Note on TBM Battery Operations Between Flights and BatteryMINDer Usage

By John M Grunsfeld PhD

Last year, Will Goldberg of Goldberg Aviation presented a TBMOPA online seminar on "Common Electrical Errors Made in the TBM".

In the briefing, Will recommended that between flights, the operator should disconnect the aircraft battery, and not keep it constantly on a BatteryMINDer. This is the best procedure if the aircraft will sit between flights for an extended period (roughly a week or more).

The recommendation from Concorde, the manufacturer of our RG-380E/44 battery, is the following:

Recommended practice for maintaining the Concorde battery when the aircraft is not in use for more than 7 days, in order of preference:

1. Disconnect fully charged battery from aircraft and top charge with BatteryMINDer every 30 days for 24 hours and also the day before next flight.

   -or-

2. Connect to BatteryMINDer after engine cooldown and leave connected until next flight

Both methods are used by TBM owners with satisfactory results. Because of the continuous charging, Method #2 may shorten battery life slightly. However, since the charging is at a reduced voltage level (float voltage), it will not shorten the life substantially.

The rationale for disconnecting the battery is two-fold. There are small loads the aircraft puts on the battery, even when the switches are all off and the crash bar is down. For the TBM 700-850, this parasitic load draws approximately 17mA, and for the TBM 900s 2mA. This small drain on the battery over time leads to sulfation of the electrodes. Disconnecting the battery reduces the drain on the battery to the lowest level possible, reducing sulfation, minimizing charging cycles, and maximizing the life of the battery.

Leaving the BatteryMINDer on all the time with battery connected keeps the battery fully charged and de-sulfates the battery. The

If it is desired to have a remote way to turn on the BatteryMINDer periodically, with the aircraft battery connector removed, a remote switch can be connected between the BatteryMINDer and battery clips which attach to the terminals of the aircraft battery. The BatteryMINDer can then be left powered, and a remote command to a relay will connect it to the battery. Devices to accomplish this can be cell phone text commanded, or for hangars with alarm systems or Wi-Fi can be remotely commanded via Wi-Fi relays or Z-wave relay devices. Many such devices are widely available.

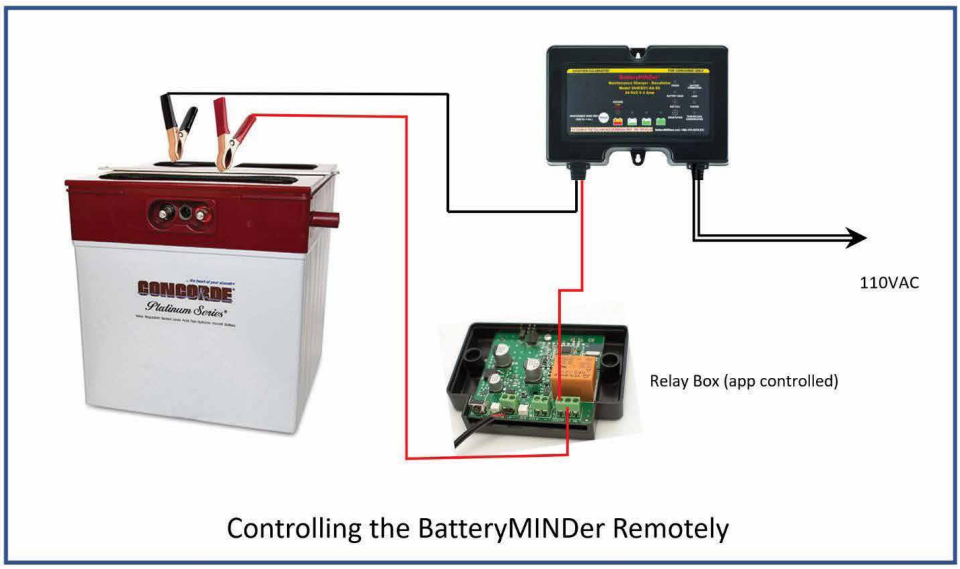
Examples are:

KKmoon GSM Remote

Wireless Z-Wave Multi-Input/Output

WHDTS WiFi Smart Switch Module Home

(All readily available through retailers such as Amazon.com)



Controlling the BatteryMINDer Remotely

One could remotely switch the 120V AC power to the BatteryMINDer, but this is not recommended. Leaving the BatteryMINDer connected but not powered on (connecting directly to the battery terminals with the main battery connector disconnected) will power on an LED in the BatteryMINDer, indicating it is connected to the battery. This will increase the drain on the battery, lead to sulfation of the electrodes, and drain the battery over time.

BatteryMINDer does this by keeping the battery at a constant voltage, providing just enough current to completely balance both the parasitic loads and the internal discharge rate of the battery. However, this small, constant current may decrease battery lifetime.

By disconnecting the battery after a flight — when the battery should be fully charged — the parasitic load is removed and the capacity of the battery will be preserved, except for a very slow decrease due to self-discharge. Charging the battery with the BatteryMINDer every 30 days and 24 hours before a flight will ensure the battery has full capacity when needed, as well as de-sulphate the electrodes.

Detailed Discussion

Battery

Batteries work by converting chemical energy into electrical energy during discharge and reversing the chemical reaction during charge. In our lead-acid aircraft batteries the reaction is:

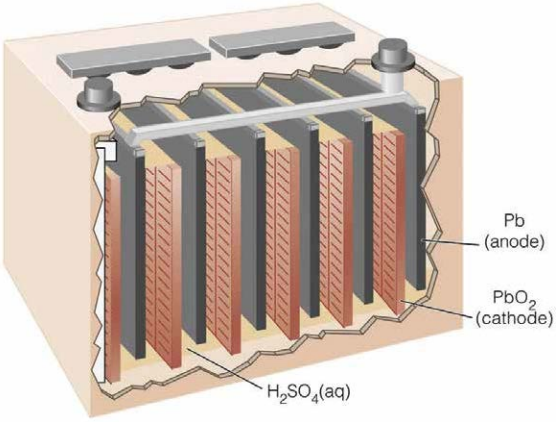
$$\underset{\text{Lead}}{Pb} + \underset{\text{Lead Dioxide}}{PbO_2} + 2\,\underset{\text{Sulfuric Acid}}{HSO_4^-} + 2H^+ \longleftrightarrow \underset{\text{Lead Sulphate}}{2\,PbSO_4} + \underset{\text{Water}}{2\,H_2O} \qquad \underset{\text{Electrical potential}}{E_o \approx +2.1\ V}$$

Discharge → ← Charge

An electrical load is applied to the battery lead and lead oxide in the battery electrodes reacts with sulfuric acid in the electrolyte to produce lead sulphate and water, while producing electrical current between the cathode (+) and anode (-) with a potential of ~2V/cell. When current is applied to the battery during charging, the chemical reaction is reversed. Our batteries have 12 cells inside resulting in a 24V battery.

The Concorde RG-380E/44 battery in our aircraft is a recombinant gas (RG series) valve regulated lead-acid absorbed glass mat battery design. It is a sealed battery in which the byproduct gasses of discharge recombine in the battery. The positive and negative plates are sandwiched between layers of fiber glass mats, which promote maximum retention of the electrolyte, and which enable efficient gas recombination. Each of the cells in the battery have pressure relief valves that open when the internal pressure exceeds the valves relief pressure, then re-closes. These features allow the battery to be virtually maintenance free and promote a long life.

During charging and discharging, there is some degradation of the electrodes, and minor loss of electrolytes. Over time, this reduces the capacity of the battery, and eventually the battery must be replaced when it can no longer support its function. This is determined by either watching the minimum voltage under starting loads, or capacity testing during maintenance inspections. During discharge, lead sulfate forms within the battery from a reaction of the lead plates and the sulfuric acid in the electrolyte. Long term buildup of lead sulphate crystals is called sulfation. Eventually sulfation can increase the internal resistance of the battery to the point that the battery can no longer be fully recharged. Sulfation may be reversed by a specific maintenance procedure or by the use of the BatteryMINDer which has a de-sulfation mode.



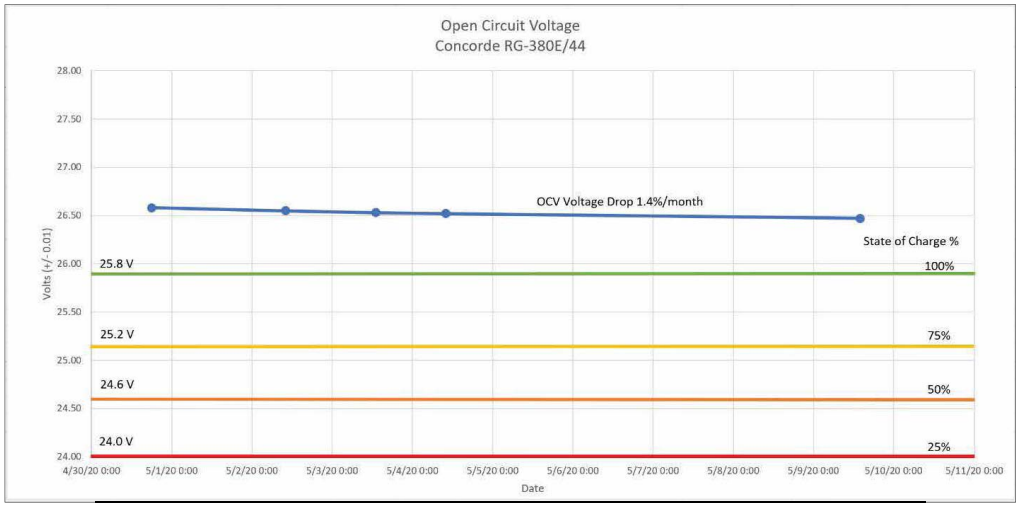
Good battery capacity is critical for starting our turbine powerplants and as a backup in the event of electrical failure of the generator or standby alternator. To keep the battery healthy, it should be stored fully charged, the number of cycles should be minimized, and sulfation should be kept to a minimum.

The state of charge (SOC) of the battery can be approximately determined by measuring the open circuit voltage (OCV) of the battery. This measurement can be accomplished by putting a digital multimeter (high impedance) across the battery terminals. The battery should be stabilized (no charging or discharging for at least 4 hours) before the OCV is measured.

State of Charge versus Open Circuit Voltage

Voltage	State of Charge (%)
25.8V	100%
25.2V	75%
24.6V	50%
24.0V	25%
23.4V	0%

In my aircraft I measured the OCV starting with a fully charged battery and monitoring for 10 days with the connector removed. The OCV declined very slowly, and over the period the OCV stayed in the "~100%" state of charge region.



Concorde therefore recommends that the battery should be disconnected to preserve the maximum state of charge, minimize cycles of charge and discharge on the battery, and minimize sulfation. ***Note: The SOC does not necessarily indicate the State-of-Health of the battery, and batteries should be checked at maintenance events to determine health and airworthiness.***

BatteryMINDer

The engineers at VDC Electronics, producer of BatteryMINDer, have worked closely with Concorde to develop a battery maintainer that performs several functions when we plug it on to our batteries. The units act as an aviation battery charger, charge maintainer, and de-sulfator. The Model 244CEC1-AA-S5 is designed specifically for Concorde 24V aviation batteries.

After a flight, the batteries are likely at their warmest, and the internal pressure likely at its highest as a result. To avoid the relief valves from opening and releasing gas it is best to allow the battery to cool before attaching the BatteryMINDer or any other charger.

When we attach the BatteryMINDer, the logic in the controller measures the voltage of the battery. If the voltage is below 21.0V it will use a low constant current in order to slowly bring it up to a higher voltage.

Normally it will start a constant current charging stage, initially putting 4A into the battery until the battery voltage reaches approximately 28.5V (temperature compensated, so this may vary).

It then begins a constant voltage charge, adjusting the current while maintaining the voltage. As the battery nears full charge the current will continually decrease until it falls below 0.1A. This stage lasts a minimum of 1 hour.

Following the charging phase, the battery will then perform a test of the battery by measuring the voltage of the battery for 10 minutes (without any charging).

Once the test is successfully completed, the BatteryMINDer begins Float mode. In this maintenance mode, the voltage is held constant at approximately 26.5V (temperature compensated, so this may vary), providing just enough current to compensate for any parasitic loads. In Float mode the battery is kept fully charged, ensuring no lead sulfate can form. There is no cycling of voltage in Float mode, the state of charge of the battery is held constant. The current is adjusted several times per second to keep the voltage constant. Every 12 hours the test mode is repeated during Float.

To help remove lead sulphate in the battery, the BatteryMINDer has a de-sulfation feature in which it injects short pulses of higher voltage into the battery. This is similar to the Concorde maintenance procedure, but instead of a deep discharge followed by a high-voltage/high-current charge (as high as 34V), the BatterMINDer uses short high-voltage pulses to remove the lead sulphate crystals on the electrodes over time. This feature is automatic in the BatteryMINDer and is shown on the front display when active by a blinking blue LED. A deeply sulphated battery may take 2-weeks to de-sulphate completely.

Even though the BatteryMINDer has been designed specifically for the Concorde battery in our aircraft, experience in the field suggests that leaving the BatteryMINDer full-time on the batteries, with or without the battery connector attached, may decrease battery lifetime. Concorde indicates this decrease in lifetime is not significant, but there are some reports of batteries experiencing premature retirement when on a BatteryMINDer full-time. Reduced battery life can be caused by many factors including starting at low temperatures, short flights in which the battery doesn't reach full charge, charging when the battery is still hot from a long flight, or allowing the battery to become deeply discharged.

Regardless, following the recommendations from Concorde by disconnecting the battery after flight, and only using the BatteryMINDer periodically to fully charge and de-sulfate is a sound procedure to maintain a healthy battery with a long life when not flying regularly.

In all cases, the recommendations in the operations manuals, maintenance manuals, and instructions for continued airworthiness should be followed in consultation with aircraft service technicians.

Additional information from conversations with Dave in technical support at VDC Electronics, technical support at Concorde, and with maintenance staff at AVEX.

Sources and References:

1. *Concorde Battery RG Series Aircraft Battery Owner/Operator Manual, Document No. 5-0324 Revision F, November 26, 2019, http://concordebattery.com/otherpdf/5-0324-rg-manual.pdf*

2. *Concorde Battery Main Aircraft Battery Component Maintenance Manual, Document No. 5-0171, Revision Q, December 4, 2018, http://concordebattery.com/otherpdf/5-0171.pdf*

3. *BatteryMINDer 24-Volt 244CEC1-AA-S5 Aviation Calibrated Maintenance Charger-Desulfator Instruction Manual, Revision B-012517, https://www.batteryminders.com/content/manuals/CEC%20Aviation%20128CEC1244CEC1%20RevA4%20050416.pdf*

4. *www.concordebattery.com, www.batteryminders.com*