

GS Yuasa E-Learning Support Documentation

Battery Failure Modes

Overview:

This support documentation has been designed to work in conjunction with the GS Yuasa e-learning course “Battery Failure Modes” and covers of the following subjects:

- **Battery failure overview**
- **Battery quality & performance**
- **Service wear & temperature related failure**
- **Sulphation & acid stratification**
- **Deep cycling & charging**
- **Short circuit, dead cell & internal breaks**

Battery failure overview

Battery failure overview

Understanding the life cycle and factors that affect both the performance and failure of Lead acid batteries is key to accurate battery issue diagnosis. Once the condition of a suspect battery has been established it is possible to use this data to identify the reasons for the failure. This can help to prevent further failures for the same reasons by educating end users with good battery care, usage and maintenance advice. To do this we must first understand the life cycle of a Lead acid battery before looking at the reasons for battery failure.

Battery quality & performance

Production cost savings

The mean weight of an OE manufacturer premium brand battery when compared to a private brand battery of the same size and specification is a good quality indicator. Some private brand battery manufacturers limit the amount of materials used in battery construction to reduce costs. The costliest product used in the manufacture of a battery is Lead therefore the Lead content is reduced by using smaller, thinner and fewer plates which reduces battery reliability, specification, performance and lifecycle

Electrolyte ratio

Battery performance and lifespan is achieved using a careful balance of plate numbers and electrolyte acid strength.

Some non-OE brands with reduced lead content may use higher concentrations of acid than OE brands to ensure the battery can deliver the specified performance. However, this higher acid concentration is more corrosive and accelerates the rate of wear and tear, reducing service life. It also limits the length of time the specified performance can be maintained. Therefore, when compared to the OE equivalent, it will deliver the same performance initially, but this will decrease far more quickly.



Battery life cycle

The life cycle of a battery can be split into three phases formatting, peak and decline. Each phase can be adversely affected by battery usage and vehicle operating conditions.

OE battery life cycle

The formatting phase takes place during the first few cycles the battery is subjected to. During this phase the plates act like a sponge, absorbing more electrolyte and swelling. This increases the available plate surface area and therefore the battery capacity cranking amperage and output. When the formatting phase has been fully completed the battery enters the peak phase of power delivery. The battery remains in the peak phase until conditions such as natural wear and tear alongside acid corrosion begin to reduce performance. At this point the battery enters the decline phase where battery performance begins a steady decline as the deteriorating conditions escalate. This reduces the ability of the battery to perform and produce the specified cranking amperage until there is not enough plate surface area available to produce the current required to crank the engine.

Non-OE battery life cycle

As previously described the formatting phase takes place during the first few cycles the battery is subjected to. Plate impurities are burnt off and the plates act like a sponge during this phase, absorbing more electrolyte, effectively increasing the available plate surface area and therefore the cranking amperage output. Once the formatting phase is complete the battery enters the peak power delivery phase which is shorter in duration due to the lower number of plates, reduced lead content in each cell and the increased corrosive effects of higher acid concentration in the electrolyte. At this point the battery enters the decline phase where the effects of natural battery cycling, and the higher corrosive effects of the increased acid concentration escalate resulting in a much sharper and accelerated decline in battery performance reducing the time between the start of decline and eventual battery failure.

Service wear & temperature related failure

Battery application

As we have already covered in the mandatory courses it is essential that the correct battery technology and specification is applied to vehicle type and driving habits. Even when applied correctly a battery is still a consumable item and will deteriorate through the effects of normal wear and tear.

Wear & tear

When in service, each time a battery is cycled i.e. discharged and charged a small amount of the active materials within the battery plates is permanently lost and therefore performance is reduced. Over time and dependent on factors such as operating temperature, operating state of charge and duty cycle this natural ageing process will eventually result in the battery capacity being reduced. While it is impossible to stipulate a maximum or minimum battery life expectancy due to the possible variations in the operating conditions of the battery this ageing and deterioration will eventually result in the failure of the battery to start the engine or power vehicle equipment.

Further information can be found in the battery testing and warranty handling course.



Cold weather failure

Cold weather battery failure is caused by low battery temperatures and increased vehicle cold cranking requirements. Low temperatures slow down the chemical reaction between the battery's plates and the electrolyte. At 0°C a fully charged battery loses approximately 30 percent of its cranking performance, therefore even a new battery will only deliver around two thirds of the specified performance at this temperature. If the battery has also been subjected to wear and tear this 30% loss of efficiency may take it below the level of cranking performance needed to start the engine.

As the temperature falls further cranking performance losses increase. Additionally, reduced temperatures increase the engines cranking requirements as the oil is more viscous and the engine components have a higher resistance to rotation. This increased engine starting requirement added to the battery performance losses are the reasons for cold weather battery failure.

Hot weather failure

During warmer weather, average under bonnet or ambient temperatures over 60°C accelerate the break-up of negative plate material and increase electrolyte evaporation, also a 10°C rise in battery temperature doubles the battery self-discharge rate from approximately 0.1 to 0.2 Volts per month. Both factors significantly reduce battery service life.

Sulphation & acid stratification

Plate sulphation

Plate sulphation is a natural part of the battery discharge process and begins to occur when a battery is discharged to a level of 12.40 Volts. Sulphation is seen as a white/grey coating on the positive plates and a non-metallic lustre on the negative plates.

If the battery is recharged within a short space of time the chemical reaction that creates the sulphation coating during the battery discharge process can be reversed, removing the sulphation from the battery plates and converting it back into sulphuric acid.

If, however the battery is left in a discharged state either on or off a vehicle for a long-time period the sulphate crystals alter state, growing larger and turning into a hard-crystalline material. This coating reduces the chargeable area of the plates and impedes the recharge process, even at very low charge rates, leading to permanent plate damage and increasing the possibility of short circuits and battery failure.

Plate sulphation is more likely to occur if the battery is installed on an infrequently used vehicle, subjected to poor stock control and recharge procedures prior to fitting, undercharged when in service due to loose drive belts, charging system faults or high resistance in battery cables and connections and exposed to uncontrolled extra electrical loads fitted to the vehicle.

The symptoms of sulphation are excessively long battery charging times and a reduced full charged voltage.



Acid stratification

Normally the sulphuric acid within the electrolyte solution is equally distributed throughout each of the cells, therefore, the entire surface area of each plate is in contact with it and the battery will be able to supply the maximum available Cold Cranking Amperage (CCA) and capacity

In a battery with stratified electrolyte, the sulphuric acid is concentrated at the bottom of the cells, resulting in low acid strength in the upper cell area. This limits the plate activation area, promotes corrosion and reduces the performance of the upper cell region. This increased acid strength in the lower area artificially raises the battery voltage so that it appears fully charged but provides low cranking performance. Acid stratification also results in the plates in the lower cell area becoming heavily sulphated resulting in premature battery failure.

Acid stratification can be caused by constantly keeping a battery below 80% state of charge, short distance driving while using a lot of electrical consumers and is also more likely in the winter as cold temperatures mean it takes longer to charge the battery.

Deep cycling & charging

Deep cycling

As a battery is cycled normally through a discharge and recharge phase, a small amount of the plate material is permanently lost as it reacts with the sulphuric acid in the electrolyte to produce current.

If a starter battery is subjected to deep discharging more than 35% and rapidly recharged this process of plate material loss is accelerated and large amounts of active material are permanently lost causing permanent and irreversible damage. If the battery is not fully recharged, excessive grid corrosion will also occur resulting in premature failure.

Even after recharging the battery the Open Circuit Voltage (OCV) will be low (Less than 12.40 Volts) but if the Specific Gravity of each cell is checked the results will generally be approximately the same.

This type of failure is common on taxis, delivery and passenger service vehicles.

Overcharging

Overcharging can occur if the vehicle charging system or alternator is faulty, or if incorrect off-vehicle charging procedures and equipment are used. In this scenario, the battery will overheat causing electrolyte evaporation, break-up of the positive plates reduced battery performance and premature failure.

Tell-tale signs of overcharging include a strong hydrogen sulphide or rotten egg odour, low electrolyte levels, and a black coating on cell filler plugs.

Undercharging

Undercharging is the opposite of overcharging and occurs if the battery does not receive enough charge to charge it fully and if left undiagnosed slowly causes plate sulphation to occur.

The causes of undercharging are usually the same as those for plate sulphation and include using the vehicle occasionally for short journeys or start/stop urban motoring only, low alternator charging voltages (13.60 – 13.80 Volts), loose alternator drive belts and worn battery cables that have a high resistance.



Short circuits, dead cells & internal breaks

Short circuit & dead cells

Short circuit, dead cell and internal break conditions are typically seen within the first 12 months of a battery's service life and it is possible to identify a short circuit or dead cell with most conductance testers.

A voltage of approximately 10.50 Volts on a fully charged battery is usually also an indication of a dead cell and when the Specific Gravity of the electrolyte in each of the cells is checked one will give a dramatically lower reading than the others which should give a value of 1.26 and above. Also, when the battery is subjected to a high discharge the cell in question will also usually boil visibly.

Internal Breaks

An internal break results in the battery circuit becoming incomplete therefore no voltage will register when tested. A battery in this condition would give a good Specific Gravity reading from each cell (1.26 and above) but no Open Circuit Voltage (OCV) when measured.

