Australian Government
Civil Aviation Safety Authority

# AIRWORTHINESS BULLETIN

Aircraft Lead Acid Main Battery Failures

**AWB** 24-008 **Issue** : 1
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## 1. Applicability

Aircraft wet lead-acid (flooded cell) main battery installations.

## 2. Background

CASA continues to receive reports describing serious safety issues including battery terminal separation, fire and explosion originating from the main battery and battery compartment or battery “box”.

## 3. Discussion

The aircraft main batteries identified in this bulletin are wet lead-acid (flooded cell) batteries with positive and negative threaded battery terminals or studs which are cast or soldered into the battery positive and negative terminations during manufacture. Installation hardware consists of a spring lock-washer and a low-profile terminal wing-nut, which is hand-tightened to clamp the aircraft main power supply cable terminals to the battery.

While some battery failures are caused by manufacturing quality escapes and ageing, many battery failures have been caused by inadequate maintenance practices.

Battery Terminal Failure

Loose terminals, corrosion in the terminal assembly clamp-up and failing battery terminal posts result in low and intermittent battery power, sparking and overheating. Should the battery terminal overheat, melt and either partially or completely detach from the battery it can result in total electrical power loss in flight. (See Figure 1) Reports received by CASA also describe battery explosions and fires in aircraft on the ground following battery terminal separation.

Figure 1

Photo- Courtesy Ben Wilhelmi

Battery terminal separation failures (pictured) are typically caused by excessive heat resulting from high current draw during engine starter motor cranking the engine and high resistance between the battery terminal post and the aircraft main system supply terminal.

High battery terminal resistance can be caused by inadequately torqued battery terminal attaching hardware, or tight terminal connections but having a layer of corrosion build-up between the contact faces of the battery terminal and the aircraft main system supply terminals.

In another instance, an investigation into a total in-flight electrical failure found the aircrafts' battery terminals were burnt off, that the starter had become engaged in flight and had failed internally. Although the investigator suggested lightning strike as the initiating event, it is also well known that should a starter motor become activated in flight, typically due to a faulty starter relay, the motor will overheat as it runs to destruction and then overload the battery.

## Battery Explosion and Fire.

During a period of high current draw, typically during extended engine starting attempts on the ground, explosive mixtures of hydrogen gas accumulate in the aircraft battery compartment. Should a battery terminal overheat to the point of melting, the spark generated as it separates from the battery can ignite the hydrogen and oxygen gas mixture given off by the discharging battery and has resulted in an explosion and fire on more than once occasion. (See Figure 2).

Figure 2

Photo: Courtesy John Schwaner.

Because the typical simple small aircraft battery compartment venting system works best during flight, explosive and noxious mixtures of hydrogen gas can accumulate in the battery box during both starting and charging on the ground, when there is insufficient air circulation in the aircraft battery compartment. For this and many other reasons, battery manufacturers generally advise against "jump" starting an aircraft using an alternate external battery power source when the installed aircraft battery has been depleted. Such action also allows the aircraft alternator to immediately deliver a high charge rate to the depleted battery, which will occur even at idle RPM on the ground following a "jump" start and can damage the battery.

Battery Compartment Drain

The battery is contained and mounted in a purpose-built compartment or "box" designed to protect the aircraft and occupants by securing the battery to the aircraft structure; containing and ventilating noxious and explosive vapour and draining any corrosive fluid that might escape from the battery.

When the battery box drain becomes blocked, any spills or leaks from the battery case collect in the battery box, under the battery. The highly acidic electrolyte from the battery can penetrate the walls and bottom of the battery box in a relatively short period of time. Uncontained acid has been known to attack the surrounding primary structure. In one case, battery acid penetrated the firewall and attacked and compromised the flight controls.

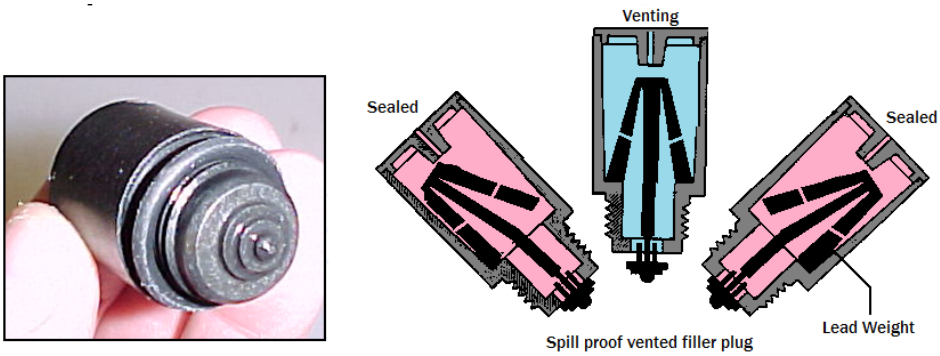
Battery Cell Venting

Some batteries have failed with sections of the top part of the case bulging upward, due to a combination of overheating, low electrolyte levels, internal failure and pressure build-up inside the battery case, due to the rubber tip seal in the cell cap failing to re-open. (See Figure 3). Aircraft battery cell caps allow the individual cells to vent gasses and also have some form of "non-spill" arrangement inside the cap to prevent electrolyte leakage from the cell during turbulence and unusual manoeuvres. A popular version of non-spill cap uses an inverted hollow "U" shaped lead weight which pulls a rubber tip into the vent hole and seals the cell when the battery is in unbalanced flight. (See Figure 4).

Figure 3

Note bulging top case and internal battery cell debris around the base of the cell filler cap at the positive terminal

Figure 4




Whenever servicing the battery, ensure correct level of electrolyte in each cell and check that the self-sealing function in each cell top is free (rattles) and that the rubber sealing tip drops clear of the vent hole when the top is held near vertical.

<u>Battery Compartment venting</u>

The battery compartment requires a source of fresh air to disperse noxious fumes and explosive mixtures of hydrogen gasses generated during operation. This is achieved by louvers or air vents in the lid of those battery compartment covers which are exposed to the airstream. Internally mounted batteries typically use two plastic tubes, each with one end connected to the battery compartment and the other end protruding into the airstream. Each tube protruding into the airstream is usually cut at an angle of about 45°. To provide the intended air flow, one tube should face forward into the airstream to provide a positive air pressure source to the battery compartment and the other face aft to create a negative pressure.

## 4. Recommendations

Following a review of the SDR history describing various modes of wet (flooded) cell battery failure, CASA recommends the following actions, in conjunction with the battery and aircraft manufacturer’s instructions for continuing airworthiness:

1. Remove the battery from the aircraft for servicing (usually about every twelve months) and check that the aircraft battery compartment is serviceable, secure and clean, has adequate anti-corrosive coatings and that the drain and vent tubes are secure, clear and correctly oriented.
2. Any time the battery is removed, consider rinsing the empty battery compartment (and lid) with a water and baking soda solution to neutralise any acid and to check battery compartment drain function.
3. Check that the battery structural tie-down arrangement is serviceable.
4. Inspect the battery case for deterioration, cell caps for function and cells for charge state. If the battery terminals are damaged, loose or deformed, the battery should not be installed.

5. Before installing any battery, ensure the battery is the correct model for the application, including battery terminal polarity and aircraft wiring system polarity and orientation in relation to the battery container.
6. Ensure that the battery terminals and the aircraft cable terminals are clean and free from corrosion, oxidation, chafing and contamination and take care to observe correct terminal attaching hardware sequence, using the OEM hardware supplied with the battery.
7. Ensure the battery terminal wing nuts are adequately tightened, that the battery is properly secured and the battery container cover is correctly installed.

CAUTION. Do not over tighten the terminal wing nut. Over tightening may result in deformation of the terminal post material which will eventually result in the terminal post becoming loose in service.

## 5. References

a. FAA AC 43.13-1B, Chapter 11, Section 2, Battery Ventilating Systems
b. Aircraft lead acid (flooded cell) battery manufacturers data. (Various).
c. CASA SDR System Reports.

## 6. Enquiries

Enquiries with regard to the content of this Airworthiness Bulletin should be made via the direct link e-mail address:

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