GS Yuasa E-Learning Support Documentation

Battery Testing & Warranty Handling

Overview:

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

- **GS Yuasa warranty conditions**
- **Battery visual inspection**
- **Testing methods & equipment**

GS Yuasa warranty conditions

Warranty statement

GS Yuasa batteries have a warranty against premature failure due to manufacturing or material defects for a period of 12 months. Most distributors and retailers will offer a longer warranty; however, this is administered independently of GS Yuasa.

In the event of a warranty claim, the battery must be returned to the original seller with proof of purchase. Subject to a visual inspection and testing by the seller, the battery will be exchanged free of charge if deemed to have failed under warranty conditions.

Points of reference

There are several points that must be taken into consideration when dealing with a warranty claim:

- The distributor has the right to test and if necessary charge the battery before agreeing to a claim against the Yuasa warranty
- This does not affect the statutory rights of the customer in any way
- The Guarantee is subject to the Terms and Conditions of Sale of GS Yuasa Battery Sales (UK) Ltd
- The Yuasa warranty is only valid for the purchaser of the battery and is in no way transferable

The warranty starts from the date of purchase of the original battery. If the battery is subsequently replaced under warranty the new battery is subject to the warranty sold with the original battery and is not renewed or extended because of the replacement.

Recommended market warranties & exclusions

GS Yuasa recommend market warranties are based on battery type, technology, specification and application. These can be adjusted to suit each distributor’s internal warranty conditions. There are also a range of exclusions to the manufacturer’s warranty based on battery use in high abuse applications.

The GS Yuasa battery warranty does not cover failure resulting from wear and tear, misuse and negligence either before or during use. Examples of this are:

- Sulphation
- Undercharging
- Deep cycling
- Overcharging
- Physical damage
- Incorrect battery application
- Failure resulting from the use of any fluids other than distilled or deionised water, or from any action not recommended for Yuasa batteries

NOTE: No warranty claim will be actioned without dated proof of battery purchase.

Visual inspection

GS Yuasa pre-consignment dispatch inspection

Before GS Yuasa batteries are shipped a rigorous condition and quality checking procedure is carried out during the picking process. Batteries that fail to pass the quality checking procedure are not shipped for delivery. All batteries are inspected for damage throughout the picking process and are photographed prior to dispatch to ensure shipping quantity and quality targets are met. Once visually inspected and photographed battery pallets are then heat shrink wrapped. This acts as a security seal and if damaged is a clear indication of consignment mishandling.

NOTE: If when delivered battery damage is identified notification of said damage must be sent to GS Yuasa Battery Sales (UK) Ltd. by e-mail within 48 hours of delivery taking place. The customer also has the right to refuse delivery if battery damage is identified by inspection of the consignment on arrival

Warranty returned battery visual inspection

Pre-inspection checks

Before carrying out any battery tests using battery test equipment a visual check of the batteries condition must be made. This must be done to firstly confirm the warranty period is applicable to the battery, its usage and its condition.

Begin by checking that it is the correct specification and technology battery for the vehicle using the appropriate GS Yuasa Battery Look-up. Then check that the purchase date falls within the warranty period and the unique ID number on the recharge label is the same as the one recorded on the original proof of purchase. The warranty is deemed invalid if the recharge label has been removed as there is no way to tell if this battery is the one originally purchased.

If the battery complies put on the appropriate personal protective equipment and carefully examine the battery for signs of the following conditions that will invalidate the warranty:

- Electrolyte leaks
- External damage
- Swollen container
- Terminal damage & corrosion
- Overfilling
- Cloudy and discoloured electrolyte

Electrolyte leaks & external damage

Check the battery for signs of any external damage which may also be the cause of electrolyte leaks.

Swollen container

A swollen battery may be a sign that it has been left in a discharged state for extended time periods, resulting in permanent damage caused by sulphation. It may also be a result of overcharging which causes heat and pressure to deform the battery case.

Terminal damage & corrosion

Check the battery terminals and surrounding area for signs of any damage caused by incorrect lead connection. Examples of this are terminal clamps forcibly removed or installed and incorrectly tightened which cause arcing and melting of the terminals. Both can cause serious damage.

Overfilling

If the battery is not a sealed type and has an open vent, check for signs of acid leakage. Overfilling when in service can cause electrolyte to leak during normal operation. This is because the electrolyte heats and expands during charging increasing the electrolyte level to a point where it leaks from the vent aperture.

Cloudy or discoloured electrolyte

On non-sealed types remove the battery filing plugs and check for cloudy or discoloured electrolyte, which indicates overcharging or excessive vibration in service.

NOTE: If any of these conditions are found during inspection the warranty claim should be rejected as the battery has failed due to in-service abuse.

Testing methods & equipment

Introduction

Traditionally testing has been carried out using techniques and equipment that pose a serious Health & Safety risk. These include:

- Hydrometer and refractometer specific gravity testing that require potentially hazardous electrolyte samples to be removed from each cell and analysed.
- High rate discharge and drop testing which requires the battery to be fully charged and then excessively discharged. This causes damage during testing and generates dangerous sparks and heat.

Specific gravity testing

The condition of the electrolyte in a battery varies depending on its state of charge. The change in the characteristics of the electrolyte affects its specific gravity and by measuring this we can determine the state of charge of the battery.

‘Specific Gravity’ is a term meaning ‘Exact Weight’ and is used to describe the comparison in the weight of a volume of liquid with the weight of an equal volume of water at the same temperature.

For example, the weight of 1 litre of water (H_2O) compared with the weight of 1 litre of Sulphuric acid (H_2SO_4).

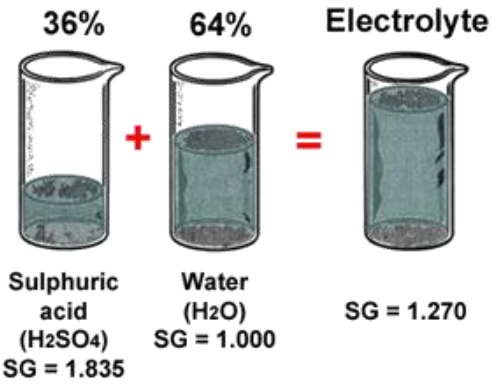
When the two liquids are weighed the scales would drop on the side of the Sulphuric acid (H_2SO_4). This indicates that 1 litre of Sulphuric acid (H_2SO_4) is heavier or has a higher Specific Gravity than water (H_2O).

Water (H_2O) has a Specific Gravity of 1.000 and weighs approximately 1Kg per litre, Sulphuric acid has a specific gravity of 1.835 and weighs approximately 1.8 Kg per litre.

If Sulphuric acid (H_2SO_4) is diluted with water (H_2O) and the same experiment was carried out the scales would still tip in the direction of the acid/water solution, but the degree of scale movement would be proportional to the concentration of Sulphuric acid (H_2SO_4) in the diluted solution.

Lead acid battery electrolyte is a mixture of Sulphuric acid (H_2SO_4) and water (H_2O). From this we can say the following:

- High electrolyte acid concentration the higher the specific gravity
- Low electrolyte acid concentration the lower the specific gravity



A fully charged battery has a high Sulphuric acid (H_2SO_4) concentration in the electrolyte and therefore a high specific gravity because the chemical reaction used to produce an electrical charge has not broken down the acid.

A discharged battery has a low Sulphuric acid (H_2SO_4) concentration in the electrolyte and therefore a low specific gravity because the chemical reaction used to produce an electrical charge has broken down the acid and formed water (H_2O).

By measuring the Specific Gravity of the electrolyte in each cell it is possible to check the condition of the battery and determine if the battery is:

- Fully charged
- Discharged
- In need of replacement

Specific gravity testing equipment

Specific gravity test can be performed using the following equipment:

- Hydrometer
- Refractometer

Hydrometer

A hydrometer consists of a glass barrel and a bulb syringe which is used to draw up a sample of the electrolyte in a battery cell. This is achieved using the vacuum created by compressing the bulb prior to submerging a pick-up pipe below the level of the electrolyte in the cell.

Within the glass barrel is a graduated float which is calibrated to read Specific Gravity. When electrolyte is drawn up into the glass barrel the float rises. The depth to which the float sinks in the electrolyte indicates the Specific Gravity of the electrolyte compared to that of water.

The Specific Gravity of battery electrolyte changes with temperature, therefore temperature correction is required:

- Low temperatures thicken the electrolyte and increase the Specific Gravity reading
- Hot temperatures thin the electrolyte lowering the Specific Gravity reading

Hydrometers are calibrated at approximately 27°C (80°F) therefore Specific Gravity measurements taken when the electrolyte is above or below this temperature will require adjustment.

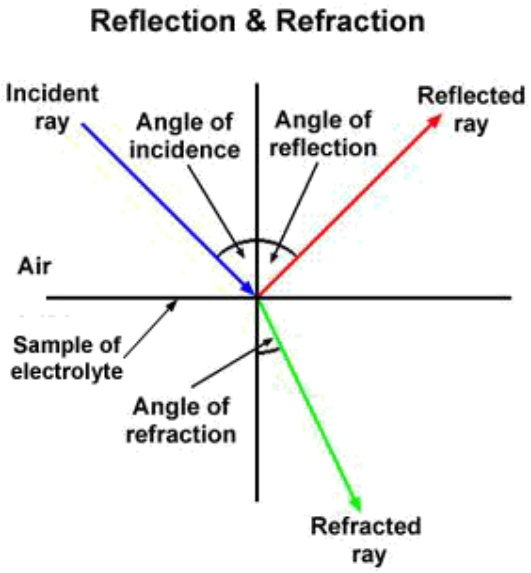
Temperature ºC	Temperature ºF	Adjustment
71	160	+0.032
65.5	150	+0.028
60	140	+0.024
54.5	130	+0.020
49	120	+0.016
43	110	+0.012
37.5	100	+0.008
32.5	90	+0.004
27	80	0
21	70	-0.004
15.5	60	-0.008
10	50	-0.012
4.5	40	-0.016
-1	30	-0.020
-6.5	20	-0.024
-12	10	-0.028

Refractometer

A refractometer is a handheld optical instrument used for measuring the refractive index of a substance using the critical angle principle. It utilizes lenses and prisms to project a shadow line onto a small glass reticle inside the instrument, which is then viewed by the user through a magnifying eye piece.

A sample of a few drops of electrolyte is sandwiched between a measuring prism and a small cover plate. Light waves (incident rays) striking the electrolyte sample are either refracted through it to the glass reticle or totally internally reflected.

Refraction is the change in direction of the light waves (incident rays) due to a change in its speed as it strikes the sample of the electrolyte sandwiched between the measuring prism and cover plate.



Total internal reflection is the return of the light waves (incident rays) after they have struck the surface of the electrolyte sandwiched between the measuring prism and cover plate.

The amount of light refracted or reflected is dependent on the Sulphuric acid content of the sample of electrolyte sandwiched between the measuring prism and the cover plate.

The effect of the Sulphuric acid in the electrolyte on the light rays projects a shadow line that is projected on to graduated Specific Gravity display viewed through the viewfinder.

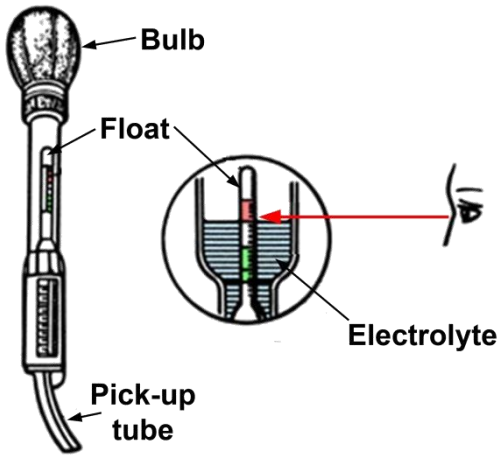
NOTE: Because refractive index is very temperature dependent, it is important to use a refractometer with automatic temperature compensation. Compensation is accomplished using a small bi-metallic strip that moves a lens or prism in response to temperature changes.

Specific gravity test procedure

Prior to carrying out a Specific Gravity test ensure all appropriate Personal Protective Equipment (PPE) is being worn and all Health & Safety procedures are being followed.

Specific Gravity readings can only be taken on batteries where it is possible to access the electrolyte in each individual battery cell via the vent plugs. It is not possible to take specific gravity measurements on sealed batteries as there are no cell access points.

Hydrometer

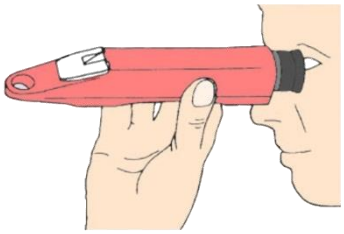


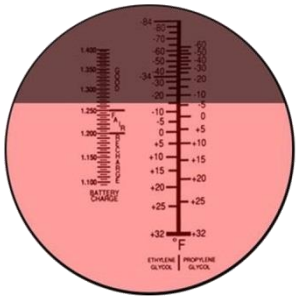
- Remove the battery vent plug from each of the battery cells
- Squeeze the hydrometer bulb and insert the pick-up tube into the electrolyte of the battery cell closest to the positive (+) terminal
- Slowly release the hydrometer bulb to draw in enough electrolyte to cause the float to rise ensuring the pick-up tube remains submerged under the level of the electrolyte
- Read the Specific Gravity reading indicated by the float level in the electrolyte
- Record reading and repeat the procedure for the remaining battery cells

NOTE: Ensure the float is drifting free in the electrolyte and is not in contact with the sides or top of the hydrometer outer glass tube. Always bend down to read the hydrometer float position at eye level disregarding the curvature of the liquid on the float.

Refractometer

- Remove the battery vent plug from each of the battery cells
- Using the dropper (supplied with the refractometer kit) draw a small sample of electrolyte from a cell
- Place one drop of the electrolyte on the refractometer lens and close the prism daylight cover plate
- Hold the refractometer up to the light and look through the viewfinder at the graduated Specific Gravity display
- Record reading and repeat the procedure for the remaining battery cells





Specific gravity test results & calculations

A battery in good condition should have the same specific gravity reading for each cell. The expected tolerance between all six battery cells should be 0.03g/cc e.g. 1.26g/cc to 1.29g/cc

If one battery cell has a specific gravity reading less than the others, the battery should be replaced. For example:

- SG 1.26 SG 1.25 SG 1.25 SG 1.26 SG 1.26 SG 1.15

Once the specific gravity of each cell has been taken the results must be adjusted (hydrometer specific gravity tests only) based on the temperature using the appropriate adjustment figure from the correction table.

Battery electrolyte specific gravity readings have a direct relationship to the voltage of a battery. It is possible to calculate the voltage of an individual battery cell and the total battery using the following formula:

Cell voltage

- Specific gravity reading + 0.845

Battery voltage (12V battery)

- (Specific gravity cell 1 + cell 2 + cell 3 + cell 4 + cell 5 + cell 6 ÷ 6 + 0.845) x 6

For example:

Adjusted specific gravity readings: 1.27, 1.26, 1.25, 1.27, 1.26 and 1.25

Total specific gravity reading: 1.27 + 1.26 + 1.25 + 1.27 + 1.26 + 1.25 = 7.56

Average specific gravity reading per battery cell: 7.56 ÷ 6 = 1.26

Average voltage per cell: 1.26 + 0.845 = 2.105

Total battery voltage: 2.105 x 6 = 12.63V

Specific gravity test result interpretation

Automotive Battery	Typical SG	Typical Voltage
Fully charged battery	1.25 – 1.28	12.57 – 12.75
Partially charged battery (Requires recharge)	1.20 – 1.25	12.27 – 12.57
Low state of charge (Charge immediately)	<1.20	<12.27

NOTES: Insufficient charging of a flat battery may lead to reduced mixing of the acid in the electrolyte solution above the battery plates. Using a digital multimeter/voltmeter with minimum 2-digit resolution confirm that the stabilised measured battery voltage is equal to the voltage calculated from the specific gravity measurement.

If the readings are not approximately the same continue to charge the battery at the recommended charge rate which can be found in the battery specification section of the Automotive battery catalogue and the required time, which is calculated from the open circuit voltage of the battery.

Open Circuit Voltage	Charging Time (Hours)
>12.40	4
12.31 - 12.40	6
12.21 - 12.30	8
12.11 – 12.20	10
12.01 – 12.10	12
11.91 – 12.00	14
11.81 – 11.90	16
11.71 – 11.80	18
11.00 - 11.70	20

High rate discharge testing

A high rate discharge test is designed to test the ability of a battery to supply a large current. The test subjects the battery to a high amperage discharge for a short period of time to simulate cranking the engine in cold weather conditions.

High rate discharge tests should only be carried out on batteries with a voltage more than 12.50V, which has been checked no less than three hours after the battery has been charged or used. If the battery is not at the required voltage recharge according to the recommended recharge rates and time as previously described.

It is essential that the load applied to the battery in the form of the high rate discharge tester's internal resistor can be adjusted.

The tester's internal resistance must be adjusted to allow a current equal to the following performance ratings of the battery to flow through the tester for 15 seconds:

- Three times the Ampere-Hour (Ah) capacity
- 50% of the Cold Cranking Amps (CCA)

High rate discharge testing result interpretation

If the indicated battery voltage on the high rate discharge tester is stable and above 9.60V the battery is in a satisfactory condition and has no faults.

If the indicated battery voltage on the high rate discharge tester is below 9.60V after 15 seconds and is unstable and falling quickly, the battery should be replaced.

NOTE: Fixed load high rate discharge testers are not appropriate for testing GS Yuasa batteries as they can only apply a fixed load to the battery. This means that the condition of the battery is open to interpretation by the tester operator and is not a decision about battery condition based on definite loads and time periods.

Drop testing

Drop testers consist of a voltmeter to indicate discharge voltage, a fixed value resistor connected to two variable position spikes.

To carry out a battery test the operator presses into the positive and negative terminals of the battery.

When the spikes are pushed into the battery terminals a load is applied to the battery through the resistor and the battery discharge voltage is displayed on the voltmeter.

NOTE: GS Yuasa do not recommend the use of this type of tester for the following reasons:

- **When the spikes are first pressed into the terminal's sparks are produced which are a Health & Safety risk due to the possible presence of the volatile gases produced by Lead acid batteries**
- **A large amount of heat is generated by the resistor during the test which poses a Health & Safety risk**
- **The discharge rate is similar for all battery sizes which does not give an accurate indication of battery condition**
- **Tests carried out on discharged batteries give misleading results**

NOTE: GS Yuasa do not recommend the use of any of the previously described testing methods due to the inaccuracy of the test results and health and safety dangers to the user.

Conductance testing

GS Yuasa recommend using a conductance tester for all warranty and standard battery tests.

Conductance is a unique electrical measurement that determines the state of charge (SOC) measured in Volts (V), available plate surface area and therefore how much power the battery can generate. The conductance value of a battery has a direct relationship with its ability to provide a current, specified as the Cold Cranking Amps (CCA) and is also a good indicator of its State of Health (SOH).

A conductance test checks the ability of a battery to transmit current through its internal structure. The results of this measurement provide a reliable indication of the State of Health (SOH) of the battery which has a direct relationship to its cranking ability.

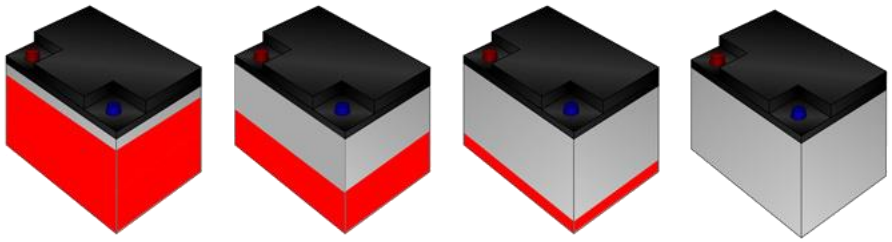
The use of conductance as a method of testing the state of health of a battery has the following advantages over other testing methods:

- Conductance correlates with the ability of the battery to produce current
- No discharge of the battery during the test
- This passive test method is safe, solid and repeatable
- Possibility to test deeply discharged batteries
- Gives a unique indication of the battery's current CCA value
- No external battery or adapter required

Wear & tear

A new, fully charged battery will have a high level of conductance with a reading approximately 10 – 15% higher than the full CCA rating of the battery.

Every time the battery is cycled it loses a small amount of its rated performance specification. These losses can never be recovered and over time its state of health deteriorates, and its performance is reduced. Its internal components wear out because of corrosion and vibration These losses accumulate, and as the battery reaches the end of its service life it can still be fully charged but will have a low state of health. This means that due to the performance deterioration the battery is no longer fit for purpose.



New battery
Rating: 500 CCA
Measured:
600 CCA

Service battery during life
Measured:
450 - 600 CCA

Battery approaching end of life
Measured:
430 CCA

Replace battery
Measured:
350 CCA

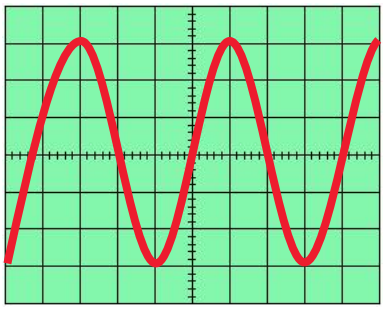
These conditions significantly degrade the performance of the battery and can be measured through its conductance value.

State of charge & state of health

If a battery is in good condition, fully charged and has encountered low levels of wear its state of health will be good. This battery will start the engine and meet the vehicles electrical demands. If it is completely discharged its state of charge will be low, but it's state of health will still be high. This means that after recharge all its cold cranking amps be available.

Conductance testing method

A conductance test checks the ability of a battery to transmit current through its internal structure. The test is carried out by sending a small AC signal through the battery positive pole which passes through the internal structure of the battery where it encounters resistance before returning through the negative pole where it is measured.



Firstly, the tester displays the state of charge as a voltage reading.

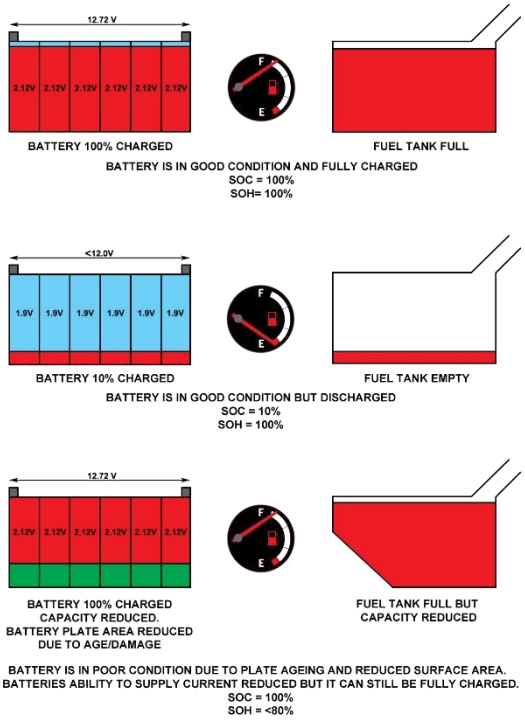
To measure the state of health a fixed frequency AC pulse is introduced into the battery through the positive terminal. The resulting signal measured at the negative terminal is then used in a calculation against a fixed algorithm. The amount of cold cranking amps remaining and therefore the battery's state of health is then displayed.

Conductance testers are usually also capable of detecting cell defects such as short circuits, open circuits and low acid concentrations

Battery condition assessment

The following analogy provides a better understanding of the information provided by a conductance test. A healthy battery, when fully charged, can be directly compared to a vehicle fuel tank when at FULL capacity. A healthy battery, when discharged, can be directly compared to a vehicle fuel tank when at LOW capacity.

When a battery has aged, and its state of health has declined the reduced active plate surface area results in a reduction in the batteries ability to supply current. This can be compared to a damaged fuel tank which has a reduced volume however when the tank is full the fuel gauge still indicates FULL even though its capacity has been reduced.



Conductance testing results & warranty administration

If the battery has passed the visual inspection process carrying out a conductance test will establish if the battery has failed internally due to a manufacturing or material defect. The results displayed on the conductance tester vary depending on its manufacturer and a number test results are possible. Only if the tester indicates BAD CELL should the battery be replaced under the GS Yuasa warranty conditions.

NOTE: There may be other variations of the BAD CELL decision depending on the teste