TITLE: RECORD OF REVISIONS

MANUAL NO:_______ ASSIGNED TO: ___________________________

RETAIN THIS RECORD IN THE MANUAL. UPON RECEIPT OF REVISIONS, INSERT THE REVISED PAGES INTO THE MANUAL AND ENTER THE REVISION NUMBER, REVISION DATE, INSERTION DATE AND THE INITIALS OF THE PERSON INCORPORATING THE REVISION IN THE APPROPRIATE BLOCKS ON THE RECORD OF REVISIONS. RETURN ACKNOWLEDGMENT FORM TO THE CHIEF INSPECTOR. WHEN THE NEED IS APPARENT, ALL PERSONNEL ARE EXPECTED TO SUGGEST REVISION REQUIREMENTS TO THE PRESIDENT.

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REVISION NUMBER	EFFECTIVE DATE	NATURE OF CHANGE	APPROVAL	INSERTED BY	INSERT DATE
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REV 1	SEPT. 8, 1999	WORDING IN SECOND PARAGRAPH PAGE 1	GL	GL	SEPT. 8, 1999
REV 2	SEPT. 1, 2000	ADDITION TO WORDING	GL	GL	SEPT. 1, 2000
REV 3	JULY 10, 2001	ADDITION TO WORDING, CHANGE IN CALCULATION	JD	JD	JULY 10, 2001
REV 4	SEPT. 14, 2001	ADDITION OF ILLUSTRATION ON PAGE 11	JD	KK	SEPT. 14, 2001
REV 5	NOV. 19, 2001	ADDITION OF TABLE AND WORDING, ADDRESS CHANGE	JD	KK	NOV. 19, 2001
REV 6	JAN. 24, 2002	ADDITION OF TABLE ABOUT APPROVED CELLS	GL	KK	JAN. 24, 2002
REV 7	DEC. 06, 2002	ADDITION OF BATTERIES TO SPECIFICATION TABLE	SW	KK	DEC. 06, 2002
REV 8	JAN. 29, 2003	ADDITION OF BATTERIES TO SPECIFICATION TABLE	JD	KK	JAN. 29, 2003
REV 9	FEB. 21, 2003	ADDITION OF BATTERIES TO SPECIFICATION TABLE AND ADDITION TO TABLE 1	JD	KK	FEB. 21, 2003
REV 10	MARCH 25, 2003	CORRECTION TO SPECIFICATION TABLE, REVISION TO WORDING AND ILLUSTRATION ON PG 10-11	JD	KK	MAR 25, 2003
REV 11	MAY 19, 2003	CHANGE THE MANUAL CONTROL #, CORRECTION TO SPECIFICATION TABLE	SW	KK	MAY 19, 2003
REV 12	JULY 21, 2003	CHANGE WORDING ON PAGE 7	JD	KK	JULY 21, 2003
REV 13	FEB. 23, 2005	CORRECTIONS TO CHART ON PG 25-26, PRELIMINARY CLEANING, & DEEP CLEANING	SW	KK	FEB. 23, 2005
REV 14	SEPT. 27, 2006	CORRECTIONS TO WORDING ON PAGES 13,15,18-20, 26-27	RS	KK	SEPT 27, 2006
REV 15	MAY 1, 2007	CORRECTION TO WORDING ON PAGES 13,15, 22, 25, 26	SW	KK	MAY 1 2007
REV 16	AUG 8, 2008	ADDITION OF FORWARD. ADDED VERBIAGE TO PG 21	RS		

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AERO DESIGN, INC.

A HEICO AEROSPACE COMPANY

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FORWARD:

This document, BWI 4.19.5.1, is supplemental information provided as a courtesy to the customer regarding Aero Design, Inc mainship batteries and cells. This document is only supplemental information because the Original Equipment Manufacture (OEM) manual should be used to maintain our batteries and cells.

Aero Design ensures that our Parts Manufacture Approval (PMA) parts meet or exceed the requirements of the Original Equipment Manufacturer's parts in durability, reliability, and performance. Our PMA process is accomplished in accordance with FAA Order 8110.42. Per 8110.42, no additional Instructions for Continued Airworthiness (ICA) are required for the PMA part as long as the product's ICA is valid with the PMA part. An Aero Design ICA will be provided if the existing Type Certificate (TC) and/or Production Certificate (PC) Holder ICA is impacted by the installation of the PMA part. When no additional ICA is provided by Aero Design, please use existing TC and/or PC Holder ICA.

DESCRIPTION:

SCOPE OF THE MANUAL

Aero Design, Inc. is the holder for the FAA-PMA's. Battery Shop LLC is the repair facility. Both are located at 385 Industrial Drive. Hazardous material requirements should be strictly adhered to. Battery Shop LLC qualifies for several exemptions to the hazardous material regulations. Most of Battery Shop's batteries and cells are shipped non-hazardous. For the latest information contact Battery Shop LLC.

The information provided in this manual is intended to help obtain the best performance and maximum life from your nickel-cadmium vented cell batteries. It describes the construction of these batteries, as well as the operation of nickel-cadmium batteries. It will also instruct the users and technicians on operation, maintenance, repair, overhaul and general care. All applicable Aero Design, Inc. batteries and battery cells are approved by the FAA under 14 CFR FAR 21.303 (c)(4), test and computation; showing that all design, materials, processes, test specifications, system compatibility, and interchangeability are supported by an appropriate test and substantiation report. These tests and reports have been reviewed and approved by the FAA per guidance stated in FAA order 8110.42a, para. 9.a.3.c. All battery cells in table 1, below, are FAA-PMA approved to be interchangeable with like Saft and Eagle Picher battery cells in either battery. All Aero Design, Inc. parts are identified by an "AD" prefix to the SAFT, Eagle Picher, and Marathon part number.

TABLE 1

S.I. NO	Aero Design Cell Designation	Capacity in AH	Equivalent Make	Approved	Equivalent Make Cell Designation
1.	AD-VP160KH	16	SAFT	APPROVED	VP160KH
2.	AD-VP160KM	16	SAFT	APPROVED	VP160KM
3	AD-VP170KH	17	SAFT	APPROVED	VP170KH
4.	AD-VHP170KH-3	17	SAFT	APPROVED	VHP170KH-3
5.	AD-VP230KH	22	SAFT	APPROVED	VP230KH
6.	AD-VHP230KA-3	23	SAFT	APPROVED	VHP230KA-3
7.	AD-VO23KH	23	SAFT	APPROVED	VO23KH
8.	AD-VHP270KH-3	27	SAFT	APPROVED	VHP270KH-3
9.	AD-VO25KA	25	SAFT	APPROVED	VO25KA
10.	AD-3030-1	30	EPI	APPROVED	3030-1
11.	AD-43B034AC14-2	34	SAFT	APPROVED	43B034AC14-2
12.	AD-VHP370KA-3	37	SAFT	APPROVED	VHP370KA-3
13.	AD-VP380KH	38	SAFT	APPROVED	VP380KH
14.	AD-VP400KH	40	SAFT	APPROVED	VP400KH
15.	AD-VP400KHAC	40	SAFT	APPROVED	VP400KHAC
16.	AD-VO40KH	40	SAFT	APPROVED	VO40KH
17.	AD-VHP430KH-3	43	SAFT	APPROVED	VHP430KH-3
18.	AD-VHP450KA-1	40	SAFT	APPROVED	VHP450KA-1
19.	AD-43B050AC01-2	50	SAFT	APPROVED	43B050AC01-2
20.	AD-3H120	3	MARATHON	APPROVED	3H120

Answers to most questions regarding the nickel-cadmium vented cell battery should be easily found in this manual. Further information and assistance regarding this product may be obtained from Aero Design, Inc. or Battery Shop LLC.

In the event that batteries have a specific component maintenance manual(CMM) assigned to a particular product, this CMM will supercede all information contained in this manual for those specific battery types.

Batteries

Each nickel-cadmium battery consists of a metal case containing a number of individual cells connected to each other in a series. These cells are enclosed in polyamide containers and are placed within the battery case without additional insulation between the cells being necessary.

Nickel plated copper link bars are used to connect the cells, and are held in place by nickel-plated copper nuts. The end-cells are connected by either a solid or a flexible link (also nickel-plated copper).

Plastic wedges retain the cells and further movement is prevented by a retainer bar made of plastic attached to the battery case or by a silicon rubber insulating material attached to the cover.

Depending on the model, the battery case is made of metal or other appropriate rigid material. Depending on the particular model, the battery case may be made of stainless steel, plastic coated sheet steel, painted sheet steel or titanium. All batteries are ventilated to allow the escape of gases that are produced during overcharge and/or to permit cooling during operation.

Cells

The cell is where the electrochemical reaction takes place which converts chemical energy into electricity.
Two groups of nickel plates, both thin and porous make up the active elements of the nickel-cadmium cell. One set is impregnated with nickel-hydroxide to give it its positive polarity. The other is impregnated with cadmium hydroxide to give it a negative polarity. Within the cell container, the plates of opposite polarity are separated by synthetic materials that act as an insulator and as a gas barrier during the charging process. The electrolyte consists of potassium hydroxide and water. This solution is approximately 70% water by weight. It serves as the conductive medium for ion flow between positive and negative plates. The electrolyte remains in contact with the plates through the wicking ability of the separator material. Inside the cell, each set of positive and negative plates is connected to its respective terminal post (positive or negative)
which is brought out through the cover of the polyamide cell container. An O-ring is used to seal the opening for the terminals, to prevent leakage of the electrolyte. Each cell has a metal vent plug or a removable polyamide filler cap that also serves as a venting valve which allows gas to escape during overcharge and, at the same time prevents air from entering the cell.

The entire cell container is made of a polyamide plastic formed into a single leakproof unit by a thermal polyfusion process.

Connectors

Each Aero Design, Inc. battery is connected to the aircraft system by either a standardized connector, such as a MS3509 type connector, or by a special connector for an unusual application. See table.

Specifications

Battery manufacturers manufacture many types of aircraft batteries. These differ in size or weight or capacity or electrical performance or, possibly in all these characteristics, depending on which batteries are compared. Most of these types are listed along with their physical and performance specifications and other pertinent data in the table provided.

Battery ratings

Note: Cell or battery capacity notation explanation:

As a cell or battery's discharge current increases, its ability to deliver all of its stored energy decreases. To let the user know what a cell or battery can deliver at certain discharge rates, cell or battery manufacturers conventionally use notation of Cn = A-h, which means that this cell or battery's Capacity, when discharged in 'n' hours, equals, at least, the stated number of Ampere-hours. For example: A cell or battery rated C = 38 A-h, means that this cell or battery can deliver 38 Amperes for at least one hour before reaching a terminal voltage of one volt per cell at room temperature. Higher or lower discharge or charge rates are frequently expressed by multiplying the 'C' discharge rate by a multiplier such as 0.1, 10, 20 etc... For example, high discharge currents for engine starting might be 20C, (20 x 38 Amps or 760 Amperes), while charging currently is usually 0.1C (0.1 x 38 = 3.8 Amperes).

Nickel-Cadmium cells have a nominal discharge voltage of 1.2 volts. Therefore, the nominal battery voltage is 1.2 times the number of cells.

Nickel-Cadmium batteries, like all batteries, are normally rated by their nominal discharge voltage and their nominal/rated capacity.

Rated capacity is defined as the quantity of electricity, measured in ampere-hours (Ah), that the battery can deliver from its completely charged state to its discharged state at $^{+}23°$ C ±3° (73.4° F). The battery is considered to be discharged when its terminal voltage equals 1.0 volt per cell times the number of cells (i.e. 20 volts for a 20-cell battery).

American Standard AS8033 defines capacity as:

"$1C_1A$ - The numerical value of the minimum expected capacity in units of ampere hours, at a discharge rate of $1C_1A$ amperes (the one hour rate), and a battery temperature of 23 ±3° C. $1C_1A$ is the rating which indicates the relative amount of available emergency electrical capability of a particular cell/battery design.

Capacity - The dischargeable ampere hours available from a fully charged cell/battery at any specified discharge rate/temperature condition."

Listing the capacity at 40 Ah without any qualifying discharge time would imply that the battery could be discharged at any rate, and the current multiplied by the time would equal 40 Ah. This is not true. A battery with a capacity of "40 Ah at the 5-hour rate" would not deliver 40 amperes for one hour, or 20 amperes for 2 hours. At higher current drains, it would have less capacity. All Aero Design, Inc. vented cell batteries are rated at the 1-hour discharge rate. An Aero Design, Inc. AD- 4076and SAFT 4076 , discharged at 40 amperes will deliver 40 amperes for 1 hour before reaching the 1.0 V per cell average. At the 5-hour rate, the capacity of the AD-4076 would be more than 40 Ah, in other words, if it were discharged at 8.6 amperes, it would provide that current flow for over 5 hours before its voltage dropped to the 1.0 V per cell average.

OPERATIONS:

Assuring optimum performance

A. Keep all inter-cell connectors, and the power connector between the battery and aircraft clean and tight for maximum electrical output. Inspect the aircraft connector each time the battery is removed for corrosion, worn contacts, and other damage.

Note: Worn aircraft connectors will greatly effect the performance of the battery.

B. Exercise great care, particularly during maintenance procedures, to prevent foreign substances from entering the cells and contaminating the electrolyte.

C. **Never correct the level of the electrolyte with anything except distilled or demineralized water.** Electrolyte leveling can only be accurately accomplished during the last thirty minutes of a full charge.

D. Keep as much air as possible out of the cells. Carbon dioxide in the air will combine with electrolyte to form potassium carbonates which decrease the performance of the battery at low temperatures or at high rates of discharge. To prevent air from entering the cells, check for loose, damaged, or missing relief valves and replace or repair as needed.

E. Although nickel-cadmium batteries perform over a wide temperature range {from -40°C (-40°F) to +71°C (+160°F)} performance is markedly reduced at the extremes of this range. In the range of +40°F (+4°C) to +115°F (+46°C) the discharge performance is optimized. Charging should not be attempted below -20°F (-30°C) or above + 135°F (+57°C).

F. Aero Design, Inc. aircraft batteries must be charged as specified in this manual to avoid battery damage and loss of warranty. Particular attention must be paid to the recommended charging rates. Overcharging at a high rate causes overheating that could, in turn, cause damage to the cells. On the other hand, a low rate of charge could result in a low output from the battery.

G. Frequent rapid discharge followed by a constant potential recharge (as frequently is the case in some aircraft operations) may produce an imbalance between cells and a loss of available battery capacity. When such condition occurs, it should be corrected by means of the discharge/charge cycle procedures outlined in another section.

Placing the battery in service

Before the initial charge, remove the battery cover and loosen the vent valve of each cell, using either a screwdriver or the plastic wrench provided in the tool kit. It is NOT recommended that the vent valve be removed during charging.

Charge the battery at a constant current according to one of the procedures for a completely discharged battery as described in another section. It is important to keep the current constant.

During the last half hour of charging, and without interrupting the flow of current, remove the vent valves and check the level of the electrolyte in each cell. If necessary, correct the level by adding **distilled (or de-mineralized)** water as instructed in another section, Electrolyte Level Adjustment. Replace the vent valves, but do not tighten them.

NOTE: The electrolyte level changes considerable with the state of charge. Even with a fully charged cell, it varies according to the time elapsed between the end of charge and the time of measurement. No water should be added under any condition other than those described herein or under another section.

When the charge cycle is complete, tighten the vent valves using only the special plastic Allen head wrench or screwdriver provided in the Aero Design, Inc. or SAFT tool kit. **(<u>Do not over tighten</u>)** and reinstall the battery cover.

Aircraft applications

Batteries are built in a variety of dimensions and mounting arrangements, and are interchangeable with any other batteries of the same physical dimensions, mounting configuration, terminal voltage, and electrical capacity as approved by the airframe manufacturer or other FAA authorized agency.

When replacing a lead-acid battery with a nickel-cadmium type, it is vitally important to clean all the battery mounting and holding fixtures in the aircraft prior to the installation of the nickel-cadmium battery. All traces of acid and salt must first be removed by washing with a neutralizing agent such as a solution of sodium bicarbonate (baking soda) in water. Following the washing, the mounting and holding parts should be dried thoroughly and, for added protection, coated with an alkaline resistant paint.

Although Aero Design, Inc. batteries will operate over a temperature range of {-40°C (-40°F) to +71°C (+160°F)} without failure, it is best to install them in locations where the expected temperature will normally be between +40°F (+4°C) and +115°F (+46°C).

Most Aero Design, Inc. batteries have tubes that must be connected to the aircraft's battery venting system. In a few special applications, battery venting is through the cover plate to the battery compartment.

Ground applications

When an Aero Design, Inc. battery is used in such ground applications as starting gas turbine generators, ground mobile equipment, or in-shop equipment testing, the same general guidelines as for aircraft use should be observed.

Ventilation is equally important regardless of where the battery is used. Ventilation can be provided by connecting the battery via tubes to a ventilation system or by adequately venting the area where the battery is installed.

TESTING:

Delivery inspection

A new battery is normally delivered in a **discharged state,** and with its cells filled with the proper amount of electrolyte. Although great care is taken in packing the battery for shipment, it should be carefully inspected visually for any evidence of damage or electrolyte leakage.

In addition these checks should be made:

A. Measure the insulation resistance as described in another section (5).

B. Check the torque on each cell terminal connection against the figure listed for your type of battery in the Specifications Table, see page 25.

C. Check all ventilation openings to make sure that they are clean and clear.

State of charge

There is no way of determining the precise state of charge of nickel cadmium batteries without discharging the battery at a known current rate, checking the time for the discharge and then calculating what the state of charge had been.

Neither the specific gravity of the electrolyte, nor the terminal voltage of the battery or of its individual cells is an indication of the state of charge. The electrolyte does not significantly change its density or composition (hence specific gravity) with its state of charge. (The specific gravity of the electrolyte does change, however, with the addition or loss of water in the electrolyte solution. Since the potassium hydroxide has a higher density than water, the specific gravity will increase if water is lost and will decrease if too much water is added).

Since terminal voltage will remain almost constant over a wide range of charge levels, its measurement will not provide a valid state-of-charge indication.

Thus, the only positive method of determining state of charge is to discharge the battery at a fixed current flow and measure the time it takes for the voltage to drop to an average of 1.0V per cell.

Determining the approximate state of charge

It is possible to determine the approximate state of charge of the Aero Design, Inc. nickel-cadmium battery by discharging it at 0.2 C_1A amperes for about 10 seconds and then by measuring the terminal voltage with an accurate voltmeter.

If the reading is 1.25 V or more per cell, the battery is at least half charged. If the cell voltage is less than 1.25 V, the battery should be recharged.

Precautions

SERIOUS INJURY CAN RESULT FROM CARELESSNESS WHILE HANDLING AND WORKING WITH NICKEL-CADMIUM BATTERIES. All metal articles, such as watch bands, bracelets and rings, should be removed. Inadvertent contact of these metallic objects with metallic parts or connectors of opposite polarity could result in the fusing of the metal and severe burns to the wearer.

Tools used to service nickel-cadmium batteries should be of insulated material. Metal tools dropped onto the battery could short-circuit connectors and cause arcing which could not only damage the battery but injure 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 handling the solution. If any electrolyte does contact the skin, the area should be flushed immediately with large amounts of water, and neutralized with a 3% solution of acetic acid, vinegar, lemon juice, or with a 10% 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.

As in all rechargeable batteries, hydrogen and oxygen gases are generated during overcharging. These gases should not be allowed to concentrate in any confined space.

Note: Local regulations have priority on the following recommendations.

Therefore, the battery area, be it in an aircraft, a ground vehicle or a battery maintenance shop, must be well ventilated. Battery connections must be tight. Loose connections not only reduce the terminal voltage, but they can cause arcing with attendant explosion hazards. Technicians should make it a special point to see that all connectors between individual cells within the battery, and between the battery terminals and aircraft electrical system are the correct size, clean and properly torqued.

CHARGING:

General

Because this manual applies to all Aero Design, Inc batteries, many of which differ in capacity, all charge and discharge rates are expressed in terms of $1C_1A$ amperes - where $1C_1$ Ah is the capacity at the one-hour rate of the battery. Hence, a charge or discharge rate of $0.1C_1A$ means a current equal to 1/10 of the figure given for the rated capacity of that particular battery. For example, if a battery has a capacity of 36 Ah, the figure for $1C_1A$ would be 36 amperes. Consequently, $0.1C_1A$ would be 3.6 amperes and $0.5C_1A$ would be 18 amperes.

Ground charging of Aero Design, Inc. batteries must always be done with the battery cover removed or with the battery connected to a ventilating system. Otherwise, gas could accumulate in sufficient concentrations to be a potential explosion hazard.

Before charging, check for correct polarity between the battery terminals and leads of the battery charger. Charging a nickel-cadmium battery in reverse at a high rate will damage it permanently. Another precaution: never set the charger current or voltage above zero until closing the switch to the battery.

Charging at Constant Current

Completely Discharging Battery

To charge a completely discharged battery use one of the following procedures:

A. Charge at 0.1 C_1A amperes until the battery voltage reaches an average of 1.5 volts per cell (30 volts for a 20 cell battery). Then continue charging at this same current rate for 4 additional hours. When following this method, the total charge time must be at least 14 hours, but no more than 16 hours.

B. (1) Charge at 0.5 C_1A for at least 2 hours. If after this time the battery voltage has not yet

Table of Constant Current Charge

Constant current charge @ 23 ±3° C		
Ref	Main charge	End of charge
A	$0.1C_1A$ until terminal voltage reaches 30 volts. Time: Min. 10 hrs/Max. 12 hrs	$0.1C_1A$ for 4 hours
B	$0.5C_1A$ until terminal voltage reaches 31 volts. Time: Min. 2hrs/Max. 2.5 hrs	$0.1C_1A$ for 4 hours
C	$1C_1A$ until terminal voltage reaches 31.4 volts. Time: Min. 1 hr/Max. 1.25 hrs	$0.1C_1A$ for 4 hours

reached an average of 1.55 volts per cell (31 volts for a 20 cell battery), continue to charge at this current rate until the voltage rises to this level. However, do not charge at this rate for more than 2 hours and 30 minutes.

(2) Then charge at 0.1 C_1A for 4 additional hours.

C. (1) Charge at 1 C_1A amperes for at least 1 hour. If after this time the battery voltage has not yet reached an average of 1.57 volts per cell (31.4 volts for a 20 cell battery), continue to charge at this current rate until the voltage rises to this level. However, **do not charge at this rate for more than 1 hour and 15 minutes.**

(2) Then charge at 0.1 C_1A for 4 additional hours.

Partially discharged battery

If a charged battery has remained inactive for more than 2 weeks, and less than 2 months, before putting it into service it should be charged at a rate of 0.1 C_1A amperes until the battery voltage reaches an average of 1.5 volts per cell (30 volts for a 20 cell battery).

If a charged battery has remained inactive for more than 2 months, or if its exact state of charge is unknown, the battery must be discharged at a rate not to exceed 1 C_1A amperes to a terminal voltage of 1 volt per cell average (20 volts for a 20 cell battery). It should then be recharged.

Rapid partial charge

Charge at 0.5 C_1A amperes until the battery voltage reaches an average of 1.55 volts per cell (31 volts for a 20 cell battery), but for no longer than 2 hours 15 minutes.

Charge at 1 C_1A amperes until the battery voltage reaches an average of 1.57 volts per cell (31.4 volts for a 20 cell battery), **but not longer than 1 hour 15 minutes.**

Either of these two methods will charge the battery to about 80% of its capacity. In an emergency, the battery can be placed in the aircraft in this condition where it will be fully charged in flight. This charge should not be used during maintenance of the battery.

Charging at a constant potential

In aircraft installation, the most common method of charging is the Constant Potential method.

Note: When installed in an aircraft or other mobile unit using a constant potential charging system, the battery charging voltage should be checked frequently - preferably when the battery is at or near the floating charge condition. At normal temperature {70° ± 10°F (20°C± 5°C)}, this voltage should be between 1.4 and 1.425 volts per cell (or 28 to 28.5 V for a 20 cell battery). If an ambient condition or battery operation raises the cell temperature or to above 140°F (60°C), and this is likely to be the usual operating temperature for the installation, the voltage must be between 1.375 and 1.4 volt per cell (27.5 to 28 V for a 20 cell battery) to prevent rapid depletion of the water in the electrolyte.

This constant potential method of charging is most commonly used in aircraft with D.C. electrical systems, ground carts and other mobile equipment. Conventionally, it uses an engine-driven generator in combination with a transformer-rectifier. It has the advantage of being able to rapidly recharge a discharged battery and then to maintain it in the fully charged condition by a continuous float or overcharge during generator operation.

Two important disadvantages of the constant potential system at typical aircraft bus voltages are:
1. Capacity imbalances can be created among cells during discharge/charge cycles, and;

2. Continuous float or overcharge results in the consumption of the water from the electrolyte.

Both of these conditions require that the battery be periodically reconditioned.

If the constant voltage system can deliver 10 times the ampere-hour of the battery, it will then require only 1 hour to restore approximately 90% of the battery's rated capacity.

Special charging systems

In addition to the constant current and constant potential methods of charging, there are a number of combinations of the two. There are also other methods, such as pulse charging.

Aero Design, Inc. aircraft batteries may be charged with these non-standard methods, but to avoid possible warranty abridgement, Aero Design, Inc. or SAFT should first be contacted for specific recommendation.

Electrolyte level adjustment

The water consumed by nickel-cadmium vented cells is directly proportional to the amount of overcharge current they received; the required period between the electrolyte level adjustments will depend on operating conditions.

This relationship between ampere hours of overcharge and water consumption results in $1cm^3$ of water being electrolyzed in H_2 and O_2 for every 3 Ah of overcharge. If the battery is used with a constant potential charging system, the initial check should be made after the first 50 hours of operation. The amount of water used during that period should be compared with the maximum consumable quantity for that type battery.

This comparison should provide the operator with an estimate of the safe number of hours between adjustments. For example, if, after the first 50 hours of flight, an aircraft battery requires 10cc of additional water per cell to reach the correct electrolyte level, the Specifications table shows 25cc as the consumable maximum per cell for that type battery, 100 hours would be a safe estimate for the period between adjustments(80% of 25cc Max./10cc used x 50 hrs = 100 hrs. This estimate assumes, of course, that the battery will be operated under similar conditions as during the first 50 hours.

The adjustment of electrolyte level must be in conjunction with the electrical tests outlined elsewhere in this text.

The period between required maintenance for the checking of cell balance is a function of the number of deep discharges and constant potential recharges. Unfortunately, there is no formula to establish this period. However, for most applications, the period between required electrolyte leveling is shorter.

Caution: The addition of water by any method other than that given herein is prohibited as it may cause spewing and loss of electrolyte during overcharge.

In a nickel-cadmium battery cell, the level of electrolyte changes considerably with its state of charge. Even when a cell is fully charged, the electrolyte level will vary during the time between the end of the constant current charge and the instant the measurement is made. This is due to the slow and uncontrollable rise of the gas bubbles that were generated between the plates during the overcharge portion of the charge cycle.

The electrolyte is at its maximum level and is most uniform from cell to cell near the end of the recommended constant current charge with the charging current still flowing. At this time, the gas bubbles within each cell are simultaneously being evenly generated over the surface of the plates and rising to the surface of the electrolyte. Therefore, the level may now be most accurately adjusted with a minimum of variation from cell to cell.

Before the adjustment of the electrolyte level, remove the relief valves with a screwdriver or the specific plastic tool provided in the Aero Design, Inc. tool kit. Immerse the valves and their O-rings in distilled or de-ionized water and let them soak to dissolve any salts.

The Aero Design, Inc. tool kit also contains a plastic syringe, (similar to a hypodermic syringe) with a nozzle that is cut to a specific length for each type of battery. Note: The proper nozzle length for each battery type is given in the Specifications Table. Please see this table for the appropriate electrolyte level.

To check the liquid level of the cell, insert the syringe into the cell opening until the shoulder of the nozzle rests on the valve seat. Withdraw the plunger and check for any liquid in the syringe. If the level is too low, the syringe will remain empty, indicating that the end of the syringe nozzle did not reach the liquid in the cell. Any excess liquid in the cell will be drawn into the syringe until the level of the electrolyte corresponds to the end of the nozzle. This is the correct level for the electrolyte.

After inspecting the vent valve assemblies, reinstall the vent valve assembly in the cell. **Do not tighten.**

If the electrolyte is low, the procedure outlined below should be followed using only distilled or de-mineralized water:

A. Draw a measured amount of distilled water, such as 5 cc, into the syringe and inject it into the cell.

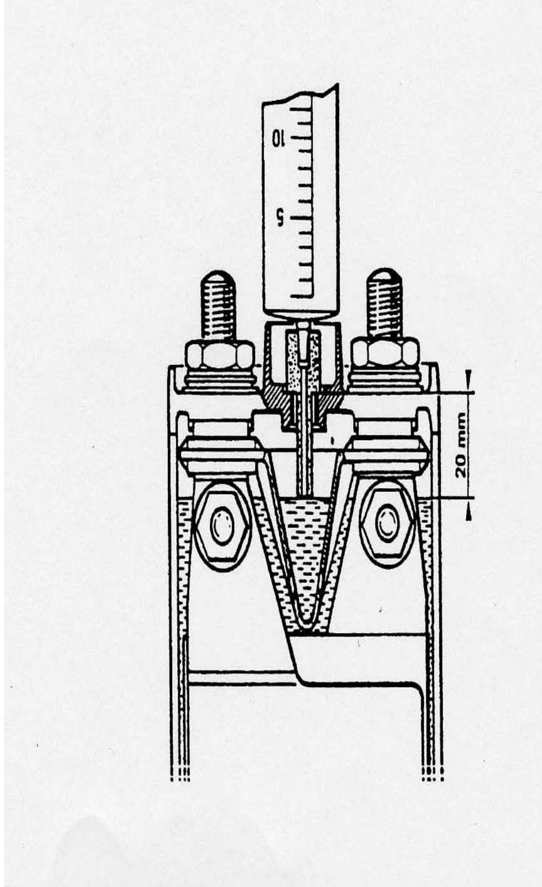
B. With the syringe nozzle resting on the valve seat, fully withdraw the plunger on the syringe.

C. If the syringe remains empty, repeat A and B, counting the number of 5 cc injections required to achieve the correct level.

D. At the point in step B when some excess liquid is drawn into the syringe, the correct level for that cell has been reached. Expel the excess liquid into a container for later disposal.

E. The number of cc's of distilled water required to fill the cell to the correct level will serve as an approximate guide to the amount required for the remaining cells. The water in each cell, however, must be adjusted individually to the correct level.

It is important to check that the quantity of water added per cell does not exceed the maximum allowable consumption for the battery type being serviced. If the consumption is too high, check the setting of the charging system or regulator. If this setting is correct, then shorten the period between maintenance intervals.



TOPPING UP WITH SYRINGE FITTED WITH A CALIBRATED ADAPTOR

ELECTRICAL TESTS:

General

In addition to the checks prescribed for ground and airborne use in the Operations section, maintenance of Aero Design, Inc. vented cell batteries consists essentially in keeping the cells clean, periodically correcting the electrolyte level and re-balancing cell capacities.

Battery records

Because of the importance of keeping track of the liquid level as well as the general state of charge and condition of the battery, it is strongly advised that a maintenance log be kept for each battery. Not only will careful records be a big help in correcting battery malfunctions in normal servicing, but they are vital to the substantiation of warranty claims.

A suggested service record form is supplied with new batteries and is also in the back of this manual.

Facilities

Service facilities for nickel-cadmium batteries must be entirely separated from those for lead-acid batteries. Fumes from lead-acid batteries or small traces of sulfuric acid entering a nickel-cadmium battery can damage it permanently.

Use not only separate filler equipment but separate supplies of distilled water to avoid contamination of the nickel-cadmium cells. Brushes, scrapers, cloths, tools or other implements used to maintain lead-acid batteries should never be used on nickel-cadmium types.

Preliminary cleaning

IMPORTANT: Do not use petroleum spirits, trichloroethylene or other solvents for cleaning the battery.

Wipe the battery case and its cover with a clean cloth.

Remove the cover and clean the top of the battery.

Using filtered compressed air with a non-metallic nozzle, blow around the tops of the cells to eject from the battery case any dust and salt crystals that may have been deposited.

Loosen stubborn deposits with a plastic bristle brush and then blow away the particles.

Caution: Wear eye protection and a dust mask when performing this operation.

Electrical tests

Check that all end-cell and inter-cell connections are tight according to the recommended torque figures given in the Specifications Table, and that they are not damaged or show signs of overheating.

Discharge

The purpose of this discharge is to determine the electrical characteristics of the battery when it is removed from the aircraft, either for routine maintenance or to investigate a malfunction. The results of this initial discharge will determine the steps to be taken to electrically recondition the battery.

Discharge the battery at a rate not to exceed $1C_1A$ amperes (for example, 40 amperes for a 40 Ah battery).

Record the time at the start of the discharge and the discharge current.

Monitor individual cell voltages periodically during discharge.

Record the time at which the first cell reaches 1.0 volt. **It is not a cause for concern if a cell goes to zero voltage or reverses polarity during the battery discharge.** Simply short out such a cell's terminals for the remainder of the discharge.

Stop the discharge, and record the time when the battery terminal voltage corresponds to 1.0 volts per cell (20 volts for a 20 cell battery minus 1.0 V per previously shorted cell).

Calculate the elapsed time required to discharge the first cell to 1.0 volt and the elapsed time required to discharge the battery to an average of 1.0 volt per cell.

With the above information, make the following calculations:

Minimum cell capacity = elapsed time to discharge first cell (in minutes) divided by 60

Battery capacity = elapsed time to discharge the battery to 1.0 volts per cell (in minutes) by 60.

Interpretation of the first discharge results

Rev 15

Based on the values obtained for minimum cell capacity and battery capacity, proceed as follows:

- The minimum cell capacity for AD-VO and AD-VP Series cells is equal to or greater than 85% . All other designs require 100% of the rated capacity of the battery.

These results reflect a battery which is receiving a good charge in the aircraft, and whose cells are within acceptable range of capacity balance.

Therefore, after allowing the battery to cool to room temperature, it need only be charged, and the electrolyte leveled as per another section in this manual. It can then be placed back into service.

- The minimum cell capacity for AD-VO and AD-VP Series cells is equal to or greater than 85% . All other designs require 100% of the rated capacity of the battery.

Depending upon the battery capacity, these results can be due to any one of the following:

- The voltage regulator in the aircraft is set too low.
- The battery was used to power equipment after the last landing.
- The battery cells have temporarily or permanently lost electrochemical capacity.
- A condition of cell capacity imbalance has developed.

In view of the fact that it may be difficult to determine the exact cause, the battery should be given a deep cycle and a recharge as follows:

Each cell in the battery should be discharged to zero volts using one of the following procedures:

A. Continue to discharge the battery and as each cell reaches 1.0 volt, place a 1.0 ohm (1.0 watt minimum) resistor across the terminals. Leave the resistor in place for 16 to 24 hours to allow each cell to completely discharge. (The resistors should be fitted with alligator clips for a firm connection).

B. Continue to discharge the battery and as each cell reaches 0.5 volt, insert a shorting clip between its terminals. Leave these clips for 16 to 24 hours to allow the cells to completely discharge and the battery to cool.

After removing the shorting clips and/or discharge resistors the battery should then be charged, and its electrolyte level adjusted per another section, then discharge again.

Charge

During charging, the battery cover should be removed and all **vent valves loosened, but not removed.**

If the battery had been completely discharged (deep cycled), check the cell voltages to assure that they are at or near zero volt and then remove the resistors or shorting clips. Charge at a constant current following one of the previously outlined methods.

NOTE: Check individual cell voltages at the beginning of the charge. If any cell indicates an immediate voltage rise above 1.5 volts, inject into it a small amount of deionized or de-mineralized water. Also check its performance closely to assure that there has been no permanent damage. See troubleshooting guide.

During the last 30 minutes of the charge at 0.1 C_1A amperes, measure the individual cell voltages and adjust the electrolyte level following the procedure outlined in another section.

If all the cells have an end of charge voltage of between 1.5 and 1.7 volts, the battery should be either returned to service or given a second discharge, depending upon the results obtained in the first discharge.

A low end of charge voltage (below 1.5 volts per cell) can be caused either by a partial dry up of the cell or by a damaged separator.

In the first case, a too low electrolyte level could leave part of the plates exposed during the charge and lead to a significant rise of cell temperature and consequent decrease in cell voltage.

This problem can be diagnosed by recording the quantity of distilled water added per cell which should not be greater than the maximum value indicated on the Specification Table.

If this is the case, the battery must be discharged according to previous specifications. Let the battery stand for 12 or 24 hours then conduct the complete charge/discharge cycle.

Damage of the separator (degradation of the gas barrier or metallisation of the insulator) will cause either a low end of charge voltage or a significant decrease in cell voltage after the cell has reached 1.5 volt.

Such damage can be diagnosed by conducting the following procedure:

After the prescribed charge time has elapsed, continue to overcharge the battery at a 0.1 C_1A rate for an additional 5 hour period during which cell temperature and voltage must be carefully monitored.

Cells having a damaged gas barrier will show an important and continuous temperature increase as well as a drop in voltage. Cells having a metallised insulator will show rapid drops in voltage.

Second discharge

The purpose of this second discharge is to verify that the initial maintenance cycle of discharge and charge corrected the low capacity and/or the cell imbalance that existed in the battery when it was removed from the aircraft.

Discharge the battery at a constant current not to exceed 1C_1A amperes, exactly as was done previously. Again record the actual current, the time at which the discharge was started, the time when the first cell reaches 1.0 volt, and the time when the discharge is terminated (battery voltage equals to 1.0 volt average per cell).

From this data determine the elapsed time to discharge the first cell to 1.0 volt, and the elapsed time to discharge the battery to 1.0 volt per cell.

With these figures, make the following calculations:
Minimum cell capacity = elapsed time to discharge first cell (in minutes) divided by 60.

Battery capacity = elapsed time to discharge the battery to 1.0 volt per cell (in minutes) divided by 60.

Interpretation of test results

Rev 15

Regardless of the results obtained in the first discharge, the battery is in good condition if:

1. The minimum cell capacity for AD-VO and AD-VP Series cells is equal to or greater than 85% . All other designs require 100% of the rated capacity of the battery.

2. The end of charge of <u>all</u> cells was between 1.5 and 1.7 volts.

Therefore, the battery may be placed back into service after it is charged and the electrolyte level adjusted per previous section.
The battery must be given a detailed examination for possible repairs if either of the following results is obtained:

1. Minimum cell capacity was less than 85% of the rated capacity of the battery;
2. The end of charge voltage of any cell was less than 1.5 volts.

Although the battery capacity is not used as a criteria above, records of the total battery capacity should be maintained.

Cell-to-case insulation test

A breakdown in electrical insulation between the cells and the battery case will result in “leakage” current, which over a period of time, can discharge the battery. The most common cause for the loss of insulation is the leakage of electrolyte from the cells which can act as a conductor between the cell plates (or terminals) and the battery container. Because the leakage current can affect battery performance, it is necessary to assure that it is kept to a minimum.
Because of their unique polyfusion welded construction, Aero Design, Inc. cells are guaranteed never to leak at the cell case-to-cover joint. In addition, most cell covers incorporate a lip which will contain any electrolyte that might escape either through the vent or around a terminal seal.

For these reasons, the permissible leakage current in a Aero Design, Inc. battery should not exceed 10 micro-amps. However, taking into consideration the precision instrumentation required to measure such a small current, the following test can be made using a standard electrical shop instrument:

NOTE: The test below is best performed with an analog multi-function meter capable of measurement in the 500 mA range.

A. Adjust the meter and input leads for a measurement of 500 mA.
B. Connect the negative lead from the instrument to the battery container.
C. Touch the positive lead from the instrument to the positive terminal of the battery and then to the positive terminal of each cell.

If, while performing the above, there is any deflection of the needle from zero, the insulation should be considered compromised and the battery should be disassembled and cleaned as outlined.

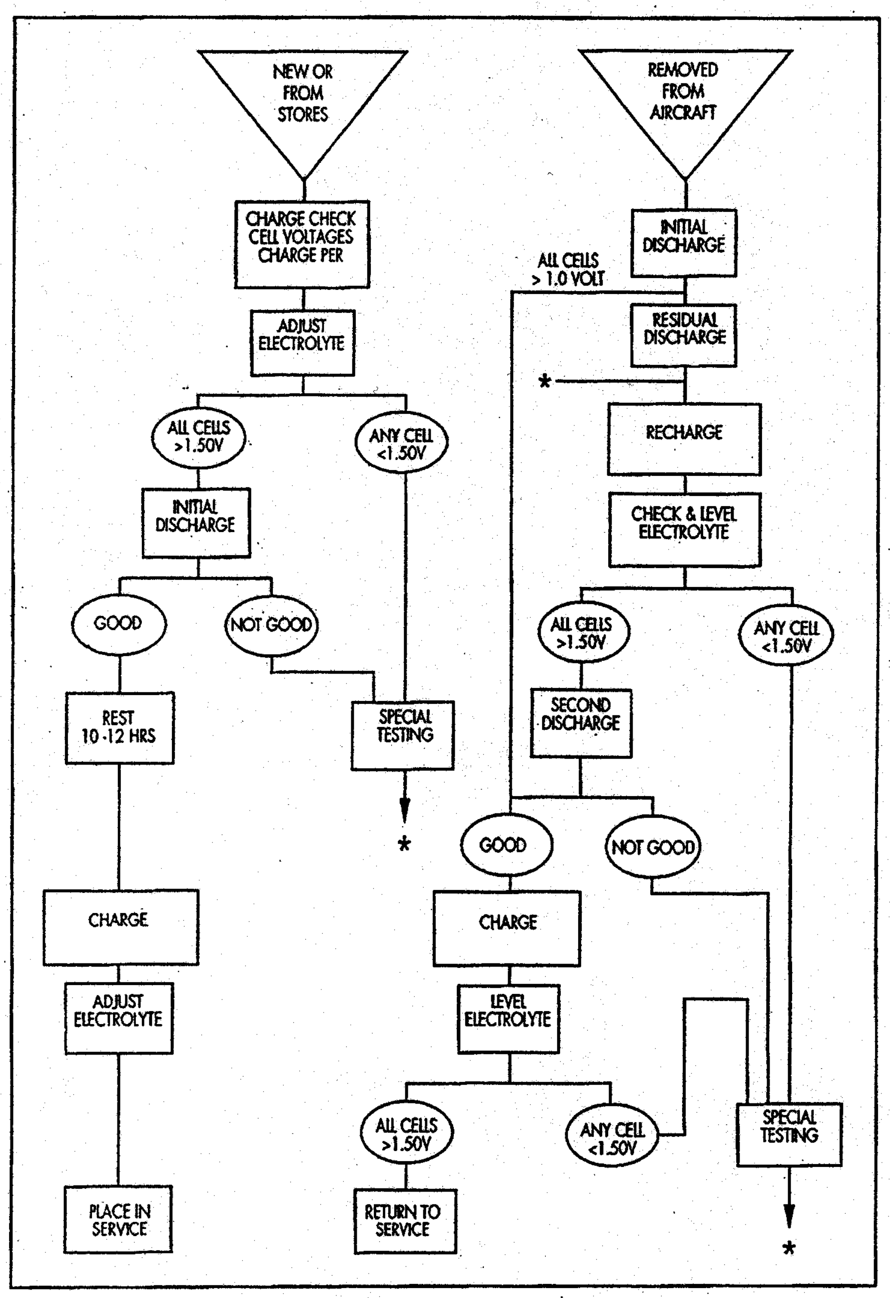
If, after cleaning and assuring that everything is dry, a leakage current is still indicated by a deflection of the needle, it should be traced to the defective cell or cells which should be replaced.

The value of insulation resistance between the negative output terminal and the battery case shall be at least 250 kΩ under 250 Vdc after removal from the aircraft and at least 10 MΩ after cleaning and drying.

Temperature sensor and heater blanket test

Aero Design, Inc. temperature sensor harness assemblies and heater blankets must be tested at least once a year. However, these components should be tested at each service interval.

ELECTRICAL TESTS



NOTE: Record all discharge data in battery log.

* - Reentry point from SPECIAL TESTING

Test Procedure block diagram

OVERHAUL:

General

For best operation and maximum life Aero Design, Inc. nickel-cadmium batteries should be completely disassembled and all their components thoroughly inspected and cleaned once a year. In aircraft applications, many operators find it convenient to schedule the overhaul to coincide with a major inspection of the aircraft.

Disassembling

A. Discharge as previously explained, being certain to record all of the data.

B. On those types of batteries where they are used, remove the plastic members holding down the cells.

C. Remove all inter-cell connector nuts, washers, and connector link bars.

D. Remove the main connector.

E. Remove the temperature sensor harness assembly if applicable.

F. Loosen the relief valves with a screwdriver or the special tool provided in the Aero Design, Inc. tool kit.

G. Remove the cells from the case, using a cell puller. Tighten the puller on the cell terminal and remove each cell with a steady, straight-up pull. Before removing the cells, re-install the relief valves with the special plastic wrench. The polarity arrangement of the cells should be noted.

H. Remove all cell wedges and case insulation.

Inspecting

A. Look over each cell carefully for evidence of electrolyte leakage, cracks, corrosion, burns or holes. Excessive salt around a terminal post indicates leakage.

B. Inspect connector links for bends, tarnish, loss of nickel-plating, corrosion or burns. Tarnish can be polished off with a fine wire brush.

C. The temperature sensor harness assembly should be inspected for correct operation as well as for corrosion, damaged connectors/pins, and wire insulation damage <u>at each overhaul.</u> Replace the entire harness assembly if any damage is discovered.

D. Cell wedges and case insulation should be clean and free of cracks or holes. Replace any that are defective.

E. Check the main battery connector for evidence of arcing, corrosion, cracks or bends in the terminals. With an Ohmmeter check the insulation between the positive and negative pins. Defective connectors can cause dangerous overheating or battery discharge as well as result in low voltage service.

F. Inspect the battery case and cover for bends, cracks, burns or other damage. Re-coat cases in which damage has exposed the metal, if applicable. Replace parts that cannot be repaired.

Deep Cleaning

A. Remove greasy residue on primary connector and cell hardware with warm water.

B. After assuring that the relief valves and terminal seal nuts are tight, wash each cell in running water. <u>Do NOT</u> allow any water to enter the cell. Dry with air or with a clean towel.

C. Wash the battery case, cover, insulation, plastic hold-down bars, gaskets and cell hardware in warm soapy water to remove dirt and salt deposits. A plastic scraper or a stiff (non wire) brush may be used to aid in the removal of heavy deposits. Rinse away all soap and dry with air or a clean cloth.

D. Remove the vent valve assemblies from the cells and submerge them in a clean container of distilled or de-ionized water. The purpose of this treatment is to dissolve out salt which may have accumulated in the vents of the valves or around the gaskets or O-rings. During this soaking, cover the cells with a clean cloth or take other precautions to prevent any foreign particles from falling into the cells.

Inspection/testing cell vent valves

Before replacing the valves in the cells, their condition and operation should be checked as follows:

1. Examine the vent valve band for cracks, holes, and for a good fit. If any defective condition is noted, replace the vent valve.

2. Examine the vent valve gasket or O-ring for distortion, splits or cracks, and for proper fit. If any defective condition exists, replace the gasket or O-ring.

3. Screw the valve, with its gasket or O-ring, into the end of a tube with matching threads.

4. Attach the tube to a compressed air line through an adjustable pressure reducing valve/gauge assembly.

5. Immerse the valve and the end of the tube in water. Slowly raise the air pressure on the assembly. A valve in good order will open before 10 psi (0.7 bar) and close before 2 psi (0.14 bar).

Note: PSI = Pounds of pressure per square inch.

Re-use only those valves found to operate as noted above. Dry the valves by wiping or blowing out with compressed air after removing them from the test fixture. Make certain that the gaskets or O-rings are in good condition; replacing those that are defective.

Re-install the vent valve into the cell. **DO NOT OVER TIGHTEN** the valves. Use only a screwdriver or the special wrench supplied in the tool kit for this procedure.

Valves that do not open between 2 and 10 psi should be re-soaked until they do. Those which are not gas-tight at low pressure should be discarded.

Re-assembling

A. Make sure all components are clean and dry before re-assembly.

B. Check the torque on the terminal lower seal (lower nut) on each cell terminal.

C. Install the cells, insulating sheets and wedges into the case, being certain to position the cells to maintain correct polarity. Insertion of the last cell may be assisted by pushing down on its two terminals with a small block of soft wood. The cells, when re-assembled, should not be loose in the battery case. The cells should be tight enough to require some effort to remove them.

D. Install the main connector in the case.

E. Coat cell terminals and connector links lightly with neutral, non-acid, petroleum jelly, using a small brush.

NOTE: Excessive use of petroleum jelly on the terminals and connector links will contribute to current leakage in high ambient temperature operations. Extreme care should be exercised in the use of this product.

F. Re-check all cell polarities, then mount the inter-cell connector links, discarding for new any that are bend, burnt, or have defective nickel-plating. Use new terminal nuts and washers where needed to assure maximum cell to cell conductivity.

G. Tighten all terminal nuts to the specified torque, as per specifications table.

H. Re-install any top cell retaining bars if used.

I. Charge the battery, following the procedures specified elsewhere in this manual.

J. Determine whether the battery is ready for service using the criteria outlined elsewhere in this manual.

K. Check the insulation resistance between cell terminals and the metal case of the battery as outlined in this manual.

NOTE: If the battery is in good electrical condition, dry off the cell tops with compressed air, if necessary, and lightly grease its terminals and connections. Use only neutral (non-acid) petroleum jelly and apply it with a small paint brush.

REPAIR:

Electrical tests before repair

It is possible that the initial maintenance charge was not fully effective due to abnormally low electrolyte level (the electrolyte level is not corrected until the end of the charge). Therefore, before removing a cell or cells as defective, the following additional tests should be performed.

A. Charge using one of the methods described in another section of this manual.

B. Check the electrolyte level during the last half hour of charging as described elsewhere, adding distilled water if necessary, to achieve the correct level.

C. Measure cell voltages during the last quarter hour of charge.

D. Discharge as outlined elsewhere in this manual, measuring individual cell voltages during and at the end of the discharge.

Faulty cells will be:

- **Those with a final charge voltage of less than 1.5V.**

- **Those that do not meet capacity requirements**

Replacing faulty cells

A. Discharge all cells in the battery to zero volts before attempting replacement.

B. Remove any cell hold-down bars that may be retaining defective cells.

C. Remove the inter-cell connectors from the terminals of defective cells to be taken out of the battery.

D. Fasten a cell-puller to a terminal of the cell to be removed and extract it with a steady, vertical pull.

E. Replace each defective cell with a **fully discharged** factory new Aero Design, Inc.

F. Double check each cell's position for correct polarity. Push straight down on the two terminals of each replacement cell with a small block of soft wood until the cell is firmly seated.

G. Install inter-cell connectors, replacing any that are damaged. Place washers between connectors and terminal nuts.

H. Torque nuts to specifications provided.

I. Coat terminals and connectors <u>lightly</u> with neutral petroleum jelly.

J. Replace any top retainer bars that may have been removed when disassembling the battery. Charge as prescribed elsewhere.

STORAGE AND SHIPPING:

General

The storage room should have an atmosphere free of acid, dust and dampness. No corrosive liquids or gases should be stored in the same room. The most desirable range for long term storage is between 40°F (4.4°C) and 86°F (30°C).

Active stand-by storage *rev 16*

Warning: Trickle charge is not recommended since it will consume water over time. Failure to check electrolyte levels before installation onto an aircraft could result in a premature failure of the battery.

Aero Design, Inc. vented cell batteries may be stored charged, ready for service in the normal upright or vertical position. Stand-by (trickle) charging or periodic charging can be used since nickel-cadmium batteries automatically self-discharge at about 0.25% per day at 68°F (20°C). For trickle charging in the temperature range of 60°F (15°C) to 90°F (32°C), charge at a rate of 1 milliampere per ampere hour of rated capacity. For example, 40 milliamperes (0.04 amperes) for a 40 Ah battery. Regularly check the electrolyte level and prevent accumulation of corrosion during stand-by charging. The electrolyte must be leveled prior to installation in an aircraft.

Inactive long term storage

Aero Design, Inc. batteries are best kept, discharged in the same package in which they were shipped for long term storage.

To store batteries in the charged condition, and maximize the charge retention, they are best stored at freezing temperature (about 0 °F). This has been known to cause some capacity degradation - probably due to a dry out, similar to freeze drying. This only occurred after nine months to a year.

Best results occur when a battery is stored at 40 °F and kept cool until ready for use. This maintains the charge for a long period of time and allowed the batteries to function properly when placed in service.

Shelf life

Aero Design, Inc. vented nickel-cadmium batteries may be stored, in the normal upright or vertical position, charged or discharged for a period of up to 10 years without damage.

Aero Design, Inc.'s warranty policy states that its nickel-cadmium aircraft batteries are warranted for a period of two years from the date of manufacture stamped on the battery data plate or from the date of delivery of a factory new Aero Design, Inc. battery from the aircraft manufacturer or from an authorized distributor. This "shelf life" does not postpone or extend the warranty period once delivered from the aircraft manufacturer or authorized distributor.

Preparation for service after storage

Check all relief valves in the battery for white salt deposits. If such deposits are evident, remove, clean and test the valves. Re-install the cleaned and tested vent valves in the cells.

If the battery removed from inactive storage is at a low or high temperature, it should be allowed to reach 60°F (15°C) to 90°F (32°C) range before charging.

Charge; check electrolyte level; and completely discharge then recharge. If difficulty in completely charging a new or in service battery that has been in long term inactive storage is experienced, it may be necessary to:

A. Terminate the charge sequence where the difficulty occurs. (Voltage plateau or temperature rise).

B. Completely discharged (deep cycle) the battery.

C. Repeat the above charge/discharge sequence until the unit accepts a full charge and delivers its rated capacity.

Packing and transportation

The normal packing for shipment of Aero Design, Inc. nickel-cadmium batteries is with fiberboard or injected foam packing enclosed is fiber-board or wooden outer containers. For overseas shipments, wrapping in sealed plastic is recommended. Precautions must be taken to keep batteries upright while in transit. All markings and documentation should conform to hazardous materials regulations as applicable.

APPENDIX SAFETY HAZARDS AND INFORMATION:

Charging is to be performed in a well ventilated area. Operating areas must also be ventilated to remove normal gases generated.

Use NIOSH/MSHA approved respirator during level charging to maintain exposure levels below the TWA.

Use goggles or face shield at all times during handling.

Use water-INsoluble, non permeable gloves such as rubber if exposure to electrolyte is likely. Do not use leather, cloth or wool.

Rubber boots, aprons or rainwear is equivalent and suitable attire for exposure to electrolyte solution.

Exposure

Eyes: Contact with electrolyte solution causes rapid and severe damage. May result in blindness. Contact with nickel oxide may cause minor irritation.

Skin: Contact with electrolyte solution may cause serious burns to skin tissue. Contact with nickel compounds may cause skin sensitization and result in chronic eczema or itch.

Ingestion: Ingestion of electrolyte solution causes tissue damage to throat area and gastrointestinal and respiratory tract. Ingestion of nickel compound causes nausea and intestinal disorder.

Inhalation: May cause varying degrees of irritation of the nasal mucous membranes and respiratory tract tissues. Inhalation of cadmium oxide fumes from fire may cause dry throat, cough, headache, vomiting, chest pain and chills. Chronic overexposure to cadmium compounds may result in pulmonary edema, breathing difficulty prostrations and kidney damage.

First Aid

Eye contact: Flush with water for 15 minutes and get immediate medical attention.

Skin contact: Remove clothing and flush affected area for 15 minutes.

Ingestion: Do NOT induce vomiting. Dilute with water, milk, if available. Seek IMMEDIATE medical attention.

Inhalation: Get to fresh air. Administer oxygen or artificial respiration if needed. Get IMMEDIATE medical attention.

In the event of skin contact with NICKEL OXIDE: Wash with cold water and soap immediately.

CAUTION:

Do not add sulfuric acid.
Electrolyte will react with aluminum, zinc, tin and other active metals, acid, chlorinated and aromatic hydrocarbons, nitrocargons, halocarbons. Tricholoroethylene will react with electrolyte solution to form dichloractylene, which is spontaneously combustible.

Note: Normal reactions inside the battery liberate flammable hydrogen gas. Battery must be vented to atmosphere.

TROUBLESHOOTING		
PROBLEM	**DIAGNOSTIC**	**SOLUTION**
Low Voltage	Loose Terminals	Tighten to specifications, test
	Defective cell or cell with reversed polarity	Replace defective unit, test
	Main connector Defective	Clean or replace and test
	Cell to case leak of current	Discharge, disassemble, clean, replace defective parts, test
Foaming during charge	Electrolytes low	Discharge and test
	Electrolytes contaminated	Discharge, replace and test
Zero Battery Voltage	Loose main connector, Broken or loose link, or battery discharged	Tighten/replace connectors, links and recharge. Check for insulation leak.
Zero cell voltage	Short circuit cell	Replace defective cell, test
Low cell capacity	Normal service wear	Replace with new cell
Loss of capacity	Low electrolyte level, charging rate too low or service interval too long	Test, adjust electrolyte level, charging voltage and shorten service interval
Low voltage output	High demand without charging	Test
	Charger set too low	Test, and reset regulator on charger
Voltage does not rise in prescribed charge time	New or inactive battery for long period	Continue high rate of charge until voltage rises (continue to check temperature)
	Faulty ammeter/voltmeter	Calibrate meter, or replace. Continue high rate of charge
	Damaged separator	Replace with new cell
High Cell voltage at beginning of charge	Dry cell	Add 5 to 10cc distilled water, adjust electrolyte level. Check cell for damage, replace.
Electrolyte overflow	Level too high	Clean, test and adjust electrolyte level
	Relief valve loose or faulty	Tighten or replace valves, clean and test. Adjust electrolyte level.
	Cell reverses during discharge at high rate	Check charge voltage, test
	Overcharging rate too high	Check charge voltage, test.
Excessive use of water	Service interval too long	Shorten service interval
	Leaky or defective cells or relief valve	Inspect and replace
	Overcharge too long at high temperatures	Check charge voltage, test

SPECIFICATIONS TABLE

TYPE OF BATTERY	NOM. VOLT.	NO. OF CELLS	TYPE OF CELL	RATED CAPACITY (Ah at 1 hour rate)	DIMENSIONS LENGTH		WIDTH		HEIGHT		WEIGHT		TORQUES LOWER NUT	UPPER NUT	ELECTROLYTE LEVEL (DISTANCE FROM VALVE SEAT TO SURFACE OF ELECTROLYTE) (mm)	CONSUMABLE WATER VOLUME (cm^3)
					IN	MM	IN	MM	IN	MM	LBS.	KGS.	LBS IN +/- 8	LBS IN +/- 4		
AD-1656	24	20	AD-VP160KH	16	10.76	273.8	6.64	167	8.13	206.5	39	17.7	43.5	69.6	20	20
AD-1656-1	24	20	AD-VP160KH	16	10.76	273.8	6.64	167	8.13	206.5	39	17.7	43.5	69.6	20	20
AD-1656-6	24	20	AD-VP160KH	16	10.76	273.8	6.64	167	8.13	206.5	39	17.7	43.5	69.6	20	20
AD-16156	24	20	AD-VP160KH	16	10.69	271.53	6.41	162.81	7.36	186.94	39.7	18.0	43.5	69.6	20	20
AD-16156-1	24	20	AD-VP160KH	16	10.69	271.53	6.41	162.81	7.36	186.94	39.7	18.0	43.5	69.6	20	20
AD-1606-1	24	20	AD-VP160KM	16	14.06	356.5	4.74	118.6	8.257	204.5	38.5	17.5	43.5	69.6	20	20
AD-1756	24	20	AD-VP170KH	17	12.625	320.675	6.43	163.322	7.923	201.244	40.8	18.5	43.5	69.6	20	20
AD-1756-3	24	20	AD-VP170KH	17	12.625	320.675	6.43	163.322	7.923	201.244	40.8	18.5	43.5	69.6	20	20
AD-2376	24	20	AD-VP230KH	22	10.0	254.0	7.8	198.1	8.75	222.3	58.8	26.7	43.5	69.6	20	21
AD-2376-4	24	20	AD-VP230KH	22	10.0	254.0	7.8	198.1	8.75	222.3	58.8	26.7	43.5	69.6	20	21
AD-23180	24	20	AD-VP230KH	22	10.0	254.0	7.63	193.80	8.44	214.38	55.0	25.0	43.5	69.6	20	21
AD-23576	24	20	AD-VP230KH	22	9.94	252.5	7.69	195.3	8.75	222.3	55	25.0	43.5	69.6	20	21
AD-23576-1	24	20	AD-VP230KH	22	9.94	252.5	7.69	195.3	8.75	222.3	55	25.0	43.5	69.6	20	21
AD-23676	24	20	AD-VP230KH	22	18.04	458.2	4.78	121.4	8.88	225.6	56.0	25.4	43.5	69.6	20	21
AD-23676-1	24	20	AD-VP230KH	22	18.04	458.2	4.78	121.4	8.88	225.6	56.0	25.4	43.5	69.6	20	21
AD-2758	24	20	AD-VHP230KA-3	23	9.92	251.97	9.719	246.63	7.39	187.71	56.22	25.5	43.5	69.6	20	21
AD-18164	24	22.8	AD-3030-1	36	13.88	352.55	9.63	244.60	4.81	122.22	84.5	38.2	50.0	150.0	25	25
AD-18164-3	24	22.8	AD-3030-1	36	13.88	352.55	9.63	244.60	4.81	122.22	84.5	38.2	50.0	150.0	25	25
AD-18164-4	24	22.8	AD-3030-1	36	13.88	352.55	9.63	244.60	4.81	122.22	84.5	38.2	50.0	150.0	25	25
AD-401176-9	24	20	AD-VP400KH	40	9.92	252.0	9.69	246.0	10.25	260.4	79.2	36.0	43.5	87.0	20	25
AD-40176	24	20	AD-VP400KH	36	10.0	254.0	9.77	248.0	10.11	264.0	81.8	37.1	43.5	87.0	20	25
AD-40176-4	24	20	AD-VP400KH	36	10.0	254.0	9.77	248.0	10.11	264.0	81.8	37.1	43.5	87.0	20	25
AD-40176-7	24	20	AD-VP400KH	36	10.0	254.0	9.77	248.0	10.11	264.0	81.8	37.1	43.5	87.0	20	25
AD-4076	24	20	AD-VP400KH	36	10.0	254.0	9.77	248.0	10.32	262.0	83.0	37.7	43.5	87.0	20	25
AD-4076-1	24	20	AD-VP400KH	36	10.0	254.0	9.77	248.0	10.32	262.0	83.0	37.7	43.5	87.0	20	25
AD-4076-2	24	20	AD-VP400KH	36	10.0	254.0	9.77	248.0	*10.32*	262.0	83.0	37.7	43.5	87.0	20	25
AD-4076-3	24	20	AD-VP400KH	36	10.0	254.0	9.77	248.0	10.32	262.0	83.0	37.7	43.5	87.0	20	25
AD-4076-4	24	20	AD-VP400KH	36	10.0	254.0	9.77	248.0	10.32	262.0	83.0	37.7	43.5	87.0	20	25
AD-4076-5	24	20	AD-VP400KH	36	10.0	254.0	9.77	248.0	10.32	262.0	83.0	37.7	43.5	87.0	20	25
AD-4076-6	24	20	AD-VP400KH	36	10.0	254.0	9.77	248.0	10.32	262.0	83.0	37.7	43.5	87.0	20	25

TYPE OF BATTERY	NOM. VOLT.	NO. OF CELLS	TYPE OF CELL	RATED CAPACITY (Ah at 1 hour rate)	DIMENSIONS						WEIGHT		TORQUES		ELECTROLYTE LEVEL (DISTANCE FROM VALVE SEAT TO SURFACE OF ELECTROLYTE) (mm)	CONSUMABLE WATER VOLUME (cm^3)
					LENGTH		WIDTH		HEIGHT				LOWER NUT	UPPER NUT		
					IN	MM	IN	MM	IN	MM	LBS.	KGS.	LBS IN +/- 8	LBS IN +/- 4		
AD-4076-7	24	20	AD-VP400KH	36	10.0	254.0	9.77	248.0	10.32	262.0	83.0	37.7	43.5	87.0	20	25
AD-4076-8	24	20	AD-VP400KH	36	10.0	254.0	9.77	248.0	10.32	262.0	83.0	37.7	43.5	87.0	20	25
AD-4076-9	24	20	AD-VP400KH	36	10.0	254.0	9.77	248.0	10.32	262.0	83.0	37.7	43.5	87.0	20	25
AD-4076-10	24	20	AD-VP400KH	36	10.0	254.0	9.77	248.0	10.32	262.0	83.0	37.7	43.5	87.0	20	25
AD-4076-11	24	20	AD-VP400KH	40	10.0	254.0	9.77	248.0	10.32	262.0	83.0	37.7	43.5	87.0	20	25
AD-4076-12	24	20	AD-VP400KH	36	10.0	254.0	9.77	248.0	10.32	262.0	83.0	37.7	43.5	87.0	20	25
AD-4076-13	24	20	AD-VP400KH	40	10.0	254.0	9.77	248.0	10.32	262.0	83.0	37.7	43.5	87.0	20	25
AD-4076-14	24	20	AD-VP400KH	36	10.0	254.0	9.77	248.0	10.32	262.0	83.0	37.7	43.5	87.0	20	25
AD-4076-15	24	20	*AD-VP400KH*	36	10.0	254.0	9.77	248.0	10.32	262.0	83.0	37.7	43.5	87.0	20	25
AD-40576	24	20	***AD-VP400KHAC***	36	10.0	254.0	9.72	246.9	10.32	262.0	81.1	36.8	43.5	87.0	24	25
AD-40676	24	20	***AD-VP400KHAC***	36	10.0	254.0	9.75	247.7	10.50	266.7	80.0	36.3	43.5	87.0	24	25
AD-40776	24	20	***AD-VP400KHAC***	40	10.0	254.0	9.77	248.0	10.32	262.0	80.0	36.3	43.5	87.0	24	25
AD-40678-2	24	20	AD-VHP430KH-3	43	9.915	251.84	9.75	247.65	10.25	260.35	84.7	38.5	43.5	87.0	20	25
AD-4078	24	20	AD-VHP430KH-3	43	9.915	251.84	9.75	247.65	10.25	260.35	84.7	38.5	43.5	87.0	20	25
AD-4078-2	24	20	AD-VHP430KH-3	43	9.915	251.84	9.75	247.65	10.25	260.35	84.7	38.5	43.5	87.0	20	25
AD-4078-3	24	20	AD-VHP430KH-3	43	9.915	251.84	9.75	247.65	10.25	260.35	84.7	38.5	43.5	87.0	20	25
AD-4078-6	24	20	AD-VHP430KH-3	43	9.915	251.84	9.75	247.65	10.25	260.35	84.7	38.5	43.5	87.0	20	25
AD-4078-7	24	20	AD-VHP430KH-3	43	9.915	251.84	9.75	247.65	10.25	260.35	84.7	38.5	43.5	87.0	20	25
AD-4078-10	24	20	AD-VHP430KH-3	43	9.915	251.84	9.75	247.65	10.25	260.35	84.7	38.5	43.5	87.0	20	25
AD-4078-11	24	20	AD-VHP430KH-3	43	9.915	251.84	9.75	247.65	10.25	260.35	84.7	38.5	43.5	87.0	20	25
AD-4078-14	24	20	AD-VHP430KH-3	43	9.915	251.84	9.75	247.65	10.25	260.35	84.7	38.5	43.5	87.0	20	25
AD-4078-19	24	20	AD-VHP430KH-3	43	9.915	251.84	9.75	247.65	10.25	260.35	84.7	38.5	43.5	87.0	20	25
AD-4078-24	24	20	AD-VHP430KH-3	43	9.915	251.84	9.75	247.65	10.25	260.35	84.7	38.5	43.5	87.0	20	25
AD-BTSP-4445L	24	20	AD-VHP430KH-3	44	15.5	393.7	6.45	163.83	10.125	257.18	85.2	36.6	43.5	87.0	20	25
AD-4579	24	20	AD-VHP450KA-1	40	10.89	276.5	9.781	248.4	11.063	281.0	96.0	43.5	43.5	87.0	20	88
AD-43B034LB03	13.2	11	AD-43B034AC14-2	35	8.81	223.77	7.15	181.50	11.44	290.60	46.0	20.8	N/A	72.0	20	36
AD-43B050LB01	13.2	11	***AD-43B050AC01-2***	50	11.90	302.26	7.65	194.31	10.3	262.0	63.0	28.6	N/A	96.0	20	65

NICKEL CADMIUM BATTERY SERVICE RECORD

BATTERY TYPE __________ RATED CAPACITY _________________ Ah CHARGE RATES:

SERIAL NO. _____________ MIN ALLOWABLE CELL 0.5 C1 ____________ AMPS

AIRCRAFT: ______________ CAPACITY: ______________ Ah 0.1 C1 ____________ AMPS

ALLOWABLE H_20 CONSUMP. ________ cc

REMOVAL DATE	HOURS SINCE SERVICED	CONDITION FROM AIRCRAFT			CHARGE AND WATER CONSUMPTION DATA						2nd DISCHARGE		CELL TO CASE INSUL	REMARKS
		VISUAL	MINIMUM CELL CAPACITY (C_A)	BATTERY CAPACITY (C_a)	CELL END OF CHARGE VOLTAGE			DISTILLED WATER ADDED TO CELLS			MIN CELL CAP	BATT CAP		
					AVER	MAX / CELL NO	MIN/ CELL NO	AVER	MAX/ CELL NO	MIN / CELL NO				

NOTE: NUMBER CELLS BY STARTING WITH THE CELL CONNECTED TO THE POSITIVE BATTERY TERMINAL AND PROCEEDING SEQUENTIALLY AS THE CELLS ARE