Stand-by Batteries

Technical Manual dryfit.

Sonnenschein

Sonnenschein:

Know-how you can rely on.

Systematically Devised Batteries

The Energy Experts

dryfit batteries are sealed, maintenance free lead acid batteries. It is no longer necessary to refill with water.

Compared with other conventional battery systems when using dryfit batteries you save expensive maintenance costs. dryfit – economy that pays

Sonnenschein

Main Characteristics of the dryfit-System :

- Lead acid system
- Sealed
- Rechargeable
- Maintenance free
- Pb-Ca-Sn-alloy
- Immobilised gel electrolyte (preventing acid layer formation)
- Extremely economical and efficient

Sonnenschein offers 40 years world-wide dryfit technology experience in various fields of application. Since 1957 the system developed by Sonnenschein has maintained a key position in the market and is continually being developed further.

From all aspects the dryfit battery types available are suitable for the extreme service life requirements for standby parallel operation and durability demands in cyclic applications.

Contents

dryfit:

dryfit – Perfection from A to Z.

1. dryfit – Perfection from A to Z

1.1 Chemical Reaction

The electrochemical reactions in a lead acid battery when discharged can be easily described with the following formula :

- Negative Plate :
  $Pb + SO_4^{2-} \rightarrow PbSO_4 + 2e-$
- Positive Plate :
  $PbO_2 + 4 H^+ + SO_4^{2-} + 2 e- \rightarrow PbSO_4 + 2 H_2O$
- Total :
  $Pb + PbO_2 + 2 H2SO_4 \rightarrow 2 PbSO_4 + 2 H_2O$

This reaction is reversible and when charged runs in the opposite direction to the above arrow.

1.2 Valve Regulated Technology for Lead-Acid Batteries

Main Characteristics :

- Immobilised Electrolyte
- Pb-Ca-Sn-alloy

Valve regulated lead-acid batteries are distinguished by the immobilised electrolyte and the vented casing. Each battery cell has a valve through which any resulting hydrogen gas (due to excess pressure in the cell) can be released (typical value: 100 mbar $\hat{=}$ 1.4 PSI). The valve closes airtight to external pressures. After release of the hydrogen the valve closes again and prevents O_2 entering the cell.

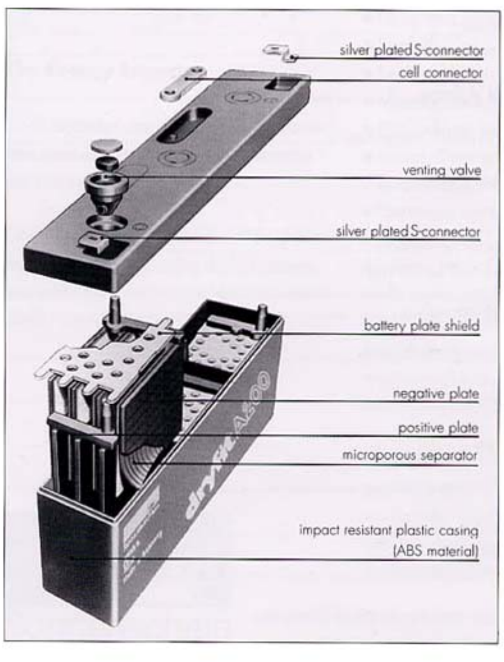

Fig. 1 :
Explosion view of valve regulated lead-acid battery with grid plates.

The sealed lead-acid batteries are maintenance free for three reasons :

- The Pb-Ca-Sn alloy guarantees the mechanical stability of the plates and increases the system gassing voltage to high values.
- The electrolyte is immobilised.
- By closing the system with a valve, the released oxygen can recombine and reduce the production of hydrogen.

The electrolyte is immobilised either in a gel or by absorption of the electrolyte in a glass fibre separator. This is the AGM (= Absorbed Glass Mat) technology. The electrolyte in the dryfit batteries is immobilised in a gel.

1.3 Plates

dryfit batteries of the series A 200, A 300, A 400, A 500, A 700 and OGiV contain grid plates. These gravity cast lead grids, produced for positive and negative plates, are pasted with a lead oxide paste, cured and then formed.
The positive plates for the series A 600 are tubular plates for which the dry raw material (powder) is vibrated into polyester gauntlets. The plates are then cured and formed.

- Active negative plate substance : Spongy lead.
- Active positive plate substance : Lead dioxide.

1.4 Separator

The separator separates the positive and negative plates mechanically and electrically from one another. It must not only guarantee a high porosity to allow electrolyte acceptance and ion migration, but it must also prevent short circuits.

1.5 Electrolyte Gel System

The electrolyte in the dryfit batteries is immobilised in a gel (sulphuric acid : H_2SO_4). The gel is a mixture of sulphuric acid, water and SiO_2. The gel system also offers the possibility of varying the components and to include certain additives for the cycle stability.

1.6 Water Loss and Recombination

When the battery is fully recharged, water decomposition takes place causing water loss. In the valve regulated lead-acid battery the water decomposition is almost fully compensated by the recombination of the oxygen on the negative plates. This oxygen recombination is made possible by the immobilised electrolyte.

As the speed of diffusion of oxygen into sulphuric acid is very low, there is hardly any recombination in a conventional lead-acid battery. However, in batteries with the gel electrolyte system channels are formed through with the oxygen (which forms on the positive plate) can migrate to the negative plate without any interference.

The dryfit system electrolyte reserve is regulated so that the service life is not influenced by the water loss.

1.7 Casing

The dryfit batteries are available with the following casing material:

- A 200, A 300, A 400 and A 500
  Standard material :
  up to 16 Ah : Acrylnitrile-butadiene-styrene-copolymer (ABS)
  for 20 - 200 Ah : Polypropylene (PP)

  Both materials are classified with normal flammability (UL94-HB).

  As special type
  up to 16 Ah : Acrylnitrile-butadiene-styrene-copolymer (ABS) (UL94-V0)
  for 20 - 200 Ah : Polypropylene (PP) (UL 94-V2)

- OGiV and A 700 (blocks)
  Standard material :
  Polypropylene (PP) (UL 94 HB)

- A 600, A 600 WE and A 700 (cells)
  Standard material :
  Styrene-acrylnitrile-copolymer (SAN) (UL 94 HB)
  ABS UL 94-VO on request

Further information on this point can be found in the Standards IEC 707 and VDE 0304, Part 3.

dryfit:

Capacity, Nominal Voltage

2. Capacity

For the series A 200, A 300, A 400 and A 500 the nominal capacity is given for discharge at the 20 hour rate.

Discharge with constant current for the period of 20 hours corresponds to C_N. The final discharge voltage U_E with which the discharge is terminated is 1.75 V/cell.

- $I_{20} = C_{20} / 20$ h
  (see also DIN 43539, Parts 1 and 5).
- All discharge currents are given in multiples of I_{20}.

For the series A 600, A 700 and OGiV the nominal capacity is given for discharge at the 10 hour rate. The final discharge voltage U_E for the nominal capacity C_{10} is 1,8 V/cell.

- $I_{10} = C_{10} / 10$ h

The nominal capacity of solar batteries is given at the 100 hour rate, C_{100} (final discharge voltage 1.85 V/cell) and the series A 500 C nominal capacity is given at the 5 hour rate, C_5 (final voltage 1.7 V/cell).

The capacity of valve regulated lead-acid batteries depends on the temperature and the output current (cf. fig. 2).

Discharge within the electrolyte freezing zone could lead to destruction of the battery.

The final discharge voltage and discharge times, as well as the characteristic currents can be taken from the discharge curves in the brochures on the respective series. The discharge curve for the A 500 is given below as an example (cf. fig. 5).

With currents lower than I_{20} or I_{10} the battery output can exceed the nominal capacity. With currents higher than I_{20} the battery output is lower than the nominal capacity.

3. Nominal Voltage

The cell nominal voltage U_N is a fixed value. The nominal battery voltage results from the number of cells and the nominal cell voltage (2 V).

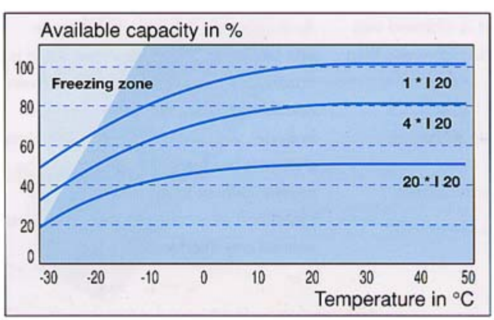

Fig. 2 :
Capacity according to the ambient temperature for A 500 series

, Discharge.

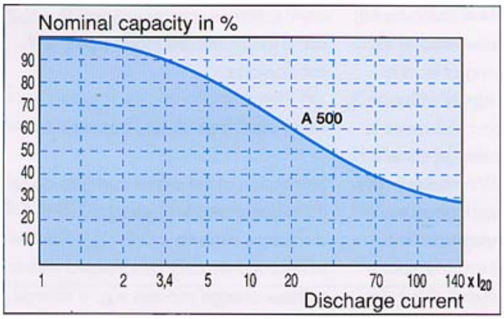

Fig. 3 :
Output capacity in relation to discharge current

4. Discharge

4.1 Final Discharge Voltage

The final discharge voltage is specified as the value below which the voltage must not fall when discharge occurs at the respective current.
If the battery is discharged further, (i.e. the battery voltage is lower than the final discharge voltage), the area of deep discharge is entered.
The final discharge voltage is normally given in V/cell and depends on the discharge current.

- U_E (battery) = n · U_E (cell)

n = number of cells (battery nominal voltage divided by 2 volts)

4.2 Discharge Current

The discharge current in multiples n I_{20} or I_{10} for a I_x current can be determined using the following formula :

$$n = \frac{I_x \cdot 20\,h}{C_{20}} \quad \text{or} \quad n = \frac{I_x \cdot 10\,h}{C_{10}}$$

The following maximum discharge currents are stated in the series brochures for the dryfit batteries :

- The given maximum battery load is the maximum discharge current for continuous output.
- The given maximum current for 5 sec is used for dimensioning the battery fuse.

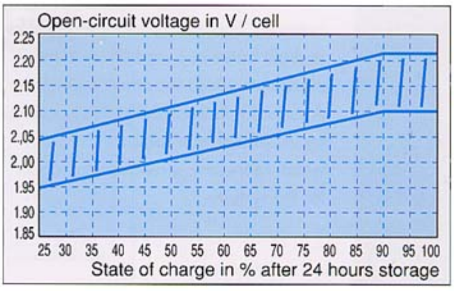

Fig. 4 :
Typical open-circuit voltage in dependence of the state of charge

4.3 Depth of Discharge

The capacity taken from the battery is termed as the depth of discharge. For example, if 80% of the nominal capacity is used from the battery then the depth of discharge is also 80%.

The maximum permitted depth of discharge depends on the level of the discharge current and the temperature.

4.4 State of Charge

An approximate determination of the state of discharge by measuring the open-circuit voltage is possible with a tolerance of about 15% (cf. open-circuit voltage, fig. 4).

4.5 Deep Discharge

The battery enters the deep discharge zone when :

- discharge is continued below the given point of final discharge voltage, e.g. when continuous loads are not switched off during laid-up periods.
- the battery regenerates due to intervals during discharge so that when the final discharge voltage is reached the depth of discharge is too low.

All data for deep discharge refers to single batteries. With a series of blocks or cells different behaviour may occur with respect to the depth of discharge.

dryfit:
Discharge, Charge.

In accordance with DIN 43539, Part 5, the deep discharge test is defined as follows : A battery having at least its nominal capacity is bridged with a load resistance. The load resistance is selected so that the discharge current with a cell voltage of 2V/cell lies in the range between $2 \cdot I_N$ and the maximum permissible discharge current. The battery is stored at room temperature for 30 days. At the end of the storage period the battery is charged for 48 hours. The following capacity test must show a capacity of over 75%.

- *After this recharge dryfit batteries reach between 90 and 100% of their nominal capacity.*

During the discharge of lead-acid batteries the acid density decreases giving a low conductivity for deep discharged batteries. This effect is compensated for in dryfit batteries by additives to the electrolyte which increase conductivity. A surplus volume in the plates is formed by increased lead sulphate formation, which represents a mechanical load for the system.

dryfit batteries are constructed to withstand the increased load largely without damage.

Deep discharge should be avoided.

Sulphation of the plates can also occur if the batteries are discharged with discharge currents $< 0{,}2 \cdot I_{20}$. The batteries can then only be charged with a suitable charge process e.g. a charge with the IUI-characteristic (cf. fig. 8).

4.6 Discharge Voltage

The discharge voltage is the battery voltage during the discharge process. As an example figure 5 shows the discharge curves for various discharge currents for the A 500. The diagram shows the time during which the respective current can be drawn, the battery discharge voltage and the final discharge voltage at the discharge current.

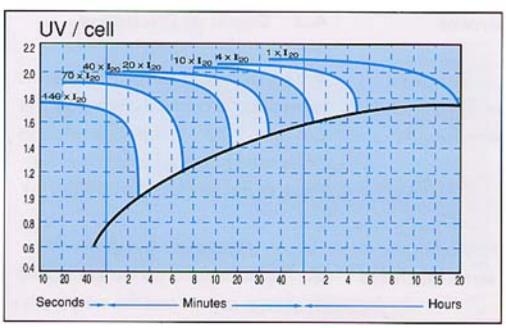

Fig. 5 :
Discharge Curves
A 500

5. Charging

dryfit batteries can be charged with the most simple recharging methods.

5.1 Charging Characteristics

The applicable charge technologies for dryfit batteries are :

Constant Voltage Charging (Fig. 6)

The battery limits the charge current when under constant voltage charge – the easiest kind of charge for dryfit batteries. The battery lowers the charge current with increasing charge level.

- dryfit batteries are generally charged with constant voltage.

IU-characteristic Charging (Fig. 7)

The IU characteristic is the most suitable characteristic for charging dryfit batteries and for valve regulated lead-acid accumulators. It is also recommended for valve regulated lead-acid batteries. The battery is first charged with constant current until the recommended charge voltage is reached. The voltage is then maintained constant and the battery limits the charge current as with the U-characteristic.

IUI-characteristic Charging (Fig. 8)

For applications in cycle operation, where a maximum charging time of 16 hours must be guaranteed, the IUI-characteristic charging is recommended.

The IUI-characteristic is an extension to the IU-characteristic. When the current reduces to a certain value, this current is constantly charged until the charging equipment is switched off.
Here the following recommendations must be adhered to :

I_1 : $2 - 6 \cdot I_{20}$
U_1: see selection table p. 17
I_2*: $0.24 \cdot I_{20}$
*Switch-off after a maximum of 4 h.

Fully charged condition

The battery is fully charged when the residual charge current does not change within 2 hours.

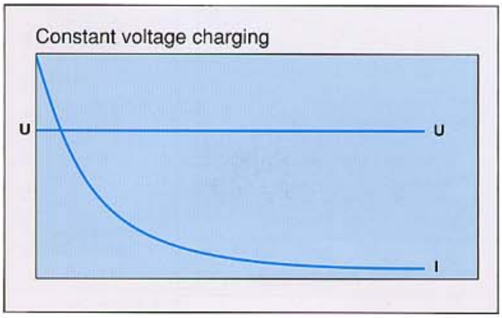

Fig. 6 :
U-Characteristic

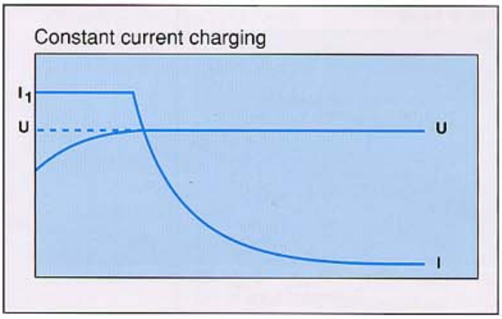

Fig. 7 :
IU-Characteristic

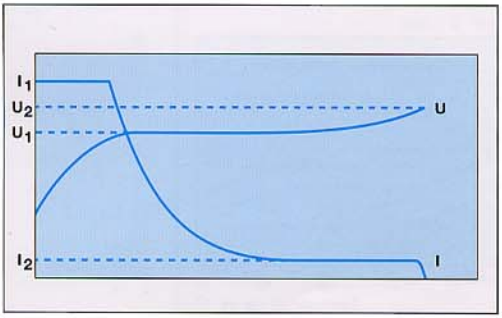

Fig. 8 :
IUI-Characteristic

dryfit:
Charging.

5.2 Charging Voltage

The charging voltage is determined by the recommendation given by the manufacturer for each battery type.

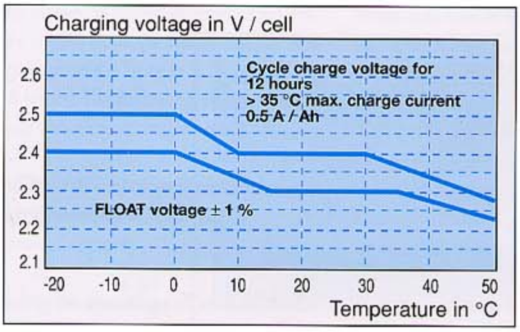

Fig. 9 :
A 200 charging

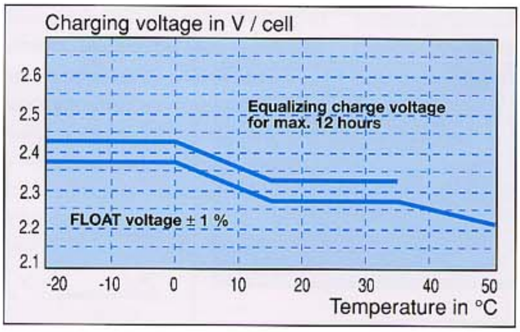

Fig. 10 :
A 400 charging

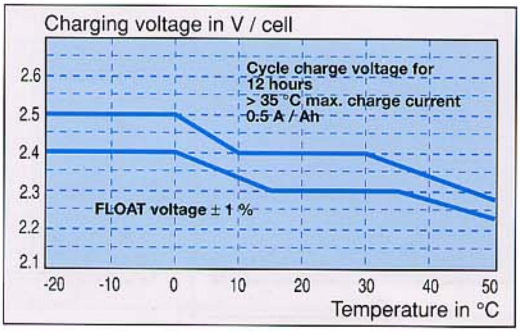

Fig. 11 :
A 500 charging

5.3 Temperature Compensation of Charging Voltage

Temperature compensation of the charge voltage is necessary when the temperature fluctuates, to avoid increased gassing at higher temperatures.

We recommend the following temperature compensation :

- Standby parallel operation outside 15 °C to 35 °C.
- Cycle operation outside 10 °C to 30 °C.

- Battery charging is not allowed above +50 °C.
- When charging the battery below +5 °C substantially longer recharge times must be expected, as the chemical reactions are very slow and the charge factor is increased up to 60%.
- The individual temperatures within the battery must not vary by more then 3 °C when installing blocks/cell.

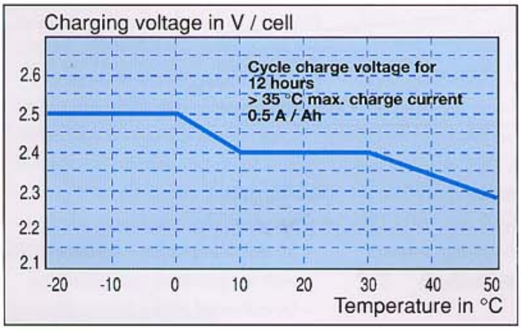

Fig. 12 :
A 500 C charging

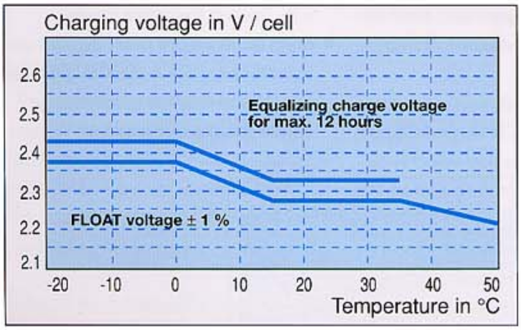

Fig. 13 :
A 600, A 700 and OGiV charging

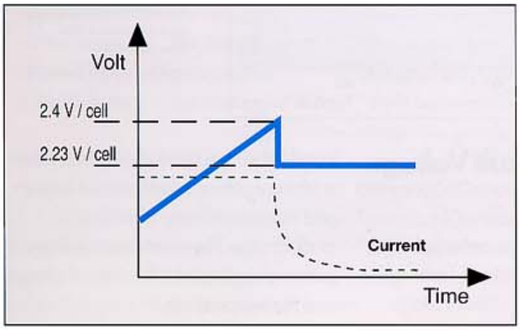

Fig. 14 :
Heavy charging for A 400, A 600, A 700 and OGiV (compare Fig. 13 and 10)

dryfit:

Charging, Open-Circuit Pot
Permissible Ripple Current,

5.4 Recharge Time

Overcharging and Permanent Charge

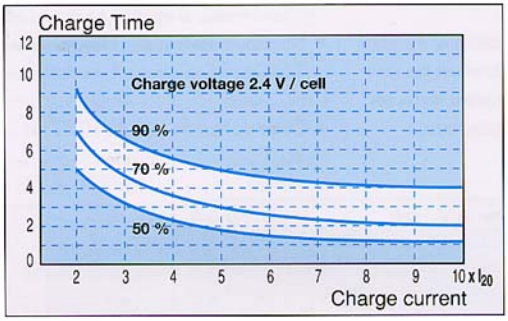

Fig. 15 :
Examples of charge current and recharge time for various states of charge for the series A 500 at 20 °C

5.5 Charge Currents

We recommend the following nominal currents for dryfit batteries :

- Standby-parallel operation:
  0.1 to 0.2 A/Ah
  resp. $2 \cdot I_{20} - 4 \cdot I_{20}$ $(1 \cdot I_{10} - 2 \cdot I_{20})$
- Cycle operation:
  0.2 to 0.4 A/Ah
  resp. $4 \cdot I_{20} - 8 \cdot I_{20}$ $(2 \cdot I_{10} - 4 \cdot I_{20})$

Stability :

- Overcharging is to be avoided:
  - by adhering to the IU-characteristic with temperature compensation.
  - by adhering to the recommended charge currents.
  - by limiting the ripple current.
- dryfit batteries are proof against continuous charging in standby parallel operation when the given charge conditions are adhered to.

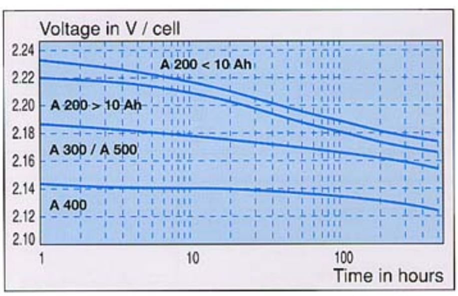

Fig. 16 :
Typical open-circuit voltages for fully charged dryfit batteries in relation to the storage time after recharge

6. Open-Circuit Voltage

The open-circuit voltage potential can only be measured on stored batteries. This means : the open-circuit voltage potential can only be determined after a storage period of at least 24 hours and not immediately after charge or discharge. The open-circuit voltage potential depends on the state of charge and the temperature.

ential, Series and Parallel Connection, Application.

7. Series and Parallel Connection

- dryfit batteries of an equal capacity can be connected as a serial arrangement.
- Parallel connections of serial arrangements are possible without a network to the batteries of the serial arrangement. It is sufficient to connect together the series connected batteries at the plus and minus connectors. EUROBAT, an association of battery manufacturers and users, recommends a parallel arrangement of a maximum of four strings.

8. Permissible Ripple Current

- A 200, A 300, A 400, A 500
The maximum permissible ripple current for cycle operation (charge and discharge) is $0.1 \cdot C_{20}$. The maximum allowed ripple current for a 24-Ah battery is, therefore, 2.4 A.
- Should the batteries be used in FLOAT operation, the maximum ripple current of $0.05 \cdot C_{20}$ must not be exceeded. The maximum allowed alternating current for a 24-Ah battery in this case is 1.2 A.
- A 600, A 700 and OGiV
in standby parallel operation:
5 A/100 Ah.

Permissible ripple current causes warming of the battery. During charging the temperature increase is not to exceed 3 °C.

9. Application

9.1 Installation and Ventilation

When installed in containers, cabinets, etc. the VDE 0510, Parts 2 and 7, must be adhered to, as hydrogen in a volumetric concentration of more than 4% forms an explosive mixture.

dryfit battery gassing is extremely low. The required maximum gas volume of 30 ml per 1 Ah and cell in 30 days for the series A 200, A 400, A 500, A 600 and A 700 in the proposed IEC 896, Part 2 is adhered to.

9.2 dryfit Battery Transport

Based on tests the following regulations have been specified for new and used dryfit batteries :

Dangerous Goods Regulations for Road Transport (German GGVS) :
"dryfit batteries are not classified as dangerous goods"

Dangerous Goods Regulations for Rail Transport (German GGVE) :
"dryfit batteries are not classified as dangerous goods"

Dangerous Goods Regulations for Air Transport IATA/DGR :
"dryfit batteries are not classified as dangerous goods"

Dangerous Goods Regulations for Sea Transport (German GVV See) :
"dryfit batteries are classified as non dangerous goods"

9.3 Storage

When dryfit batteries are stored fully charged :

- the storage temperature is - 40 °C to +50 °C
- the maximum storage time is 2 years at 20 °C
- at a constant storage temperature of 30 °C recharge is to be carried out after 12 months, at 40 °C after 6 months.

9.4 Disposal and Recycling

Your old dryfit batteries will be taken back without any problems by the following :

- Accumulatorenfabrik Sonnenschein GmbH
- Lead recycling smelters

Sonnenschein and the smelters recycle the lead and plastic materials in the batteries.

Batteries are taken back under the following conditions :

- the batteries are delivered by the stated mode of transport
- the batteries are packed according to the packing regulations.

dryfit:
Service Life, Cycle Durability

10. Service Life

The service life for dryfit batteries in constant charge operation, is the period of time after which the battery has only 80% of its nominal capacity C_{20} i.e. C_{10}. This is valid for discharge at I_{20} up to U_E = 1.75 V/cell i.e. I_{10} up to U_E = 1.8 V/cell at room temperature.

The service life of the battery is an important factor for the standby parallel operation.

The service life of the battery depends on the temperature and can only be reached if the given charge voltage is adhered to.

The diagrams show the service life in relation to the temperature.

Other parameters with influence on the service life are :

- charge voltage
- any deep discharges
- discharge frequency
- permissible ripple current

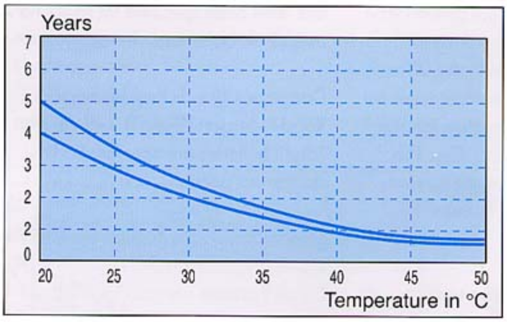

Fig. 17 :
Service life in relation to temperature
A 200 / A 300

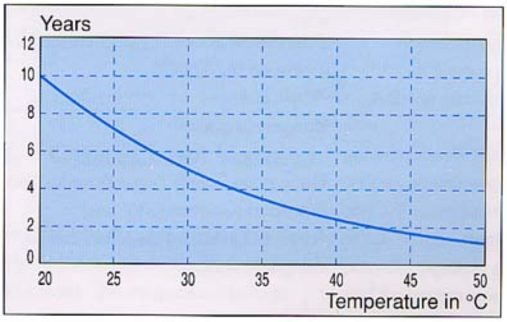

Fig. 18 :
Service life in relation to temperature
A 400

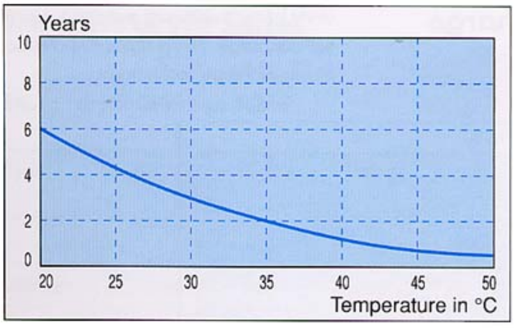

Fig. 19 :
Service life in relation to temperature A 500

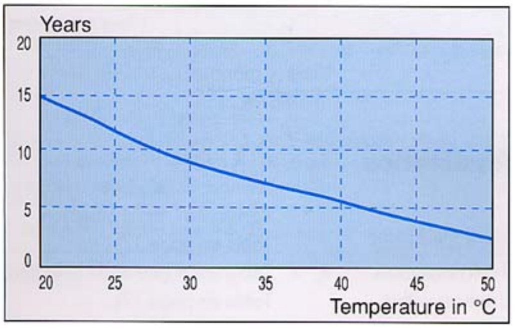

Fig. 20 :
Service life in relation to teperature A 600

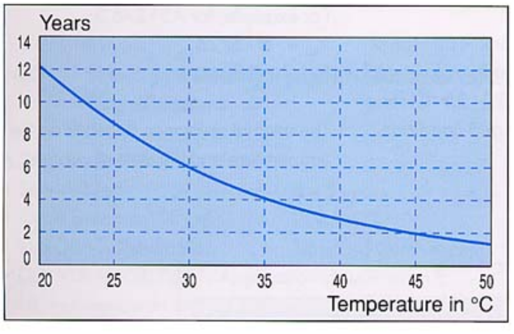

Fig. 21 :
Service life in relation to temperature OGiV and A 700

11. Cycle Endurance

Apart from the service life, the cycle endurance is also defined. The cycle endurance is applied when the battery is not used in standby parallel operation. Currently, the standard definitions are to be applied according to the follwing controls :

- Testing of the cycle according to DIN 43539, Part 5 :

  The test is to be carried out on batteries which have reached their nominal capacity.
  Discharge is to be carried out with $3.4 \cdot I_{20}$ up to $U_E = 1.7$ V/cell.
  The calculation of the number of cycles is terminated when the discharge time has dropped below 3 hours.

- Testing of the cycle endurance according to IEC 896, Part 2 :

  The test is to be carried out on batteries which have reached their nominal capacity.
  The discharge is $2 \cdot I_{10}$.
  Discharge time is 3 hours.
  A capacity test is to be carried out after each 50 cycles.
  The test is terminated when the battery has less than 60% of its nominal capacity.

The number of cycles which a battery can perform, depends on the battery construction and the depth of discharge.

The number of cycles a dryfit battery can perform in accordance with the above tests is given in the selection table on page 17.

dryfit:
Self-discharge, Internal Resi

12. Self-discharge

dryfit batteries have an extremely low self-discharge. This is a positive characteristic of the gel technology.

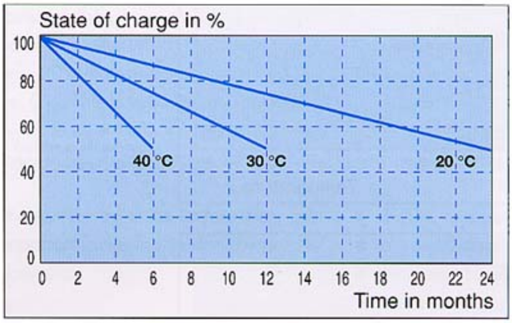

Fig. 22 : Self-discharge in relation to temperature for the A 600 battery

13. Internal Resistance

The total battery resistance is the accumulation of all internal cell resistances and all connection resistances within the battery (cf. DIN 40729).

To calculate the RIG total resistance of the battery the following formula is valid at room temperature (20 - 25 °C) for a battery in a fully charged condition.

R_{iG} = $n \cdot R_i$ / Battery capacity in Ah
n = Number of cells (see "Internal Resistance", dryfit Selection Table on page 17)
R_i = Table value (see dryfit Selection Table on page 17).

For example, for A512/6.5:
$R_{iG} = 6 \cdot 57/6.5$
$R_{iG} = 52.6\ m\Omega$

The internal resistance depends on the temperature and the state of charge.

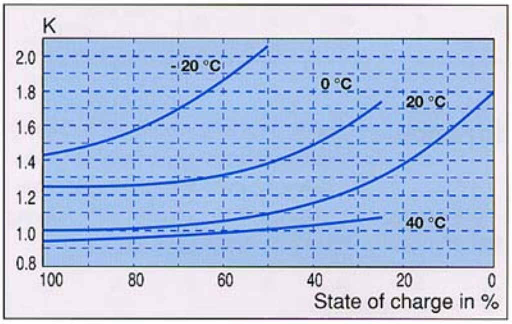

Fig. 23 : Correction factor K for R in relation to state of charge and temperature, for the series A 200, A 300, A 400 and A 500

stance, Series.

14. The dryfit Series

14.1 dryfit Selection Table

Type	A 200	A 400	A 500	A 500 C	A 600 / A 600 WE*	OGiV	A 700
Service Life in Years	4 – 5	10	6	–	15 – 18	12	12
Cycle Durability according to DIN	200	100	300	400	450	160	160
according to IEC	400	200	600	800	900	320	320
Self-Discharge/Day	< 0.1 %	< 0.05 %	< 0.06 %	< 0.1 %	< 0.05 %	< 0.05 %	< 0.05 %
Internal Resistance Ri in mΩ · Ah/cell	≤ 15 Ah 40 > 15 Ah 64	90	57	57	180	100	250
FLOAT charge voltage in V/cell	2.30 – 2.35	2.27	2.30 – 2.35	–	2.25	2.25	2.25
Cycle charge voltage in V/cell	2.35 – 2.40	2.30	2.40 – 2.45	2.35 – 2.40	2.30	2.30	2.30

* Series A 600 WE: The series A 600 is available for horizontal installation as A 600 WE.

14.2 Brief Type Description with National and International Classifications

A 200 Series
- Service Life : 4 – 5 years
- Cycle Durability DIN/IEC : 200/400
- EUROBAT classification : Standard Commercial
- DIN VDE 0108, Part 1; Application classification E
- UL: »yellow card« MH 12546

A 400 Series
- Service Life : 10 years
- Cycle Durability DIN/IEC : 100/200
- EUROBAT classification : High Performance
- DIN VDE 0108, Part 1; Application classification Z
- BP Telekom, TL 6140-3003

dryfit:

Brief Type Description, Classifications.

A 500 Series

- Service Life : 6 years
- Cycle Durability DIN/IEC : 300/600
- EUROBAT classification : General Purpose
- Types available with VdS classification
- DIN VDE 0108, Part 1; Application classification E and A
- UL : »yellow card« MH 12546

A 500 C Series

- Service Life : according to cycles
- Cycle Durability DIN/IEC : 400/800
- EUROBAT classification : none

A 600 / A 600 WE Series

- Service Life : 15 – 18 years
- Cycle Durability DIN/IEC : 450/900
- EUROBAT classification : High Integrity
- UL : »yellow card« MH 12546
- available for horizontal installation (WE)
- German Lloyd
- Bureau Veritas

A 700 Series

- Service Life : 12 years
- Cycle Durability DIN/IEC : 160/320
- EUROBAT classification : High Integrity

OGiV Series

- Service Life : 12 years
- Cycle Durability DIN/IEC : 160/320
- EUROBAT classification : High Integrity
- DIN VDE 0108, Part 1; Application classification Z
- UL : »yellow card« MH 12546
- German Lloyd
- Bureau Veritas

dryfit charger SM

- dryfit chargers SM have been designed according to the requirements of dryfit A 200, A 500 and A 500 Cyclic batteries
- short charging times due to absolutely constant direct current
- proof against incorrent polarity due to clear indicators
- light and compact construction
- immediately ready for operation, ideal for mobile use

dryfit:

Overview of technical data.

Series	dryfit							
	A 500	A 500 C	A 400	A 700	A 600	solar	solar block	A 600 solar
Applications								
Telecommunication	✓		✓	✓	✓	✓	✓	✓
Power generation and distribution			✓	✓	✓	✓	✓	✓
Telecontrol/traffic engineering, safety power supplies and data technology	✓		✓	✓	✓	✓	✓	✓
UPS	✓			✓				
Alarm signalling and safety lighting	✓		✓		✓			
Mobile systems (small drives, lighting, portable equipment, photovoltaic)		✓				✓	✓	✓
Main features								
Grid plate / Tubular plate / Planté plate	Grid plate	Grid plate	Grid plate	Grid plate	Tubular plate	Grid plate	Grid plate	Tubular plate
Version: Block battery / Single cell	Block battery	Block battery	Block battery	Block battery / Single cell	Single cell	Block battery	Block battery	Single cell
Nominal capacity in Ah	1.2-115	15-110	5.5-180	21-1470	200-3000	6.6-230	60-200	240-3500
Service life (to 80% remaining capacity)	6 years		10 years	12 years	15-18 years			
Cycles acc. to IEC 896 P2		800 cycles				400 cycles	1200 cycles	1600 cycles
Special high current performance				✓				

In line with on-going development and product improvements, the right is reserved to make technical changes.