GS Yuasa E-Learning Support Documentation

Lead Acid Battery Construction

Overview:

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

- **Battery components overview**
- **Container & lid**
- **Grids, plates, elements & separators**
- **Final assembly & filling**
- **Charging & formation process**
- **Finishing & labelling**

Battery components

Overview

GS Yuasa lead acid batteries are manufactured from the following separate components using quality materials and state of the art assembly procedures:

- Container
- Lid
- Plates
- Separators
- Electrolyte
- Inter-connectors
- Terminals

Container & lid

Container

GS Yuasa vehicle battery containers are manufactured in a single piece from injection moulded polypropylene and industrial battery containers from Acrylonitrile Butadiene Styrene or ABS.

The container is divided into equal sections called cells. The number of cells is dictated by the voltage of the battery, 3 cells for a 6 Volt battery and 6 cells for a 12 Volt. For a typical 12 Volt automotive battery the container is partitioned into six equal sections called cells.

The internal base of the container also features recesses which are used as sediment chambers to collect any active material shed by the electrodes (plates). This helps to prevents internal battery short circuits as the sediment contains lead which is electrically conductive.

Lid

The lid is manufactured from injection moulded polypropylene with holes for the positive (+) and negative (-) terminals and dependent on battery type and specification can have the following design features:

- Gas recombination labyrinth
- Flame arrestor valve to prevent any external source of ignition entering the battery
- Pressure relief valve to release any excess pressure created during operation
- State of charge indicator to give a visual guide to battery voltage
- Vent pipe aperture for open vent types
- Cell caps apertures for maintenance if required

Once the internal construction of the battery is complete the lid is fitted and sealed to the case.

Grids, plates, elements & separators

Grid function & manufacture

The grids have a dual function. Firstly, they provide mechanical support for the active material paste that reacts chemically with the electrolyte to produce and store electrical energy. Secondly, the grid is used to transport the electrical energy produced by the chemical reaction out of the battery via the current collection tab, intercell connectors and terminals.

Depending on the battery specification the grids are manufactured from alloys of lead antimony or lead calcium using one of the following techniques:

- Casting
- Expanding
- Punching.

Cast grids

Cast grids are formed in a mould from molten Lead alloy. The molten Lead alloy is poured into the top of a mould of a complete grid, including the current collection tab, and allowed to fill the mould using gravity. Gravity filling of the mould ensures any air is forced out as the molten lead alloy is poured reducing the number of imperfections or blowholes in the finished grid as it cools. Production of cast type grids in this way is very labour intensive and costly therefore a modern, more efficient process known as continuous casting or concast has been developed which is a high speed continuous automated version of the standard casting process.

Expanded grids

Expanded grids are manufactured using a continuous automated process. The Lead alloy strip is passed through a slitting machine where it is pierced, stretched and then expanded to form a grid with a diamond pattern. The grid is then cut from the roll.

Expanded type grids have a higher resistance to corrosion but a resistance to active material paste bonding/curing. Production of expanded type grids is very cost effective as expanded grids are approximately 25% the weight and 20% the thickness of a cast type grid

Punched foil grids

Punched foil grids are also manufactured using a continuous automated process. A rolled lead alloy sheet is fed through a stamping machine that punches the grid from the sheet using a die. This production process also features an improved active material paste bonding and curing process which increases plate and battery life.

The use of foil grids increases CCA delivery over an expanded grid comparable battery and improves the ability of the battery to recover from deep discharge Punched foil type grids also have a higher resistance to corrosion over expanded.

Performance optimised grids

Performance optimised grids can be manufactured using either a casting or punching process and have been designed to reduce the grid's electrical resistance increasing the battery's ability to quickly supply high levels of current.

The grid wires around the current collection tab carry the high currents generated by the whole grid during battery discharge. Performance optimised grids reduce the resistance in the grid area around the current collection tab. The reduction in resistance ensures the fast delivery of the high currents required during the cranking phase.

Performance optimised grids have the following design features:

- Different thickness grid wires (Thickness increases nearer to current collection tab)
- Increased number of vertical grid wires
- Use of diagonal grid wires

Plates (Electrodes)

Once manufactured the grids have an active paste material applied to their surface. Positive plates are formed using the grid as a skeletal support and applying a paste of Lead Oxide (PbO), Lead Sulphate ($PbSO_4$) and a mixture of other materials as well as Sulphuric acid (H_2SO_4) and water (H_2O). Negative plates are formed in the same way however an expander material of powdered Sulphates is added to the paste material which gives the battery good discharge performance at low temperatures. The complete plates are then dried in an oven to cure and harden the paste and bond it to the grid. The paste is the material that reacts with the sulphuric acid in the electrolyte solution to produce and store electrical energy.

Separators

Once the positive and negative plates have been formed and have cured they are placed together alternately in a plate pack. To prevent short circuits between the positive and negative plates they must be kept apart. To do this an insulating separator is inserted in between the plates to prevent any contact.

Separators are thin sheets of insulating material which are resistant to both the high temperatures and strongly acidic oxidizing conditions inside the battery.

The separators are manufactured from either:

- Thin envelopes of microporous polyethylene
- Sheets of paper
- Glass fibre matting.

Separators made from microporous polyethylene feature very small holes which allows the acid in the electrolyte solution access to the active material paste enabling the chemical reaction that produces and stores electrical energy to take place when discharging or recharging the battery.

Plate pack

Once the plates and separator pack has been assembled all the negative plates in the pack are connected and all the positive plates are connected via their current collection tabs.

The number of plates in a pack is dictated by the required battery specification. Higher specification batteries will always contain more plates per pack than lower specification products.

Final assembly & filling

Assembly

One plate pack is inserted into each cell of the battery container with the positive and negative post lugs in the correct position for lid installation.

Once a pack has been inserted into each cell in the battery container each cell is then connected in series using an electrically conductive inter cell connecting plate or over partition cell connector. Positive plates in one cell to the negative plates in the adjoining cell to achieve the required battery voltage.

The battery lid is installed, and heat sealed or glued to the container. The positive and negative posts are then welded to the relevant post lug and the complete battery pressure tested for leaks.

Electrolyte filling

It is then filled with an electrolyte solution typically made up of approximately 35% concentrated sulphuric acid (H_2SO_4) and 65% deionised water (H_2O).

The strength or ratio of acid in the electrolyte solution has a direct relationship to the batteries performance and service life. Higher acid concentrations increase plate corrosion, paste deterioration and therefore reduce battery life.

At this point industrial product has a high voltage test carried out to ensure there are no pin hole leaks in the case. This is known as a pin hole test.

Charging & formation process

Once the battery has been fully assembled it must be finished using a process known as formation charging.
To do this the battery is connected to a direct current charging device for several hours and charged to a nominal voltage. For a lead acid battery, the nominal voltage is 2 Volts per cell which is the mid-point between the fully charged and fully discharged state. However, when the battery has rested and stabilised after charging, the actual voltage will be approximately 2.12 Volts per cell After charging any capacity testing will be carried out.

When the formation charging process is complete the positive plate paste becomes lead dioxide (PbO_2) and the negative plate paste porous lead (Pb).

Finishing & labelling

The battery is then cleaned, and the relevant labels are applied. All GS Yuasa batteries are manufactured and labelled in compliance with all required European and international standards.

Battery specification labels are not always a true indication of battery performance and are therefore regulated by the EU Commission (EU1103:2010) which dictates that:

- The label must accurately reflect the rated CCA & Ah specification of the battery
- For every reference, 100% of supplier battery stock must have at least 95% of the stated 20hr capacity and 100% of stated CCA capacity specification
- Minimum label font sizes require compliance