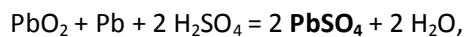


Effects of PX on Lead Acid Battery

Desulfatization

Hydrogen peroxide eliminates coarse-grained sulphates (that are non-conducting and prevent battery charging and discharging). The coarse-grained sulphate elimination takes place by means of elemental oxygen released from hydrogen peroxide, which crushes crystalline sulphate into fine-powdered. This is incorporated during charging into battery electrodes, while the sulphuric acid concentration increases.

Sulfatization is a natural phenomenon during lead acid battery discharging. There are two types of sulfatization: reversible and irreversible sulfatization. Reversible sulfatization is a part of an electrochemical reaction during battery discharging.



where PbSO₄ is the sulphate itself being formed during discharging. Such sulphate is formed in the form of a very fine powder and forms the electrode surface. Electric current may pass among sulphate grains in the form of ions. The energy of the ions is sufficient for back transformation of such fine-grained sulphate during the battery charging, which allows transformation of Pb (on the negative electrode) and PbO₂ (on the positive electrode). When we talk about the sulfatization as a negative phenomenon, we thereby mean the irreversible sulfatization. The irreversible sulfatization arises from the fine powder coming from the reversible sulfatization in such a manner that in case of a suitable external environment, the fine powder starts to form bigger clusters and crystals of sulphate. Since the sulphate clusters and crystals are too big compared to the energy of the ions, these remain untouched during charging. These clusters can be partially made smaller by charging the battery by small current (1-2% of the battery capacity). In this way, however, only fine sulphate grains are released from the surface of the sulphate crystals. The sulphate firmly inbuilt in the crystal remains untouched.

Effects of Hydrogen Peroxide:

Hydrogen peroxide is a reactive material which, when in contact with most other substances, gradually releases elemental oxygen. Hydrogen peroxide in the liquid state flows into fine pores of the sulphate crystals. By releasing elemental oxygen, having a significantly bigger volume in the gaseous state than that bound in peroxide, de facto breaks sulphate crystals into a fine powder. This powder is, with regard to its fine structure, dispersed in the electrolyte close to its formation, i.e., close to the active mass of the electrodes. During charging, with respect to its size, it is being broken down by the electrolyte ions and gradually incorporated in the active mass of the electrodes.

This results in an increased concentration of the electrolyte (sulphuric acid) in the charged state of the battery after using PowerXtender and following several charging cycles when compared to the electrolyte concentration in the battery charged state before PowerXtender is used. The increased electrolyte

concentration results from the reaction of the released SO_4 group from crystalline PbSO_4 , which forms sulphuric acid with released hydrogen during charging.

Optimization of the Active Mass Morphology

The organic dispersing component is able to favourably adjust the morphology of active mass crystals, create a fine film around them and thereby disallow their intergrowth into a coarse-grained structure (which is then one of the consequences of the capacity reduction). In addition, it forms crystallization nuclei, whereby it allows the formation of a favourable fine-grained structure.

The proper morphology (spatial organization of the material in the mass) is a very important assumption for the battery capacity preservation. It has become evident that the prismatic morphology of the positive electrode favourably affects the active mass quality. The preservation of the active mass morphology requires the creation of suitable conditions (of the energy during the battery charging) and an optimum dispersion of the material in the electrolyte in the close proximity of the active mass. The PowerXtender organic component creates optimum dispersion of the material for the preservation of the active mass proper morphology. It at the same time forms a fine film on the active mass surface, which prevents the clustering of the active mass fine-grained material, whereby it preserves its fine-grained structure. The fine-grained structure of the active mass directly affects the size of the electrode surface.

Thanks to the dispersion properties of this organic component and its fine structure, there is a formation of a big number of crystallization nuclei. The number of these crystallization nuclei directly determines the number of the newly formed crystals, in which the whole material of the positive mass crystallizes during charging. Since the material quantity is definite, more crystallization nuclei form finer crystallizing structures. The finer structure means a larger effective area and higher capacity of the positive electrode.

Acceleration of Diffusion Processes

The organic dispersing component is at the same time, with respect to its dispersion properties, able to accelerate diffusion processes in the cell and prevent the formation of acid layers with various densities (the so-called acid stratification).

Diffusion processes are the slowest processes in lead batteries. The speed of such processes is directly responsible for the quantity of the transferred charge in a time unit. The transferred quantity of the charge (number of ions) per unit of time is determined by the serial internal resistance of the battery.

The PowerXtender organic component accelerates the diffusion processes of the battery and thereby increases the quantity of the transferred charge per time unit. This results in a reduction in the serial internal resistance of the battery. The battery voltage will drop more slowly during discharging thanks to the smaller voltage drop on the internal serial resistance, whereby the quantity of the suppliable energy will increase, which is measurable as an increase in the battery capacity.

Dispersion properties of the organic component at the same time homogenize the electrolyte and thereby prevent its density stratification in the battery. This phenomenon results in a more equal

usability of the active mass of the electrodes regardless of whether the given active mass is close to the battery bottom or close to the electrolyte level.

Increase in Porosity and Strength of Active Mass (Especially Positive)

Salts contained in PowerXtender are able to increase the porosity of active masses and at the same time increase their strength.

The battery capacity directly depends on the size of the electrode active surface. PowerXtender contains salts that increase, during the battery charging, its porosity and strength, while preserving its morphology. This effect generally improves mechanical properties of the positive electrode active mass and prevents its early disintegration.

Formation of Bridges

The salts in PowerXtender mechanically and electrically join grains of the positive electrode active mass by needle-shaped crystals but at the same time prevent the active mass intergrowth into big crystals, whereby the active area of the electrode would be reduced.

The positive electrode is, like ceramic material (PbO_2), particularly sensitive to mechanical stresses resulting from local overheating or improper battery handling. The salts contained in PowerBatt support the intergrowth of needle-shaped crystals in between grains of the positive active mass, whereby its mechanical strength and electrical conductivity improve. Together with other components, they prevent the active mass intergrowth into big crystals, which would reduce the total area of the active mass grains and thus reduce the energy efficiency of the battery too.

Formation of Passivation Films

The ions contained in PowerXtender favourably affect the charging and discharging voltages and polarizations and at the same time suitably modify conditions on the "active mass/grid" interface (these conditions are often a reason for expiration of the battery life) and provide for the formation of passivation films.

The grid corrosion resulting from the reaction of lead with lead dioxide takes place quite slowly under normal circumstances, as a non-porous, the so-called passivating layer is formed on the interface of these substances. The corrosion speed depends on temperature and potential size. It is therefore necessary to prevent the charging at high temperatures (above 40 °C) and overcharging in excess of the technically necessary limit. The passivating layer is interfered also with some impurities from the electrolyte, e.g., anions of organic acids, chlorates, nitrates, or anions that oxidize (e.g., chlorides). The corrosion speed also considerably depends on the crystalline structure of the grid metal. This may be regulated by the battery manufacturer by suitable additives or by the grid manufacturing technology (e.g., by the casting regime and cast ageing).

The chemicals contained in PowerXtender create, on the grid/active mass interface, the so-called passivating films that significantly reduce the corrosion on this interface. By this, conductivity of the grid/active mass

interface is being preserved for long, which results in the preservation of the internal serial resistance of the battery at a low value.

Increasing Discharging Characteristics

The salts contained in PowerXtender provide for increasing the discharging voltage and thereby also the total quantity of the supplied electric power during discharging.

The values of electrode potentials depend not only on the metal character or oxidation agent but also on the activity of the reacting ions. According to the Nernst equation, the following applies to the electrode potential in a solution of its salts:

$$E = E^0 \pm \frac{R \cdot T}{n \cdot F} \cdot \lg a,$$

where: E is electrode potential

R = molar gas constant = 8.314 472(15) J K⁻¹ mol⁻¹

T is absolute temperature

E^0 is normal (standard) metal potential

n is metal valence

F is a charge of 1 gram equivalent (faraday), equal to 96,500 Coulombs

a is activity of metal ions in the solution

By changing the activity of the ions (if we change, for instance, their concentration or give an ion with another activity), it is possible to increase or decrease E (i.e., voltage) of one and the same cell.

Thus, for instance, cell



(metal electrodes and mono-normal solutions of their salts) has $E = -0.762 - (+0.34) = -1.1 \text{ V}$

If we, however, immerse a zinc anode in a 0.1n solution of complex salt $\text{K}_2\text{Zn}(\text{CN})_4$ with a very small concentration of Zn^{2+} ions, then zinc is being charged, according to the Nernst equation, for the more negative potential, which equals to -1.033 V , and E (i.e., the cell voltage) is 1.373 V .

$$E = -1.033 - (+0.34) = -1.373 \text{ V}$$

It is thus possible to change the cell voltage by adjusting its electrolyte.

Values of the activity of particular ions and their logarithms can be found in tables.

In our case, we have added such additive in the electrolyte that has also changed the value of the total logarithm, " a ", and has thereby increased the discharging cell voltage, i.e., the total quantity of the electric power that has been supplied by the battery.

Reduction of Self-Discharging and Conversion of Conductive Components of the Sludge Layer into Non-Conductive

Conductive particles dispersed in the electrolyte and sludge layer, causing self-discharging and short circuits, are transferred by PowerXtender into the non-conductive state, whereby the said self-discharging and short circuits are eliminated.

Active oxygen has, at disintegration of hydrogen peroxide, strong oxidizing effects. In case of interaction with the material in the sludge layer, there are effects of sulphuric acid leading to a transformation of the surface of the dropped-out material from the electrodes of PbO_2 , or PB into PbSO_4 . After the particles of the dropped-out active material are covered by a PbSO_4 thin layer, these are becoming non-conducting and creating no further short circuits. Self-discharging is being at the same time reduced. During this reaction, there is a permanent conservation of these particles, whereas these are not participating in the electrochemical reaction during further battery charging.