THE POWER OF TPPL

The answer to the battery challenges faced by today's transportation and service vehicles

In recent years, the electrical loads on trucks and buses have increased sharply. Evidence shows that this is leading to a rise in vehicle breakdowns, as batteries are unable to handle the heavier demand, and dissatisfaction from fleet owners and operators, who are seeking to source better-performing batteries as a result. This technical guide is based on an interview with Dr Thomas Verghese, Technical Manager at EnerSys®, in which he explains why this problem is increasing, and describes how a new solution based on advanced Thin Plate Pure Lead (TPPL) battery technology is now available to solve it.

Introduction

The transportation industry encompasses a wide variety of large commercial vehicles used in many different ways, yet all have experienced a common trend in recent years. Although engine starting currents have not changed, evidence shows that ever-increasing electrical demand on vehicles, including running GPS devices, heaters, Wi-Fi on buses and hotel loads for trucks parked up overnight, is leading to higher battery failure rates. Fleet owners, operators and users are therefore becoming increasingly dissatisfied with current levels of battery performance and reliability.

To understand the depth of their dissatisfaction, it's worth considering how a battery's failure to support a heavier load can affect people in different situations. Long-distance truck drivers, for example, often have cabs designed for sleep during overnight stops, to save on the cost and inconvenience of finding accommodation. However, if the cab becomes their hotel room, the truck battery is their sole source of power, as the cost of running the engine all night would be prohibitive. The battery must provide all the energy needed for warmth or air-conditioning, cooking, entertainment and communications. However, this will lead to lost productivity for both the truck and the driver if these demands reduce the battery's charge to a point where it can't provide sufficient cranking power to start the engine the following morning.

Productivity is also severely impacted if a vehicle does not start reliably on a Monday morning, even after a weekend left standing in an icy yard. Lack of availability for promised deliveries could damage the operator's reputation, on top of any immediate losses or costs incurred. Other problems can also arise; consider, for example, a hundred buses parked on a narrow site. If one at the front won't start, all those behind are blocked in – a loss of service that could well make the local news headlines. Additionally, bus companies can be fined for providing a poor service.

The effect on buses can be more widely detrimental. While trucks have just one driver, buses also have many passengers, who will all suffer the consequences of a vehicle breakdown – from a jobseeker being late for an interview to a tourist missing their onward connection.

These scenarios show that any shortfall in battery performance, as well as immediately affecting the vehicle's driver and passengers, can also have a cumulative effect on the fleet operator in terms of lost productivity, revenue and reputation.

This technical guide looks more closely at the problem as well as a new solution that harnesses the power of specialist Thin Plate Pure Lead (TPPL) battery technology. We start by considering why traditional batteries are not suitable for such demanding applications, and then describe the next-generation battery technology now available to overcome this trend. The guide covers the technology in terms of its benefits to users, and supports this with evidence and results gathered from over 15 years' related field experience. We then review the underlying battery chemistry to show how it provides a range of benefits.

Why are batteries failing to cope?

As described, batteries are becoming more problematic due to increased loading – but why has the loading increased? The answer includes several factors – especially rising consumer expectations, more widespread use of personal devices within commercial vehicles, and increasingly stringent legislation – rather than a single reason.

'Hotel loading', referring to truck drivers sleeping in their cabs overnight, is a prime example. Using cabs as overnight accommodation is not a recent idea, but as technology has become available to make stopovers more pleasant and comfortable, drivers quite naturally want to benefit from it. They use a variety of equipment for lighting, cooking, heating and air-conditioning, as well as to power gaming consoles, phones and computer hardware for entertainment and work. But a coffee maker in brew mode, or a microwave, can draw surprisingly high currents. Additionally, many devices are AC powered, so an inverter becomes necessary, and this brings associated losses. The challenge for the battery is typically to run a vehicle on the road all day, then supply hotel power without the need to repeatedly start the engine, with enough in reserve to reliably crank the engine for the morning start. This scenario must be repeated time after time, throughout the battery's operating life.

Similarly, buses and coaches, while not experiencing the same level of hotel loads as trucks, often now include sockets to support the use of entertainment and communication devices by both passengers and drivers. In this scenario, for example when a coach is parked at a service station with the engine switched off, increased demand is placed on the battery – but it must still to be relied on to start the engine when required.

European emission standards and low emission zones focused on reducing diesel pollution are also having an effect. Drivers are being encouraged or instructed to use electric night heaters instead of running the engine in the morning to warm their cab, or when awaiting deliveries or collections. There are also anti-idling strategies to prevent drivers from running the engine for power or heating, so they rely more on the battery. In either case, operators use on-board telematics to check on engine idling and ensure that it is minimised.

More sophisticated electrical management systems can mean that drivers are affected sooner rather than later as the battery voltage drops. When this happens, such systems may initiate load shedding, in which power is denied first to non-essential loads such as hotel types, while preserving the ability to start the engine.

Technology driving change

All of the above shows that, as battery loads grow, there is an increasing need for battery technology that will support these loads reliably, time and time again. One answer is in the form of TPPL batteries, which offer a true technological alternative to the lead-calcium flooded or newer lead-calcium AGM battery types currently in popular use. Optimised for the high load demands of the modern automotive sector, TPPL battery technology addresses the challenges of heavy loading in several ways.

To quantify the advantages of TPPL, industry-standard testing has been carried out on the latest ODYSSEY® batteries from EnerSys®. They proved able to support a typical load for over 14 hours and then start an engine, compared with a competing product's 6.5 hours' endurance. This represents an unmatched performance improvement of over 100 per cent.

The technology accommodates more energy-storing pure lead plates in a given volume, resulting in considerably more useable capacity on demand, and a superior cycle life compared with competing products. This enables the batteries to cope with multiple engine starts, and meet heavy demands associated with hotel loading, auxiliary power, on-board systems and other modern fleet vehicle requirements where conventional batteries have failed.

Additionally, the batteries can be discharged to a much higher depth compared to conventional types, while still providing a successful engine start on demand.

This means they can be run for far longer without requiring an engine start, resulting in fuel savings, reduced carbon footprint and NOx emissions. Furthermore, this energy density provides an industry-leading cold crank amps (CCA) rating of up to 1500A for the DIN C (625) battery and 1300A for the DIN B (629) battery.

There are also total cost of ownership (TCO) gains in addition to the batteries' direct on-the-road advantages. For example, the batteries can be stored on an open circuit, with no load across the terminals, without recharging for up to 24 months at 20°C. This massively outperforms alternative batteries that would normally achieve only six months' storage life. As the service life also far exceeds that of comparable types, the batteries reduce TCO as well as optimising performance.

Vehicle maintenance costs are also slashed, as the TPPL batteries provide the optimal stable voltages required by today's electro-mechanical systems for longer than comparable battery types. This reduces stress on certain components, with fewer starts and lower currents. Maintenance time and costs are further reduced by eliminating the need for water top-ups.

The proven ability to run at a 30 per cent lower state of charge compared with conventional flooded automotive batteries significantly increases the time between forced engine starts, which research has shown can result in major cost and CO^2 emissions savings. The batteries' ability to recharge quickly, with no limit on the charging current complementing their fast charge acceptance capabilities, reduces engine running costs and fuel use, while making more power available. Fast charging has the potential to revolutionise delivery truck applications, where the stop-start nature of the application can lead to batteries never fully being charged.

Alongside their unmatched power performance, ODYSSEY® batteries offer operational benefits. They have a high vibration tolerance, rated to EN 50342-1 V3 standard, reducing the risk of permanent failure. Additionally, they have an extreme temperature tolerance of -40°C to +50°C. Their maintenance-free, non-spillable design enables more flexible mounting, unrestricted transportation and safer handling.

Experience on the road in the US and Europe

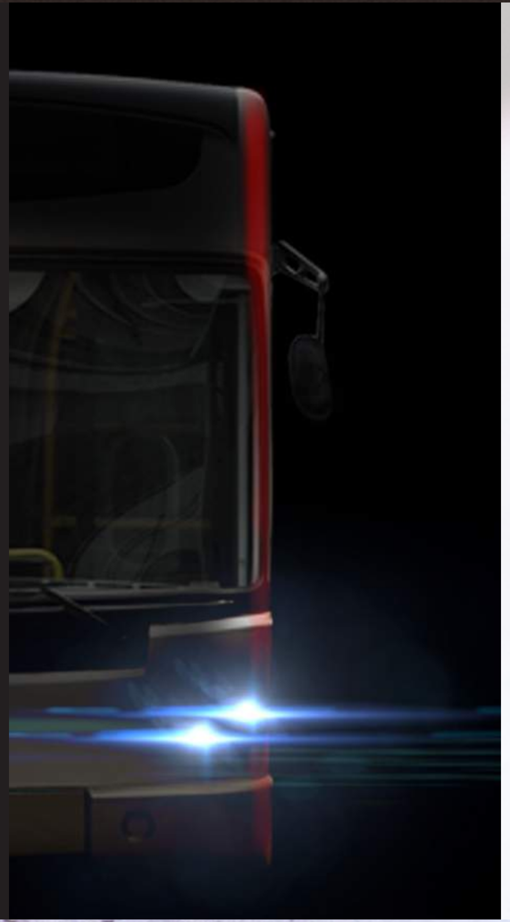
The new ODYSSEY® Performance Series™ batteries are now available to the European market. They come with 15 years' field experience, including truck operations in the US. Originally developed in 1971, TPPL technology was first used in aerospace and military environments. Then, through the 1990s, the batteries found their way into racing-car applications, where they were valued for their high-power density; weight is always a critical issue here.

Industrial versions then started appearing in the US, where they were used by police cars and other emergency vehicles that had high auxiliary loads. Since then, ODYSSEY® batteries have been extending their reach across the US automotive market. Solutions have now been developed that use the proven TPPL technology within existing battery footprints that fit the European market; the part numbers include identifiers 629B and 625B as commonly used in the UK, and DIN B and DIN C as recognised throughout Europe.

The batteries also cater for differences between US and European electrical requirements. US vehicle battery systems are 12V, with four batteries rated at approximately 100Ah each. Europe uses 24V systems, with two batteries rated at 170 - 220Ah each. However, both systems are rated for 900 to 1150 CCA and both deliver an equivalent amount of total energy.

The proven track record of ODYSSEY® batteries in the US is represented by results from their use within a major retailer's trucks. After installing these batteries, the trucks saw over a million miles on the road, until they were retired after 60 months' service in November 2014. During this service period, the retailer found that the batteries needed changing less frequently.

In another instance, data that favourably compared the ODYSSEY® batteries with conventional wet flooded types was generated in the form of Weibull curves, using B10 and B50 data points. These are shown in Figs. 1 and 2 on the following page.



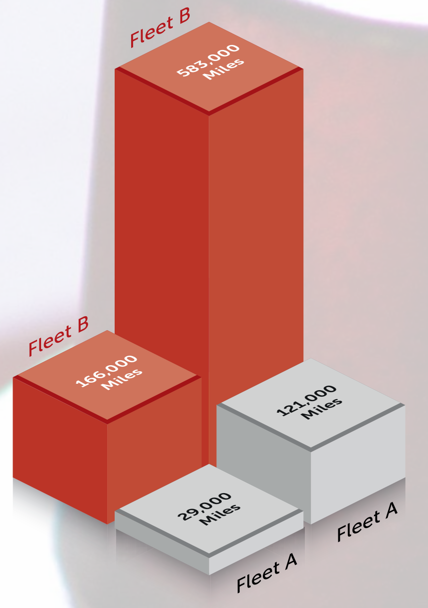


Fig. 1:
Weibull curve data showing miles covered by conventional batteries (Fleet A) and ODYSSEY® batteries (Fleet B)

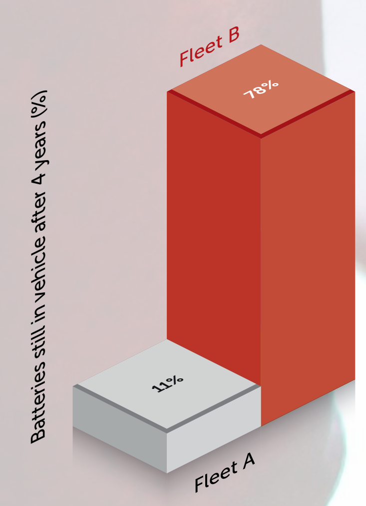
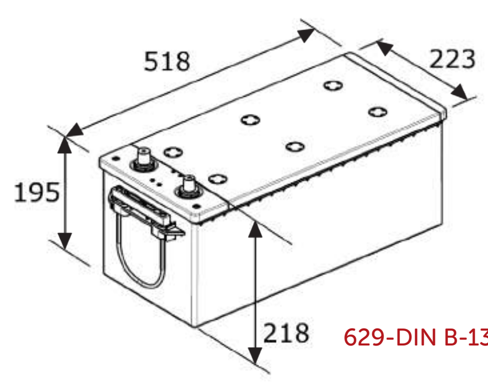


Fig. 2:
Weibull curve data showing endurance of conventional batteries (Fleet A) and ODYSSEY® batteries (Fleet B)

Although, as explained, TPPL technology for DIN B and DIN C battery footprints is relatively new to Europe, this technology has already been successful in commercial vehicle applications in the UK, for more than two years through extensive trials with ODYSSEY® batteries. In October 2016, five double-decker buses in Edinburgh each had two ODYSSEY® batteries fitted, replacing two 225Ah blocs. With a capacity deficit of 100Ah, the ODYSSEY® batteries with TPPL technology outperformed the 225Ah blocs in every aspect. On some very cold mornings, only buses fitted with the ODYSSEY® batteries were able to start without additional assistance.

In another trial that started in October 2015, small-footprint 100Ah ODYSSEY® batteries were used to replace 180Ah products. There were no issues detected. The batteries regularly reached a full state of charge after 18 months in service, with excellent discharge operation supporting both auxiliary and engine start functions.



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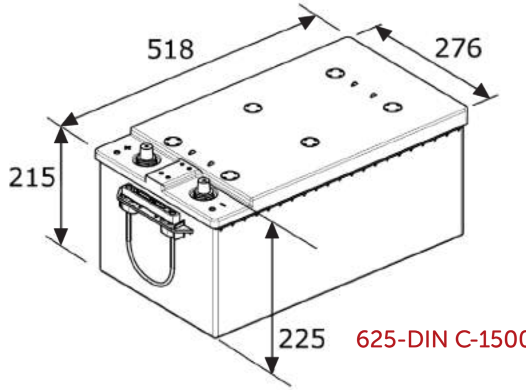


625-DIN C-1500

So far, we have seen how TPPL batteries can confront the challenges of ever-increasing vehicle battery loading, bringing benefits for vehicle operators, drivers and passengers. This has been backed up by field experience in both the US and Europe. Now, we look more closely at the technology itself, to see exactly how it differs from conventional solutions to yield the benefits discussed.

TPPL - a different battery technology

The most basic form of lead-acid battery, still in widespread use in trucks, buses and many other automotive and non-automotive applications, is the flooded cell. Standard automotive batteries use a variant of lead acid called lead calcium (PbCa), introduced in the 1970s. Calcium replaced antimony to give a maintenance-free, no-water product. Although this optimises the design to be maintenance-free, PbCa is not suited to deep-discharge applications. This means that while, over a number of years, its depth of discharge performance has improved, it is still limited when compared to TPPL technology.

Trucks and buses in Europe today typically use either lead-calcium flooded or newer lead-calcium absorbent glass mat (AGM) types. Now there is the added possibility of changing to TPPL. Accordingly, we can look at the progression from flooded, through AGM, to TPPL chemistry.

In conventional flooded batteries, as shown on the left of Fig. 3, oxygen gas is generated on the positive electrode and hydrogen gas on the negative electrode. The bubbles float to the top and are released to the atmosphere. The batteries must be periodically topped up with water.

By contrast, in the AGM system on the right, oxygen is generated at the positive electrode, but the AGM is not flooded. The AGM separator is slightly under-saturated, creating voids that allow the oxygen to travel to the negative electrode. Here, the oxygen goes through a series of reactions, including a change in active material, ultimately converting back to water. Heat is generated proportional to the rate of recombination.

During this process, as long as the recombination activity remains efficient, the hydrogen released from the water in the first step goes to the ionic state, but is recombined with the oxygen before becoming hydrogen gas. Note that during the recombination reaction, active material discharge is an essential step, so energy is used in recharging the active material. Minimising the oxygen generation rate reduces the rate of recombination and energy consumption.

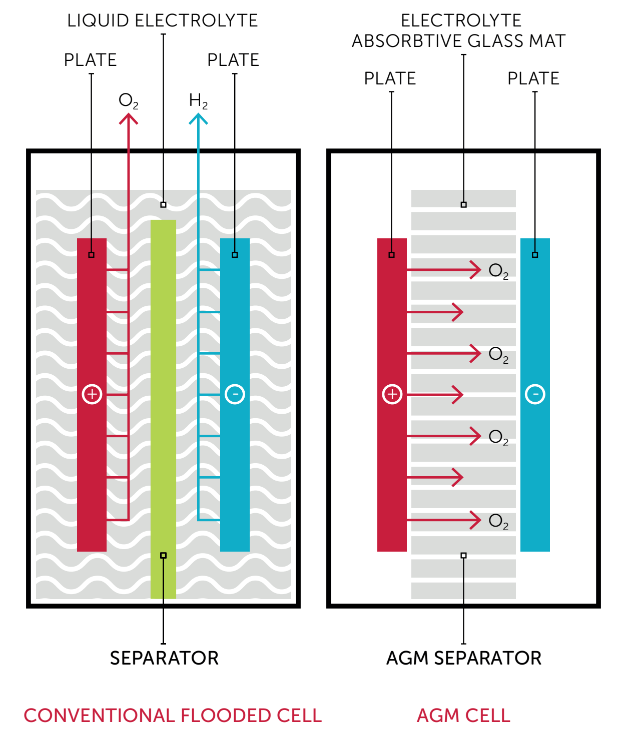


Fig. 3:
Flooded and AGM battery cell structures

TPPL as a development of AGM: TPPL's advance from AGM is based on two core concepts, as indicated by its name – thin plates and pure lead. The TPPL manufacturing process is significantly different from other lead-acid manufacturing methods.

- Thin plates: TPPL positive and negative electrodes are only 1mm thick, compared to 3mm in typical conventional lead-acid batteries. This allows many more electrodes to be fitted in the same space, increasing battery capacity and boosting power density. As a result of this increase in surface area, the space requirement for the same power density as AGM is reduced by about 30 per cent.
- Pure lead: AGM batteries use a lead-calcium alloy for their positive and negative plates. TPPL uses 99.99 per cent pure primary non-alloyed lead, together with very high-purity, medical-grade sulphuric acid. The chemical behaviour of the batteries is significantly more stable, which offers advantages relating to charging characteristics and lifetime. Also, the grain structure of the pure lead makes the plates far less susceptible to corrosion.

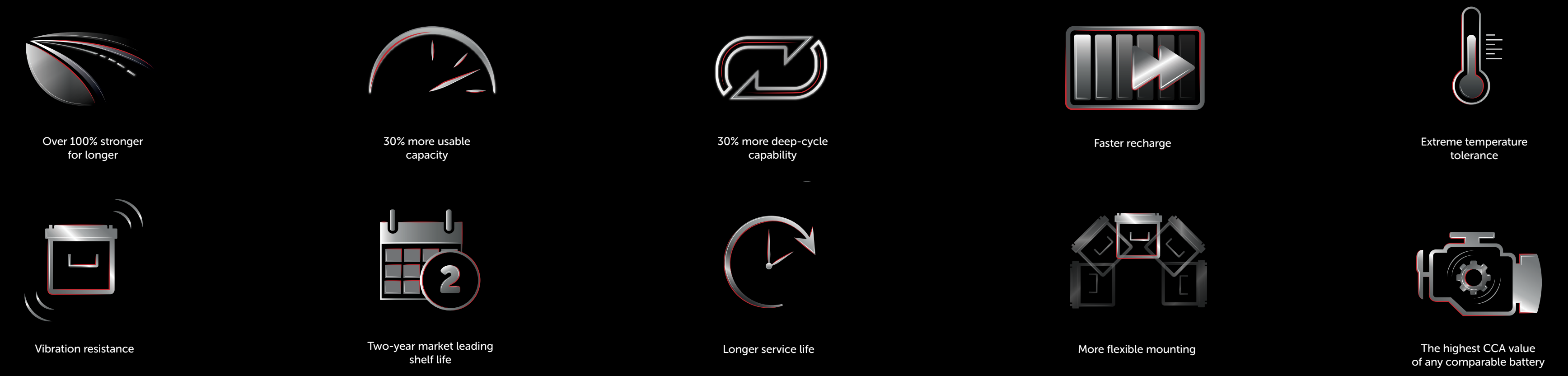
Like the earlier AGM products, TPPL batteries are sealed types, with minimal gas evolution and no need for water top-ups. However, as discussed, many other benefits also flow from these design concepts, especially as they impart very low internal impedance to the batteries. This allows both a very high rate of discharge, and quick, efficient acceptance of charge.

When implemented within ODYSSEY® batteries, the internal TPPL chemistry is complemented by external design aspects for better mechanical and environmental resilience. The high compression design, along with additional vibration proofing, creates a product with extreme vibrational resistance. Additionally, the case and cover are manufactured to EnerSys® design and moulded in polypropylene for exceptional durability and temperature tolerance. Mechanical strength is also improved with state-of-the-art inter-cell squeeze-weld connectors, and brass inserts within the terminal posts. Furthermore, there is no galvanic grid corrosion.

In both the US and Europe, the batteries are manufactured in dedicated plants – in Warrensburg, MO, USA, Arras, France and Newport, South Wales, UK – and are certified to ISO 9001:2008 for quality and ISO 14001:2004 for environmental compliance, while the factories are subject to external audit. At end-of-life, TPPL batteries retain another key advantage of lead-acid chemistry, in that they can be efficiently recycled. Ninety-five per cent of the metal, lead, acids and plastics can be recycled.

Conclusion – ODYSSEY® Performance Series™ batteries are designed to power the future

In this technical guide, we have explained how greater demands from hotel and other auxiliary loads in large trucks and buses are pushing conventional batteries far beyond their design expectations, with the result that fleet owners, operators, drivers and passengers are increasingly suffering from inadequate battery performance or even failure. As such shortfalls often lead to loss of productivity, profits, opportunities and reputation, operators are motivated to find better battery solutions that are fit for today's commercial vehicle environment and can mitigate these problems.



In searching for solutions, users have too often found a marketplace crowded with flooded cell and AGM offers, with confusion surrounding relative performance and what constitutes the optimum technology. However, this guide has set out how a better solution based on specialist TPPL battery technology is now at hand, which provides the answer modern transport and service vehicle operators have been waiting for.

Tried and tested in the heavy-duty vehicle market for more than five years, ODYSSEY® batteries harness the power of TPPL technology to deliver massive starting and endurance ability and has been optimised to meet the high load demands of the modern commercial vehicle sector.

In particular, the batteries' incomparable durability, starting ability at high depths of capacity, and deep-cycle capability combine to support today's auxiliary load levels, time and again, through every cycle of operational life. This brings a significant reduction in TCO, so crucial to today's commercial vehicle fleet operators.

TPPL technology is now available to the UK and European heavy commercial vehicle markets thanks to ODYSSEY® Performance Series™ batteries. As well as being 'form, fit and function' replacements for existing technology types, the batteries comply with DIN B and DIN C size standards for Europe, and the widely recognised – although no longer formally accepted – 629 and 625 references for the UK.

For more information about the ODYSSEY® Performance Series™ batteries, please visit: www.discovertppl.com

References

Department for Transport (Scottish Government) Fuel Saving in a Scottish Haulage Fleet – Case Study – February 2010

https://www.transport.gov.scot/media/14303/fuel_savings_in_a_scottish_haulage_fleet_.pdf

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