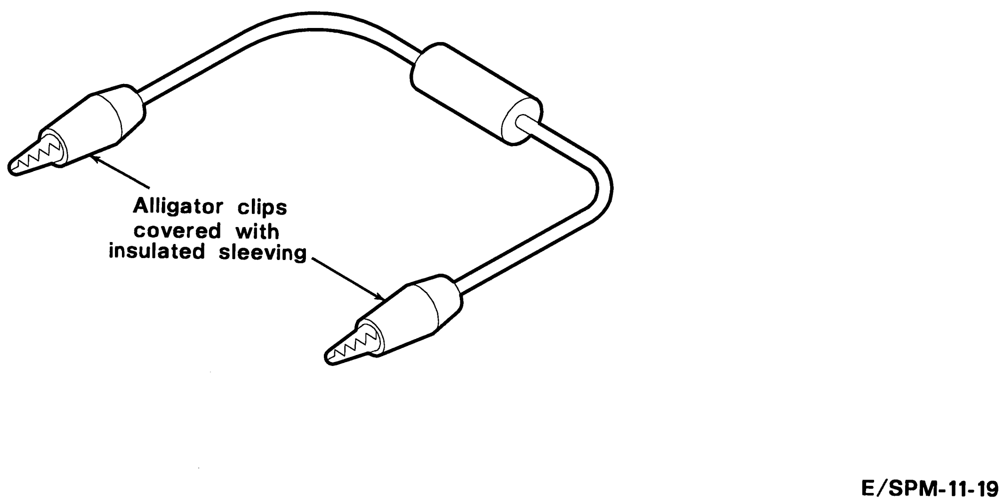


Figure 11-19. 1.0 ohm, 2 watts resistor

(6) Connect DC OUTPUT to battery receptacle, using one of two cables supplied.

NOTE

Battery testing cannot be accomplished unless correct cable is used. Use appropriate cable for MA-300H and MA-500H positions. Positive (+) lead or charger to positive terminal of battery. Negative (–) lead of charger to negative terminal of battery.

e. Operating procedure:

(1) Switch AC POWER ON-OFF switch to ON. Red AC POWER indicator lights.

(2) Set AUTOMATIC CYCLE-MANUAL DISCHARGE switch to AUTOMATIC CYCLE.

(3) Advance TIMER control to (4) TOPPING CHARGE. Red BATTERY LOW lamp goes out. Automatic operation will not commence until battery voltage climbs to 19 volts (within approximately 5 minutes).

(4) At this point, TIMER control should be at (4) TOPPING CHARGE. TIMER will advance automatically during topping charge. Topping charge normally takes two hours.

(5) Top charge until battery voltage reaches 30 volts minimum. If battery voltage does not rise to 30 volts within 30 minutes, check voltage of each cell to see that there are no shorted cells. If a shorted cell is found, replace it in accordance with manufacturers maintenance manual instructions.

(6) The TOPPING charge ends when TIMER programmer has advanced to (6) OFF. Charger/analyzer turns itself off and END OF CYCLE yellow indicator lights illuminate.

f. Check the electrolyte level in the cells and adjust in accordance with paragraph 11-97.

g. Start of discharge:

(1) PCA-131. To start automatic charge/analyze cycle, advance TIMER control to (S) DISCHARGE. Yellow END OF CYCLE light goes out. Battery will discharge for two hours while TIMER pointer advances automatically in a clockwise direction.

(2) PCA-131, 50/60 series. To start automatic charge/analyze cycle, advance TIMER control to (S1) DISCHARGE for 60 cycle operation and advance TIMER control to (S2) DISCHARGE 50 cycle operation. Yellow END OF CYCLE light goes out. Battery will discharge for two hours while TIMER pointer advances automatically in a clockwise direction.

(3) If battery gives proper capacity, it will automatically go into the main and overcharge modes. If capacity is less than 120 minutes required, the battery LOW LIGHT on PCA-131 will illuminate. If this occurs, and total discharge time is less than 100 minutes, turn automatic-manual switch to MANUAL DISCHARGE and continue discharge. As each individual cell reaches 0.5 volts or less, place a shorting strap across the terminals while the load is applied. Refer to figure 11-18. Continue discharge until approximately 75 percent of the cells are shorted out with straps, then place a 1.0 ohm, 2-watt resistor across each of the remaining cells. Disconnect battery from PCA-131 and allow it to remain shorted for at least three hours before removing shorting straps and resistors.

RESULTS:

(a) If discharge capacity is more than 100 minutes, proceed as described in step h. through k.

(b) If discharge capacity is less than 100 minutes, the battery must be charged (step h.), discharged (step g.), and then charge (step h.), etc.

h. Final charge:

NOTE

PCA-131 will not operate until the voltage builds to 19 volts. This is accomplished automatically.

(1) Connect battery to PCA-131, throw automatic-manual switch to AUTOMATIC position, turn PCA-131 power ON and rotate clock to MAIN CHARGE MODE. Charge will continue until both main topping charges are completed.

(2) During final five minutes of topping charge (in event unit has turned off, reset to TOPPING for 10 minutes); check voltage of each cell (with current flowing). With battery at a room temperature of 70 to 75°F (21.1 to 23.8°C), minimum voltage should be 1.55 volts per cell (1.53 on low impedance cells) and a maximum 1.75 volts per cell. If any cell fails to rise to at least 1.55 volts, reset TOPPING CHARGE for one hour and recheck voltage (with current flowing).

RESULTS:

(a) Any cell that fails to rise to 1.55 volts (1.53 on low impedance cells) or peaks above these voltages then decreases below 1.50 volts must be removed from battery. any cell whose voltage rises above 1.75 volts should also be removed. (Reference manufacturers maintenance manual for cell removal/replacement instructions.)

(b) If five or more cells are found to be defective, either at one time or over a period of time, it is recommended that entire battery be replaced because the probability is great that remaining cells have also been damaged and will shortly have to be replaced.

(c) If battery has passed all requirements preceding steps a. through h., proceed as described following steps i. through k.

i. Electrolyte level recheck. Following the satisfactory completion requirements of steps g. and h., recheck electrolyte level in cells paragraph 11-97 and readjust, if necessary.

j. Torque adjustment. Using a torque wrench, tighten nuts, allenhead, or hexhead screws that attach intercell connectors to cell terminals. Reference manufacturer maintenance manual for correct torque value.

k. Electrical leak recheck. Final step is to recheck the current path between cells and battery in accordance with paragraph 11-96.

RESULTS:

(1) If battery has passed all of the preceding requirements, it is ready for installation or storage.

(2) If battery has not yielded 100 minutes after three charge-discharge cycles, it should be removed from service.

11-102. EAGLE-PITCHER RECOMMENDED PROCEDURE.

NOTE

In all cases the manufacturers recommend procedures take precedence.

CAUTION

CELL TEMPERATURE MUST BE MONITORED DURING CHARGING ONBOARD HELICOPTER. THE MAXIMUM TEMPERATURE FOR BATTERY CELLS WILL VARY WITH DIFFERENT BATTERIES. REFERENCE MUST BE MADE TO MANUFACTURERS MANUAL TO DETERMINE THIS TEMPERATURE AND ACTION TO BE TAKEN.

11-103. OPERATION AND MAINTENANCE.

NOTE

For information on consumable material, refer to Chapter 10.

WARNING

BECAUSE SERIOUS INJURY CAN RESULT FROM CARELESSNESS WHILE HANDLING AND WORKING WITH NICKEL-CADMIUM BATTERIES, CERTAIN PRECAUTIONS MUST BE OBSERVED. ALL METAL ARTICLES, SUCH AS WATCH BANDS, BRACELETS, AND RINGS SHOULD BE REMOVED BEFORE WORKING WITH NICKEL-CADMIUM BATTERIES. INADVERTENT CONTACT OF THESE METAL OBJECTS WITH CURRENT CARRYING PART OF THE BATTERY WOULD RESULT IN THE FUSING OF THE METAL, VERY HIGH TEMPERATURE, AND SEVERE BURNS TO THE WEARER.

TOOLS USED TO SERVICE NICKEL-CADMIUM BATTERIES SHOULD BE COVERED WITH INSULATING MATERIAL. METAL TOOLS DROPPED INTO THE BATTERY WILL SHORT-CIRCUIT CONNECTOR BARS AND CAUSE ARCING WHICH CAN DAMAGE THE BATTERY AND CAUSE INJURY TO THE TECHNICIAN.

THE POTASSIUM HYDROXIDE AND WATER SOLUTION THAT FORMS THE ELECTROLYTE IS CAUSTIC AND CAN CAUSE SERIOUS BURNS IF IT COMES IN

CONTACT WITH THE SKIN. PROTECTIVE CLOTHING, SUCH AS RUBBER GLOVES, GOGGLES, AND A RUBBER APRON, SHOULD BE WORN WHILE WORKING WITH NICKEL-CADMIUM BATTERIES. IF ANY ELECTROLYTE DOES CONTACT THE SKIN, THE AREA SHOULD BE FLUSHED IMMEDIATELY WITH LARGE AMOUNTS OF WATER AND NEUTRALIZED WITH A 3 PERCENT SOLUTION OF ACETIC ACID, VINEGAR, LEMON JUICE OR A 10 PERCENT SOLUTION OF BORIC ACID.

ELECTROLYTE IN THE EYES IS EVEN MORE SERIOUS; IT SHOULD BE FLUSHED AWAY WITH LARGE AMOUNTS OF WATER AND A PHYSICIAN SHOULD BE CALLED IMMEDIATELY.

BECAUSE HYDROGEN AND OXYGEN GASSES ARE GENERATED DURING OVERCHARGING, ANY AREA IN WHICH A NICKEL-CADMIUM BATTERY IS OPERATED OR MAINTAINED MUST BE WELL VENTILATED.

EXPLOSIONS MAY OCCUR IF GASSES ARE ALLOWED TO CONCENTRATE IN ANY CONFINED SPACE.

BATTERY CONNECTION MUST BE TIGHT. LOOSE CONNECTIONS MAY CAUSE ARCING WHICH WOULD CAUSE THE GASSES TO EXPLODE.

CAUTION

BECAUSE SERIOUS DAMAGE TO THE BATTERY CAN RESULT FROM CARELESSNESS WHILE HANDLING AND WORKING WITH NICKEL-CADMIUM BATTERIES, CERTAIN PRECAUTIONS MUST BE OBSERVED.

DO NOT CONTAMINATE ELECTROLYTE. DO NOT USE ACID ELECTROLYTE. ADD ONLY DISTILLED OR DEIONIZED WATER TO CELLS. DO NOT USE TOOLS OR EQUIPMENT SUCH AS A SYRINGE THAT IS DIRTY OR HAS BEEN USED WITH ACID ELECTROLYTE. THE ACID OR IMPURITY CAN SERIOUSLY SHORTEN THE LIFE AND DECREASE THE USEFULNESS OF THE BATTERY. DO NOT USE WIRE BRUSHES TO CLEAN THE BATTERY; USE ONLY SOFT BRISTLE BRUSHES WITH NYLON OR SIMILAR BRISTLES. THE BATTERIES MAY BE WASHED WITH WATER AND BLOWN DRY. DO NOT ALLOW TAP WATER TO GET INTO THE CELLS.

11-104. OPERATIONS.

1. Placing battery in service.

a. Inspection. Upon receipt of the battery it should be inspected for shipment damage and electrolyte leakage. Check each cell terminal connection, paragraph 11-105 (step 5, f.). Check all ventilation openings to make sure they are unobstructed.

b. Charging. A new battery is shipped in a discharged state with the electrolyte adjusted prior to discharge. Before charging, loosen the vent of each cell but do not remove. The battery should be at 68°F (20°C) for an optimum charge.

(1) Charge the battery at a constant current according to one of the procedures for a completely discharged battery as described in paragraph 11-108.

(2) When charging is complete and electrolyte level adjustment is done (if required), reinstall all vent assemblies. Replace the battery cover and install in helicopter. Electrical connections to the helicopter must be clean and tight and the vent system must be attached.

11-105. MAINTENANCE.

NOTE

A service record form is enclosed in the manual and must be maintained for each battery to validate any warranty claim. Careful attention to maintaining this record will be invaluable in correcting battery malfunctions in servicing as it will keep track of the general state of charge and condition of the battery and adjustments to the electrolyte. Refer to figure 11-13.

1. Routine maintenance. Whenever possible, the battery should be removed from the helicopter and examined for the following conditions:

a. Loose terminal nuts. This will be indicated by burns or arcing on intercell links. Replace the links and nuts and torque to 150 inch-pounds (16.950 newton-meters).

b. Terminal seal failure. If there are heavy white carbonate deposits around a cell terminal, remove all hardware and the packing. Clean the cavity, insert a new lubricated (silicone) packing, and replace hardware in the correct sequence. Refer to **figure 11-20.** Torque bottom terminal nut to 50 inch-pounds (5.650 newton-meters).

c. Vent failure. If there are heavy white carbonate deposits on or around the vent valve, the valve may have been installed improperly or the vent sleeve or packing has failed. Check the packing seal to the cell cover to see that it is properly seated. The packing should be lubricated with a light film of silicone before reinstalling in the cell. If the carbonate is around the vent sleeve, remove the vent and rinse in deionized or distilled water. Replace the cleaned assembly or install a new vent if the sleeve is broken or torn.

d. Electrolyte level. Overcharging a nickel-cadmium battery will cause loss of water in the electrolyte. This loss of water is proportional to the amount of overcharge a battery experiences. The 3030-1 cell assembly used in the EPI- 8162 battery has a reserve of 25 cc of electrolyte. If more than 25 cc of water is required to properly adjust the electrolyte, the cell should be checked for capacity. If capacity is acceptable, the time between electrolyte adjustment should be shortened. The maintenance cycle is in part determined by operating conditions.

e. Whenever a battery is charged in the shop, the electrolyte level should be adjusted before placing battery back in service. Perform proper electrolyte level adjustment procedure **paragraph 11-110.**

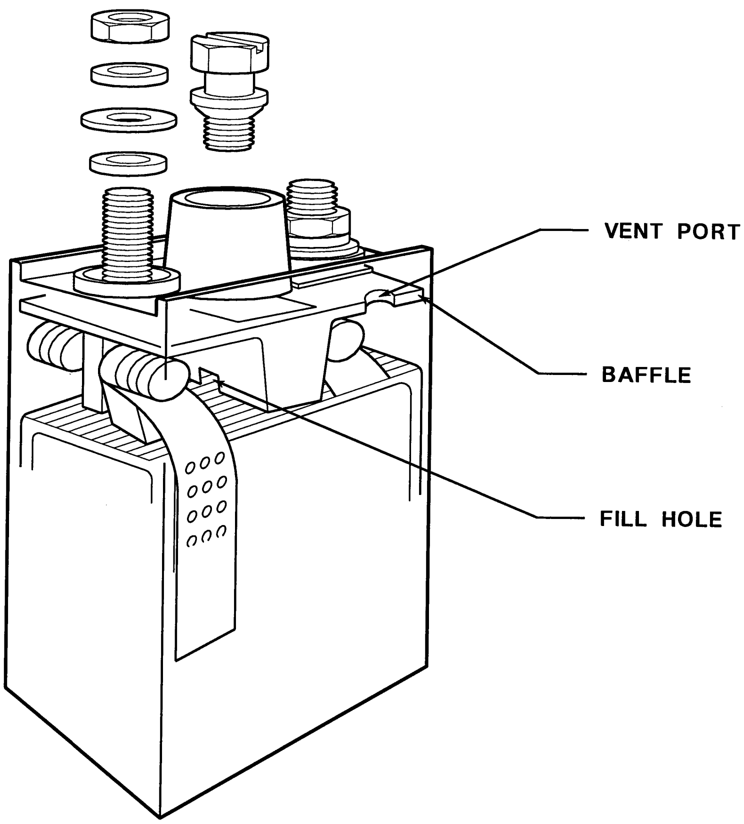


Figure 11-20. Cell construction

2. Deep cycle maintenance. Periodic maintenance in a qualified service center is necessary for optimum performance from a nickel-cadmium battery. It is recommended that deep cycle maintenance be performed every 1000 flight hours or 500 starts, whichever comes first, or when any abnormal operation of the battery is observed. The following steps are recommended for the deep cycle maintenance:

a. Examine the battery, tops of cells, and all connections for any obvious physical damage; if there is physical damage, damaged parts must be replaced before proceeding. Clean and tighten any loose connections.

b. Discharge battery at approximately 36 amperes. As voltage of each cell drops below 0.3 volts, short individual cells and maintain the short for a minimum of 16 hours.

c. Charge battery (paragraph 11-108) and adjust electrolyte level (paragraph 11-110).

d. The battery may now be returned to service or checked by discharging at a constant rate to determine that it has the rated capacity. (The 36 AH rated battery should run at 36 amperes for one hour minimum above 1.0 volt per cell.)

NOTE

Once the battery has been placed in service, an aging process begins with a corresponding decrease in capacity during maintenance checks; a measured capacity of 85 percent or more of nominal capacity is acceptable and the battery may be returned to service. With proper care, the batteries should give years of good service.

3. Disassembly. In the event that it is necessary to disassemble the battery for repairs or cleanup, observe the following procedures:

a. Discharge battery.

b. To remove cells, remove terminal nuts and intercells. Use a cell puller to remove cells by pulling straight up. Fabrication of a cell puller is illustrated in figure 11-21.

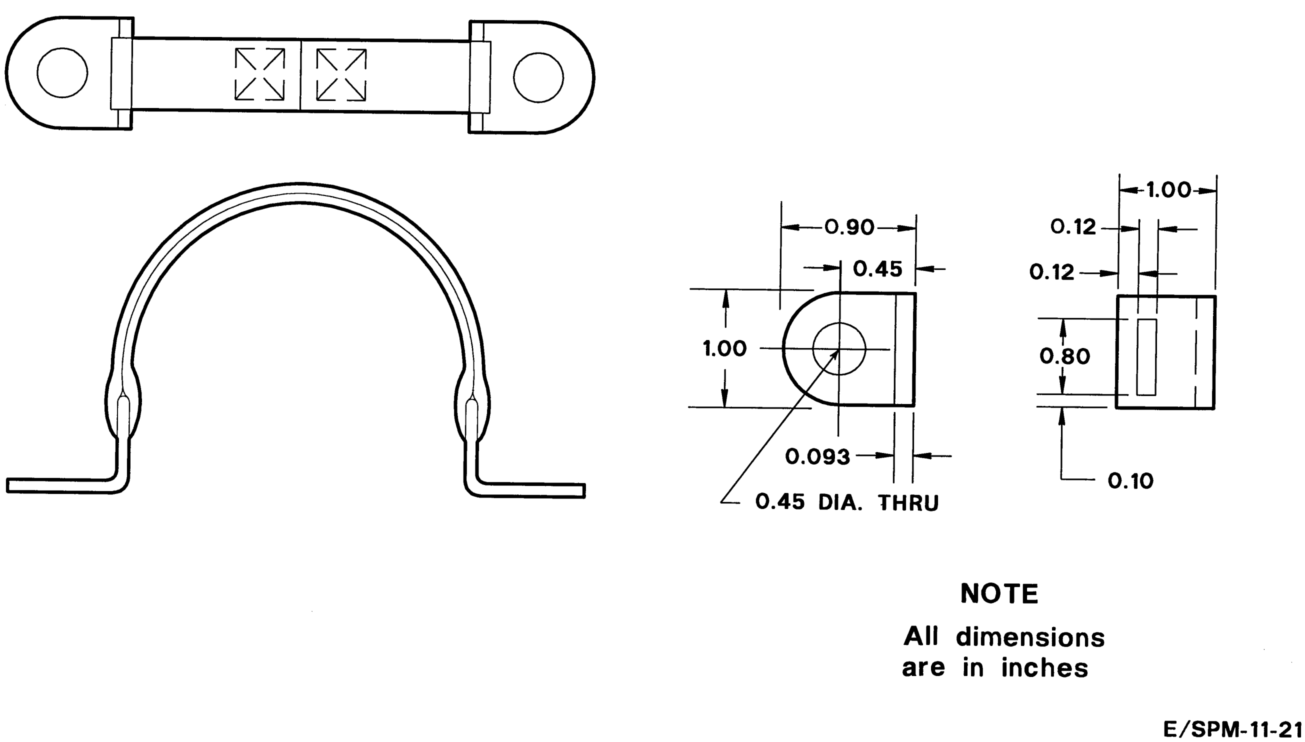


Figure 11-21. Cell puller

4. Cleaning. Before reassembling the battery, it is recommended that the following cleaning steps be performed:

a. Degrease all metal hardware. Replace any damaged parts.

b. Wash each cell in water; make sure the vent cap is tight before washing. Dry exterior of each cell completely.

c. Wash the battery case cover, shims, and connector in water. Rinse and dry completely.

d. Remove vent caps and wash thoroughly in distilled or demineralized water. If a leak around the terminal is suspected, check packing for deterioration. Replace if necessary. Protect the cell from spillage or contamination while vent is removed. Dry each vent and replace in cell. Do not allow cells to stand for periods greater than a few hours without vent valves installed. Carbon dioxide in air combines with electrolyte to form potassium carbonate. This compound is detrimental to cell performance. Exposure of electrolyte to air should be minimized.

5. Assembly. To correctly reassemble the battery, perform the following steps:

a. Ensure that all parts are clean and dry.

b. Replace shims in their original positions.

c. Install the thermostat/connector assembly.

d. Replace cells while observing correct polarity. Some force may be required to replace the last cell in each row. If required, push on the terminals with a small block of soft plastic, wood or other nonconductive material.

e. Replace intercell links and hardware; check polarity of each cell. Refer to figure 11-22.

f. Terminal nut torque. All terminal nuts with the exception of the four nuts associated with the power connector (figure 11-22), should be torqued to 150 inch-pounds (16.950 newton-meters). Torque four nuts shown in figure 11-23) to 100 inch-pounds (11.300 newton-meters). This should be done by gradually tightening these nuts, moving from one to another. This will prevent twisting and subsequent cracking of the power connector.

g. Lightly coat all terminals, terminal nuts, intercell connectors and small connector beneath large power connector with petrolatum (EC-030).

h. Charge battery and discharge for capacity check, recharge and return to service.

CAUTION

IF DAMAGED PARTS OR CELLS ARE REPLACED, ENSURE THE REPLACEMENT PARTS ARE OF THE SAME TYPE, AND THAT REPLACEMENT CELLS ARE FULLY DISCHARGED. THE BATTERY SHOULD BE DISCHARGED WHENEVER CELLS OR HARDWARE ARE REPLACED. IF MORE THAN ON CELL IS TO BE REPLACED, ENSURE THAT AN EQUAL NUMBER OF NEW CELLS, IF POSSIBLE, ARE INSTALLED ON EITHER SIDE OF THE 10TH CELL VOLTAGE TAP. THIS WILL MAINTAIN AS CLOSELY AS POSSIBLE, THE CELL BALANCE INDICATOR TO THE CHARGER MONITOR SYSTEM. USE ONLY EAGLE-PITCHER PARTS.

11-106. Component testing.

1. The temperature sensor may be tested by fabricating a test harness as shown in figure 11-24.

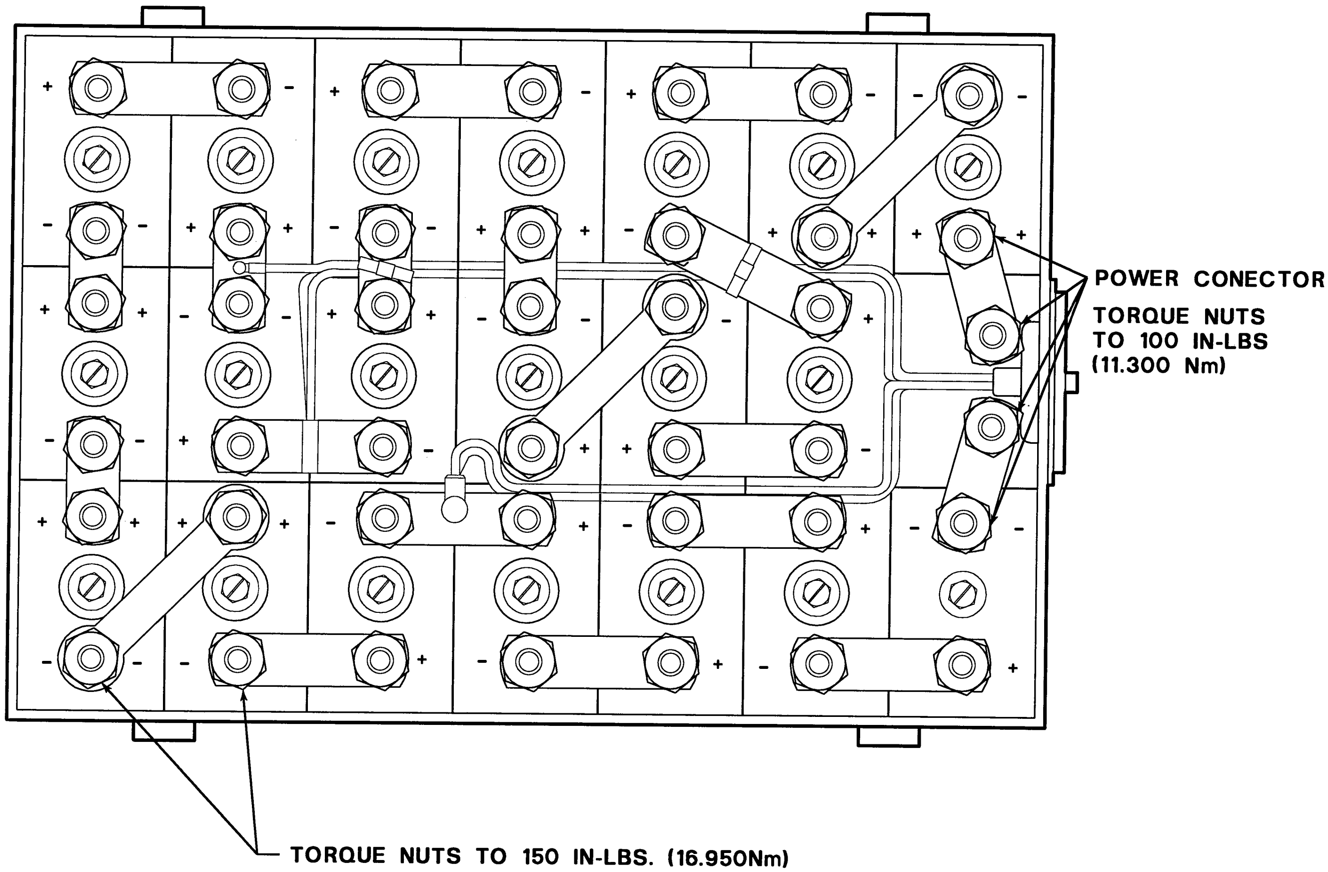
2. Using a voltmeter connect the test harness red lead to voltmeter H1, the black lead to voltmeter LO, and the alligator clip to the battery negative terminal (helicopter ground if the power connector is connected). Read the voltage and convert to temperature using figure 11-25. A thermocouple should be placed in the battery at approximately the same location as the temperature sensor to obtain a comparative temperature.

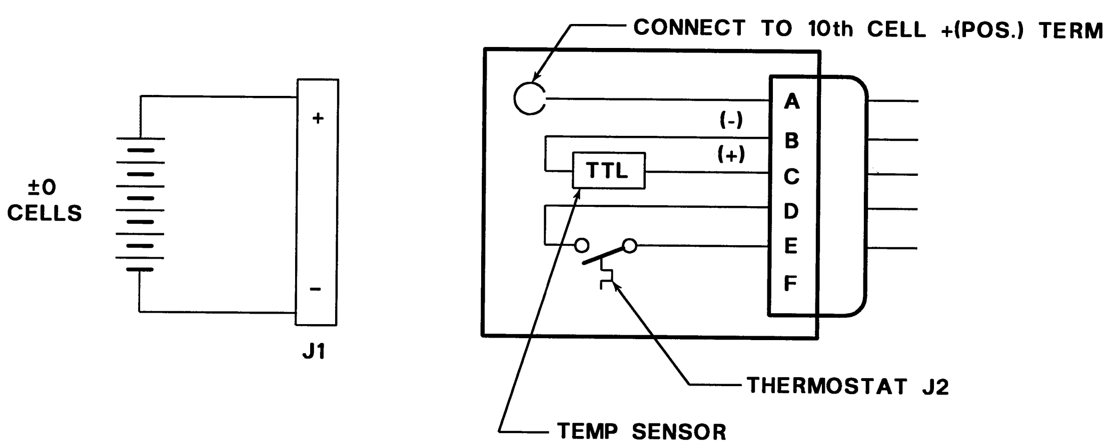
11-107. STORAGE.

MATERIALS REQUIRED

NUMBER	NOMENCLATURE
EC-030	Petrolatum

1. Duration of storage. Ni-Cad batteries may be placed in storage at temperatures ranging from –65 to 120°F (–53.8 to 40.0°C) for an unlimited period.





E/SPM-11-22

Figure 11-22. Battery schematic

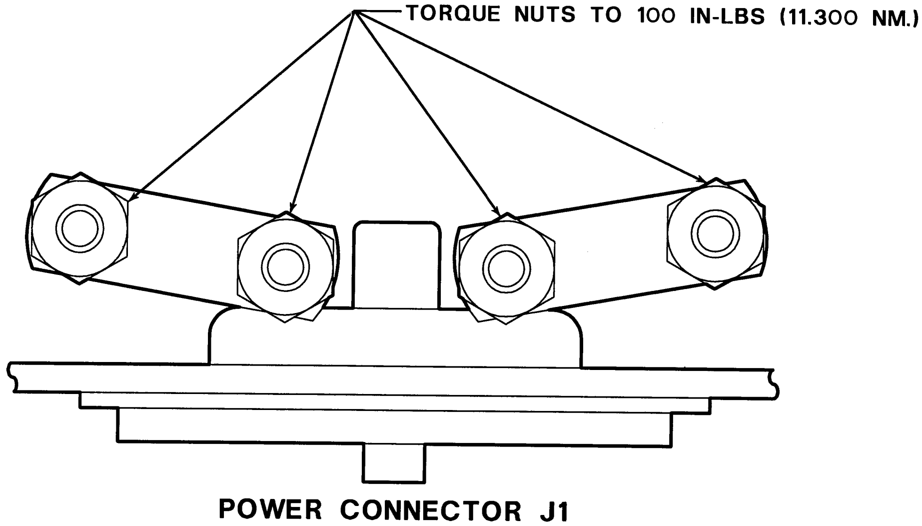


Figure 11–23. Power connector torquing guide

2. Condition of battery for storage. The battery should be clean and dry before placing it in storage. Intercell hardware should have a light coating of petrolatum (EC-030). Petrolatum will prevent corrosion. Battery should be discharged and shorted out for storage periods greater than 30 days.

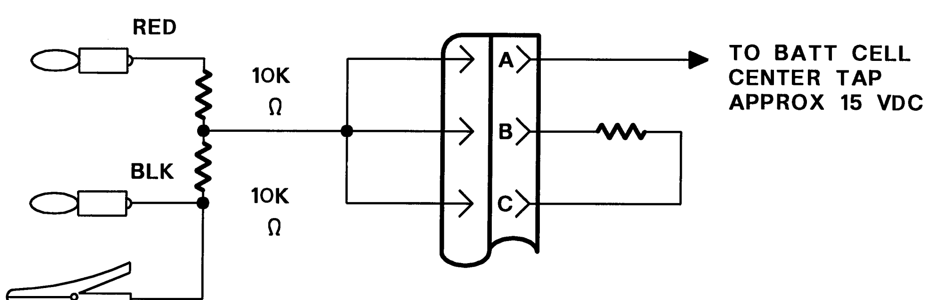
3. Charge retention. Retention of charge of a fully charged battery placed in storage is a function of time and temperature. Storage at high temperatures 95°F (34.9°C) and above will result in a greater loss of charge than room temperature. Storage at low temperature will reduce loss of charge below that experienced at room temperature.

4. Returning to service. Batteries placed in storage condition should receive a topping charge as described in **paragraph 11-109** before placing in service if they have been in storage more than 30 days. Fully discharged batteries may be recharged by the method described in paragraph 11-108. Batteries stored more than 30 days should be slow charged in accordance with paragraph 11-108.

11-108. CHARGING THE BATTERIES.

NOTE

Before charging observe all precautions mentioned in **paragraph 11-101** operation and maintenance. Ensure the correct polarity between charger and the battery. Charging a nickel-cadmium in reserve at high rate will cause permanent damage.



NOTE

Construct test lead with the two resistors and the jumper inside the back shell of plug

E/SPM-11-24

Figure 11–24. Temperature sensor test harness

11-109. Charging procedure.

One of several procedures may be selected for charging a nickel-cadmium battery depending on its state-of-charge and the charging equipment available.

1. Constant current - completely discharged battery.

a. Using a constant current charger, charge at 30 amperes until the voltage reaches 1.57 volts per cell. If battery temperature increases 15°F (9.44°C) above ambient, discontinue charge. Allow battery to cool and start again.

b. Charge at 20 amperes until the voltage reaches 1.60 volts per cell or two hours, whichever occurs first, then reduce the rate at 10 amperes, and continue the charge for two hours.

c. Fifteen minutes before the end of charge, check individual cell voltage. Each cell should have a voltage between 1.5 and 1.7 volts. A voltage below 1.5 indicates a cell which is not charged. This voltage should increase as the charge is continued. If the voltage does not increase and the cell is unusually warm, the cell has an internal short and should be replaced.

d. If a damaged cell(s) is found, discharge the battery, replace the cell, and repeat preceding steps a., b., and c.

e. A voltage measurement which is too high (over 1.7 volts) may indicate a cell which is low on electrolyte. Add water cautiously to any of these cells. Do not final fill until voltage indicates cell is charged.

2. Constant potential.

NOTE

Constant potential charging is a method whereby a constant voltage is applied across the battery terminal. Several disadvantages are inherent in this method. First, it can create capacity imbalance between cells; secondly, continuous overcharge or floating the battery results in excessive water loss from the electrolyte. Apply a constant voltage equivalent to 1.45 volts per cell across battery terminals until charge rate drops below two amperes. If charge can produce a rate 10 times the rated capacity of the battery, this charge should take approximately one hour at 70°F (21.1°C). Voltage required to accomplish a proper charge varies with temperature as shown in figure 11-26.

3. Various combinations may be used to charge nickel-cadmium batteries and achieve excellent results as the battery is very rugged and may be charged rapidly or slowly without damage. If battery is charged rapidly, the battery temperature should be monitored and charge terminated if temperature exceeds 120°F (48.8°C), or rises more than 15°F (–9.44°C) during charge. Repeated charging at very low rates will result in a temporary loss of capacity which may be restored by deep cycle maintenance.

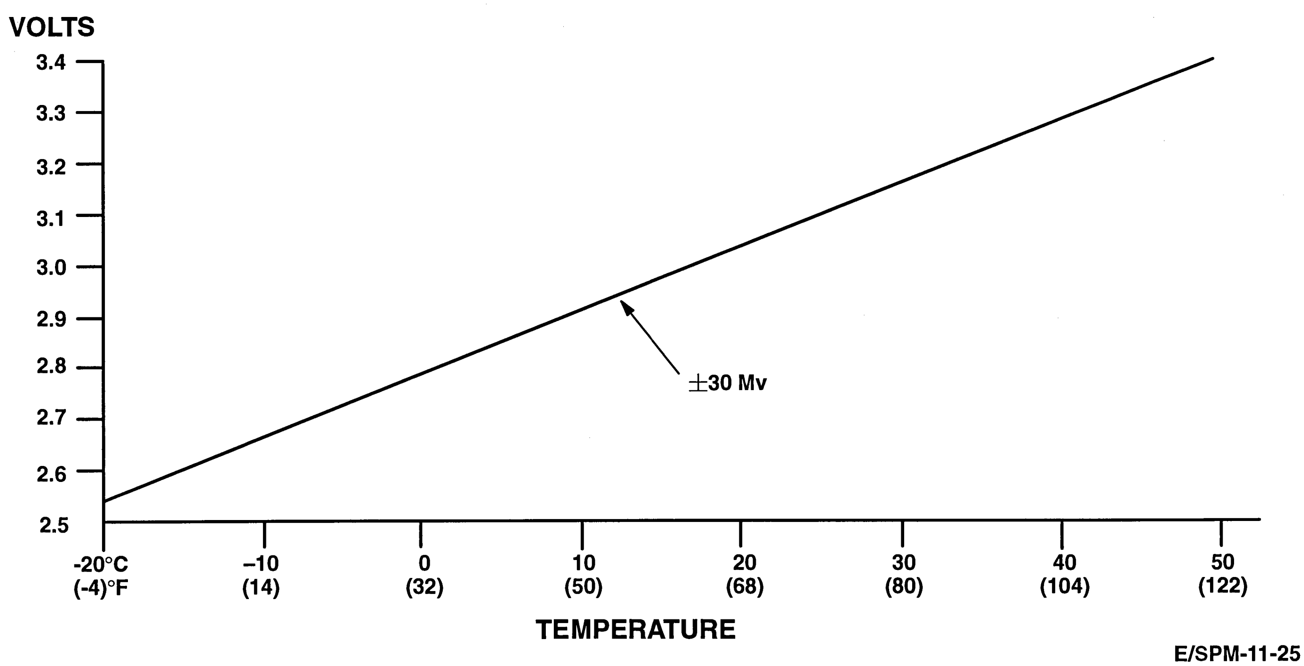


Figure 11–25. Temperature sensor conversion chart

4. Pulse chargers are available from various manufacturers and have demonstrated some advantages over constant current and constant voltage charging techniques. Contact battery manufacturer for specific pulse charger information.

11-110. ELECTROLYTE ADJUSTMENT.

WARNING

BATTERY MUST BE FULLY CHARGED OR CHARGE STATUS KNOWN BEFORE WATER IS ADDED. WATER MUST NEVER BE ADDED TO A BATTERY IF THE CHARGE STATE IS UNKNOWN.

THE FOLLOWING PROCEDURES MUST BE ADHERED TO IN ORDER TO PREVENT SPEWING OF ELECTROLYTE DURING ONBOARD CHARGING. WATER LEVEL ADJUSTMENT MUST BE PERFORMED ON A BATTERY WITHIN 25 MINUTES OF COMPLETION OF A CHARGE CYCLE. THIS IS TRUE WHETHER USING ONBOARD CHARGE MONITOR OR A BENCH CHARGING SYSTEM.

NOTE

After long flights the battery must be topped to simulate an actual end of charge electrolyte level. This can be done by discharging on the helicopter and recharging or in a maintenance shop. In either case, 10 to 30 minutes in the topping mode at 10 amperes is required.

11-111. ELECTROLYTE ADJUSTMENT PROCEDURES.

NOTE

Hydrogen gas has been generated within cell during charge. Remove caps slowly allowing gas to escape without spewing electrolyte.

1. Carefully remove vent cap assemblies and soak in distilled or deionized water.

Temperature	Recommended Voltage Per Cell
–20°F (–29°C)	1.68
0°F (17°C)	1.58
+20°F (6°C)	1.53
+40°F (6°C)	1.51
+60°F (16°C)	1.50
+80°F (27°C)	1.48
+100°F (38°C)	1.46
+120°F (49°C)	1.42

E/SPM-11-26

Figure 11–26. Charge voltage requirement

NOTE

Any large capacity (10 cc or greater) medical syringe can be used for this purpose. However, a large gage needle cut to proper length must be used. Ferrule at top of needle acts as the stop when inserting needle into cell. Figure 11-27 illustrates electrolyte adjustment. Figure 11-28 illustrates modification of a needle for this use. Additional electrolyte adjustment syringe assemblies may be obtained from Eagle-Pitcher (FSCM 50120) as Syringe Assembly, SYR-105.

2. A syringe has been provided with the battery for use in electrolyte adjustment. Insert the syringe into the vent opening as far as it will go. Apply suction with the syringe. If no liquid is withdrawn, add distilled or deionized water until it is possible to withdraw liquid. Withdrawing liquid with the syringe until no more can be withdrawn will result in a properly adjusted cell. Repeat procedure adding 10 cc of water to each cell and with the syringe in as far as it will go. To properly record water additon in the maintenance log, determine difference between amount added to cell and amount withdrawn. Graduations on the syringe may be used for this purpose. If cold weather (below 32°F (0°C) operation is anticipated, the electrolyte level needs to be lowered because of excessive gassing (high charge voltage) of cold batteries. Two techniques can be used: lengthen syringe by 1/4-inch or top charge battery at 30 amperes for the adjustment. Both methods assuming room temperature batteries.

CAUTION

DO NOT OVERTIGHTEN.

3. Rinse off vent caps and reinstall.

4. Syringe should be thoroughly rinsed, cleaned, and dried after each use.

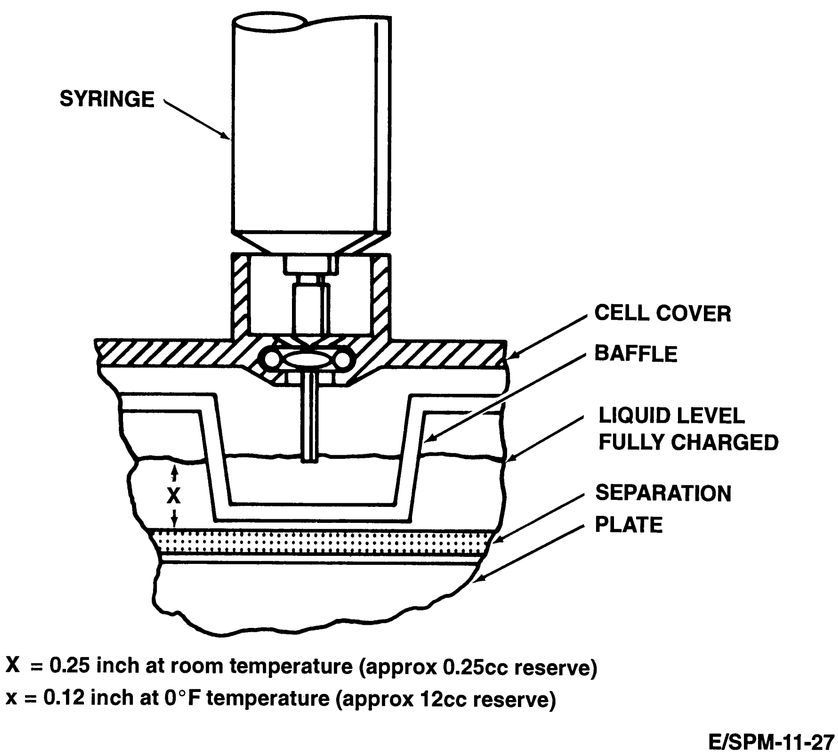
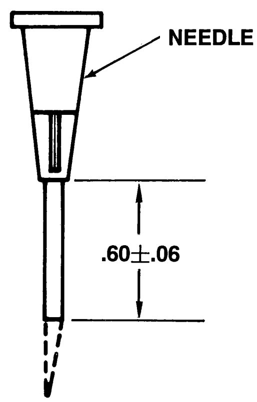


Figure 11–27. Electrolyte level adjustment



Needle, Perfectum 12 ga. x 1., Reorder No. 7230 VET.
As supplied by Propper Manufacturing Co., Inc.
Long Island City, NY
or Equivalent

E/SPM-11-28

Figure 11-28. Syringe needle modification