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POWER FROM INNOVATION

WHITEPAPER

WHITEPAPER

gridXtreme VR

Pure Lead Batteries

More power – less energy consumption

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Author: Jens Bäcker | Product Manager Lead Applications Reserve Power

► INTRODUCTION

High-performance mobile communications networks with LTE (4G) and the new 5G mobile communications standard are key technologies for advancing digitization and are therefore indispensable for the competitiveness of today's business locations worldwide. In addition to reliable and powerful networking of devices, they also enable the development of numerous new applications. Autonomous driving of vehicles, as well as increasing communication of industrial machines to improve production processes are becoming more and more a reality.

When the first generation of mobile communications (1G) was introduced in 1985, which was completely analog and only allowed voice and no data transmission, it was not yet possible to foresee the prospects that 5G would open up for many industries today. The Internet was also still a long way off at that time.

It was not until the introduction of the 2nd generation of mobile communications (2G) in 1991 - GSM - that the possibility of transmitting data between mobile devices in addition to voice was created.

The mobile use of the Internet as a real communication and information tool was first achieved with the introduction of the 3G standard - UMTS - in 1998. The quality of calls improved and the first audio, picture or video apps were launched. With 3G, our phones could also make video calls, which led to the integration of the front camera for selfies, which is now present in every cell phone.

4G - LTE - or the 4th generation is the standard we use most today. This technology brought higher speed to meet the need for higher data volumes. Thanks to 4G it is possible to watch movies or sports in real time and even in HD quality.

The latest generation, which is currently being implemented, is called 5G. It is more than 10 times faster than 4G and enables communication between millions of IoT1 devices with very low latency (1ms). Unlike its predecessors, the 5G network can intelligently align itself to specific requirements via software and provide virtual subnetworks for respective tasks. For example, the data transmission capacity can be adjusted according to whether large volumes of data are to be sent particularly quickly, whether many subscribers want to be active in a radio cell at the same time, or whether, for example, many different machines on a production floor need to be networked with one another with low data volumes.

What all mobile communications standards have in common is the existence of a nationwide network of base stations to integrate the terminals into the respective radio network. These stations are usually supplied with electrical energy from the public power grid or, in some countries, from autonomous power supply systems such as diesel generators, fuel cells or solar systems.

In the event of a short-term complete failure of these power supply systems, batteries use their stored energy to ensure the continuous operation of the IT components. In an international comparison, bridging times with battery storage vary from a few minutes to several hours and also place a high energy throughput load on the storage systems in the event of volatile energy supply.

Considering that base stations account for approx. 80% of the energy consumption in mobile networks, the pure number alone, with sufficient network coverage, ensures that savings potentials meet with great interest on the part of operators.

What contribution can HOPPECKE pure lead technology make in such applications and how should the slogan "More power – less energy consumption" be understood in this context?

The following whitepaper will help to answer this question.

[1] IoT = Internet of Things – enables the networking of objects (e.g., devices, machines, vehicles) for data exchange and collaboration.

► SPECIAL FEATURES OF HOPPECKE PURE LEAD TECHNOLOGY COMPARED TO CLASSIC LEAD BATTERIES

Pure lead batteries grid | Xtreme VR

grid | Xtreme VR pure lead batteries belong to the family of AGM batteries and also follow their basic structure, with the difference that the electrode thicknesses used correspond to only a fraction (approx. 25%) of classic products. The potential of this technology is to maximize the number of electrodes used. This results in a larger electrochemical reaction surface and is trend-setting in terms of energy and power density for lead-acid storage technologies.

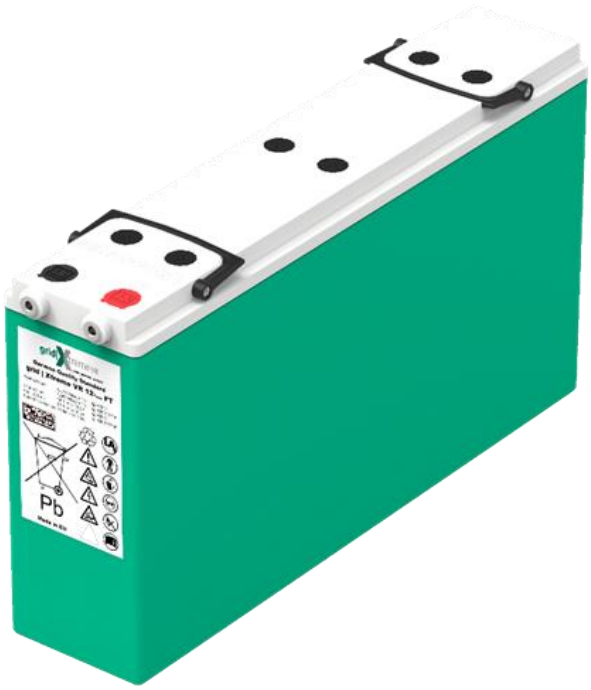

Figure 1: grid | Xtreme VR pure lead battery (Front-Terminal-variant)

This is achieved by using the name-giving pure lead for the production of the electrodes. Its superior corrosion properties compared with other lead alloys enable a significant reduction in electrode thickness while at the same time increasing service life. Furthermore, pure lead technology uses active masses with a higher density, which were previously reserved exclusively for cycle-resistant or long-life lead batteries.

The use of high-quality, low-impedance glass fiber separators in combination with HOPPECKE's typical and proven ESS technology makes grid | Xtreme VR a unique product and forms the basis for making the potential of pure lead technology fully available to the user.

Figure 2: Comparison of plate stack AGM (classic) vs. pure lead design (grid | Xtreme VR) at same volume

To simplify installation and maintenance work, grid | Xtreme VR front terminal batteries are equipped with real front pole connections and dedicated pole contact points incl. touch protection. This also allows effortless and precise impedance measurements to be carried out later in use to determine the condition of the battery system.

► CONSIDERATIONS OF TCO FOR THE USE OF GRID | XTREME VR PURE LEAD BATTERIES IN BASE STATIONS OF MOBILE RADIO NETWORKS

The increasing performance of today's mobile communications networks, the steadily growing range of functions (e.g. autonomous driving, etc.), as well as the social significance for a strong and successful economy in the future require, not least, nationwide availability. This is only possible through a close-meshed network of corresponding base and satellite stations in conjunction with a secure energy supply at all times.

The latter is becoming increasingly ambitious from a global perspective and in relation of the fact that a large proportion of the associated power supply systems are located in outdoor cabinets and are thus additionally exposed to environmental influences.

Central influencing factors for the TCO consideration of battery systems are:

a.) High operating temperatures → Accelerated battery aging
b.) Unreliable power supply networks → High cycle load / reduced availability
c.) Remote base stations → Limited maintenance

High operating temperatures

As already described in detail in the whitepaper **"High Performance Pure Lead (HPPL) – The energy storage system for tomorrow's data centers"**, the elimination of intergranular positive grid corrosion is the most significant advantage of pure lead batteries. The resulting degrees of freedom make it possible to design high-performance lead-acid batteries with a long service life.

Without sacrificing service life compared to classic AGM batteries, grid | Xtreme VR batteries can be operated at an average temperature of 30°C, thus conserving resources. The extended operating temperature range of up to 55°C also offers the user additional safety.

What impact can an adjustment of the mean operating temperature have on the total cost of ownership (TCO) will be explained below?

Mobile base stations usually consist of a radio mast with antennas and an associated building for housing the sensitive IT system technology (e.g., LTE), or the power supply equipment with or without battery backup. With the expansion to today's 4G infrastructure, not only the IT computing power has successively increased, but also the associated power consumption. This trend will not change with the change to 5G topology, so that reliable and efficient air conditioning of the electronic components and battery is essential due to the heat generated. Depending on the respective location and the prevailing ambient conditions, the heat load described above can be further increased by intense solar radiation (Fig. 3).

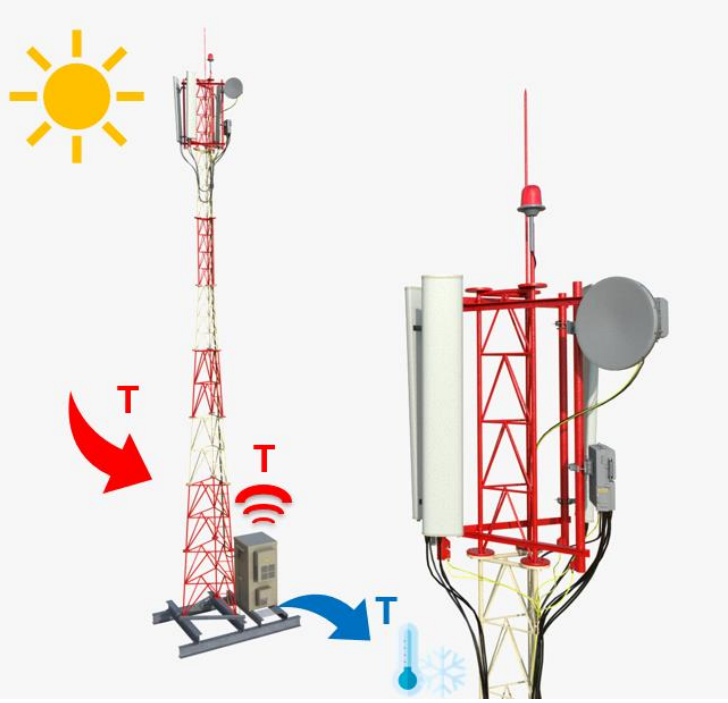

Figure 3: Temperature loads in mobile radio stations

The additional cooling capacity required due to external influences can be calculated using the following rule of thumb:

Characteristic values for the average energy input into a building:

approx. 40W per m3 (with high solar radiation, poor insulation)
approx. 24W per m3 (with low solar radiation, good insulation)

Example: Room size (LxWxH): 1.5m x 0.6m x 2m = 1.8m^3

=> Necessary cooling power (PK): 1.8m^3 x 40W/m^3 = 72W

Due to the strong dependence of the battery life on the average operating temperature, lead-acid batteries are usually operated at 20°C to 25°C, although this temperature range in theory already means a 30% difference in the expected service life for classic technologies.[2]

By using grid | Xtreme VR batteries, it is now possible for the first time to increase the average operating temperatures to up to 30°C and, in turn, to reduce expenses for cost-intensive air conditioning of the entire plant. Since air conditioners require on average about 4% more energy for each additional degree by which a battery room must be cooled down, an increase in the average operating temperature from 20°C to 30°C results in a savings potential of about 40% in energy costs (Fig. 4).

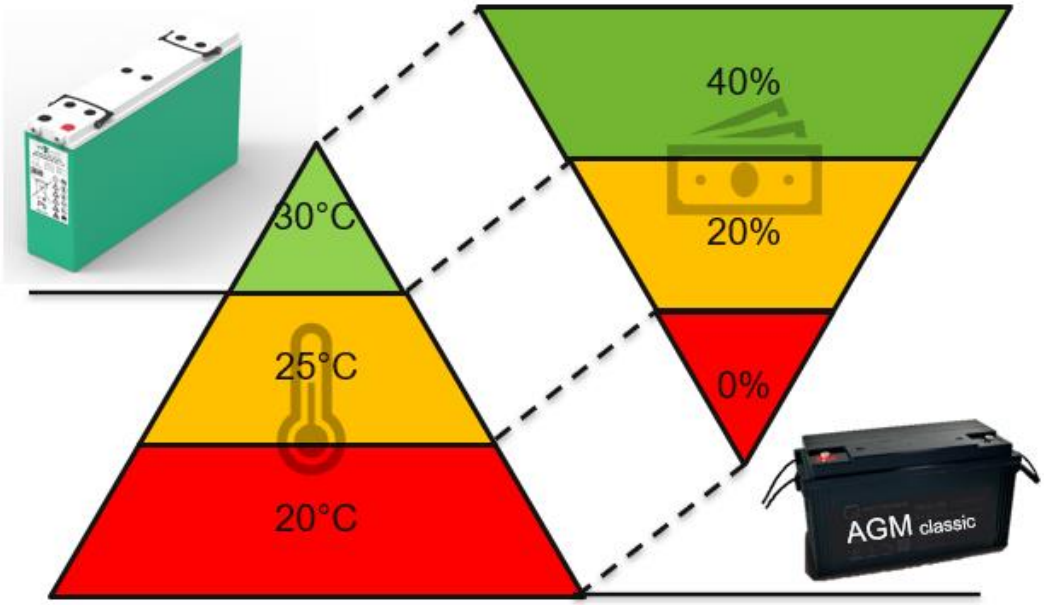

Figure 4: Cost savings for air conditioning

[2] A 10K increase in the average operating temperature halves battery life if no other aging effects, such as dry-out of sealed batteries or mass softening due to cyclic loading, have an influence.

The annual operating costs of air conditioning are calculated as follows:

$$K_{AC} = P_K \times 0{,}275\ \frac{kW}{kW} \times \left(1 - (T - 20\,°C) \times 0{,}04\ \frac{1}{°C}\right) \times 8760\,h \times K_E$$

with

K_{AC}	= Annual operating costs for air conditioning
P_K	= Necessary cooling capacity (solar radiation and electrical losses)
Factor 0,275	= 0.275 kW drive power must be applied per kW cooling capacity
T	= Average operating temperature in °C
Factor 0,04	= 4% Energy cost per K
K_E	= Energy costs (€/kWh)

Unreliable energy supply networks

While mobile communications networks with 3G, 4G or 5G standards are now available worldwide, the requirements for a secure power supply for the respective base stations and thus for the battery storage system can vary greatly. Densely populated regions of the world with good infrastructure are usually also accompanied by a good power supply, so that network failures occur only very rarely or for a very limited time. Small battery capacities, which mainly remain in standby parallel operation and perform only a few discharge cycles during their service life, are the logical consequence.

The situation is different in structurally weak areas where there is no or only limited and unreliable access to public power supply facilities. The use of autonomous power supply systems in the form of diesel generators, fuel cells or even solar-powered systems are often the only way out. For the backup system of a base station, this means withstanding frequent charging and discharging cycles as well as longer bridging times, since the availability of autonomous power supply systems is also generally limited in time.

Can grid | Xtreme VR pure lead batteries help to save costs even under such operating conditions and thus reduce the TCO for the user?

– We say yes! –

The design-related advantage of pure lead-acid batteries of generally being able to use thinner electrodes and thus increase their number in a given volume creates the prerequisite for using higher and more cycle-resistant active mass densities without having to compromise on charge and discharge performance. An impressive 1200 discharge cycles at 60% depth of discharge speak for themselves and, assuming the above-mentioned operating conditions, mean extended running times and a later replacement of the system for the user.

The high number of electrodes in a given volume also offers the potential to facilitate the charging reaction due to the increased electrochemical reaction surface, thus improving the charging acceptance of the storage system. Consequently, for grid | Xtreme VR pure lead batteries, the maximum permissible charge current could be extended from the previous 20A to an impressive 40A per 100Ah and, as a result, the recharge time after a discharge could be significantly reduced. This can be a decisive advantage when it comes to saving fossil fuels in an autonomous energy supply or also to increasing the availability of the battery system.

Furthermore, the use of high active mass densities in combination with increased electrolyte density allows a lot of energy to be provided in a very small space, which can be used to extend bridging times or to reduce the number of parallel battery strings in a given system (Fig. 5).

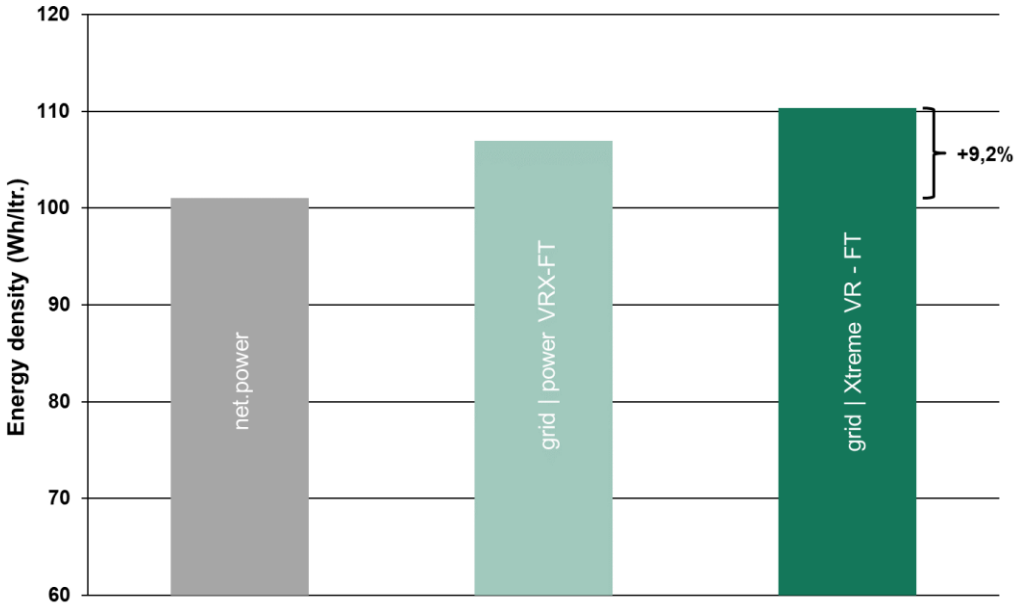

Figure 5: Comparison of volumetric energy density of AGM battery

Remote base stations

Who among us has not experienced that mobile communications coverage in structurally weak areas was sometimes only available to a very limited extent or not at all, meaning that desired network services such as Internet, e-mail, etc. could not be used? This makes it even more necessary to equip also remote areas with the appropriate technology for comprehensive mobile communications coverage.

In addition to the previously discussed question of the actual energy supply to these locations, an operator must simultaneously solve requirements for accessibility, the possible supply of fossil fuels, or even the simple maintenance of the energy storage systems. In an international comparison, this is particularly true the less densely populated a region is. However, the pure number of possible base stations already makes it clear that checking the performance of the energy storage system via e.g., capacity samples does not appear to be very practicable. Checking the individual block voltages also offers little information about the state of health, so that the battery system is usually renewed after a fixed time interval regardless of its performance. The fact that even functioning systems fall victim to this procedure is accepted in the interest of supply security.

However, grid | Xtreme VR pure lead batteries can make an important contribution to the careful use of resources. The unique dual pole design with dedicated pole contact points including touch protection enables precise impedance or conductance measurements to be carried out quickly and easily after installation and during maintenance work (Fig. 6)

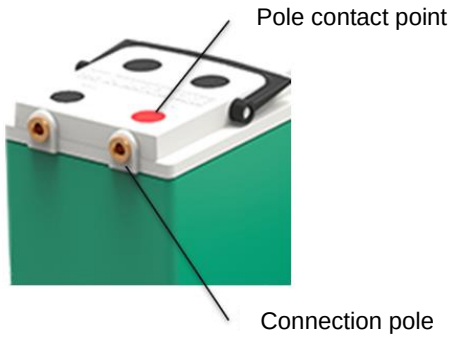

Figure 6: Representation of connection poles and pole contact points for grid | Xtreme VR - FT

Since the resistance-dependent influencing factors in sealed lead-acid batteries (VRLA), such as positive grid corrosion, dry-out (electrolyte) and sulfation, correlate with those of battery aging, and impedance or conductance measurements can also be performed during operation, this provides a reliable assessment of the battery condition over the service life. The initial condition is ideally a measurement after commissioning of the battery system in float charge and regularly recurring reference measurements.

To ensure comparability of the measured values over the service life of the battery system, it is important to always measure under the same conditions (fully charged, same temperature, etc.), and with the same instrument technology as well as test probes and test cables with the same shape and dimensions.[3]

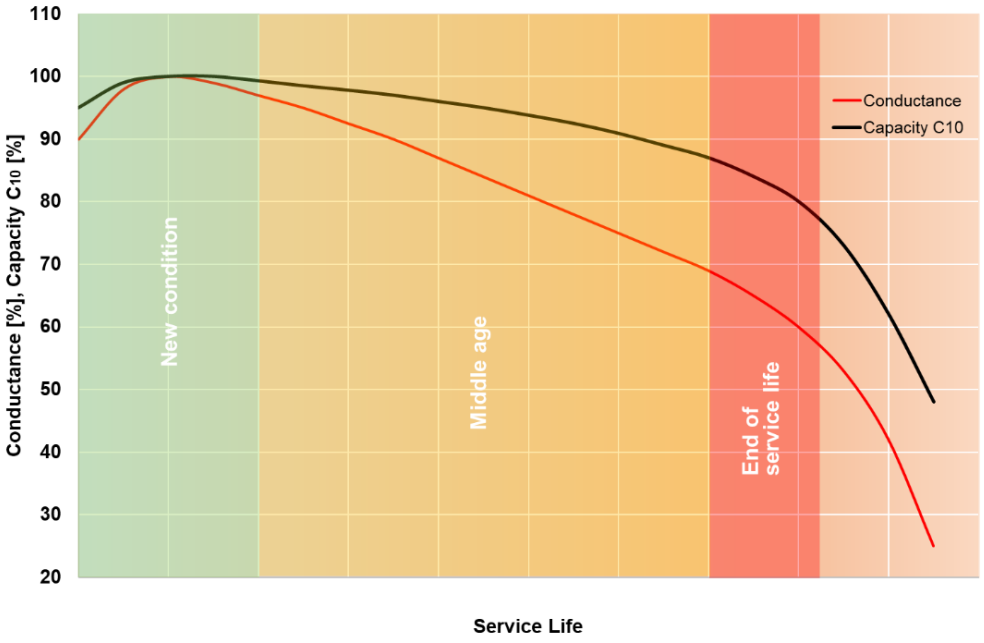

Figure 7: Typical characteristic "battery conductance versus service life".

The graphical processing of the data determined in this way results in a curve, as shown in Fig. 7 as an example, which allows the expected service life of the battery system to be estimated at any time. Replacement of the battery system after a fixed time interval (or only in the event of failure) can thus be omitted. Instead, the replacement is demand-oriented, can be planned by the user and is also resource-saving.

[3] Further information in ZVEI leaflet 34 – "Evaluation of measured values for the capacity assessment of stationary lead-acid batteries".

► CONCLUSION

This whitepaper has shown that the limits of the lead-acid battery have once again been pushed further despite a history of more than 130 years. In addition to the need for state-of-the-art manufacturing technologies, the sufficient availability of high purity lead today is also responsible for this further progress in development.

With the grid | Xtreme VR product, it has not only been possible to further improve existing properties of lead batteries, but also to add new features that ensure a significant contribution to the careful use of the energy resources at our disposal.

In short:

"More power - less energy consumption"

► ABOUT HOPPECKE

HOPPECKE Batteries is the largest producer of industry battery systems in European ownership. Since 1927, the family company has been developing and producing in Germany, and thanks to its leading research and development activities, it has all reliable and innovative storage technologies in its product portfolio.

Electric energy is required everywhere and in ever more applications. In this world, where everything becomes electrical, HOPPECKE is your partner and expert. We understand our customers and with our energy solutions, designed for safety and availability, we serve four principal areas of application: emission-free drives (trak), secured power supply (grid), storage of regenerative energies (sun) and railway and metro-systems (rail).

From the comprehensive product programme of batteries and cells to complete energy systems with the most modern charging technology, monitoring units and engineering to consumption dependent energy billing – our portfolio always contains the suitable product tailored to the individual customer requirements. With the development of marketable, forward-looking energy storage solutions, HOPPECKE makes an important contribution to solve the societal challenges that result from the implementation of the global climate protection goals.

Since its foundation in 1927 HOPPECKE has been owned by the Zoellner family. Today, Dr. Marc Zoellner is the fourth generation of the family to manage the industrial company as a family business. With its headquarters in Brilon-Hoppecke and 23 subsidiaries, representative offices, partners and distributors as well as production and assembly facilities worldwide, the company employs more than 2080 people and generates a turnover of over 430 million Euro.

INTILION - the new brand from HOPPECKE

Since April 1, 2019 there has been a new company in the HOPPECKE Group, INTILION GmbH. It represents another milestone in the company's successful history. INTILION stands for lithium-based systems and innovative operator models for industrial traction and stationary battery storage applications. INTILION always pursues the goal of achieving even stronger customer loyalty and agility. It is the partner for future-oriented lithium-ion energy storage solutions and innovative business models.

HOPPECKE Baterie Polska Sp. z o.o.
ul.Logistyczna 10
63-006 Śródka
Tel.: +48 61 64 65 000
Fax: +48 61 64 65 001
E-Mail: sbo@hoppecke.pl

HOPPECKE Batterien GmbH & Co. KG
Bontkirchener Str. 1
59929 Brilon
Phone: +49 (0) 2963 61-374
Fax: +49 (0) 2963 61-270
Email: reservepower@hoppecke.com