Electric Aircraft

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no visible differences
Sources of Danger

- High Voltages and currents
- Burning lithium batteries
- Unexpected propeller spin up
- Hybrid Aircrafts may have:
  - Internal combusting engine and fuel
  - Fuel cell with hydrogen

- Others
  - Rocket engine for ballistic recovery system
High Voltage

- Certification requirements:
- Orange cables for HV
- Automatic disconnects close to the battery
- Disconnection plug not mandatory

How to switch all off?
- Switches are often in the Cockpit
- Multiple batteries possible (unplug)
High current

• May produce electric arc
• Do not cut unknown structures
  – a power cable may be behind it
The five safety rules

Not 1:1 applicable for a Battery system!

- Disconnect completely. Meaning that the electrical installation must be disconnected from live parts on all poles. ...
- Secure against re-connection. ...
- Verify that the installation is dead. ...
- (Carry out earthing and short-circuiting.)
- Provide protection against adjacent live parts.

An Electric Aircraft does not have the Earth as a reference point. The voltage measured between the Earth and the Aircraft is therefore always 0. Short-circuiting the battery is not a good practice.
Where are the high power cables?

Batteries can’t switch off

Source of the Danger

Disconnect as close as possible by the source

Distributor

Inverter

Charger connection
On the Aircraft

Batteries are heavy – mostly they are not installed in the wing Tips or in the Tail.
Rescue map

Not (yet) generally available

The Swiss register will have them available for all electric HB Aircrafts in the near future.
Battery Fire

Lithium Batteries may burn hot

Some chemistry may produce the needed oxygen itself

How to distinguish?
- Some tones of sand
- A lot of Water

Extinguishing access is not mandatory
USE WATER TO FIGHT A HIGH VOLTAGE BATTERY FIRE. If the battery catches fire, is exposed to high heat, or is generating heat or gases, use large amounts of water to cool the battery. It can take approximately 3,000 gallons of water, applied directly to the battery, to fully extinguish and cool down a battery fire; always establish or request an additional water supply. If water is not immediately available, use dry chemicals, CO2, foam, or another typical fire-extinguishing agent to fight the fire until water is available.
What is in the smoke

The environment around a burning lithium battery can be hazardous

- Hydrogen
- Graphite dust (Explosion)
- Heavy metal
  - Cobalt, Nickel, Mangan
- Lithiumhexafluorophosphat (LiPF$_6$) ->
  - Hydrofluoric (HF), Contact poison (MAK: 1ml/m$^3$)
  - Phosphoric acid (H$_3$PO$_4$) (MAK: 1mg/m$^3$)

Use adequate protection
Is the fire extinguished?

Batteries may start burning hours after an accident
• Store them outside only
• Have extinguishers ready
• Take adequate measures for a transport
Is the motor off?

Electric motors may spin up quickly
  • Aircraft may roll or fly away
  • Propellers are a source of danger
  • Disconnect all electric sources

If necessary, close off the propeller area and secure the aircraft from rolling away
Hybrid aircraft

Power generation

Distributor

Inverter

Charger port

Fuel cell

Fuel

Hydrogen
Ballistic Recovery System

1. Bouclage périmètre diamètre minimum 200 mètres
   Selon conditions du terrain

2. ZONE DE DANGERS

3. Point d’accès

4. Toujours accéder à l’aéronef par l’arrière

Electric Aircraft
Place of a Fire

- Hangar, probably while charging
  - Smoke
  - Connection to ground possible
  - Other Aircrafts with fuel around
- Tarmac
- Taxiway
  - Engine may be «hot»
- Runway
  - Pressure to vacate the runway
- In Flight
  - Not the airport firefighters on place
- Ditching
  - Electric is not grounded. Therefore no big risk
  - Hydrogen may be produced
Next steps

Swissfire Association, STSB and FOCA
- Guidance Material
- Report in magazine
- Rescue map in the (public) aircraft registry of Switzerland
- Training

Questions
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