

# An Understanding of the New Generation of Battery Technology fitted to Modern Day Cars and the need to replace with equivalent Technology

## Background

With the current increasing global warming issues, the environmental pressures on vehicle manufacturers to reduce their vehicle exhaust carbon dioxide emissions alongside improve fuel economy has been reinforced with EU Legislation. This new EU legislation on emissions targets which were passed in 2009 have committed vehicle manufacturers to cut average CO<sub>2</sub> emissions from new cars to 130g/km by 2015 and 95g/km by 2020.

Various methods are being used to influence the vehicle manufacturers to reduce their emissions, from increased costs of vehicle duty, increased fuel taxation, increased frequency of inner city road toll charges and other costs on high emission vehicles through to be introduced government introduced "Showroom tax" on new vehicles proposed to be increased over forthcoming years based on fleet average emissions of vehicles made by the particular manufacturer. Legislation discussions have stated figures up to 250euro per gm. of CO<sub>2</sub>/km may be charged based on the manufacturer's average fleet emissions which exceeds the legislative level for the period to be charged on every vehicle sold by that manufacturer

Based on figures published by Department of Energy and Climate Change DECC (2012), in 2009 cars contributed 69.7 million tonnes of CO<sub>2</sub> to the UK atmosphere 13.8% of the total published CO<sub>2</sub> emissions in the UK. The UK average new car CO<sub>2</sub> emissions in 2004 was 171.4gm CO<sub>2</sub>/km compared by 2011 reduced to 138.1gm CO<sub>2</sub>/km (19% reduction)

## Eco – Initiatives

Meeting the growing environmental challenges, manufacturers have developed various eco-solutions to help drivers save fuel and reduce vehicle CO<sub>2</sub> emissions. Some initiatives are related to changes in the battery technology and requirements.

Looking at the effect on volume vehicle sales, the following initiatives require changes in battery technology to support their implementation:

- Stop Start Technologies – (Micro hybrid 1)
  - Initial solutions manually, now becoming automatic, cut the engine when a vehicle is stationary. The engine is restarted by releasing the brake or depressing the pedals. Initial solution could be manually switched off, but next generation vehicles this option is disabled
  - As well as increasing the number of engine starts on the battery, the battery is also required to support the electrical loads whilst the engine is stopped and the alternator is not charging
  - New methods of electronic monitoring the state of charge and state of health of the battery are increasingly present on vehicles as the number of stop/start cycles required is increased, but the car has to know whether it can restart the vehicle if it will stop the engine in the first case.
  - Initial solutions would not stop/start the engine below 3°C. Latest solutions are looking at -10°C all putting greater demand on the battery to supply minimum voltages of the electronic circuits on the vehicle
  - A typical fuel saving by Stop/Start alone of up to 8% is stated by some manufacturers based on their standard European drive cycles. In current terms of electronics technology a relatively low cost gain for improved emissions
  - New battery technologies such as improved flooded (EFB) and AGM have been developed subject to the new duty cycle requirement of the particular OEM manufacturer.
  - A recent experience based on a journey across London lead to 87 Stop start cycles , compared with following Motorway journey where obviously the Stop/Stat feature was not used. This has introduced a new band of battery failure modes, previously not experienced by the vehicle manufacture
- Alternator Management & Brake Regeneration (Micro hybrid 2)
  - It is likely that as a customer you would not be aware of this technology being fitted on your vehicle, as its operation is seamless, unlike Stop Start when you clearly know that the engine has stopped
  - Effectively switch/declutching of alternator during driving, The alternator when running can typically take up to 10% of the power of the engine, letting the battery support the load although pushing more requirements on the battery can significantly improve fuel economy.

- This fuel saving method is clearly more fruitful on longer distance journeys and it shows that one technology alone is not the solution to every drive cycle but as part of an overage package of initiatives
  - The battery during these times is supporting all the electrical loads on the vehicle leading again to greater life expectations of the battery
  - New battery technologies have been developments based on increased levels of technology from improved flooded design (EFB) to AGM designs which are significantly better in cyclic life and operating in low states of charge
- Regenerative Braking – the energy normally given as heat during braking is fed back to the charging system to attempt to recharge the battery whenever this excess energy is available
- A standard technology battery is very inefficient when operated in this mode and would be lucky to reuse 5-15% of the available energy – New battery technologies are being continuously developed such as mentioned above improved flooded (EFB) and AGM as the demands on the batteries increase verses the overall cost of the solution and fuel economy
- Passive Boost (Micro hybrid 3)
  - Future new technologies are coming to the new generation of vehicles on the road; solution such as “Passive boost”, a simpler cost effective solution to that currently used in Formula 1 race teams over the last couple of seasons (Kinetic Energy Recovery (KERS)). In this evolution of the technology, the conventional alternator and starter have been replaced by what is being called a combined alternator starter generator fitted between the engine and the gearbox. Here the generator polarity can be reversed to change the generator into a motor (going back to your GCSE year 9 physics class), and the battery can be used to assist with the acceleration of the vehicles.
- These new requirements clearly expect significantly more from the battery and the technology has to be continually improved to match the further increase in demands

## Review of Requirements

- It is clear from the above changes in vehicle technology, that the battery is becoming a critical component is ensuring that the new eco –initiatives will deliver the fuel and CO2 saving needed by the legislation
- Battery Technologies have been developed over recent years to meet the increasing demands of the vehicle now entering the aftermarket. It should hopefully be clear that it is impossible to expect the current day standard flooded lead acid battery to meet the requirement of Stop Start and Micro hybrid 2 and 3 fitted vehicles. In the aftermarket, it is therefore essential to replace the manufacturer specified battery with that of the same or increased technology
- The fitting of a standard battery to a Stop/Start only vehicle will result in a significantly lower life and also increased likelihood that the battery will go flat in service and it will be unable to recover sufficiently during its residual driving cycles
- The fitting of a standard battery to a Alternator Management and Brake Energy Recovery, will again lead to a major reduction in expected life and an even greater chance of the battery repeatedly going flat in service and the charge acceptance of the battery is even more critical to ensure that the battery can accept the available current from the alternator and the brake regeneration

## Battery Technologies

The constant requirement for more efficient, cleaner and technologically advanced vehicles means that the introduction and development of vehicles featuring these systems will have increased to approximately 70-80% of all vehicles produced in Europe by 2015 (over 30 million vehicles within the EU alone) as the EU legalisation starts to bite the vehicle manufacturers sales verses competitors who have invested and gained the fuel and emission savings.

For volume productions cars, two advanced development modifications of the Lead Acid battery are currently being installed onto the first generation of vehicles (volume introduction starting back in 2008/09).

- For high performance vehicles, with advanced Stop Start functionality with alternator/brake energy recovery, AGM technology is used
- For Entry level start stop vehicles (usually where fuel emission/CO2 saving requirements are less) a more cost effective solution based on an improved flooded design (being recognized in the market as EFB)

## Understanding of Technology 1: AGM (Absorptive Glass Mat)

The AGM battery has been designed to fulfill the very special requirements of modern day vehicles featuring high levels of electrical equipment and emission target driven Carbon Dioxide control systems such as:

- Microhybrid 1 Idle Stop Start (ISS)
- Micro hybrid 2 Alternator Management (Alternator control) and Brake Regeneration
- Microhybrid 3 Passive boost (Battery powered starter/generator boosted engine allowing engine downsizing with reduction in performance)

The AGM battery shares a few design technologies with the traditional flooded battery but additional features from Industrial and Motorcycle batteries such as:

- Fully sealed and leak proof
- VRLA "recombinant" technology
- Calcium calcium plates

The AGM battery has unique features that differentiate it from the traditional conventional flooded battery dramatically increasing its all-round performance in an automotive application. These include

- AGM separators between plates to retain the electrolyte in the ideal position for discharge and recharge chemical reaction to take place
- Electrolyte starved cells with no free reservoir of acid above the plate level
- Anti-spill with no acid leakage even if the battery case is damaged
- Extremely low self-discharge rates when compared to conventional flooded type
- High levels of vibration resistance and durability due to high cell pack pressures
- Increased plate numbers per cell, larger plates, increased operating pressures and higher levels of purer lead when compared to conventional flooded give a low internal resistance resulting in much reduced discharge and recharge times.
- The ability to operate the battery at high pack pressures significantly improves cyclic durability of the battery (with a flooded battery, higher pack pressures leads to acid being forced out from between the plates and the battery dying due to lack of acid to maintain the chemical charge/discharge reaction)
- As all the acid is held between the plates, the AGM battery does not suffer as much in lower states of charge from what is called acid starvation, which in a standard lead acid battery can lead to the acid strength increasing between the plates and increasing the rates of corrosion and life of the battery.

Benefits of AGM over standard flooded

- Typically increased cold cranking power by 30-40% over standard flooded battery enabling faster engine cranking speeds and lower CO<sub>2</sub> emissions
- Cycle Life endurance at deep discharge (50% DOD) typically 3-6x of standard aftermarket flooded battery
- Cyclic operation in partial state of charge (50%) - Original AGM product 3-5x that of standard aftermarket, 2013 model year vehicles up to 8-12x that of standard battery
- Maintenance of dynamic charge acceptance (DCA) currently up to 3x that of standard flooded battery
  - (DCA ability to accept charge immediately after restarting engine and from energy from brake recovery)

## Understanding of Technology 2: Improved Flooded (EFB) Technology

The improved flooded battery (increasing known as EFB technology in the market) is based on an improved flooded battery design with increased cyclic durability and improved ability to accept charge current by various changes to battery construction. The EFB technology offers a cost effective solution for entry level vehicles, where the batteries are not operating across such a low range of battery state of charge as AGM, this is due to the vehicle manufacturer having to reduce his vehicle emissions by a lower amount to meet the EU targets, as the base line vehicles already have a lower emission level than the high performance vehicles where an AGM battery is required.

Benefits of EFB over standard flooded

- Typically increased cold cranking power by 15-20% over standard flooded battery enabling faster engine cranking and starting and lower CO<sub>2</sub> emission
- Cyclic durability endurance at deep discharge (50% DOD) typically 2-4x than of standard aftermarket battery
- Cyclic operation in partial state of charge (50%) typical 2-3x that of standard flooded battery
- Maintenance of dynamic charge acceptance currently up to 2x that of standard flooded battery

## Cost Implications & dangers

Due to the increase in performance, higher production costs and unique characteristics of AGM batteries battery care, replacement battery sales, controlling battery warranty claims and enhancing customer satisfaction become more important.

### Battery care

When installed on the vehicle AGM battery charging voltages are the same as for any standard battery with no need for any special adjustments to the charging system. This is due the extremely low internal resistance of the battery which results in almost no heating of the battery even under heavy charge and discharge currents.

Due to the extremely low internal resistance of AGM batteries and acid starved design and reduced charging and discharge time it is essential when charging off the vehicle that the correct type of equipment is used.

Constant current or boost chargers **must not** be used as this will result in:

- Heating of the battery
- Boiling of the electrolyte
- Increased internal battery pressure
- Loss of recombinant gases to the atmosphere through the PRV (Pressure Relief Valve)
- Drying out of the battery

All of these factors will greatly reduce the lifespan and performance of the battery and cannot be rectified due to the sealed VRLA design.

### Replacement battery sales

Due to the high retail cost of replacement AGM batteries retailers may encounter customer resistance to the compulsory purchase of an AGM over conventional flooded or EFB types based on the level of technology on their vehicle.

If the battery application guide stipulates that the **only** battery type specified for the vehicle is an AGM then an AGM type is the **only** battery that is fit for purpose on that vehicle.

- As an example of the fuel saving based on an original AGM fitted " Micro hybrid 2 " vehicle over 30000miles would equate to average fuel saving of about £670 (subject to driving style and cycle)
- The fuel savings based on an original fitted EFB (Micro hybrid 1) vehicle over similar mileage would be less and roughly estimated at £280 for a similar period/driver/route

Installation of a conventional flooded or EFB type over an AGM battery will result in premature battery failure due to:

- Excessive battery cycling as conventional and EFB type batteries have significantly lower cycling specifications
- Plate damage caused by high depths of discharge which conventional or EFB batteries are not designed to support
- Accelerated loss of battery plate surface area and resultant capacity which can be as much as 16% in the first week of service

## CONCLUSION

- To achieve the emission and fuel savings designed into the vehicle by the OE Manufacturer, it is essential that a battery originally fitted with an AGM battery should be replaced with an AGM battery of equivalent quality and design
  - The fitted of a standard flooded or EFB battery, even with the more attractive initial purchase price will quickly lead to loss of Micro hybrid functionality on the vehicle, seen by loss of increased emissions and increase fuel economy and early failure of the battery. This is likely to be seen very quickly by the battery going flat or over cycled.
    - A standard flooded battery **should not** be fitted to these vehicles.
  - The same applies to vehicles fitted originally with EFB Technology; it is essential that the battery is replaced with an equivalent quality EFB battery (or higher specification AGM battery if recommended by the battery manufacturer).
    - A standard flooded battery **should not** be fitted to these vehicles.

## GENERAL COMMENT

- It is becoming increasing common that fitting new batteries to "Micro hybrid" fitted (Stop/Start) vehicles requires the OBD (Electronic Codes) error codes to be reset and new battery registered on the vehicle so full functionality can be regained on the vehicle.
- Whether the vehicle requires such coding, such be advised by the retailer of the battery at the time of purchase. The vendor should be required to advise customer how and where the reprogramming of the vehicle can be carried out, giving the customer the option to find his own garage to carry this out, but noting that the battery was clearly sold with advice only but with the vehicle not being reprogrammed by the retailer. (Not recommended supply option by battery manufacturer)

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### Warranty & Customer Satisfaction

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The higher numbers of these vehicle types on our roads will therefore mean an increase in AGM and EFB battery sales and conversely a reduction in the sale of conventional flooded types. With this in mind it becomes very important for battery retailers to understand the technology behind AGM, the special requirements placed on the battery and the consequences of supplying batteries unsuitable for application.

If EFB or conventional flooded type batteries are supplied in place of specified AGM types they will almost definitely fail a short time after the start of the battery warranty period. This situation results in increased false warranty claims and loss of customer satisfaction.

It is therefore essential that battery retailers understand the technological reasons for the correct application of AGM batteries and the consequences of fitting batteries such as EFB or conventional flooded that are not fit for purpose.

Using this information, battery retailers can make customers fully aware of the reasons for the high cost of AGM batteries and the technological and performance limits of other battery types that will affect the performance of their vehicle and potentially result in expensive recovery or repair costs.

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