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Safety Management System

Safety Bulletin

No. 03/24 19th April 2024

Battery Safety Risk Management

Purpose. This Safety Bulletin (SB) provides educational awareness and guidance for ALL members on managing safety risks associated with batteries used in gliders, and in charging systems used by clubs and registered operators. Some cascading operational safety risks arising from battery, connector and electrical systems failures, and mishandling of batteries are discussed.

This Bulletin advises on some impacts of new electric drive technologies being introduced in powered sailplanes, along with changes to Gliding Australia airworthiness systems allowing use and installation of a wider range of battery types for glider avionics only (*not* powered sailplane starter systems).

This guidance should therefore be read in conjunction with authoritative references, including:

- MOSP 3 Airworthiness AIRW-M01 Section 18.11 Batteries
- Daily Inspectors Handbook AIRW-M03 Section 8.15 Electrical Systems
- Daily Inspectors Handbook AIRW-M04 Powered Sailplanes Section 7 Recharging HV Batteries
- GPC 42 Daily Inspections, Pilot Maintenance and DI Certificate, Pilots Guide Trainers Guide

Context – Battery Safety Risk Exposure

This SB is not just about glider airworthiness. It affects gliding operations, training, pilot Daily Inspections, and day-to-day management of batteries in club and home environments. Every pilot, DI inspector, Annual Inspector, registered operator and club, needs to understand the factors driving increased battery safety risks, and the measures required to reduce these risks.

Batteries are everywhere, some obvious, many unseen. Most pilots have had to deal with the (unintended) consequences of unreliable, dying or flat batteries inflight. Some pilots have dealt with serious consequences of avionics failures, powered sailplane propulsion system failures, and an extreme case of in-flight fumes. A recent occurrence involving a changed battery type connected to an incompatible powered sailplane charging system voltage regulator required an emergency landing; the pilot was very lucky. One day someone may have to bale out.

Many (unreported) incidents arise from power failures in portable and tablet-based electronic devices, mobile phones, cameras and battery packs, or from avionics devices requiring reprogramming on startup, due to inbuilt cell batteries failing, settings being lost.

How many times have you heard a thud and seen a battery dropped onto the ground? How many times have you found batteries with bulging or damaged cases, or damaged connections and wiring? How many unapproved battery substitutions are carried out? Battery safety is everyone's problem. Figure 1 (attached) highlights several contextual factors affecting risk exposure.

Battery Chemistry. First, not all batteries are equal or interchangeable. They vary in electrical characteristics, size and weight, and battery chemistry. Sealed Lead-Acid (SLA) batteries are most commonly used currently for main glider avionics power supply, with a small number of Ni-Cad cells. Lithium ion batteries are not permitted for glider avionics power, but are embedded in many tablets and portable devices. Many power banks used to recharge phones and portable devices have embedded lithium ion gel cells, built to far less rigorous standards.

Increasing numbers of pilots and registered operators are attracted to using lighter weight, improved Lithium Ferrous Phosphate (LFP) or LiFePO4 batteries. Since 2017, use of specified Fusion LFP batteries has been permitted via MTAR 1 – 2017, with good results. The range of allowable LFP batteries is increased with changes to MOSP 3 AIRW-M01 Section 18.10.

Different battery chemistries require different charging systems, matched to the chemistry type and internal battery resistance. Risks associated with overvoltage, overcurrent and overheating differ too.

Battery Applications. The purpose or application of batteries determines the required voltage, capacity, maximum current, temperature and shock rating characteristics. High capacity, high voltage systems used in electric propulsion have different risk exposure to those used for glider avionics. A button battery used in instrument memory or a canopy lock buzzer presents different risks to those used in tablet displays or handheld radios.

Battery Damage Risks. The risks of physical or electrical damage to battery systems depends on many design, handling and battery management factors. The risk of electrical faults, malfunctions and fires is much increased for *any battery that is dropped, cracked, leaking, bulging, swollen, overheated or misused*. Misuse includes charging with *incorrect, unmatched charging systems*, which may charge with excess current due to low internal battery resistance, resulting in overheating and cell damage. Short circuit risks with exposed terminals also have to be considered.

The risk consequences for any lithium ion battery are much more serious, given the combustion temperatures and combustion products. LiFePO4 (LFP) batteries are less likely to combust, but still produce toxic smoke. *Much increased vigilance is essential in ALL Daily Inspections (DIs), Annual Inspections, and repairs to electrical systems*. Any batteries that are dropped, fall off wings, suffer impacts, must be reported and inspected, and if in any doubt bench tested. Any batteries with visible casing damage or bulging must be withdrawn from service. Damaged batteries are time bombs.

Risks Arising. Part of defining the risk context is understanding different classes of risk consequences arising from battery safety problems. In detailed aviation safety risk analysis, we look at risk probability and severity, arising from defined risk consequence level events. Here we distinguish inflight operational risk events (arising from unreliability or loss of electrical power) from another group of high consequence risk events (arising from battery damage, failure or fire).

The first group captures "cascade" risks with credible operational impacts, such as propulsion systems that won't retract or start, loss of radio comms and situational awareness aids, loss of functional variometers and other avionics. The consequences for these might vary from minor inconvenience to a near collision to an in-flight emergency.

The second group captures the life-threatening, glider damaging risk consequences of an actual battery failure or fire, or combustion products. These might occur on the ground or in flight. Note that those risks are in turn driven by battery chemistry, design, fault current, et cetera.

Impacts of Changes in Gliding Australia Battery Management

Approval to use new battery technology in sailplanes is now subject to formal change management processes defined in the Gliding Australia Part 149 Exposition and referenced manuals. These include risk assessments for proposed changes, consultations on airworthiness, operations and administrative aspects. Changes to the manuals listed in the introduction have been developed to manage inherent risks in sailplane batteries so far as is reasonably practicable.

In the case of electric propulsion, Gliding Australia works with glider manufacturers to provide in-country training courses for registered operators and airworthiness officers. There are limitations on pilot allowed maintenance of batteries and propulsion systems, including specific requirements for charging in low hazard environments. High voltages are present in those systems, so maintenance processes are carefully defined; some maintenance must be carried out by manufacturers and their agents.

When approving a wider range of LiFePO4 glider batteries for avionics (not for powered sailplane starter systems), *Gliding Australia mandates a list of approved standards* based on EASA policy, with installation, weight and balance, crash-worthiness and electrical safety requirements. Installations requiring drilling through fuselage or structures may require airworthiness inspector or design approval. Battery labelling and daily inspection requirements are changed.

Extract from MOSP 3 AIRW-M01 Section 18.11 Batteries – List of Approved Standards

IEC 62133-2 Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary lithium cells, and for batteries made from them, for use in portable applications, Part 2: Lithium systems.

RTCA DO-347, Certification Test Guidance for Small and Medium Sized Rechargeable Lithium Batteries and Battery Systems.

RTCA DO-311A, Minimum Operational Performance Standards for Rechargeable Lithium Batteries and Battery Systems.

UL 1642, Standard for Lithium Batteries.

UL 2054, Standard for Household and Commercial Batteries.

UL 62133 Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes – Safety Requirements for Portable Sealed Secondary Cells, and for Batteries Made From Them, for Use in Portable Applications.

UL 1973 Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications.

Clubs and registered operators need to pay attention to managing charging risks. LiFePO4 batteries require matched charging systems and must be carefully monitored. Charging stations should be remote from hazards and gliders, and separate charging stations for Sealed Lead Acid and Lithium Ferrous Phosphate batteries are recommended. This requires batteries to be clearly labelled as to type and the gliders they are used in.

Some training changes apply, obviously in airworthiness matters, and also what we normally consider operational training. GPC Unit 42 addresses Daily Inspection training including pilot allowed maintenance. All pilots need to be aware of the combustion and toxic smoke risks associated with batteries and electrical faults, and the possibility of inflight emergencies.

In the worst case, pilots might not have time to conduct an emergency landing, may have to jettison the canopy and bale out to avoid highly toxic smoke. Once combustion starts, it may be impossible to contain! Damage to adjacent structures is likely, likewise impacts on headrest, parcel shelf, parachute and pilot. You do not want to go there!

Costs, Risks and Benefits

No technology change is risk free, but there are also benefits and opportunities. Some registered operators will welcome the reduced battery weight and opportunity for greater cockpit weights. New technology batteries also offer benefits with battery voltage stability, current and power capacity, number of charge and discharge cycles hence better battery life. In many cases better batteries may reduce the incidence of loss of radio, situational awareness, avionics and navigation capabilities, and in turn reduce some operational risks.

The above discussion is focussed on LiFePO4 (LFP) batteries. We cannot be complacent about other USB battery banks or portable device battery risks, particularly if they are overheated or physically damaged. Most of us know someone who has suffered an overheated or bulging battery in a phone, tablet or portable device, or watched alarming videos of such incidents in social media, so careful management or exclusion of some devices might be necessary, depending on your risk appetite!

Introducing a range of permitted LiFePO4 batteries, complying with approved standards, goes a long way towards mitigating another risk, namely the risk of uncontrolled carriage and use of unapproved battery types, or unsafe battery installations. Avoiding carriage of Lithium Ion USB battery banks is also recommended; you are better off installing USB ports in your panel off the main glider battery. Installing a small voltmeter in your panel is also recommended, to monitor voltage drops and possible faults.

I commend to all members the following resources and references:

- How to Avoid a Cockpit Fire from Lithium Batteries: YouTube Video
- NZ Pipstrel Crash Investigation: Report
- Gliding Australia Magazine Article: In Flight Battery Failure
- Gliding Australia Airworthiness Webinar #6 Apr 2023: YouTube Video
- Hazard Information Lithium Ion Batteries: WA Dept Fire Emergency Services
- Outbax: Lithium Batteries – Troubleshooting your LiFePO4 Battery Article
- Health Risks from Lithium-Ion Battery Fires: Strategic Risk Paper
- Safety Data Sheet Lithium Ion Phosphate Battery: Club Assist SDS

The Aftermath of a Near Miss!

I appreciate dialogue with all members on your insights. Happy soaring, happy landings. It's only fun when it's done safely.

A.R. (Drew) McKinnie
Safety Manager
19 April 2024

Attachments: Figure 1 Battery Safety Risk Context, Figure 2 Overview of Risk Reduction Measures

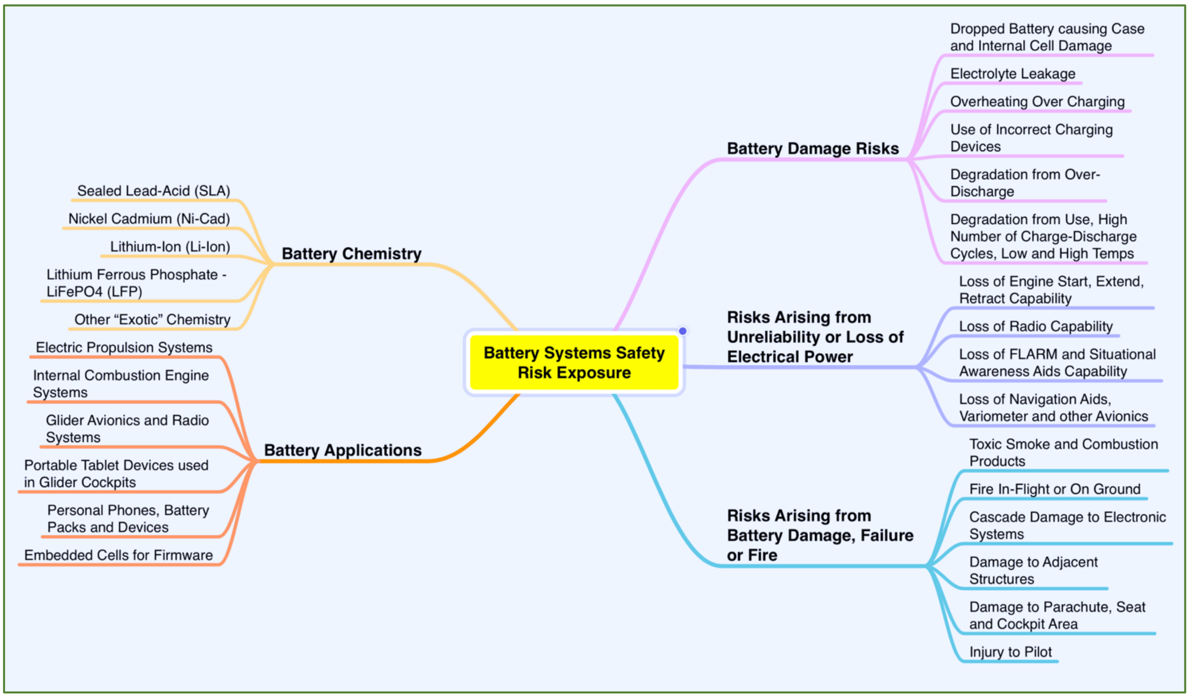

Figure 1: Battery Safety Risk Context

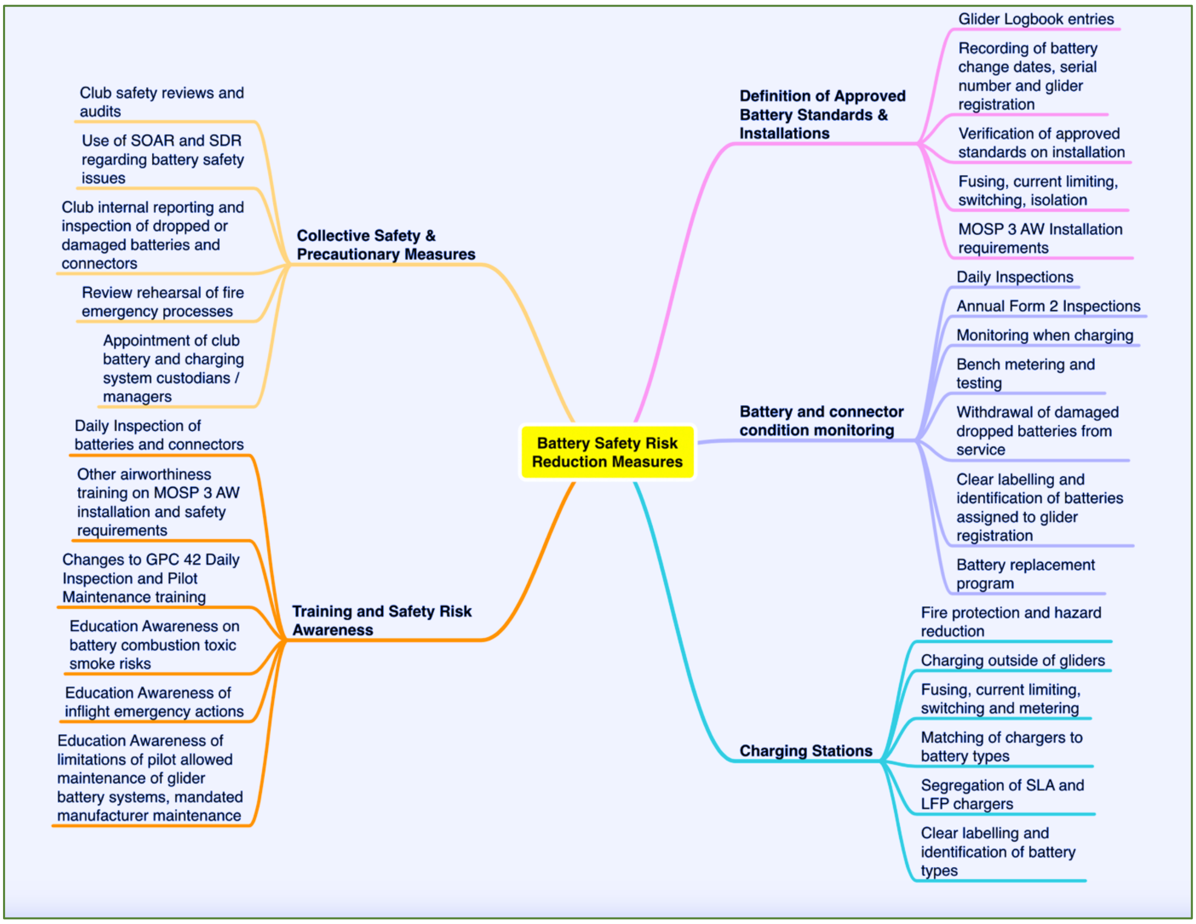

Figure 2: Overview of Risk Reduction Measures