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CONCORDE

AIRCRAFT BATTERY OWNER / OPERATOR MANUAL

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RECORD OF REVISIONS

Rev. No.	Affected Pages	Reason for Change	Date
A	COVER	TITLE	6/22/00
	6, 7, 8, 9, 14, 16, 18, 23, 24, 26, 27	Reference to RG batteries in grey text	
B	4	Delete IEC rating methods	2/27/02
	17	Add referral to ICA	
C		Deleted Warranty, rev approved water, Deleted IEC test methods.	6/19/02
D	2	Added website/Type Certificate reference.	11/18/02

Please refer to our website, www.concordebattery.com, for current FAA-PMA approved installations of batteries in Type Certified aircraft. The approvals are based on installations in specific aircraft models only.

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All Batteries are not created equal

Thank you for choosing Concorde...
Your battery has been hand-crafted to the highest quality control standards for unequaled reliability and durability. Concorde has the most extensive selection of aircraft batteries available. The heavy duty Concorde Aircraft Battery provides greater power for starting at cold temperatures, emergency performance and longer life than any comparable product.

Concorde Aircraft Batteries are preferred over other brands by the majority of the world's Air Forces. Your satisfaction is guaranteed with a transferable warranty that is honored worldwide.

Please...
Recycle your used batteries by returning them to a drop-off site where they may be sent to a secondary lead smelter. Secondary smelters separate the plastic, acid and lead. They melt and refine the lead parts. The purified lead is delivered to battery manufacturers and other industries. The plastic is sent to a reprocessor for manufacture into new plastic products. The acid is collected and either reused or treated. Eventually, the original battery components may end up being used to make new lead-acid batteries.

BATTERY LOG

Part Number:

____

Serial Number:

____

Aircraft Type:

____

Aircraft Registration Number:

____

Installation Date	Total Time
1st Test	
2nd Test	
3rd Test	
4th Test	

THEORY

Battery Elements

The lead - acid secondary cell used in aircraft batteries consists of **positive plates** made of lead peroxide (PbO_2); **negative plates** of pure spongy lead (Pb); and a liquid known as **electrolyte**, consisting of a mixture of sulfuric acid (H_2SO_4) and water (H_2O). The sulfuric acid and water are mixed in such quantities that the solution has a specific gravity of 1.275 to 1.300 for a fully charged battery.

The specific gravity of a substance is defined as the ratio of the weight of a given volume of the substance to the weight of an equal volume of pure water at $+4^0$ Celsius.

Simplified lead-acid electrochemical reaction.

Discharge >
$PbO_2 + Pb + 2H_2\,SO_4$ ____ $2PbSO_4 + 2H_2O$ < Charge

Chemical Reaction

A chemical reaction takes place when a battery is delivering current. The sulfuric acid in the electrolyte breaks up into hydrogen ions (H_2) carrying a positive charge, and sulfate ions (SO_4) carrying a negative charge. An ion is an atom or molecule which is either positively or negatively charged. A positively charged ion has a deficiency of electrons, and a negatively charged ion has an excess of electrons. The SO_4 ions combine with the lead in the plates and forms lead sulfate ($PbSO_4$).

At the same time, they give up their negative charge, thus creating an excess of electrons on the negative plate.

The H_2 ions go to the positive plate and combine with the oxygen of the lead peroxide (PbO_2) forming water (H_2O). During the process, they take electrons from the positive plate. The lead of the lead peroxide combines with some of the SO_4 ions to form lead sulfate on the positive plate. The result of this reaction is that the positive plate has a deficiency of electrons and the negative plate has an excess of electrons.

When the plates are connected together with an external conductor, the electrons from the negative plate flow to the positive plate. This process will continue until both plates are converted to lead sulfate and no further chemical action is possible. The battery is discharged.

During the charging process, current is passed through the storage battery in the reverse direction. A direct current supply is applied to the battery with the positive pole connected to the positive plate and the negative pole connected to the negative plate. If the electromotive force (emf) of the source is greater the emf of the battery, this causes the current to flow in the reverse direction.

The result is that the SO_4 ions are driven back into solution where they combine with the H_2 ions of the water, thus forming sulfuric acid. The plates then return to their original composition of lead peroxide and spongy lead. When this process is complete, the battery is charged. In as much as the sulfuric acid in the electrolyte is used up as the battery is discharged, and returned to the electrolyte as the battery is charged, a measurement of the specific gravity of the electrolyte will give a good indication of the state of charge in the battery.

In flooded (vented) batteries the oxygen generated at the positive electrode when on charge escapes from the cell. Concurrently, at the negative electrode, hydrogen is generated from water and escapes from the cell. The overall result is the gassing of the cells and water loss. Therefore, flooded cells require periodic water replenishment.

In valve-regulated (sealed) Recombinant Gas (RG) batteries, oxygen combines chemically with the lead at the negative electrode in the presence of H_2SO_4 to form lead sulfate and water. This oxygen recombination suppresses the generation of hydrogen at the negative electrode. Overall, there is no water loss during charging. A very small quantity of water may be lost as a result of self-discharge reactions, however, such loss is so small that no provision need be made for water replenishment. The battery cells have a pressure relief safety valve that may vent if the battery is overcharged.

Concorde's valve-regulated lead-acid batteries (VRB) are recombinant gas (RG) batteries. The cells are sealed with pressure relief valves that open to relieve excessive pressure within the battery.

The plates are sandwiched between layers of micro fiber glass mat. Electrolyte is absorbed and held in place by the capillary potential of the fluid and the absorptive glass mat (AGM) fibers.

The **AGM**, by design, is approximately 92% saturated with electrolyte. The remainder is filled with gas. This void space provides the channels by which oxygen travels from the positive to the negative plate during charging. The freshly generated gases, which are in their atomic state and very reactive, recombine rapidly and safely.

The recombination passivates the negative slightly, reducing electrolysis and ultimately eliminating the need to add water. Because of the compressed construction, the **RG** batteries have a much lower internal resistance and thus provide greater starting power and faster recharging, particularly at cold temperatures, than comparable flooded batteries. Additionally, the **AGM** provides a much higher degree of support against shock and vibration than in the older flooded (vented) batteries. The **RG** batteries provide electrical performance comparable to nickel-cadmium aircraft batteries without the requirement of a temperature or current monitoring system.

Battery Construction

An aircraft storage battery consists of 6 or 12 lead-acid cells connected in series. The open circuit voltage of the 6-cell battery is approximately 12, and the open circuit voltage of the 12-cell battery is approximately 24. Open circuit voltage is the voltage of the battery when it is not connected to a load.

Grids and Plates

Each cell of a storage battery has positive and negative plates arranged alternately, and insulated from each other by separators. Each plate consist of a framework, called the **grid**, and the **active material** held in the grid.

The grid is cast from a lead alloy. The heavy, outside border adds strength to the plate, and the small horizontal and vertical bars support the active material. These bars also act as conductors for the current which is distributed evenly throughout the plate.

The plates are made by applying a lead paste compound to the grid. The paste is mixed to the proper consistency, and is applied to the grid in much the same manner as plaster is applied to a lath wall.

In compounding the negative plate paste, a material is added known as an **expander**. This material is relatively inert and makes up less than one percent of the mixture. Its purpose is to prevent the loss of porosity of the negative material during the life of the battery. Without the use of an expander, the negative material contracts until it becomes quite dense, thus limiting the chemical action to the immediate surface.

After the paste is applied to the plates, they are dried by a special process until the paste has hardened. The plates are then given a forming treatment in which a large number of positive plates are connected to the positive terminal of a charging apparatus, and a like number of negative plates are connected to the negative terminal. They are placed in a solution of sulfuric acid and water and charged slowly over a long period of time. The plates are then washed and dried in an oxygen free atmosphere. The positive plates thus formed are chocolate brown in color and of a hard texture. The negative plate material has been converted to spongy lead of a pearl gray color. They are then ready to be assembled into **plate groups.**

Close quality control in processing of all materials used in a storage battery is very important. Close temperature and humidity controls are used in various phases of manufacture. All these factors are essential to produce a reliable storage battery.

Consistent with the various processes by which plates are made, it is extremely important that the user follow CBC's recommendations on placing the battery in service and its subsequent maintenance. This information accompanies the packing case in the Instructions for Continued Airworthiness (ICA) manual.

Plate Groups

Plate groups are made by joining a number of similar plates to a common terminal post by means of a plate strap. The capacity is determined by the number and size of plates in a group. Each plate is made with a lug at the top to which is fused to the strap. A positive group consist of a number of positive plates connected to a plate strap, and a negative group consist of negative plates connected in the same manner. The two groups meshed together with separators between the positive and negative plates constitute a cell element.

Separators

The separators used in aircraft batteries are made of high temperature polypropylene material. Their purpose is to keep the plates separated and thus prevent an internal short circuit. In the RG series batteries a second separator made from microfiber glass mat (AGM) is also used.

The material of the separators must be extremely porous so that the separators will offer a minimum of resistance to the ions passing through them. The material must also resist the action of the electrolyte.

Cell Containers

When the cell elements are assembled, they are placed in the **cell container** which is made of plastic. Usually cell containers are made up in a monoblock with as many compartments as there are cells in the battery. The plastic used is selected for its resistance to sulfuric acid, low permeability and impact strength.

Cell Covers, Vent Valves and Vent Caps

The assembled cell has a cover made of material similar to that of the cell container. The cell or monobloc cover is provided with holes through which the terminal posts extend, and a threaded hole for each cell into which is screwed the vent cap or valve. When the cover is placed on the cell, it is sealed in with a special sealing compound to prevent leakage and loss of electrolyte.

PRECAUTIONS

There are several precautions which must be observed when handling storage batteries, and especially when charging.

When a storage battery is being charged, it generates a substantial amount of hydrogen and oxygen. The vent caps should be left in place, and no open flames, sparks, or other means of ignition should be allowed in the vicinity. Always turn off the power before connecting or disconnecting a storage battery from a charging line.

The electrolyte contains sulfuric acid. Sulfuric acid is very corrosive and will burn flesh, cloth or wood. Be very careful not to spill the electrolyte, but if it should be spilled, rinse with water and neutralize it with a solution of bicarbonate soda or a mild ammonia solution.

There should be adequate ventilation of the area where storage batteries are being charged in order to dissipate the gasses and acid fumes.

Separate facilities for storing and / or servicing flooded electrolyte lead-acid and nickel-cadmium batteries must be maintained. Introduction of acid electrolyte into alkaline electrolyte will cause permanent damage to vented (flooded electrolyte) nickel-cadmium batteries and vice-versa. However, batteries that are sealed can be charged and capacity checked in the same area. Because the electrolyte in valve-regulated lead-acid batteries is absorbed in the separators and porous plates, it **cannot contaminate a nickel-cadmium battery even when they are serviced in the same area.**

Caution: Aircraft are certified with batteries that have reserve or essential capacity for emergency operation. Therefore, never “jump-start” an aircraft that has a “dead” or discharged battery. It takes approximately three hours to fully recharge a discharged battery with the aircraft generating system.

NOTE: Unless the battery electrolyte was accidently spilled, you should only add demineralized water in normal service. Water consumption varies with the operating temperature of the battery and the charging voltage.

1) The electrolyte level should be checked and filled to the bottom of the vent well with water. Do not allow the reserve electrolyte level to go below the top of the plates or the battery performance and life will be reduced.

2) Battery capacity should be checked annually or as often as the Regional Airworthiness Authority Regulations require.

3) Discharged batteries exposed to cold temperatures are subject to plate and separator damage due to freezing. To prevent freezing damage to a lead-acid battery, maintain each cell specific gravity at 1.275 or higher.

ACTIVATION OF DRY CHARGED BATTERIES

Caution:

1) **Do not remove the sealing tape on the cell vents until you are ready to fill the battery with electrolyte. Aircraft Batteries require a pure diluted sulfuric acid electrolyte of 1.285 S.G. at 80N F. Check the specific gravity of the electrolyte before filling the cells of the battery to be sure it is the correct type and S.G.**

2) **Use a clean hydrometer to determine the specific gravity of the battery electrolyte, which is the weight of the electrolyte compared to the weight of an equal volume of pure water.**

3) **If it should become necessary to dilute concentrated sulfuric acid to a lower specific gravity...always pour the acid into the water...never pour water into acid...a dangerous "spattering" of the liquid will result... caused by the extreme heat which is generated when strong acid is mixed with water. Stir liquid continuously while acid is being added.**

4) **When working with acid, always wear a face shield and protective clothing. Sulfuric acid can destroy clothing and burn skin, If electrolyte is spilled or splashed on clothing or on the body, it must be neutralized immediately with a solution of baking soda and water and rinsed with clean water.**

5) **If electrolyte is splashed into the eyes, force the eyes open and flood with cool clean water for approximately five minutes. Call a doctor and get medical attention immediately.**

6) **If electrolyte is taken internally, drink large quantities of water or milk, followed with milk of magnesia, beaten egg, or vegetable oil. Call a physician immediately.**

7) **Do not place battery acid within the reach of children.**

<u>CAUTION:</u> Hydrogen and oxygen gases are produced during normal battery operation. Explosive gases may continue to be present in and around the battery for several hours after it has been charged. Keep sparks, flames, burning cigarettes and other sources of ignition away at all times.

MIXING OF ELECTROLYTE

Electrolyte of a given specific gravity can be purchased; however, it is sometimes more convenient to mix it at the shop or hangar. The following table gives the proper amount of water to be mixed with a given amount of acid to obtain the desired specific gravity.

The container in which electrolyte is mixed should be made of glass, glazed earthenware, or other material which will not be attacked by the acid.

Specific Gravity Desired	Add 1 gallon 1.400 Acid to:	Add 1 gallon 1.835 Acid to:
1.275	½ gallon water	2 3/4 gallon water
1.300	1/3 gallon water	2 ½ gallon water

When mixing acid with water, always pour the acid into the water. Never pour water into the acid. The heat generated may cause the acid to be thrown out on the operator, and severe burns will result.

After the electrolyte is mixed, it may be tested for specific gravity. If the gravity is not as desired, it can easily be adjusted by the addition of acid or water. Be sure to correct the specific gravity reading for temperature.

When purchasing acid or electrolyte for battery use, "commercial" grade acid should not be used. There is a grade that is known as "battery" grade that is free of impurities which may contaminate a battery, and it is cheaper than the chemically pure grade, commonly called "C.P. grade."

BATTERY TESTING

Hydrometer Test

The most common instrument used for the testing of flooded electrolyte batteries is the **hydrometer**. It has already been pointed out that the specific gravity of the electrolyte in a battery cell is a good index to the state of charge in the cell. This is due to the fact that as the battery is discharged, the acid in the electrolyte is used in the reaction. That is, the acid has broken down, part of it combining with the lead of the plates to form lead sulfate, and part combining with oxygen to form water. Since the weight of the acid is much greater than that of the water, the reduction of acid and the increase of water will cause the specific gravity of the electrolyte to decrease.

The hydrometer is used to determine the specific gravity of the electrolyte. It consists of a small sealed glass tube weighted at the end to make it float in an upright position. The amount of weight in the bottom of the tube is determined by the specific gravity range of the fluid to be tested. In the case of a battery hydrometer the specific gravity range is usually from 1.100 to 1.300. The weight in the hydrometer must be such that when the specific gravity of the fluid is 1.100, only the tip of the stem will be above the fluid, and when the specific gravity is 1.300, almost the entire stem will be above the fluid level. A paper scale with readings from 1.100 to 1.300 is placed inside the stem. The hydrometer is placed in a glass tube syringe. With this arrangement, electrolyte may be drawn from a cell into the glass tube, and after the reading is noted, the electrolyte can be returned to the cell.

The specific gravity reading is taken at the fluid level on the stem of the hydrometer when it is freely floating in the electrolyte. It is important to see that the float is not sticking to the side of the glass tube and that the electrolyte can be seen between the bottom of the float and the rubber plug in the bottom of the glass tube. Floats made with glass projections on the wide part of the float adjust themselves to the proper level more easily. It is a good idea to have more than one hydrometer syringe on hand so that one can be checked against the other. If irregular readings are obtained, the float should be closely examined for hair-line cracks that may have allowed electrolyte to seep inside and change the weight of the float. The hydrometer syringe must be kept clean and it should be taken apart and washed occasionally.

After the specific gravity reading is taken, the electrolyte must be returned to the same cell from which it was taken. A specific gravity reading of from 1.275 to 1.300 usually indicates a fully charged cell. If the reading is from 1.200 to 1.240 it is considered that the charge is low. This does not mean that the cell is nearly discharged, but it indicates that it may not be able to furnish power sufficient for heavy loads such as starting the engines. A reading of 1.260 in a battery indicates a state of charge sufficient for normal operation, even though it is not fully charged.

It must be pointed out that the specific gravity reading is not always an indication of the state of charge in a cell. If the electrolyte is removed from a discharged cell and replaced with an electrolyte of a high specific gravity, the cell will still be in a discharged condition even though the hydrometer test shows a full charge reading.

Normally, electrolyte should never be added, or removed from, a cell. The addition of water is periodically necessary to replace that which is lost through electrolytic action and evaporation, but acid should never be added unless the electrolyte has been lost by spillage, because the acid does not evaporate. When it is necessary to add acid, the battery should be fully charged, on charge and gassing freely. Then, by means of a rubber syringe, the electrolyte is drawn off to the split ring and replaced with electrolyte having a specific gravity of 1.285. The charge should be continued for one hour before making another test.

TEMPERATURE CORRECTION OF S.G. READING

Electrolyte Temperature		**Points to be subtracted or added to specific gravity reading**
ºC	**ºF**	
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

Batteries are considered fully charged when the temperature corrected specific gravity reading is 1.285 +/- 0.005. 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 with a hydrometer. However, to determine precise specific gravity readings, temperature corrections shown in the following table should be applied to the hydrometer indication. The corrections in the table should be added or subtracted from the reading obtained from the hydrometer. For example, if the temperature of the electrolyte is 10 degrees Fahrenheit, and the hydrometer reading is 1.250, the corrected reading will be 1.250-.028, or 1.222. Notice that the correction points are in thousandths.

CHARGING METHODS

Storage batteries are charged by passing a direct current through them in a direction opposite to that of the discharge current. That is the supply must be connected to the battery, positive to positive and negative to negative. Various sources of direct current may be used, but the most commonly used devices are either rectifiers or direct current generators. The manner in which batteries are connected to the power source will vary. This is usually determined by the type and the voltage of the batteries being charged. When batteries of different voltages must be charged by the same power supply, they are usually charged by the constant - current method. Another method used is the constant potential (voltage) method. This system is usually used on aircraft, where an engine driven generator is continually charging the battery according to its requirements.

Battery charging methods may also be classified as manually - cycled and system - governed methods. Usually, where batteries are charged in the hanger or shop, the manually - cycled method is employed. This means simply that the voltage or current is controlled by an operator according to the requirements of the batteries being charged. In the system - governed method, the voltage of the power supply is automatically controlled by a carefully adjusted voltage regulator.

Constant Voltage Charging (CP)

The battery charging system in an airplane is of the constant - voltage type. An engine - driven generator, capable of supplying the required voltage, is connected through the aircraft electrical system directly to the battery. A battery switch is incorporated in the system so that the battery may be disconnected when the airplane is not in operation. The voltage of the generator is accurately controlled by means of a voltage regulator connected in the field circuit of the generator.

For a 12 volt system, the voltage of the generator is adjusted to approximately 14.25. ON 24 volt systems, the adjustment should be between 28 and 28.5 volts. When these conditions exist, the initial current through the battery will be high, but as the state of charge increases the battery voltage increases, causing a drop in the current.

When the battery is fully charged, its voltage will be almost equal to the generator voltage, and very little current will flow into the battery. When the charging current is low, the battery may remain connected to the generator without damage.

The figures given below as voltage regulator settings for 12 - or 24 - volt systems are intended to meet average conditions. However, when the airplane is to be used in hot or cold climates, the following settings are recommended:

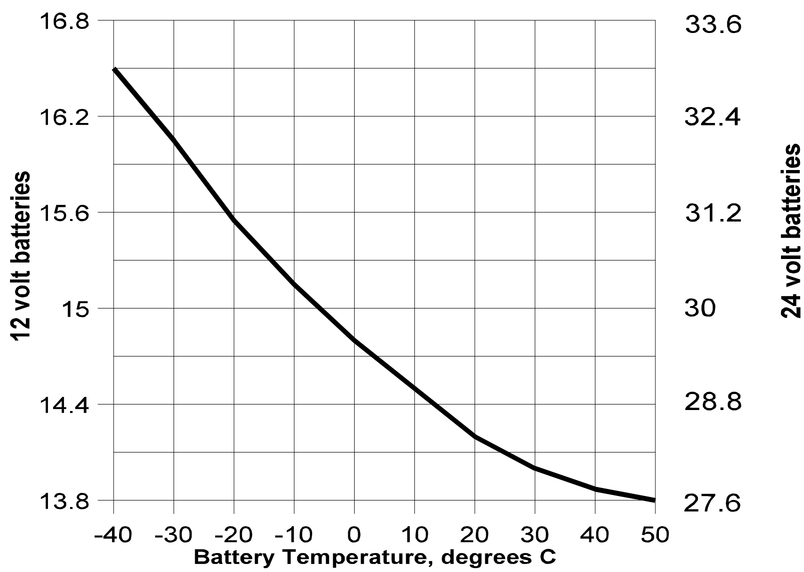
Battery Temperatures	Generator Voltage	
	24 V	12 V
90^0 F. or higher	27.5	13.75
50^0 to 90^0 F.	28 to 28.5	14.0 - 14.2
50^0 F. or lower	29.5	14.75

The reason for the above recommendations is evident when it is known that with a variation of battery temperature there is a variation of the final or full charge voltage.

At extremely low battery temperatures a setting of 28.5 volts does not supply enough current to charge a battery adequately. At battery temperatures in excess of 90^0 the current input at 28.5 volts tends to over heat the battery.

When using a constant - voltage system in a battery shop. A voltage regulator which automatically maintains a constant voltage is incorporated in the system. A battery of high capacity has lower resistance than a battery of low capacity. Hence a high capacity battery will draw a higher charging current than a low capacity battery when both are in the same state of charge, and when the charging voltages are equal.

Recommended Charging Voltage



Constant-Current Charging (CI)

Constant - current charging is the most convenient for charging batteries outside the airplane because several batteries of varying voltages may be charged at once on the same system. A constant - current system usually consists of a rectifier to change the normal alternating current supply to direct current. A transformer is used to reduce the available 110 or 220 - volt alternating current supply to the desired level before it is passed through the rectifier.

If a constant - current system is used, multiple batteries may be connected in series, provided that the charging current is kept at such a level that the battery does not overheat or gas excessively.

Conditioning after Deep Discharge see applicable ICA

CAPACITY TEST

For test procedures and instructions, see Concorde's Instructions for Continued Airworthiness.

Batteries that have a capacity greater than 80% of the C1 rated capacity may be considered Airworthy. Concorde recommends that batteries have an actual capacity greater than 85% of the C1 rated capacity for installation in an aircraft.

Capacity testing devices for aircraft storage batteries have been developed, and these give an accurate indication of the condition of a battery. A **capacity tester** incorporates load resistance, a voltmeter and a time clock. A fully charged battery is connected to a measured load until the voltage, as indicated on the voltmeter, drops to a predetermined figure. At this time the reading on the clock is noted. The reading gives the capacity of the battery tested.

After this test, the battery should be recharged by either the constant current or constant voltage method described in ICA. For discharging or charging batteries, it is best to have a disconnect switch on the discharge apparatus or on the charging panel. The closing and opening of the battery circuit by use of spring clips on the battery terminals should be avoided as the resulting arc may cause an explosion of the battery gasses.

The discharge voltage of a healthy battery does not decrease with age although it will be found that on a bench charge, an older battery may not have as high voltage when fully charged.

BATTERY STATE-OF-CHARGE (S.O.C.)

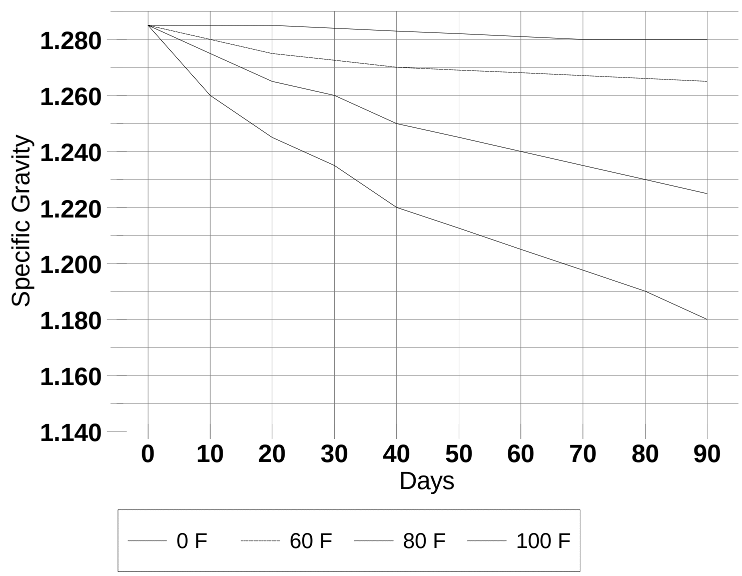
S.O.C.	12 volt O.C.V.	24 volt O.C.V.	S.G.
100%	12.9	25.8	1.300
75%	12.7	25.4	1.270
50%	12.4	24.8	1.220
25%	12.0	24.0	1.140
0%	11.7	23.4	1.090

BATTERY STATE-OF-HEALTH

A battery's state-of-health must be determined by verifying its ability to provide sufficient stored energy for essential power requirements. The amount of stored energy (battery capacity) required to start a reciprocating engine is generally less than 3%, while a turbine engine start requires approximately 10% of the rated capacity. Good starting performance is not necessarily a safe indication of the battery state-of-health. An airworthy battery must be able to provide essential power in the event of a failure of the generating system. Therefore, a periodic capacity check of the battery at the C_1 rate (one hour) is recommended.

SELF-DISCHARGE RATES
(Vented Batteries)

Self-discharge - Cause and Effect



100° F (37.8°C) - 0.0025 Specific Gravity per day
80° F (26.7°C) - 0.0010 Specific Gravity per day
50° F (10°C) - 0.0003 Specific Gravity per day

The above values are valid for approximately the first 10 days of stand after being fully charged. **Vented batteries have a higher rate of self-discharge than the VRB (RG Series) because open cell vents allow continuous entry of oxygen.** To minimize the extent of self-discharge, store charged batteries in a cool place.

COLD WEATHER OPERATION

Temperature is a vital factor in the operation and life of a storage battery. Chemical action takes place more rapidly with heat than with cold. For this reason, a battery will give much better performance in temperate or tropical climates than in cold climates. On the other hand, the battery will deteriorate faster in warm climates. In some cases, a lower specific gravity is specified for warm climate operation in order to add to the life of the battery, because chemical action is more rapid in warmer climates. It is recommended that batteries being used in tropical countries be filled with electrolyte having a maximum specific gravity of 1.260 when fully charged.

In cold climates, the state of charge in a storage battery should be kept at a maximum. A fully charged battery will not freeze even under the most severe weather conditions, but a discharged battery will freeze very easily.

When adding water to a battery in extremely cold weather, the battery must be charged at once. If this is not done, the water will not mix with the acid and will freeze.

The following table gives the freezing points for various states of charge. These are the approximate points at which ice crystals start to form. The electrolyte does not freeze solid until a lower temperature is reached. Solid freezing of electrolyte in a discharged battery will damage the plates and may rupture the container.

Specific Gravity	**Freezing Point**	
	°C	**°F**
1.300	**- 70**	-95
1.275	**- 62**	-80
1.250	**- 52**	-62
1.225	**- 37**	-35
1.200	**- 26**	-16
1.175	**- 20**	-4
1.150	**- 15**	+5
1.125	**- 10**	+13
1.100	**- 7**	+19

Capacity Loss Due to Low Temperatures

Operating a storage battery in cold weather is equivalent to using a battery of lower capacity. For example, a fully charged battery at 80^0 F. may be capable of starting an engine twenty times. At 0^0 F. the same battery may start the engine only three times.

Low temperature greatly increases the time necessary for charging a battery. A battery which could be recharged in an hour at 80^0 F. while flying may require approximately five hours for charging when the temperature is 0^0 F.

During cold weather, keep batteries fully charged. Make every effort to conserve battery power.

VENTILATING SYSTEMS

Modern airplanes are equipped with battery ventilating systems. The ventilating system provides for the removal of gases and acid fumes from the airplane in order to reduce fire hazard, and to eliminate corrosion of metal parts. Air is carried through a vent tube to the interior of the battery case from a scoop outside the airplane. After passing over the top of the battery, the air, battery gasses and acid fumes are carried through another tube to the battery sump.

This sump is a glass or plastic jar of at least one pint capacity. In the jar is a felt pad about 1 inch thick saturated with a 5% solution of bicarbonate of soda and water. The tube carrying fumes to the sump extends into the jar to within about 1/4 inch of the felt pad.

An overboard discharge tube leads from the top of the sump jar to a point outside the airplane. The outlet for this tube is so designed that there is negative pressure on the tube whenever the airplane is in flight. This helps to insure a continuous flow of air across the top of the battery, through the sump, and outside the airplane. The acid fumes going into the sump are neutralized by the action of the soda solution, thus preventing corrosion of the metal skin or damage to a fabric surface.

INSPECTION and SERVICE

See applicable ICA.

STORAGE

See applicable ICA.

GLOSSARY

Active material - electrode material which produces electricity during its chemical conversion.

Ampere - unit of electrical current.

Ampere-hour (Ah) - The capacity of a storage battery is measured in **ampere - hours**. One ampere hour is defined as a current flow of one ampere for a period of one hour. Five ampere-hours means a current flow of one ampere for five hours, a current flow of 2 ½ amperes for 2 hours, or any multiple of current and time that will give five. This relationship can be expressed as follows: Capacity (in ampere hours) = I X T, when I is the current (in amperes) and T is the time (in hours). The capacity of a storage battery is usually based on a given discharge rate, since the capacity will vary with the rate of discharge. The capacity of an aircraft battery is generally based on **1- hour discharge rate**. A 17 ampere-hour battery will supply a current of approximately 17 amperes for a period of 1 hour. A 34 ampere hour battery will deliver twice that amount of current for the same period of time. If a very heavy load is applied to the battery, it may become discharged in a few minutes.

Battery - a combination of two or more chemical cells electrically connected together to produce electric energy. (Common usage permits this designation to be applied also to a single cell used independently.)

Boost charge - a charge applied to a battery which is already near a state of full charge, usually of short duration.

C rate - discharge or current rate in amperes; numerically equal to rated capacity of a cell in ampere-hours.

Capacity - the quantity of electricity delivered by a battery under specified conditions, usually expressed in ampere-hours.

Capacity, rated - see **nominal capacity**.

Cell - an electrochemical device composed of positive and negative plates, separator and electrolyte which is capable of storing electrical energy.

Cell reversal - reversing of polarity within a cell in a multi-cell battery due to over discharge.

Charge - the conversion of electrical energy from an external source, into chemical energy within a cell or battery.

Charge rate - the rate at which current is applied to a secondary cell or battery to restore its capacity.

Charge retention - the tendency of a charged cell or battery to resist self-discharge.

Concavo-concave - RG batteries have one-way cell vent valves designed to relieve excess positive internal pressure. Occasionally, when the atmospheric pressure is greater than the internal pressure of the battery, caused by a rapid decrease in altitude, the battery case may become temporarily concave.

Constant potential (CP) charge - charging technique where the output voltage of the charge source is held constant and the current is limited only by the resistance of the battery.

Constant current (CI) charge- charging technique where the output current of the charge source is held constant.

Counter EMF - voltage of a cell or battery opposing the voltage of the charging source.

Current - the rate of flow of electricity. The movement of electrons along a conductor. It is comparable to the flow of a stream of water. The unit of measurement is an ampere.

Cut off voltage - battery voltage reached at the termination of a discharge. Also known as end point voltage or EPV.

Deep discharge - withdrawal of 50% or more of the rated capacity of a cell or battery.

Depth of discharge - the portion of the nominal capacity from a cell or battery taken out during each discharge cycle, expressed in percent. Shallow depth of discharge is considered as 10% or less, deep depth of discharge is considered as 50% or more.

Discharge - the conversion of the chemical energy of a cell or battery into electrical energy and withdrawal of the electrical energy into a load.

Discharge rate - the rate of current flow from a cell or battery,

Distilled water - water which has been freed of minerals by a process of vaporization and subsequent condensation.

Dry charge - process by which the electrodes are formed and assembled in a charged state. The cell or battery is activated when the electrolyte is added.

Effective internal resistance, R_e - the apparent opposition to current within a battery that manifests itself as a drop in battery voltage proportional to the discharge current. Its value is dependent upon battery design, state-of-charge, temperature and age.

Electrolyte - in a lead-acid battery, the electrolyte is sulfuric acid diluted with water. It is a conductor and is also a supplier of hydrogen and sulfate ions for the reaction.

Electromotive force (EMF) - potential causing electricity to flow in a closed circuit.

Electron - that part of an atom having a negative charge.

End-of-discharge voltage - the voltage of the battery at the termination of a discharge but before the discharge is stopped. See cut off voltage.

End-of-life - the stage at which the battery or cell meet specific failure criteria.

End-point voltage - cell or battery voltage at which point the rated discharge capacity had been delivered at a specified rate-of-discharge. Also used to specify the cell or battery voltage below which the connected equipment will not operate or below which operation is not recommended. Sometimes called cutoff voltage or voltage end point.

Entrainment - the process whereby gases generated in the cell carry electrolyte through the vent cap.

Fast charging - rapid return of energy to a battery at the C rate or more.

Float charge - a method of maintaining a cell or battery in a charged condition by continuous, long-term constant voltage charging at a level sufficient to balance self-discharge.

Flooded cell - a cell design which incorporates an excess amount of electrolyte, also see **vented cell**.

Gassing - the evolution of gas from one or more of the electrodes in a cell. Gassing commonly results from local action (self-discharge) or from the electrolysis of water in the electrolyte during charging.

Ground - in aircraft use, the result of attaching one battery cable to the body or airframe which is used as a path for completing a circuit in lieu of a direct wire from a component.

Hydrometer - a float type instrument used to determine the state-of-charge of a battery by measuring the specific gravity of the electrolyte (i.e. the amount of sulfuric acid in the electrolyte).

Internal impedance - the opposition to the flow of an alternating current at a particular frequency in a cell or battery at a specified state-of-charge and temperature.

Internal resistance - the opposition or resistance to the flow of a direct electric current within a cell or battery; the sum of the ionic and electronic resistance of the cell components. Its value may vary with the current, state-of-charge, age and temperature. With an extremely heavy load, such as an engine starter, the voltage may drop to approximately 1.6. This voltage drop is due to the **internal resistance** of the cell. A cell that is partly discharged has a higher internal resistance than a fully charged cell, hence it will have a greater voltage drop under the same load. This internal resistance is due to the accumulation of lead sulfate on the plates. The lead sulfate reduces the amount of active material exposed to the electrolyte, hence it deters the chemical action and interferes with the current flow.

Ion - part of a molecule or group of atoms, positively or negatively charged, which transports electricity through the electrolyte.

Joules - unit of energy, equal to a watt-second (a newton-meter).

Lead-acid - terms used in conjunction with a cell or battery that utilizes lead and lead peroxide as the active plate materials in a diluted electrolyte solution of sulfuric acid and water. Nominal cell voltage about 2.1 volts.

Lead dioxide - a higher oxide of lead present in charge positive plates and frequently referred to as lead peroxide.

Lead sulfate - a lead salt formed by the action of sulfuric acid on lead oxide during paste mixing and formation. It is also formed electrochemically when a battery is discharged.

Load tester - an instrument which measures the battery voltage with an electrical load on the battery to determine its overall condition and its ability to perform under engine starting conditions or essential power requirements.

Nominal capacity - a designation by the battery manufacturer which helps identify a particular cell model and also provides an approximation of capacity; usually expressed in ampere-hours at a given discharge current.

Nominal voltage - voltage of a fully charged cell or battery when delivering rated capacity at a specified discharge rate.

Open-circuit voltage - the voltage of a battery when it is not delivering or receiving power.

Overcharge - the forcing of current through a cell after all the active material has been converted to the charged state. In other words, charging continued after 100% state-of-charge is achieved. The result will be the decomposition of water in the electrolyte into hydrogen and oxygen gas.

Oxygen recombination - the process by which oxygen generated at the positive plate during charge reacts with the pure lead material of the negative plate and in the presence of sulfuric acid reforms water.

Parallel connection - a circuit in which battery poles of like polarity are connected to a common conductor.

Polarity - the electrical term used to denote the voltage relationship to a reference potential. (+ or -)

Power - rate at which energy is released or consumed (expressed in watts).

Rated capacity - the number of Ahs a battery can deliver under specific conditions (rate of discharge, end voltage, temperature).

Recombination - state in which the hydrogen and oxygen gases normally formed within the battery cell during charging are recombined to form water.

Re-sealable - in a cell, pertains to a safety vent valve which is capable of closing after each pressure release, in contrast to the non-resealable vent cap.

Sealed cell - cells that are free from routine maintenance and can be operated without regard to position.

Self-discharge - the decrease in the state-of-charge of a cell or a battery, over a period of time, due to internal electro-chemical losses.

Separator - a porous, insulating material placed between plates of opposite polarities to prevent internal short circuits.

Specific gravity (S.G.) - the weight of the electrolyte is compared to the weight of an equal volume of pure water, used to measure the strength or percentage of sulfuric acid in the electrolyte.

Starved cell - a cell containing little or no free fluid electrolyte solution; this enables gases to reach electrode surfaces readily, and permits relative high rates of gas recombination.

State-of-charge (SOC) - the available ampere-hours in a battery at any given time. State-of-charge is determined by the amount of sulfuric acid remaining in the electrolyte (specific gravity) at the time of testing or by the stabilized open-circuit voltage.

Sulfation - in its common usage, the term refers to the formation of lead sulfate of such physical properties that it is extremely difficult, if not impossible, to reconvert it to active material.

Swelling - RG battery cases swell or bulge when the cell vent valves maintain an internal pressure that is greater than the outer (atmospheric) pressure.

Trickle charge - a continuous, low rate charge, the rate being just about sufficient to compensate for self-discharge losses.

Vent valve - a normally sealed mechanism which allows the controlled escape of gases from within a cell.

Vent cap - the plug on top of a cell. It can be removed to allow for electrolyte level adjustment.

Venting - a release of gas either controlled (through a vent) or accidental.

Volt - unit of electromotive force, voltage or potential. The volt is the voltage between two points of a conductor carrying a constant current of one ampere, when the power dissipated between these points is one watt

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