SECTION 2. STORAGE BATTERIES

11-15. GENERAL. Aircraft batteries may be used for many functions, e.g., ground power, emergency power, improving DC bus stability, and fault-clearing. Most small private aircraft use lead-acid batteries. Most commercial and military aircraft use NiCad batteries. However, other types are becoming available such as gel cell and sealed lead-acid batteries. The battery best suited for a particular application will depend on the relative importance of several characteristics, such as weight, cost, volume, service or shelf life, discharge rate, maintenance, and charging rate. Any change of battery type may be considered a major alteration.

a. Storage batteries are usually identified by the material used for the plates. All battery types possess different characteristics and, therefore, must be maintained in accordance with the manufacturer's recommendations..

WARNING: It is extremely dangerous to store or service lead-acid and NiCad batteries in the same area. Introduction of acid electrolytes into alkaline electrolyte will destroy the NiCad and vice-versa.

11-16. BATTERY CHARGING. Operation of storage batteries beyond their ambient temperature or charging voltage limits can result in excessive cell temperatures leading to electrolyte boiling, rapid deterioration of the cells, and battery failure. The relationship between maximum charging voltage and the number of cells in the battery is also significant. This will determine (for a given ambient temperature and state of charge) the rate at which energy is absorbed as heat within the battery. For lead-acid batteries, the voltage per cell must not exceed 2.35 volts. In the case of NiCad batteries, the charging voltage limit varies with design and construction. Values of 1.4 and 1.5 volts per cell are generally used. In all cases, follow the recommendations of the battery manufacturer.

11-17. BATTERY FREEZING. Discharged lead-acid batteries exposed to cold temperatures are subject to plate damage due to freezing of the electrolyte. To prevent freezing damage, maintain each cell's specific gravity at 1.275, or for sealed lead-acid batteries check "open" circuit voltage. (See table 11-1.) NiCad battery electrolyte is not as susceptible to freezing because no appreciable chemical change takes place between the charged and discharged states. However, the electrolyte will freeze at approximately minus 75 °F.

NOTE: Only a load check will determine overall battery condition.

TABLE 11-1. Lead-acid battery electrolyte freezing points.

Specific	*Freeze point*		*State of Charge (SOC) for sealed lead-acid batteries at 70°*		
Gravity	*C.*	*F.*	SOC	12 volt	24 volt
1.300	-70	-95	100%	12.9	25.8
1.275	-62	-80	75%	12.7	25.4
1.250	-52	-62	50%	12.4	24.8
1.225	-37	-35	25%	12.0	24.0
1.200	-26	-16			
1.175	-20	-4			
1.150	-15	+5			
1.125	-10	+13			
1.100	-8	+19			

11-18. TEMPERATURE CORRECTION. U.S. manufactured lead-acid batteries are considered fully charged when the specific gravity reading is between 1.275 and 1.300. A 1/3 discharged battery reads about 1.240 and a 2/3 discharged battery will show a specific gravity reading of about 1.200, when tested by a hydrometer and the electrolyte temperature is 80 §F. However, to determine precise specific gravity readings, a temperature correction (see table 11-2) should be applied to the hydrometer indication. As an example, a hydrometer reading of 1.260 and the temperature of the electrolyte at 40 °F, the corrected specific gravity reading of the electrolyte is 1.244.

TABLE 11-2. Sulfuric acid temperature correction.

Electrolyte Temperature		Points to be subtracted or added to specific gravity readings
°C	°F	
60	140	+24
55	130	+20
49	120	+16
43	110	+12
38	100	+8
33	90	+4
27	80	0
23	70	-4
15	60	-8
10	50	-12
5	40	-16
-2	30	-20
-7	20	-24
-13	10	-28
-18	0	-32
-23	-10	-36
-28	-20	-40
-35	-30	-44

11-19. BATTERY MAINTENANCE.

Battery inspection and maintenance procedures vary with the type of chemical technology and the type of physical construction. Always follow the battery manufacturer's approved procedures. Battery performance at any time in a given application will depend upon the battery's age, state of health, state of charge, and mechanical integrity.

a. Age. To determine the life and age of the battery, record the install date of the battery on the battery. During normal battery maintenance, battery age must be documented either in the aircraft maintenance log or in the shop maintenance log.

b. State of Health. Lead-acid battery state of health may be determined by duration of service interval (in the case of vented batteries), by environmental factors (such as excessive heat or cold), and by observed electrolyte leakage (as evidenced by corrosion of wiring and connectors or accumulation of powdered salts). If the battery needs to be refilled often, with no evidence of external leakage, this may indicate a poor state of the battery, the battery charging system, or an over charge condition.

(1) Use a hydrometer to determine the specific gravity of the battery electrolyte, which is the weight of the electrolyte compared to the weight of pure water.

(2) Take care to ensure the electrolyte is returned to the cell from which it was extracted. When a specific gravity difference of 0.050 or more exists between cells of a battery, the battery is approaching the end of its useful life and replacement should be considered. Electrolyte level may be adjusted by the addition of distilled water.

c. State of Charge. Battery state of charge will be determined by the cumulative effect of charging and discharging the battery. In a normal electrical charging system the battery's generator or alternator restores a battery to full charge during a flight of one hour to ninety minutes.

d. Mechanical Integrity. Proper mechanical integrity involves the absence of any physical damage as well as assurance that hardware is correctly installed and the battery is properly connected. Battery and battery compartment venting system tubes, nipples and attachments, when required, provide a means of avoiding the potential buildup of explosive gases, and should be checked periodically to ensure that they are securely connected and oriented in accordance with the maintenance manual's installation procedures. Always follow procedures approved for the specific aircraft and battery system to ensure that the battery system is capable of delivering specified performance.

e. Battery and Charger Characteristics. The following information is provided to acquaint the user with characteristics of the more common aircraft battery and battery charger types. Products may vary from these descriptions due to different applications of available technology. Consult the manufacturer for specific performance data.

NOTE: Under no circumstances connect a lead-acid battery to a charger, unless properly serviced.

(1) Lead-acid vented batteries have a two volt nominal cell voltage. Batteries are constructed so that individual cells cannot be removed. Occasional addition of water is required to replace water loss due to overcharging in normal service. Batteries that become fully discharged may not accept recharge.

(2) Lead-acid sealed batteries are similar in most respects to lead-acid vented batteries, but do not require the addition of water.

(3) The lead-acid battery is economical and has extensive application, but is heavier than an equivalent performance battery of another type. The battery is capable of a high rate of discharge and low temperature performance. However, maintaining a high rate of discharge for a period of time usually warps the cell plates, shorting out the battery. Its electrolyte has a moderate specific gravity, and state of charge can be checked with a hydrometer.

(4) Do not use high amperage automotive battery chargers to charge aircraft batteries.

(5) NiCad vented batteries have a 1.2 volt nominal cell voltage. Occasional addition of distilled water is required to replace water loss due to overcharging in normal service. Cause of failure is usually shorting or weakening of a cell. After replacing the bad cell with a good cell, the battery's life can be extended for five or more years. Full discharge is not harmful to this type of battery.

(6) NiCad sealed batteries are similar in most respects to NiCad vented batteries, but do not normally require the addition of water. Fully discharging the battery (to zero volts) may cause irreversible damage to one or more cells, leading to eventual battery failure due to low capacity.

(7) The state of charge of a NiCad battery cannot be determined by measuring the specific gravity of the potassium hydroxide electrolyte. The electrolyte specific gravity does not change with the state of charge. The only accurate way to determine the state of charge of a NiCad battery is by a measured discharge with a NiCad battery charger and following the manufacturer's instructions. After the battery has been fully charged and allowed to stand for at least two hours, the fluid level may be adjusted, if necessary, using distilled or demineralized water. Because the fluid level varies with the state of charge, water should never be added while the battery is installed in the aircraft. Overfilling the battery will result in electrolyte spewage during charging. This will cause corrosive effects on the cell links, self-discharge of the battery, dilution of the electrolyte density, possible blockage of the cell vents, and eventual cell rupture.

(8) Lead-acid batteries are usually charged by regulated DC voltage sources. This allows maximum accumulation of charge in the early part of recharging.

(9) Constant-current battery chargers are usually provided for NiCad batteries because the NiCad cell voltage has a negative temperature coefficient. With a constant-voltage charging source, a NiCad battery having a shorted cell might overheat due to excessive overcharge and undergo a thermal runaway, destroying the battery and creating a possible safety hazard to the aircraft.

DEFINITION: Thermal runaway can result in a chemical fire and/or explosion of the NiCad battery under recharge by a constant-voltage source, and is due to cyclical, ever-increasing temperature and charging current. One or more shorted cells or an existing high temperature and low charge can produce the cyclical sequence of events: (1) excessive current, (2) increased temperature, (3) decreased cell(s) resistance, (4) further increased current, and (5) further increased temperature. This will not become a self-sustaining thermal-chemical action if the constant-voltage charging source is removed before the battery temperature is in excess of 160 °F.

(10) Pulsed-current battery chargers are sometimes provided for NiCad batteries.

CAUTION: It is important to use the proper charging procedures for batteries under test and maintenance. These charging regimes for reconditioning and charging cycles are defined by the aircraft manufacturer and should be closely followed.

f. Shop-Level Maintenance Procedures. Shop procedures must follow the manufacturer's recommendations. Careful examination of sealed batteries and proper reconditioning of vented batteries will ensure the longest possible service life.

g. Aircraft Battery Inspection.

(1) Inspect battery sump jar and lines for condition and security.

(2) Inspect battery terminals and quick-disconnect plugs and pins for evidence of corrosion, pitting, arcing, and burns. Clean as required.

(3) Inspect battery drain and vent lines for restriction, deterioration, and security.

(4) Routine pre-flight and post-flight inspection procedures should include observation for evidence of physical damage, loose connections, and electrolyte loss.

11-20. ELECTROLYTE SPILLAGE. Spillage or leakage of electrolyte may result in serious corrosion of the nearby structure or control elements as both sulfuric acid and potassium hydroxide are actively corrosive. Electrolyte may be spilled during ground servicing, leaked when cell case rupture occurs, or sprayed from cell vents due to excessive charging rates. If the battery is not case enclosed, properly treat structural parts near the battery that may be affected by acid fumes. Treat all case and drain surfaces, that have been affected by electrolyte, with a solution of sodium bicarbonate (for acid electrolyte) or boric acid, vinegar, or a 3 percent solution of acetic acid (for potassium hydroxide electrolyte).

CAUTION: 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 electrolyte. If sulfuric acid is splashed on the body,

neutralize with a solution of baking soda and water, and shower or flush the affected area with water. For the eyes, use an eye fountain and flush with an abundance of water. If potassium hydroxide contacts the skin, neutralize with 9 percent acetic acid, vinegar, or lemon juice and wash with water. For the eyes, wash with a weak solution of boric acid or a weak solution of vinegar and flush with water.

11-21. NOXIOUS FUMES. When charging rates are excessive, the electrolyte may boil to the extent that fumes containing droplets of the electrolyte are emitted through the cell vents. These fumes from lead-acid batteries may become noxious to the crew members and passengers; therefore, thoroughly check the venting system. NiCad batteries will emit gas near the end of the charging process and during overcharge. The battery vent system in the aircraft should have sufficient air flow to prevent this explosive mixture from accumulating. It is often advantageous to install a jar in the battery vent discharge system serviced with an agent to neutralize the corrosive effect of battery vapors.

11-22. INSTALLATION PRACTICES.

a. External Surface. Clean the external surface of the battery prior to installation in the aircraft.

b. Replacing Lead-Acid Batteries. When replacing lead-acid batteries with NiCad batteries, a battery temperature or current monitoring system must be installed. Neutralize the battery box or compartment and thoroughly flush with water and dry. A flight manual supplement must also be provided for the NiCad battery installation. Acid residue can be detrimental to the proper functioning of a NiCad battery, as alkaline will be to a lead-acid battery.

c. Battery Venting. Battery fumes and gases may cause an explosive mixture or contaminated compartments and should be dispersed by adequate ventilation. Venting systems often use ram pressure to flush fresh air through the battery case or enclosure to a safe overboard discharge point. The venting system pressure differential should always be positive, and remain between recommended minimum and maximum values. Line runs should not permit battery overflow fluids or condensation to be trapped and prevent free airflow.

d. Battery Sump Jars. A battery sump jar installation may be incorporated in the venting system to dispose of battery electrolyte overflow. The sump jar should be of adequate design and the proper neutralizing agent used. The sump jar must be located only on the discharge side of the battery venting system. (See figure 11-1.)

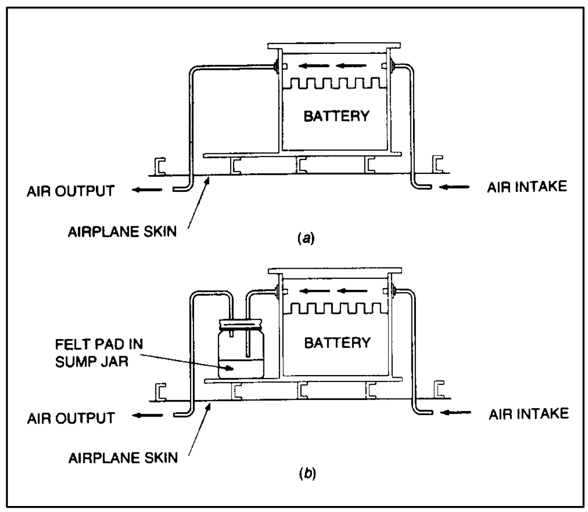

FIGURE 11-1. Battery ventilating systems.

e. Installing Batteries. When installing batteries in an aircraft, exercise care to prevent inadvertent shorting of the battery terminals. Serious damage to the aircraft structure (frame, skin and other subsystems, avionics, wire, fuel etc.) can be sustained by the resultant high discharge of electrical energy. This condition may normally be avoided by insulating the terminal posts during the installation process.

Remove the grounding lead first for battery removal, then the positive lead. Connect the grounding lead of the battery last to minimize the risk of shorting the "hot terminal" of the battery during installation.

f. Battery Hold Down Devices. Ensure that the battery hold down devices are secure, but not so tight as to exert excessive pressure that may cause the battery to buckle causing internal shorting of the battery.

g. Quick-Disconnect Type Battery. If a quick-disconnect type of battery connector, that prohibits crossing the battery lead is not employed, ensure that the aircraft wiring is connected to the proper battery terminal. Reverse polarity in an electrical system can seriously damage a battery and other electrical components. Ensure that the battery cable connections are tight to prevent arcing or a high resistance connection.

11-23.—11-29. [RESERVED.]