# AVIATION 5

## 1. PRINCIPLES

— Very low internal resistance, ensuring the availability of a high useable voltage during discharges of short duration, supplying currents which may reach 20 to 35 times the value of the rated capacity of the cell, depending on whether VOK, VPK, or VHPK cells are used.
— Possibility of operation over a very wide range of temperature (−40°C to +50°C).
— Excellent mechanical strength.
— Good charge retention.
— Ability to be recharged at constant potential using ordinary equipment.
— Very suitable for rapid charge.
— Simple and minimum maintenance.
— Ability to withstand prolonged storage irrespective of the state of charge in a wide range of temperature (−60°C to +60°C).

## DESCRIPTION

Nickel-cadmium cells of VOK, VPK and VHPK series are made up from two groups of sintered plates, thin for VOK, or very thin for VPK and VHPK.

The assembly is such that the positive plates which contain nickel hydroxide are interleaved with the negative plates which contain cadmium hydroxide. Positive and negative plates are insulated from each other by a composite separator of polyamide felt.

In addition to being the electrical insulator, this separator limits interaction between the plates and promotes polarisation at the end of charge due to the use of the gas impermeable membrane which it contains.

Cells of VHPK series have a special membrane.

These features permit the use of VOK, VPK and VHPK series of cells with simple constant potential charging systems.

The cases and covers of VOK, VPK and VHPK series of cells are in polyamide with the exception of VO 1.5 K.

All these cells with polyamide cases have benefitted for many years from a special closure system which gives a perfect and durable seal whatever may be the application. A very strict quality control of the welds between case and cover is carried out on all cells before they leave the manufacturing line.

Cells of VOK, VPK and VHPK series have valves which permit their operation on discharge whilst inverted. During overcharge, gas produced by electrolysis is allowed to escape at low pressure through this valve.

In the case where cells must operate on overcharge in the inverted position, a special valve is available.

The electrolyte is an aqueous solution of potassium hydroxide (KOH) chemically pure, of s.g. 1240 or 1300 depending on the type of cell.

All cells have a reserve of electrolyte which is intended to compensate for the loss of water during overcharge. This reserve varies according to the specific type of cell.

## CHARACTERISTICS

Nominal voltage: 1.2V per cell.

Rated capacity at +23°C: the quantity of electricity ($C_1$ Ah) assigned at the one hour rate of discharge ($C_1$ A) to an end voltage 1V per cell.

Useable capacity: the quantity of electricity useable in practice taking into account the particular performance of each type of cell in the same conditions as those for the rated capacity.

VOK, VPK and VHPK cells being essentially intended for power applications, the curves of the characteristics of these cells show the maximum power in peak discharge and discharge at high rates.

Currents or rates of charge and discharge are expressed by reference to the rated capacity:

e.g. $0.5C_1$ A corresponds to 20A for a cell of $C_1$ Ah=40 Ah.
$20C_1$ A corresponds to 800A for a cell $C_1$ Ah=40 Ah.

**BATTERY CONFIGURATIONS**
A battery is made from a certain number of cells of the same specific type connected in series inside a rigid mount, generally a box fitted with a cover. According to the application these boxes may be in reinforced plastics, painted steel, stainless steel or even in titanium.

IF N is the number of cells connected in series and $C_1$ Ah their rated capacity, the characteristics of the battery are:
— Nominal voltage: 1.2V×N.
— Rated capacity: $C_1$ Ah.

The most common batteries are built up from 5, 10 or 20 cells corresponding to nominal voltages of 6, 12 and 24V.

**CHARGE**
Nickel-cadmium cells of the VOK, VPK and VHPK series charge at either constant current or constant potential.

**Constant current or two rate charge**
Constant current charge (or two level rate) for completely discharged cells may be carried out by one of the following methods:

**Charge at $0.1C_1$ A rate** until the battery voltage reaches an average of 1.5V per cell (30V for a battery of 20 cells) then continue the charge at this rate for 4 hours.

Complete charge of the battery requires between 14 and 16 hours.

**Charge at $0.5C_1$ A rate** for at least 2 hours. If after this period the battery voltage has not yet reached 1.55V per cell (31V for a battery of 20 cells) continue the charge at the same rate until the battery reaches this level.

In any case the duration of charge at this rate must not exceed 2 hours 30 minutes.

Continue the charge at a rate of $0.1C_1$ A for 4 hours.

**Charge at the $1C_1$ A rate** for at least 1 hour. If at this period the battery voltage has not yet reached 1.57V per cell (31.4V for a battery of 20 cells), continue charging at the same rate until the battery voltage reaches this level.

In any case the duration of charge at this rate must not exceed 1 hour 15 minutes.

Continue the charge at the rate of $0.1C_1$ A for 4 hours.

Whatever the method used, the end of charge is indicated by a sharp increase of the charging voltage (see figures 1 and 2 p.137).

**Note**
Some chargers of "constant current" type apply a short reverse pulse to depolarise the plates, thus improving the rapid charge.

**Constant potential charge.** The voltage of the charging source (or the regulator) must be adjusted so that it is, depending on temperature, between 1.40 and 1.50V per cell (for an increase of the real temperature of the battery, the charge voltage must be decreased, and conversely for low temperatures).

At normal temperature (+23°C ±5°C), the voltage to be used is 1.40 to 1.45V per cell. In these conditions, current limitation is not necessary and the battery will recuperate 80% of its capacity in approximately 45 minutes.

The end of charge at constant potential is signalled by a very great reduction of the charge current (see example figure 10, 138).

**Continuous charge**

***Operation in float conditions:*** Where it is desired to keep the battery in a fully charged state, it is recommended that it should be maintained on a continuous charge at a very low maintenance current (0.5 to 1mA/Ah: for example 20 to 40 mA for a battery made up of VO 40 KH cells).

In these conditions the battery voltage stabilises at approximately 1.35V per cell.

***Operation in buffer:*** In the case of buffer operation (that is to say an assembly of charger and battery continuously supplying load), it is recommended that the battery is maintained on charge at constant potential of 1.36V per cell. This will enable recharge of the battery and support short duration high discharge currents, greater than the rated output of the charger.

**Note**
The information above is valid only for normal temperatures, that is to say between 0°C and +40°C.

For operation continuously at a temperature outside these limits it is recommended that you consult the technical services of SAFT.

**CHARGE RETENTION**
Cells of VOK, VPK and VHPK series have a very satisfactory charge retention. However, all charge retention is considerably improved at low temperature.

Thus for example, a cell will return about 80% of its capacity after storage of 3 months at +25°C, 95% after the same period of storage at 0°C and only 60% after 2 months at +35°C (see figure 9, p.138).

**DISCHARGE**
Cells of the VOK, VPK and VHPK series supply currents up to $10C_1$ A for the VOK series (or $20C_1$ A for the VPK and VHPK) for periods of the order of 1 minute.

They can supply without harm, peak currents for several seconds at rates of the order of $20C_1$ A (for the VOK) and up to $35C_1$ A (for the VHPK). Cells of VHPK series are the highest performers and thus best suited to resolve the most difficult starting problems because their lower internal resistance provides the possibility for peak discharges at high rates whilst maintaining a very acceptable level of voltage (see figures 3 to 8, pp.137 & 138).

Cells of the VOK, VPK and VHPK series are satisfactory in a range of temperatures from −40°C to +60°C. However, in the case of operation at extreme temperatures, it is recommended that SAFT is consulted.


***SAFT Delta-Plus Aircraft Batteries Cells type VHPK***

As examples, the maximum power characteristics and continuous discharge curves of VO 40 KH, VP 400 KH and VHP 430 KH cells are given below (see curves p.137 &138).

**Note**
It is recommended not to tap batteries, that is, to connect certain load circuits to only a part of the battery.

Such practice will in fact cause an imbalance of the state of charge of the various cells and impede the correct recharge of the battery as a whole.

## COMMISSIONING AND MAINTENANCE

### Commissioning
VOK, VPK and VHPK cells are usually delivered electrically discharged but even if the liquid is not always visible above the plates, they are always filled with the necessary quantity of electrolyte for correct operation and thus ready for use.

Before putting them into service it is necessary to give a complete constant current (or two rate) charge as defined in section relating to Charge (p.125 and 126).

### Maintenance
Maintenance of cells of the VOK, VPK and VHPK series comprises the following essential operations:
- cleaning in case of substantially reduced insulation,
- cleaning the valves if their condition necessitates this,
- inspection and periodical adjustment of electrolyte levels,
- periodic check of electrical characteristics if necessary.

Consumption of water from the electrolyte is directly proportional to the quantity of electricity (Ah) which the cells receive as over-charge.

3 Ah of overcharge dissipates 1 ml of water from the electrolyte.

The necessity for adjusting the levels in the cells depends essentially on operating conditions and the frequency of such adjustments can only be determined by frequent inspection of the level during the first few weeks of service.

**Notes**
Cells types VO 1.5 K, VO 3 KH, and VO 12 LKB with polyamide cases have a line on the narrow faces of the cell, which permits visual adjustment of level during the latter part of the charge.

The electrolyte level of VOK, VPK and VHPK cells varies considerably as a function of the state of charge. This takes place as the electrodes absorb some of the electrolyte during discharge and return it during charge. The electrolyte only achieves its highest level during the latter part of a complete charge.

It varies also as a function of the time of rest between the end of charge and the moment of measurement.

The most appropriate time to carry out the adjustment of levels is thus the end of charge, whilst the cells are still receiving a charge current (0.5 h before the end of charge).

The electrolyte level must be adjusted exclusively with distilled or pure demineralised water. Preferably use the syringe from the maintenance kit fitted with a calibrated nozzle (please see table below).

**Nozzles for water addition and volume of consumable electrolyte**

| Nozzle ref. | Length mm | Used for cells | Consumable electrolyte vol ml | | |
|---|---|---|---|---|---|
| | | | Normal (1) | Extra reserve (2) | Aerobatic (3) |
| 14590 | 12 | VO 1.5 K | 2 | | |
| | | VP 65 K | 8 | | |
| | | VO 12 LKB | | 7 | |
| 14591 | 15 | VO 16 KH, VP 160 KH | | 23 | |
| | | VP 160 KM, VHP 170 KH-3 | | 23 | |
| | | VO 23 KH, VP 230 KH | | 26 | |
| | | VHP 260 KH-3, VP 230 KHMS | | 26 | |
| | | VO 25 KH, VP 250 KH | | 27 | |
| | | VO 40 KH, VP 400 KH | | 32 | |
| | | VHP 430 KH-3, VP 400 KHMS | | 32 | |
| 16544 | 20 | VO 25 KA | 60 | | |
| | | VHP 370 KA-3 | 50 | | |
| | | VO 16 KH, VP 160 KH | 20 | | |
| | | VP 160 KM, VHP 170 KH-3 | 20 | | |
| | | VO 23 KH, VO 25 KH | 21 | | |
| | | VP 230 KH, VP 250 KH | 21 | | |
| | | VHP 260 KH-3 | 21 | | |
| | | VO 3 KHB | 4 | | |
| | | VO 12 LKB | 4 | | |
| | | VO 40 KH, VP 400 KH | 25 | | |
| | | VHP 430 KH-3 | 25 | | |
| | | VHP 270 KH-3 | 25 | | |
| 104184 | 20 | VP 120 KHMS | 15 | | |
| | | VP 230 KHMS | 21 | | |
| | | VP 400 KHMS | 25 | | |
| 410199 | 33 | VP 160 KM-SQ | | | 8 |
| | | VHP 260 KH-3-SQ | | | 8 |
| 410233 | 38 | VHP 370 KH-3-(SQ) | | | 10 |
| | | VP 400 KH-SQ | | | 10 |
| | | VHP 270 KH-3-SQ | | | 10 |

***(Figures in brackets refer to notes on page 130)***

## STORAGE

VOK, VPK and VHPK cells may be stored in any state of charge and at any temperature.

However for long term storage it is recommended that you first correct the electrolyte level and then discharge at $0.2C_1$ A down to an average of 1V per cell. No other special precautions or periodic attention will be required, if the cells are kept in the normal vertical position and shielded from dust and damp.

Storage temperatures may be between −60°C and +60°C but the most favourable temperatures are between 0°C and 30°C.

On return to service after storage these cells require no attention other than a complete charge (see section relating to charge p.125-126

## APPLICATIONS

Open type cells of VOK, VPK and VHPK series are particularly used in applications which require very high discharge currents, such as gas turbine or IC engine starting when the space available for the battery must be kept to a minimum.

Their dimensional and weight parameters also offer interesting solutions to problems posed by portable energy and particularly power sources.

They are designed to be able to recharge at constant potential using normally available current sources (dc generators with voltage regulators or alternators and transformer-rectifiers).

Recharge may also be carried out using standard dc power sources.

Amongst the most widely encountered uses are:

- on-board batteries for military or civil aircraft and helicopters and, in particular, those required to provide on-board starting of the propulsion engines or standby power supplies,
- equipment for vehicles and special devices,
- the provision of energy sources for transportable equipment.

### Note

(1) This value shows the volume of free electrolyte above the upper level of the plates. If use in service exceeds these values, the plates will be working partially dry which can cause, amongst other things, a premature degradation of the separators. It is thus important to determine the frequency of periodic checks in order that the amount of distilled water added per cell, during adjustment to the level, is always less than the values shown.

(2) Where it is necessary to increase the period between electrolyte replenishment in the cells, the 15mm nozzle (ref. 15.591) could be used instead of the 20mm nozzles (ref. 16.544 and 104.184).

However, great care should be taken when adjusting to avoid spillage in service and filling.

(3) These cells are also made adapted for aerobatic flight. The reference suffix SQ (e.g. VHP 270 KH-3-SQ) indicates that the cell may be used in aerobatic flight.

The cell has a special valve and requires a different adjustment of the electrolyte level. The length of the nozzle to use is shown in the table on p.129.