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WHITE PAPER:

MIXTECH TECHNOLOGY

PATENTED 360° ACID MIXING TECHNOLOGY IS COMBINED WITH THE LATEST ELECTRO-CHEMICAL ADVANCEMENTS TO PRODUCE IMPROVEMENTS IN PERFORMANCE, RELIABILITY AND LIFE IN STARTING, LIGHTING AND IGNITION BATTERIES.

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From carbon and silver boosted high performance alloys to next generation separators and gas recombinant cover designs and materials, Discover's MIXTECH EMX, MIXTECH EFB and MIXTECH EGM batteries combine the latest electrochemical advancements in battery technology with exclusive and patented 360° acid mixing technology to produce the most significant improvement in performance, reliability and life in starting, lighting and ignition batteries in 50 years.

MIXTECH is a patented technology built into every DISCOVER MIXTECH battery that uses the vehicle's natural movement to continuously mix the electrolyte inside the battery to eliminate the ACID STRATIFICATION (also known as acid build-up) that happens in every lead acid battery when heavier acid settles out of the batteries electrolyte and builds up at the bottom of the cells. (TABLE 1)

1	ACID STRATIFICATION causes the useful active material in the battery to be reduced by 40% within six to eight months of normal use creating what is known in the industry as dead lead or inactive active material (Figure 1). Acid stratification causes the batteries charge acceptance to decline by 50% to 70% within 6 months of installation increasing alternator wear and tear and decreasing fuel efficiency.
2	When this heavier or hotter acid stratifies or builds up and concentrates at the bottom of the batteries cells, the upper half of the plate is no longer capable of proper discharge activity.
3	This area of low specific gravity at the top of the cell has reduced active material activation and experiences accelerated corrosion which dramatically lowers the batteries cranking power (CCA) and capacity (AH/RC).
4	Conversely the Acid build-up at the bottom of the cell prevents proper charge activity on the bottom half of the plate. This area of higher specific gravity promotes increased internal resistance, lower conductivity and accelerated sulfation on the lower half of the positive plates.
5	A sulfated battery will eventually only accept a surface charge, resulting in a battery that appears fully charged but that provides low CCA and capacity (AH/RC).
6	This false state of charge reading confuses modern vehicle charging systems into thinking the battery is more charged than it is which leads to the battery being always in an under charged condition.
7	ACID STRATIFICATION, or the build-up of hotter acid concentrations, magnifies the development of hot spots or thermal gradients within the battery that accelerate plate corrosion, battery dry-out, premature capacity loss and reduced life particularly in extreme climates.
8	ACID STRATIFICATION is the leading cause of "ALL" of this unequal activity across the batteries plates which prematurely reduces the batteries cranking ability, its available reserve capacity and eventually its useful life.
9	Acid build-up represents the largest portion of battery warranty and related costs and increases alternator wear and tear and fuel expenses.
10	Discover's award winning 360° acid mixing technology eliminates acid stratification and more than doubles the life of any flooded lead acid battery chemistry by eliminating acid build-up.

THIS MEANS EVERY MIXTECH BATTERY DELIVERS UNIFORM ACID DENSITY, HIGHER SUSTAINED PERFORMANCE AND LONGER LIFE AT A LOWER TOTAL COST OF OWNERSHIP WHEN COMPARED WITH OTHER HIGH QUALITY CONVENTIONAL, EFB OR AGM BATTERIES.

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MIXTECH EGM

ENHANCED GLASS MAT FLOODED BATTERY

EGM batteries combine 360° electrolyte mixing with Enhanced Flooded Battery (EFB) technology and the high performance and vibration resistance of valve regulated Absorbed Glass Mat (AGM) batteries to produce a far superior Enhanced Glass Mat (EGM) battery without the same dry-out and thermal runaway risks associated with AGM batteries:

- Eliminates acid build up
- Increases material utilization, providing superior sustained performance and life
- Decreases thermal gradients and dramatically improves life in extreme temperature operation
- Has the vibration and cycle life enhancements of highly compressed AGM cells
- Offers significantly improved charge acceptance reducing alternator wear and tear

EGM batteries include Original Equipment Manufacturer (OEM) replacement market models that meet or exceed the original specifications and performance of conventional, EFB or AGM batteries installed as original in Automotive, Commercial Start-Stop and anti-idle vehicles.

Tested and shown to provide greater than 4x the cycle life of comparable conventional batteries, and greater than 2x the life of replacement market EFB or High Cycle batteries according to OEM TEST STANDARD 75073.7.14. EGM batteries maintain dynamic charge acceptance at a rate of 3x higher than conventional batteries without 360° acid mixing.

EGM batteries have been specifically designed to withstand extreme temperatures, to support power-hungry electrical equipment, and the intensive urban or long distance driving needs of people that rely on vehicles to earn their living.

EGM batteries deliver greater reliability, and longer life at a much lower Total Cost of Ownership versus other high quality conventional, EFB & AGM batteries.

- EXCEEDS OEM SPECIFICATIONS
- XVR VIBRATION RESISTANT
- CARBON BOOST
- ENHANCED ALLOYS
- GLASS MAT
- EXTREME TEMPERATURES
- HOTEL LOADS
- START-STOP MICRO-CYCLING
- 100% MIXING

4x
STANDARD LIFE CYCLE

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MIXTECH EFB
ENHANCED FLOODED BATTERY

EFB batteries incorporate 360° acid mixing technology with the latest Enhanced Flooded Battery (EFB) breakthroughs in lead alloys and unique carbon additives to significantly improve dynamic charge acceptance and cycle life.

EFB batteries are OEM replacement market parts that exceed the requirements of Start-Stop and anti-idle vehicles with regenerative braking and other powerful fuel-saving features.

EFB batteries maintain dynamic charge acceptance greater than 2x better than conventional or EFB batteries without 360° acid mixing (Figure 4 & 5). MIXTECH EFB is tested and shown to provide 3x the cycle life of comparable conventional batteries tested according to OEM TEST STANDARD 75073.7.14.

EFB batteries support micro-cycling applications that operate at a partial state of charge and that don't require the deep cycling characteristics of MIXTECH EGM batteries.

EXCEEDS OEM SPECIFICATIONS

VIBRATION RESISTANT

CARBON BOOST

ENHANCED ALLOYS

EXTREME TEMPERATURES

START-STOP MICRO-CYCLING

100%
MIXING

3x
STANDARD LIFE CYCLE

MIXTECH EMX
PREMIUM FLOODED BATTERY

EMX batteries combine 360° acid mixing technology with expanded metal grids and advanced active materials to produce premium batteries for most conventional modern vehicles equipped with standard accessories.

The EMX range includes high capacity OEM replacement market models that meet or exceed original specifications and are excellent for extreme temperature environments.

EMX batteries are tested and proven to provide dramatically improved active material utilization, delivering 2x the cycle life of comparable conventional batteries and 1.5x the life of replacement market EFB batteries according to OEM TEST STANDARD 75073.7.14.

MIXTECH EMX batteries can be used to replace original equipment EFB and AGM batteries.

EXCEEDS OEM SPECIFICATIONS

VIBRATION RESISTANT

EXTREME TEMPERATURES

START-STOP MICRO-CYCLING

100%
MIXING

2x
STANDARD LIFE CYCLE

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EXCEEDS OEM SPECIFICATIONS

Product range includes models designed to meet or exceed Original Equipment Manufacturers performance and quality requirements. Complies with Original Part Matching Quality regulations.

VIBRATION RESISTANT

ELEMENT BONDING utilizes two rows of glue applied along the top of the cell groups that help resist positive plate growth and reduces vibration related failures.

XVR VIBRATION RESISTANT

ELEMENT and ANCHOR BONDING of cell groups and MIXTECH + XVR* components mechanically lock cell connectors and plates in place reinforcing cell stabilization providing Super Heavy Duty (SHD) vibration and shock resistance.

CARBON BOOST

Negative plate CARBON additives improve Dynamic Charge Acceptance (DCA) by up to 1.5x and significantly reduce charging time. When used in conjunction with MIXTECH, original DCA is maintained at a level 3.5x greater than conventional or EFB batteries within 6 months of installation.

ENHANCED ALLOYS

High capacity grids made with silver calcium enhanced alloys resist corrosion and maximize SHD maintenance free performance and reliability at extreme temperatures.

GLASS MAT

Compressed AGM cell design with Enveloped + AGM separators reduce plate shedding, provide continuous cycling stability, improve vibration resistance and support optimal performance even in extreme temperatures.

HOTEL LOADS

Suitable for Dual Purpose High Cycle & Starting applications with continuous use starting and hotel loads.

EXTREME TEMPERATURES

Optimized for extreme temperatures. 360° acid mixing decreases thermal gradients and dramatically improves life at extreme temperatures (cold or hot) when compared with other high quality lead acid batteries.

START-STOP MICRO-CYCLING

Designed to support micro-cycling and partial state of charge use typical of start-stop, anti-idle, highly equipped vehicles and intense urban driving.

100% MIXING

MIXTECH Technology eliminates symptoms related to acid build up. This patented 360° acid mixing achieves 100% homogeneous specific gravity at twice the effectiveness, and less than half the time of pump action mixing elements (Figure 2).

2x STANDARD LIFE CYCLE

MIXTECH EMX provides 2 times more cycle life vs conventional batteries tested according to DIN 75073.7.14.

3x STANDARD LIFE CYCLE

MIXTECH EFB offers greater than 3x more cycle life vs conventional batteries tested according to DIN 75073.7.14, and greater than 2x more cycle life than replacement market EFB batteries tested according to DIN 75073.7.14 (Figure 3).

4x STANDARD LIFE CYCLE

MIXTECH EGM delivers greater than 4x more cycle life vs conventional batteries tested according to DIN 75073.7.14.

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Discover MIXTECH Features & Benefits	DISCOVER MIXTECH EGM		DISCOVER MIXTECH EFB		DISCOVER MIXTECH EMX		STANDARD NON-MIXING	
	AUTO.	COMM.	AUTO.	COMM.	AUTO.	COMM.	AUTO.	COMM.
Exclusive 360° Acid Mixing Technology	MIXTECH componenets are installed inside the battery that use the natural movement of the vehicle to keep the acid inside the battery in constant circulation; ensuring uniform acid gravity; enhancing charge acceptance; eliminating acid stratification and extending battery life.							
Eliminates acid stratification - the #1 killer of batteries ■	✓	✓	✓	✓	✓	✓	-	-
Minimizes sulphation preventing premature capacity loss	✓	✓	✓	✓	✓	✓	-	-
Maintains DCA in severe duty & PSOC use up to 3 times better than conventional or EFB batteries without mixing - reducing alternator loads and fuel consumption ❖◆	> 3x	> 3x	> 2x	> 2x	> 1.5x	> 1.5x	x	x
Sustains original performance protecting your investment	✓	✓	✓	✓	✓	✓	-	-
Ensures uniform active mass utilization guaranteeing longer high performance life	✓	✓	✓	✓	✓	✓	-	-
Eliminates internal heat gradients (hot spots) preventing premature failure	✓	✓	✓	✓	✓	✓	-	-
Delivers longer battery life in extreme environments (hot or cold)	✓	✓	✓	✓	✓	✓	-	-
Tested and proven to deliver longer life vs. conventional non-mixing according to OEM TEST STANDARD 75073.7.14 (Table 2)	> 4x	> 4x	> 3x	> 3x	> 2x	> 2x	x	x
Enhanced Flooded Battery Benefits and Features	Enhanced Flooded Battery (EFB & EGM) features with MIXTECH improves Dynamic Charge Acceptance and battery life - even in the most extreme conditions - at a lower TCO than other Conventional, EFB or AGM batteries.							
Advanced alloys increase life	✓	✓	✓	✓	✓	✓	-	-
CARBON additives improve dynamic charge performance	✓	✓	✓	✓	-	-	-	-
Increased active material density improves deep cycle performance	✓	✓	✓	✓	-	-	-	-
Fiber-Lock plate scrim reduces active material erosion	✓	✓	✓	✓	✓	✓	✓	✓
Enveloped + AGM separators increase cell compression; reduce plate shedding; provide three times the cyclic stability and ten times the vibration resistance of a standard battery. This enhanced design keeps the acid in contact with the grids maintaining its optimal performance even in extreme temperatures	✓	✓	-	-	-	-	-	-
Envelope separators reduce internal resistance and short circuits	✓	✓	✓	✓	✓	✓	✓	✓
Silver Calcium cast grids (+/-) provide Super HD reliability and life	✓	✓	-	-	-	-	-	-
Silver Calcium grids improve DCA and cyclic ability	✓	✓	✓	✓	-	-	-	-
Calcium expanded (+/-) grids with Enhanced Active Mass improve CCA performance	-	-	✓	✓	✓	✓	✓	✓
Highly compressed cell groups increase performance & vibration resistance	✓	✓	-	-	-	-	-	-
Deep set cell groups enhance maintenance free performance and life	✓	✓	✓	✓	✓	✓	✓	✓
Ideal for start-stop vehicles with regenerative breaking, tougher drive schedules, multiple accessories and/or higher than normal energy demands	✓✓✓	✓✓✓	-	-	-	-	-	-
Improved performance and life in Anti-idle start-stop vehicles, challenging drive schedules and increased accessory loads	✓✓✓	✓✓✓	✓✓	✓✓	✓	✓	-	-
Exceed SAE J240 75°C / 167°F cycle life requirements	✓✓✓	✓✓✓	✓✓	✓✓	✓	✓	-	-
Enhanced features with MIXTECH improves DCA and life at a lower cost than other Conventional, EFB or AGM batteries	✓✓✓	✓✓✓	✓✓	✓✓	✓	✓	-	-
Replacement part for AGM Original Equipment battery	✓	✓	-	-	-	-	-	-
Replacement part for EFB Original Equipment battery	✓✓✓	✓✓✓	✓✓	✓✓	✓	✓	-	-
Replacement part for conventional Original Equipment battery	✓✓✓✓	✓✓✓✓	✓✓✓	✓✓✓	✓✓	✓✓	✓	✓
Replacement part for CONVENTIONAL battery	✓✓✓✓	✓✓✓✓	✓✓✓	✓✓✓	✓✓	✓✓	✓	✓
Extreme Vibration Resistance Design Features (XVR)								
ANCHOR BONDING - at the bottom - for shock related vibration resistance	✓	✓	-	-	-	-	-	-
ELEMENT BONDING - at the top - for harmonic related vibration resistance	✓	✓	✓	✓	✓	✓	✓	✓
MIXTECH XVR*: Internal XVR devices that mechanically enhance and lock cell connectors and plates in place reinforcing cell stabilization, helping to neutralize the effects of vibration	✓	✓	-	-	-	-	-	-
Optimized and compressed cell groups increase vibration resistance and increase the effectiveness of AGM separators	✓	✓	-	-	-	-	-	-
Enveloped + AGM Separators compress active mass and prevent shedding	✓	✓	-	-	-	-	-	-
Fiber Lock plate lamination improves active mass integrity	✓	✓	✓	✓	✓	✓	✓	✓
Exceeds EN VIBRATIONS (V3) requirements	✓	✓	-	-	-	-	-	-
Exceeds EN VIBRATIONS (V2) requirements	✓	✓	✓	✓	-	-	-	-
Meets EN VIBRATIONS (V1) requirements	✓	✓	✓	✓	✓	✓	✓	✓
Up to 10 times the vibrations resistance of standard batteries according to EN level 4 & J3060 (Table 2) level 1, 2 & 3 standards	> 6x	> 10x	3x	3x	x	x	x	x
Ideal for Commercial Vehicle frame-rail installation	✓✓	✓✓	✓	✓	-	-	-	-

Discover MIXTECH Features & Benefits	DISCOVER MIXTECH EGM		DISCOVER MIXTECH EFB		DISCOVER MIXTECH EMX		STANDARD NON-MIXING	
	AUTO.	COMM.	AUTO.	COMM.	AUTO.	COMM.	AUTO.	COMM.
Extremely Safe & Environmentally Friendly Technology	Discover flooded batteries are made with recycled plastic materials. Flooded lead acid batteries are the most common battery type available in the market today. Liquid electrolyte covers all internal parts. Discover batteries have a sealed construction so that they are leakproof in normal operating conditions.							
Double cover labyrinth design provides spill protection and improves gas recombination and safety	✓	✓	✓	✓	✓	✓	✓	✓
Impact resistant case with reinforced walls for durability	✓	✓	✓	✓	✓	✓	✓	✓
Sealed tip/tilt double covers integrate flame arrestors for added safety	✓	✓	✓	✓	✓	✓	✓	✓
Maintenance free vents increase battery life and prevent terminal corrosion	✓	✓	✓	✓	✓	✓	✓	✓
Integrated folding handles allow easy carrying and installations	✓	✓	✓	✓	✓	✓	✓	✓
Terminal guards and post protectors guard against short circuits	✓	✓	✓	✓	✓	✓	✓	✓
100% recyclable materials	✓	✓	✓	✓	✓	✓	✓	✓
Designed for Industry Leading Performance in Start-Stop and Commercial, Transport and Transit Vehicles	MIXTECH batteries are specifically designed for high-performance commercial vehicles and are the state of the art in acid stratification and vibration resistance. Enhanced battery technologies (EFB & EGM) ensure reliable performance for all highly demanding applications.							
Thick High Cycle plates for improved capacity and cycle life	✓✓✓	✓✓✓	✓✓	✓✓	-	-	-	-
PE+GM separators improve cycle life and vibration resistance	✓✓✓	✓✓✓	-	-	-	-	-	-
Fiber-Lock plate lamination improves active mass adhesion	✓	✓	✓	✓	✓	✓	✓	✓
Envelope Separators prevent short circuits	✓	✓	✓	✓	✓	✓	✓	✓
Virtually eliminates Monday morning no-starts	✓✓✓	✓✓✓	✓	✓	-	-	-	-
Maintains vehicles start-stop functionality delivering desired CO^2 savings ❖	✓✓✓	✓✓✓	✓✓	✓✓	✓	✓	-	-
When left discharged for extended periods of time, charge acceptance will exceed 25 amps within 60 minutes of re-start	✓	✓	✓	✓	✓	✓	-	-
Complies with Off-Road Machine cold cranking requirements (ORMCCA) (SAE J930) (Table 2)	✓✓✓	✓✓✓	✓	✓	-	-	-	-
Exceeds OEM battery life in vehicles equipped with advanced start-stop systems and regenerative breaking (according to independent testing DIN 75073.7.14) (Table 2)	✓	✓	-	-	-	-	-	-
Exceeds OEM battery life in vehicles equipped with advanced start-stop systems (according to independent testing DIN 75073.7.14) (Table 2)	✓	✓	✓	✓	-	-	-	-
Proven to deliver up to four times the life of competitors replacement market EFB batteries in start-stop anti-idle applications according to OEM TEST STANDARD 75073.7.14 (Table 2)	4x	4x	2x	2x	1.5x	1.5x	x	x
Delivers up to four times the Industry Standard life at extreme temperatures. (SAE J240 75°C / 167°F cycle life)	4x	4x	3x	3x	2x	2x	x	x
Exceeds COMMERCIAL battery industry average standards when subjected to rigorous discharge-charge cycles (SAE J3060 - J2185.2012 -Table 2-)	4x	4x	2x	2x	1.5X	1.5X	200	200
Compliant with JIS D5301:2006 Commercial battery standards	✓	✓	✓	✓	-	-	-	-
Exceeds EN Heavy and Super Heavy Duty Battery requirements	EN4	EN4	-	EN3	-	EN2	-	-
Designed, Built and Tested for Best in Class Quality and Value								
Exceeds AGM performance at a lower cost	✓	✓	-	-	-	-	-	-
Exceeds EFB performance and life at a lower cost	-	-	✓	✓	✓	✓	-	-
Exceeds OEM replacement part quality at a lower cost	✓✓✓	✓✓✓	✓✓	✓✓	✓	✓	-	-
Backed by a strong industry leading Manufacturers free replacement warranty	3 year	3 year	2 year	2 year	1 year	1 year	-	-

■ Acid stratification happens naturally and is accelerated if (1) the battery operates in a partial State of Charge (below 80%); (2) the battery seldom receives a full charge, (3) the battery is constantly cycled, and (4) the battery is left standing for long periods of time. Driving vehicles for short distances with power hungry accessories engaged contributes to acid stratification. Large luxury cars and commercial vehicles are especially prone to acid stratification. Newer start-stop vehicles are extremely prone to acid stratification. Acid stratification is application related and is not a battery defect per se but represents the largest portion of battery warranty costs. Discover's award winning 360° acid mixing technology more than doubles the life of any flooded lead acid battery chemistry by eliminating acid stratification, the #1 killer of lead acid batteries.

❖ MIXTECH batteries maintain dynamic charge acceptance (DCA) up to 3 times greater than conventional, EFB or AGM batteries when used in severe duty and partial state of charge (PSOC) use. Higher DCA allows more energy to be recovered and stored faster allowing the battery to support electrical loads for longer periods of "no-alternator" operation. This saves fuel! Fuel savings are also secured because the stop-start function in many cars can also be better utilized if the battery maintains its DCA and is able to recover and store more current. Typical stop-start technology becomes disabled if the battery's state of charge becomes too low until the battery recharges which reduces fuel saving possibilities. The better a battery's DCA, the more efficiently the batteries active materials are utilised and the greater the number of full capacity cycles and stop-start events it can support, and the greater the fuel savings. Typical lead acid batteries start with a relatively high DCA but this degrades rapidly with use stabilizing within a few short months of use at around 30% to 50% of its original DCA[2].

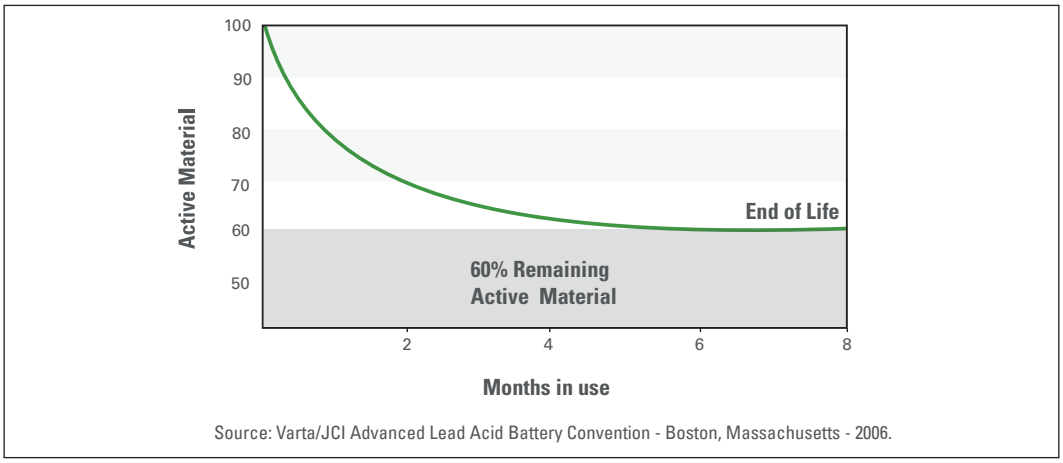
◆ MIXTECH batteries - within 6 months in service - maintain a DCA up to 3x higher than any lead acid battery without MIXTECH

✱ **XVR** not available on all models

2 Characterization of Dynamic Charge Acceptance for Lead-Acid Batteries in Micro-Hybrid Vehicles. Heide Budde-Meiwes*1, Dominik Schulte2, Julia Kowal1, Dirk Uwe Sauer1, Ralf Hecke3, Eckhard Karden4, 1Electrochemical Energy Conversion and Storage Systems Group, Institute for Power and Electrical Drives (ISEA), RWTH Aachen University, Germany, Jägerstraße 17-19, 52066 Aachen, *batteries@isea.rwth-aachen.de

GLOSSARY		
EMX Premium Battery with 360° MIXTECH Technology	**EFB** Enhanced Flooded Battery with 360° MIXTECH Technology	**EGM** Enhanced Glass Mat EFB battery with 360° MIXTECH Technology
AGM Absorbed Glass Mat	**AH** Amp Hour	**CCA** Cold Cranking Amps
HD Heavy Duty	**OEM** Original Equipment Manufacturer	**PE** Polyethylene
PSOC Partial State of Charge	**SHD** Super Heavy Duty	**SOC** State of Charge
TCO Total Cost of Ownership		
DCA Dynamic Charge Acceptance. A measurement of the battery's ability to absorb a charge in relation to the capacity of the battery expressed in Amps per amp hour of battery capacity.		

FIGURES & TABLES



Source: Varta/JCI Advanced Lead Acid Battery Convention - Boston, Massachusetts - 2006.

Figure 1

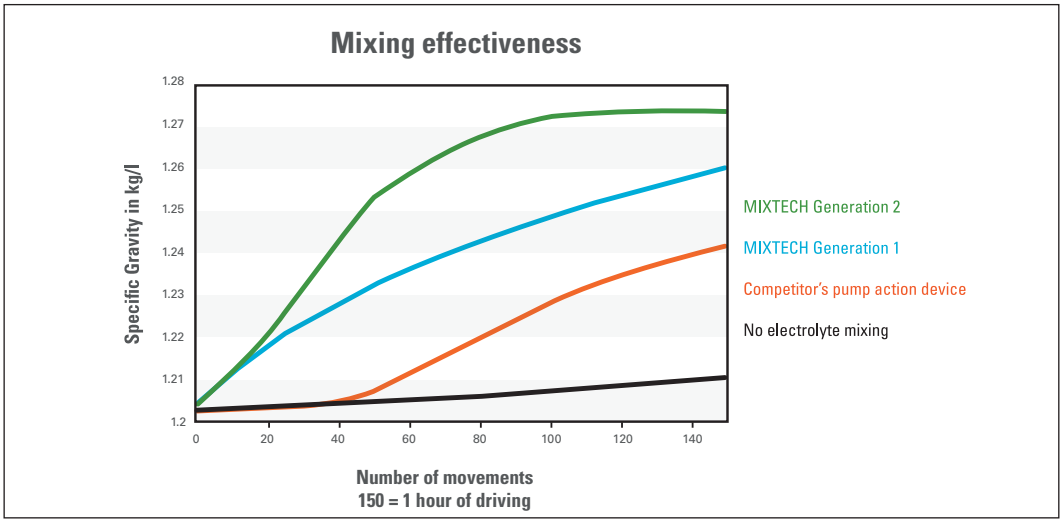


Figure 2

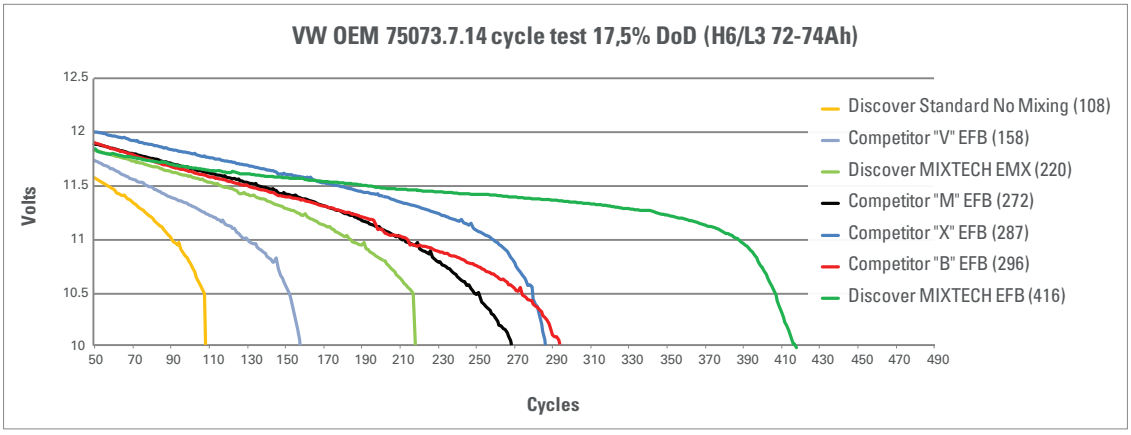


Figure 3

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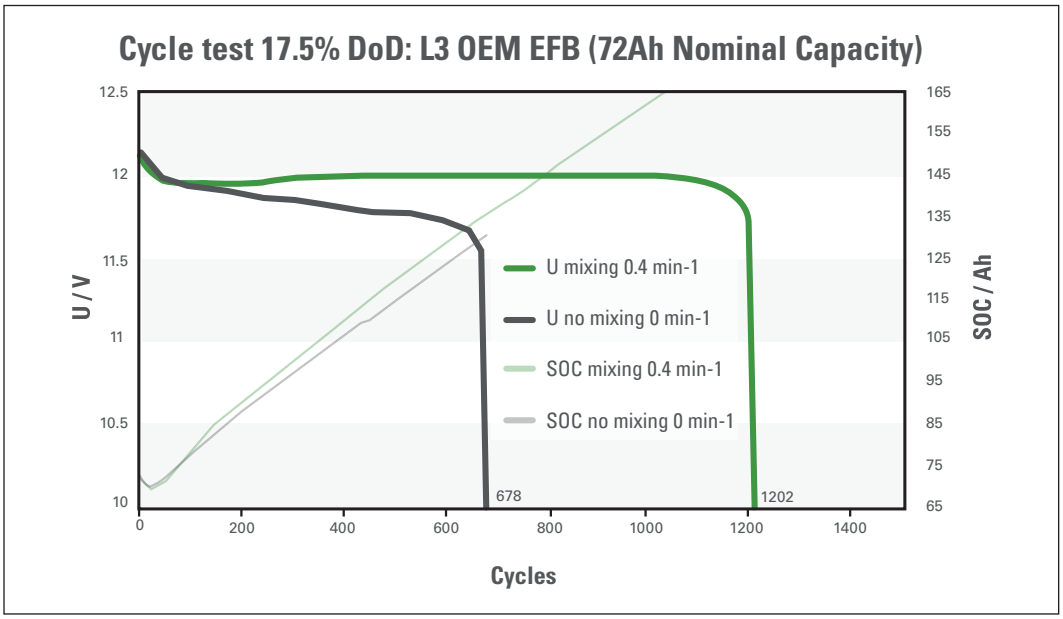

Figure 4

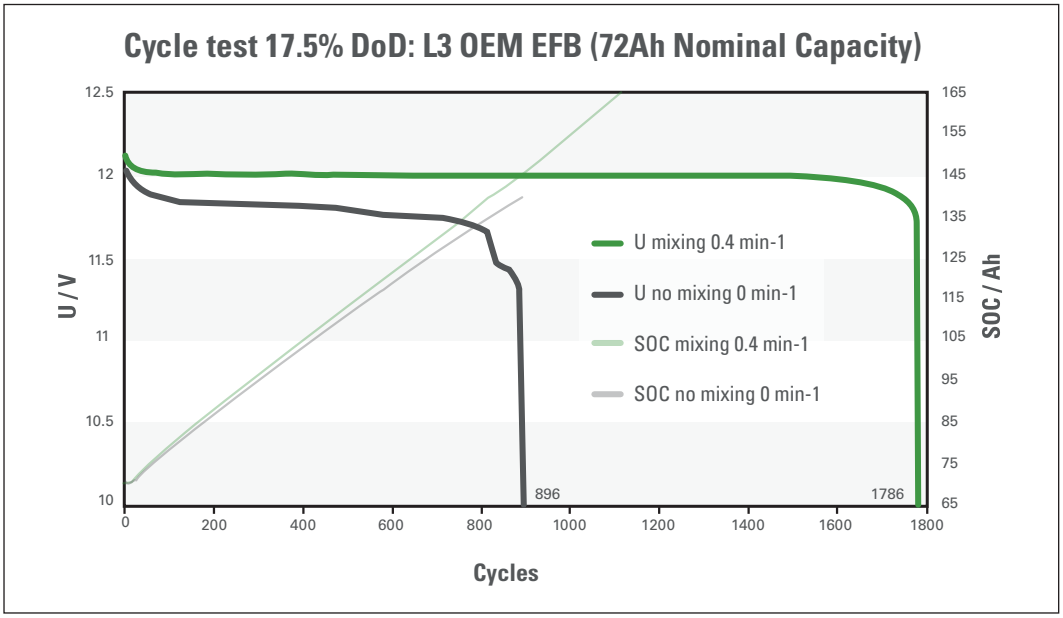

Figure 5

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What happens in a Stratified Battery vs. a Battery with Homogeneous Acid

CONDITION / FEATURE	ACID STRATIFICATION Top of Cell	HOMOGENEOUS Throughout	ACID STRATIFICATION Bottom of Cell
Specific Gravity	1.18 S.G at the cell top	1.28 S.G throughout the cell	1.35 S.G at the cell bottom
Electrolyte Conductivity	76 $m\Omega cm^{-2}$ *	82 $m\Omega cm^{-2}$ *	68 $m\Omega cm^{-2}$ *
Electrolyte Freezing point °F / °C	-4° / -20°	-76° / -60°	-49° / -45°
Positive Grid Corrosion	Accelerated	Standard	-
Negative Lug Corrosion	Accelerated	Standard	-
Charge Acceptance	High	Standard	Low & Degraded
Discharged Sulfate Concentration (SULFATION)	Low	Standard	High & Degraded
Active Material Stability	Unstable / Brittle	Standard	Unstable/Soft/Shedding
Internal Resistance to Charge Acceptance	Low	Standard	High & Increasing
State of Charge Readings	False	Generally Correct	False
Battery Condition or Status	Prematurely Failing	Normal Aging	Prematurely Failing

* LABAT 2017, Golden Sands, Bulgaria, June 13-16, 2017 Copyright Johnson Controls 2014

Table 1

OEM Start-Stop, Anti-Idle and HD Commercial Vehicle Battery Testing
VW 75073.14 vs. SAE J3060 Performance Results (historical J2185)

VW 75073.7.14 OEM Test Standard	SAE J3060 (Old J2185) test Criteria
Alternate charge and discharge	Alternate charge and discharge
Discharge at 17.5% of I20	Discharge 25A
Discharge for one hour	Discharge for one hour
Charge at 14.4CV	Charge 25A at 14.8V for 2.5 hours
No condition charge allowed	Condition Charge to eliminate ACID STRATIFICATION - every 26 cycles
No Rest	Rest
Repeat until discharge voltage fails to maintain above 10.2V	Test at rated CCA for 50S. Must pass above 7.2V
Temperature 25°C/77°F	Repeat every 26 cycles
	Temperature 50°C/122°F

Table 2

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APPENDIX

PASSIVE MIXING ELEMENTS FOR ELECTROLYTE CONVECTION IN FLOODED LEAD ACID BATTERIES STUDY

Chemie IngenieurTechnik's study provides information about the effectiveness of passive mixing elements, resulting in homogeneous electrolyte and increase of the battery life.

Chemie Ingenieur Technik — Passive Mischelemente 1

Forschungsarbeit

Passive Mischelemente zur Elektrolytkonvektion in Blei-Säure-Nassbatterien

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Blei-Säure-Nassbatterien für Mikro-Hybrid-Fahrzeuge, die im Start-Stopp-Betrieb und damit in einem Teilladezustand betrieben werden, unterliegen einer starken zyklischen Belastung. Daraus resultiert unter anderem eine inhomogene Säuredichteverteilung, die zu frühzeitigem Kapazitätsverlust führt. Zum Ausgleich von Inhomogenitäten innerhalb des Elektrolyten wurden passive Mischelemente eingesetzt. Zur Beurteilung der Wirksamkeit dieser passiven Mischelemente wurden Blei-Säure-Nassbatterien im Labor gealtert. Die Ergebnisse zeigen, dass Mischelemente zu einer Homogenisierung des Elektrolyten und damit zu einer um den Faktor 6 verlängerten Lebensdauer führen, wobei die Wirkung der Mischelemente umso stärker ist, je höher die Beschleunigungen im Fahrzeug sind, denen die Batterie ausgesetzt ist.

Schlagwörter: Blei-Säure-Nassbatterien, Elektrolytkonvektion, Mikro-Hybrid-Fahrzeuge, Passive Mischelemente, Säureschichtung

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Passive Mixing Elements for Electrolyte Convection in Flooded Lead-Acid Batteries

Flooded lead-acid batteries that are used in micro-hybrid vehicles in start-stop mode – and as a result operate in a partial state of charge – are subjected to immense cyclic loads. This results in inhomogeneous acid density distribution, which in turn causes premature capacity loss. Passive mixing elements were used to offset inhomogeneities in the electrolyte. To assess the effectiveness of the passive mixing elements, flooded lead-acid batteries were aged in a laboratory. The results show that the mixing elements homogenize the electrolyte and in doing so increase the life of the battery by up to a factor of 6. The effect increases the greater the acceleration of the car that contains the battery.

Keywords: Acid stratification, Electrolyte convection, Micro-hybrid vehicles, Passive mixing elements

1 Einleitung

Um das Ziel der Reduzierung klimaschädlicher CO_2-Emissionen zu erreichen, verfolgt die Automobilindustrie die Entwicklung verschiedener alternativer Antriebskonzepte zur Minderung des Kraftstoffverbrauchs. Hierzu gehört unter anderem die Mikro-Hybrid-Technologie, die über Funktionen wie Start-Stopp und regeneratives Bremsen verfügt. Das Start-Stopp-System veranlasst bei Fahrzeugstillstand eine automatische Motorabschaltung, z. B. an einer roten Ampel oder im Verkehrsstau. Alle elektrischen Geräte, die an das Bordnetz angeschlossen sind, erhalten bei Abschalten des Motors Strom von der Starterbatterie. Beim regenerativen Bremsen wandelt der Generator die kinetische Energie des Fahrzeuges in elektrische Energie um, die zum Laden der Batterie genutzt wird. Diese Betriebsmodi führen zu einer erhöhten Anzahl an Batterielade- und -entladevorgängen. Insbesondere hohe Ladeströme und Tiefentladungen führen zu einer inhomogenen Dichteverteilung der in der Batterie verwendeten Schwefelsäure, die sog. Säureschichtung. Säureschichtung baut sich aufgrund von elektrochemischen Prozessen auf. Beim Entladen, in Gl. (1) und (2) von links nach rechts dargestellt, wird Säure verbraucht, weil sie aktiver Reaktionsteilnehmer ist. Beim Ladevorgang laufen die Reaktionen von rechts nach links ab.

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