

LEAD/ACID BATTERIES FOR AIRPORT GROUND-SUPPORT EQUIPMENT

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Introduction

The electrically driven aircraft-towing-tractor, F246, is a good example of the use of modern lead/acid traction batteries in powering airport ground-support equipment (Fig. 1). The tractor has been developed through close co-operation between SHOPF Maschinenbau GmbH, Stuttgart and HAGEN Batterie AG. The former company was responsible for the design and construction of the vehicle, the latter company developed the battery and electrical equipment



Fig 1 F246 battery-operated aircraft towing tractor

Design features of aircraft towing tractor

Drive system

The main components of the F246 drive system are given in Table 1. Once the electric drive is put into operation by a key switch, the auxiliary motor starts ventilating the drive motors and supplying power to the hydraulics. There are selection switches for three driving stages and for the direction of travel. Electronic interlocking ensures that the selection is only operable

TABLE 1

Drive system components of F246 aircraft towing tractor

Component	Rating
<i>Drive motors</i>	
— continuous (kW)	2 × 45
— short-time maximum (kW)	2 × 108
Auxiliary motor (kW)	12
Gear oil pump motor (kW)	2.6
Electronic drive control (kW)	2 × 108
<i>Battery</i>	
— cells	120
— energy content (kW h)	213
Battery charger (V, A)	240, 150

whilst the vehicle is stationary. A foot pedal, generating 0 - 4 V, is used for speed control.

The thyristor control consists of two units, one for each motor, and is mounted in the rear of the vehicle. It includes the current control and the direction switches and is equipped with the following main safety precautions:

(i) drive pedal safeguard: on failure of the potentiometer, the control input is shorted and the vehicle will stop immediately,

(ii) acceleration limitation: a maximum acceleration can be set with a regulator in order to avoid uncontrolled revolution of the drive wheels,

(iii) low voltage protection: no overdischarge of the battery,

(iv) temperature limitations: the temperature of both the drive motors and the power semiconductors are monitored continuously, in the case of overheating, the current is reduced proportionately, if the temperature of any of the drive motors exceeds a critical value, the power is switched off,

(v) safety switch-off: this operates whenever there is a discrepancy between speed regulator and motor voltage, it can also be operated manually by a switch in the driver's cabin.

Battery

The energy is stored in a lead/acid battery of the copper-stretch-metal (CSM) type [1] consisting of 120 cells of 888 A h capacity at the 5 h rate, assembled in two steel troughs (Fig. 2). The design includes features of low maintenance and long service life, *i.e.*,

- positive plates of tubular type,
- negative grids of copper-expanded-metal,
- heat-sealed lid-to-container assembly,
- terminal feed-throughs that do not give rise to electrolyte leakage,
- automatic topping-up system,
- contact protection of intercell connectors,
- plastic-coated steel trough.

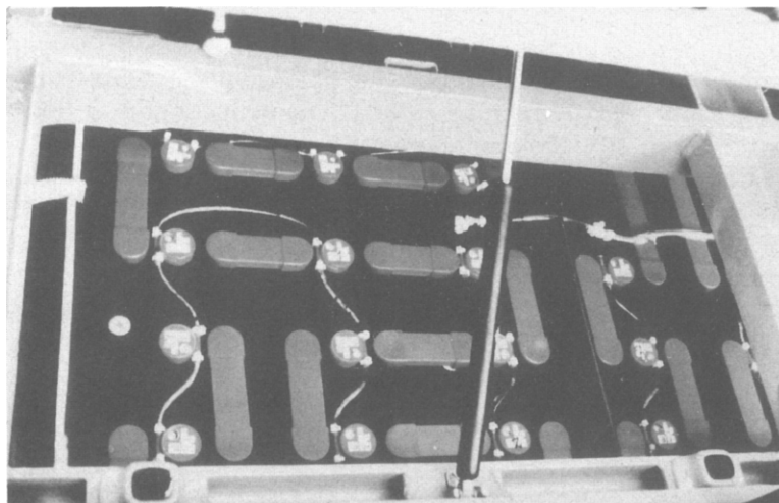


Fig 2 Batteries in F246 aircraft towing tractor

The positive tubular plates have an expected service life of 1600 cycles at 80% DOD. In practice, this will be 4 - 6 years depending on the actual load. The negative plates are not expected to deteriorate during this time.

Whereas the heat sealing might be seen as the general state-of-the-art, the perfect sealing of the terminal feed-throughs is not that common. The idea is to machine the terminals after casting in order to get a perfect bearing for an O-ring gasket. This gasket is held down by a polypropylene ring and fixed in position by means of two half-rings. Final sealing between the terminal and the lid is made by injection moulding polypropylene into the intermediate space. This design results in negligible acid spillage and excellent insulation of the battery against ground.

The plugs in the automatic topping-up device include a lever system that amplifies the valve closing force of the swimmer. Therefore, the pressure of the refilling water may be varied between 0.1 and 3 bar. Preferably, a refilling cart is used equipped with a rapid-action hose coupling. This reduces the maintenance time to a few minutes once or twice a week.

The contact protection caps should be seen as an additional measure for safe operation. With welded connectors, they are clamped-on plastic profiles. In the screw-type connections, the copper inserts in the terminals are threaded so that there is good corrosion protection of the copper.

The battery troughs, made of ordinary steel sheet, are sandblasted and heated in an oven. The heat content, controlled by the temperature, must be sufficient to melt a layer of acid-proof plastic from a fluidized powder bed onto the surface. Because of the good adherence of the plastic layer, no acid can creep underneath in the event of an accident. The troughs have the dimensions: 1750 mm (length) \times 1000 mm (width) \times 800 mm (height). The total weight of the two battery packs is 6940 kg.

Charger

An off-board charger is used and has the operational characteristics IUI_a , with the possibility of switching to IU [2]. The mains supply is three-phase a.c. with thyristor rectifying components.

A special feature is the connection of the charger to the battery. This is made by a charging plug including a "lagging pilot". This lagging pilot contact activates the charge contactors and disconnects the control unit. Inadvertent operation of the tractor is therefore excluded during charging. Once the charging plug is pulled out, the lagging pilot contact will switch off the charging current before the high current contacts are opened.

Conclusion

It has been the purpose of this paper to show the state-of-the-art and to demonstrate the necessity of close cooperation between the producers of batteries and of trucks for the development of new electric vehicles. Consideration should not be restricted to the battery, but, rather, many other features must be taken into account to ensure a long service life with low maintenance and high reliability.

References

- 1 R. Kiessling, Copper-stretch-metal technology and applications, 1st Asian Battery Conference, Hong Kong, August 10 - 13, 1986, *J Power Sources*, 19 (1987) 147
- 2 German Standard DIN 41 772