EUROBAT, the Association of European Storage Battery Manufacturers, has 36 regular and associate member companies and represents more than 85% of the battery industry in Europe. It acts as a unified voice and reference source promoting the interests of the European starter and industrial battery industry to consumers, the EU institutions and national governments.
This Eurobat guide is intended to increase the awareness, understanding and use of Valve Regulated Lead Acid (VRLA) motive power batteries.

Eurobat commissioned this publication as a reference document for use in educational institutions.

However, it can also serve as guidance for the "user" of motive power batteries in their preparation of design and purchasing specifications. Inside the reader will find reference to the technology, testing & standard, and operational aspects.

Further links can be found on the website www.eurobat.org

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Valve Regulated Lead Acid (VRLA) motive power batteries, using cells or monoblocs, require no watering maintenance during their service life. Compared with their flooded electrolyte counterparts in normal operation, hydrogen and oxygen gases are produced in very small quantities and are vented through a non-return valve that prevents the admittance of air. This arrangement acts to eliminate any risk of the working area being contaminated by traces of the acid electrolyte and no supplementary ventilation provision is necessary to prevent accumulation of hydrogen gas in the charging area. With more efficient charging techniques, electricity costs for VRLA motive power batteries are usually less than those for traditional, standard maintenance flooded electrolyte batteries.

VRLA motive power batteries require additional and more expensive components, materials and processing. For good cycle life, optimised charging calls for electronically controlled charging current with algorithm control that is more complex than that for flooded electrolyte batteries. Different VRLA technologies are in use and have different optimised charging techniques; it may not be possible to charge batteries of the same voltage and similar capacity on the same charger if the batteries are from different manufacturers and use different technologies. The manufacturing costs of VRLA motive power batteries and their chargers are greater than those for flooded electrolyte products.

For some applications, particularly for arduous discharge duty or where low temperature prevails during recharging, the cycle life of VRLA motive power batteries may be reduced. For good cycle life the application should be discussed with the battery manufacturer and the VRLA motive power battery manufacturer’s recommendations should be followed.

The charge acceptance efficiency of the positive and negative plates of the lead-acid cell decline as recharge approaches completion. Increasing voltage polarisation is accompanied by decomposition of water in the competing electrochemical reactions producing oxygen at the positive plates and hydrogen at the negative plates. Usually, the decline in charge acceptance and transition to the gassing reaction is earlier and to a greater extent at the positive plate than at the negative plate.

Sulphuric acid of the electrolyte is a reactant in the lead acid battery. It is consumed during discharge and the electrolyte density is reduced. Sulphuric acid that is produced during recharge is relatively dense and segregates, under the influence of gravity, to the bottom of the cell. Unless the electrolyte is mixed, the concentration of sulphuric acid at the bottom of the cell would be too high for efficient charging and maintenance of cell health and there would be insufficient
sulphuric acid at the top of the cell to support the discharge of the upper active materials. Electrolyte “stratification” is the term used to describe an electrolyte density gradient that is not disrupted by the regular recharging process.

In flooded electrolyte lead acid batteries overcharge has to be sufficient to complete the recharge of positive and negative plates and to mix the electrolyte with bubbles of hydrogen and oxygen. The water content of the electrolyte must be maintained by periodic watering.

The inconvenience of periodic watering of flooded electrolyte lead acid motive power batteries is effectively reduced by using an automatic central watering system.

Water consumption and the frequency of watering maintenance for flooded electrolyte lead acid motive power batteries are reduced, but not eliminated, in Low Maintenance regimes using cells with enhanced electrochemical design. Electrolyte stratification is controlled either by application of part of the overcharge at a rate that is optimised for gas mixing of the electrolyte or by using an electrolyte mixing pump. Providing that the electrolyte is mixed, battery capacity may be sustained with a lower overcharge per cycle that is achieved by modification of the charge termination algorithm. Electricity cost and water consumption are reduced.

In VRLA Batteries the electrolyte density distribution that leads to electrolyte stratification is controlled by immobilising the electrolyte either as a gel or in mat separators of absorptive glass microfibre (AGM). Electrolyte mixing is unnecessary. ‘Gel’ and ‘AGM’ product types of VRLA motive power batteries have characteristics that differ, particularly in respect of charging technique.

VRLA Batteries are not completely saturated with electrolyte so that oxygen produced at the positive plates, as their recharge approaches completion, can diffuse to and react with the negative plate, delaying the recharge of the more efficient electrode. So, with an appropriate charge regime, it is possible to balance the recharge of positive and negative plates with relatively little overcharge. In the oxygen cycle, overcharge oxygen reacts with the negative plate and prevents an equivalent hydrogen production. Typical gas evolution and water loss from VRLA Batteries equates to less than 1% of the overcharge equivalent.

In the absence of electrolyte stratification, lower overcharge per cycle is necessary for VRLA motive power batteries and thanks to the oxygen cycle, water loss and gas evolution are substantially eliminated.

Low impurity process materials and antimony-free alloys contribute to long life of VRLA motive power batteries without watering maintenance.
IEC 60254-1 (1997), “Lead acid traction batteries” is applicable to VRLA motive power batteries.

Discharge capacity is specified at the five-hour rate of discharge measured at or corrected to a cell or battery temperature of 30°C. The test discharge current of 20A per 100Ah of nominal capacity is maintained until the average cell voltage falls to 1.70V.

Cycle life is determined during cycles of 70% discharge at 20 A /100Ah for 3.5h and recharge according to the manufacturer’s recommendation. During these cycles, cell temperature should be within the range of 33 to 43 °C.

The cycle endurance test is completed when, in a periodic measured discharge, the available capacity falls below 80% of nominal. In this test, a cycle number, at least equal to that stated by the manufacturer should be achieved.

For conventional, flooded electrolyte lead acid motive power batteries, cycles are with 75% discharges at 25A per 100 Ah until measured capacity falls below 80% of nominal.

**Maintenance**

VRLA motive power batteries have no requirement or provision for topping up the electrolyte with water. Any risk of spillage is eliminated, so avoiding electrical tracking or corrosion of the battery, battery tray, vehicle or charging area.

**Charging**

Chargers for AGM or Gel batteries differ according to how each technology is implemented. The gas recombination effect, which virtually eliminates water loss in the form of hydrogen and oxygen, influences the voltage response to the charge. That affects the charge algorithm, the way in which current is delivered to the battery and the different security controls that should be applied. Electronically controlled chargers are used with VRLA motive power batteries so that the specified charging profile and termination algorithms are followed independently of mains fluctuations. Charging must conform to the battery manufacturer’s recommendation or specification.

Temperature has an effect on charging: the higher the temperature, the lower the voltage response to the current. Charge compensation based on battery temperature may help to overcome this effect. For operation at low temperature (cold stores), consult the battery manufacturer.

Although possibly contributing to higher battery working temperature, opportunity charging may be appropriate for some applications but optimum
service life may require special profiles for the opportunity charge and for the full recharge. The battery manufacturer should be consulted for specific guidance.

**Temperature of Operation**

The rated capacity is for a battery temperature of 30° C. As illustrated in the figure, available capacity is influenced by temperature and is significantly reduced at low temperatures. Service life is reduced for high temperature operation and charge efficiency is reduced at low temperatures. Battery temperature is dependent on discharge duty and battery size as well as by ambient temperature. For applications where ambient temperature is outside the indicated acceptable range, the battery manufacturer should be consulted.

**Service Life and Depth of Discharge Control**

The relationship between service life and depth of discharge is illustrated in the figure. More critical than for flooded lead acid motive power batteries, where good cycle life may be achieved by limiting depth of discharge to 80% of nominal, VRLA motive power battery life benefits, generally, through limitation to 70% depth of discharge. Installation of a hydraulic lockout or battery discharge meter may be necessary for optimised service life. For advice on setting up this type of device and for general guidance on improving service life, the ‘User’ should refer to the battery manufacturers operating instructions. Reference can also be made to ZVEI paper “Considerations on the life of Traction Batteries”.