Subject: Automobile Electrical system Diagnosis & Testing
subject code:3360203

Chapter 1: Diagnosis & Testing Notes on Automobile Battery

Objectives

After studying this chapter on automobile battery the reader should be able to:

1) Identify various battery troubles/Faults and its causes and remedies.
2) Diagnose battery troubles from symptoms causes of battery failure.
3) Explain different tests carried out on battery.
4) Explain charging of the battery.
5) Determine of battery condition and serviceability.
6) Perform periodical checking of the automobile battery

DIAGNOSIS AND TESTING NOTES ON AUTOMOBILE BATTERY

- In normal case the battery light comes on in your car when you turn it on, (ignition) you probably have nothing to worry about. Sometimes the battery light will come on when you start your car, but then the light will quickly flick off.
- This indicates that charging system is OK.

CAN YOU DRIVE YOUR CAR WITH THE BATTERY LIGHT ON?

- The short answer to this is, “Yes.” The full answer is, “Probably not for too long.”
- The car’s battery light coming on generally means that there is something preventing your car’s electric system from the battery charged and thus, the car is running on battery power only.
- It indicates that all electrical system and electrical components are receiving current from battery which will soon be discharged.
- Understand that driving with the light on can cause issues with your battery in the long run, most notably the rapid discharging can cause your battery to also go bad, and not be able to be recharged. Many customers end up replacing the alternator.

MAIN BATTERY TROUBLES:

SIGNS / SYMPTOMS OF A CAR BATTERY TROUBLES

A Sudden, Slower Start

When temps drop below 20 degrees, generally any car's starting will slow down. If you notice this behavior suddenly and the temperature hasn't dropped – a slow, dragging start suddenly begin, get your battery tested as soon as possible.

(If a slow starting battery seems to be able to take a charge and test fine, it's likely that a parasitic drain, or draw is discharging the battery while the vehicle sits, and the electrical system will need to be looked at.)

Dim Headlights and poor Horn

Headlights And Power, But No Start

Your lights work, the radio works, but you get a click or buzz once you hit the key. Or, your headlights are very dim. The purpose of the battery is to crank the engine by providing a full dose of high-amperage power to the starter. When the battery is low, it cannot deliver that power but often can still supply enough power for lights or accessories, that don't require as much amperage. Get the battery tested as soon as possible, and do not rely on the alternator to charge the battery back up!

No Radio

Your radio doesn't turn on. Don't mistake it for a minor inconvenience. When the ignition is in the ON position, the battery will run the radio, windshield wipers, and headlights, among other electronic devices. If these flicker or dim before starting, your battery charge is weak.

Swollen Battery

The battery is fat, or swollen. If the battery swells in size, you should be able to see it. If you have a bloated battery, the alternator has a faulty voltage regulator and has over charged the battery. This over charging of the battery is caused by a buildup of hydrogen gases faster than the battery can dissipate. Damage to the battery has already been done and cannot be reversed.

Odd Smell From Your Battery

If the battery smells – This is a warning sign that your battery is ready to fail, if it hasn't already. Usually, a battery has no smell, by design. If you smell rotten eggs, this means that your battery has vented gas. It has also released sulfuric acid that could harm other parts of your engine. So this smell is potentially the costliest problem listed here if you aren't proactive in fixing it. AutoZone recommends replacing the battery quickly.

Check Engine Light Flashes

The check engine light flashes or stays on constantly. Generally, this light identifies serious problems in your engine that will require costly maintenance. But you may get lucky and discover that it's only your car battery that needs replacement.

Vehicle Starts, then dies Immediately

This is a very strange issue that can indeed happen on certain makes / models of vehicles. The battery will have enough voltage to start the vehicle, but then it immediately dies and will not idle. If you encounter this issue, there are a multitude of things that could be wrong, but doing a simple battery check is the first and easiest place to start. The basis behind this is when a battery fails, it can cause interruptions to the constant signals it sends to the ECU. Then if the battery can muster enough might to start the car, the sensors controlling engine idle, speed, and fueling have already lost signal, and the car immediately dies.

If you're having car battery trouble, it's time for battery testing. If the battery is discharged but still technically sound, we can charge up the battery.

If the battery fails the test, find a suitable replacement.

Uses water in one or more cells—This indicates that the plates are sulfated and that during the charging process, the water in the electrolyte is being turned into hydrogen and oxygen gases.

Excessive corrosion on battery cables or connections—Corrosion is more likely to occur if the battery is sulfated, creating hot spots on the plates.

Slow Cranking and need to press on the gas pedal hard to start.

Clicking Sound when you turn the key(start). This clicking sound is of starter solenoid which receives the signal from battery. But a discharged or failing battery cant supply enough current to Crank the engine.

CAUSES OF BATTERY FAILURE / WHY DO CAR BATTERIES DIE?

Car batteries are designed for one purpose – provide a powerful, quick, high-amperage current to the starter to start the car, and then constantly have this charge of 12.4 volts maintained by the alternator once the car is running. The following things, however, can cause a battery to either not retain that charge, or not supply the proper current to start the car.

- **Slow discharging / recharging:** All batteries, if left untended, very slowly discharge from 12.4 volts. But unlike, the deep-cycle battery, a car starting battery is not meant to be discharged beyond it's starting cycle, and charged again over a multitude of times. when a battery is left in a vehicle that hasn't started for a long period of time, or, the vehicle has a parasitic drain, or draw, that is stealing voltage as the car sits. When this happens, in most cases, the battery must be re-charged. A starting battery loses the ability to be recharged due to wear on a battery where after so many years and start cycles, the battery again loses its ability to maintain a charge.
- **Structural failure:** Batteries are made up of a series of lead grids, submersed in electrolyte, which in this case is Sulfuric Acid. They also live a hard life, being bumped around with a car's movements and suspension, and subject to massive, rapid temperature changes either inside an engine compartment, or going from a hot summer day to freezing temperatures in the winter. Because of this, some batteries can simply have an internal structural failure, which many people have labeled a "dead cell". Many times, failure is due to a loss of electrolyte, which causes one of the grids, or cells, to become exposed to the air. The battery cannot take a charge, and therefore must be replaced when any structural failure happens.

- **Internal short circuit:** It is caused due to failure of separator. If overcharged or poorly maintained battery low electrolyte level will cause sulphate ions to fall down regularly in container forming branched 'tree' like structure which causes internal short circuit.

- **Sulphation:** Excessive sulphation is caused due to battery kept in discharged condition for long time. As a result sulphate ions so formed on the plates will become hard. Also volume occupied by these ions is more than peroxide molecule and so the tend to defom the plate grid if battery is kept in discharged state for long time.

- **Overcharging :** Similar to slow discharging, a rapid overcharge often happens when an alternator – the battery's source for maintaining charge, causes issues. If an alternator begins to over-charge the battery, the electrolyte can boil over, leak, overheating of plates, warpage, and eventually the battery fails.
- **Rapid discharging / alternator failure:** If the alternator stops charging, or a break in the charging circuit between the alternator and battery happens, the cars entire electrical and ignition system is now running off of the battery, which causes a quick and rapid drain.

This failure also triggers the Battery Light, which is a bit of a misnomer as the Battery Light indicates that your charging system is not charging the battery, not that the battery is suddenly bad. Many times, however, the battery often fails at the same time as the alternator, due to this rapid discharge, and many days until it's discovered.

AUTOMOBILE BATTERY TESTS

1. OPEN CIRCUIT BATTERY VOLTAGE TEST (*Read Practical 1)*

Testing the battery voltage with a voltmeter/multimeter is a simple method for determining the state of charge of any battery. The voltage of a battery does not necessarily indicate whether the battery can perform satisfactorily, but it does indicate to the technician more about the battery's condition
than a simple visual inspection.
A battery that "looks good" may not be good. This test is commonly called an **'open circuit battery voltage test'** because it is conducted with an open circuit—with no current flowing and no load applied to the battery.

1. If the battery has just been charged or if the vehicle has been driven recently, it is necessary to remove the surface charge from the battery before testing. A surface charge is a charge of higher-than-normal voltage that is just on the surface of the battery plates.
2. To remove the surface charge, turn the headlights on high beam (brights) for 1 minute, then turn the headlights off and wait2 minutes.
3. With the engine and all electrical accessories off, and the doors shut (to turn off the interior lights), connect a voltmeter to the battery posts. Connect the red positive lead to the positive post and the black negative lead to the negative post.
4. Read the voltmeter and compare the results with the following state-of-charge chart. The voltages shown are for a battery at or near room temperature (70° to 80°F or 21° to 27°C).

Battery Voltage (V)	State of Charge
12.6 or higher	100% charged
12.4	75% charged
12.2	50% charged
12.0	25% charged
11.9 or lower	Discharged

2. HYDROMETER TESTING / SPEIFIC GRAVITY TEST *(Read Practical 1)*

If the battery has removable filler caps, the specific gravity of the electrolyte also can be checked. The specific gravity test indicates the charge state of the battery.

When testing a battery using a hydrometer, the reading must be corrected if the temperature is above or below 80°F (27°C).
This test also can be performed on most maintenance-free batteries because the filler caps are removable from most maintenance-free batteries.
It can indicate a defective battery if the specific gravity of one or more cells varies by more than 0.050 from the value of the highest-reading cell.

Specific Gravity	Battery Voltage (V)	State of Charge
1.265	12.6 or higher	100% charged
1.225	12.4	75% charged
1.190	12.2	50% charged
1.155	12.0	25% charged
Lower than 1.120	11.9 or lower	Discharged

3. BATTERY LOAD TESTING / HIGH RATE DISCHARGE TEST: ***(Read Practical 1)***

The most accurate test to determine the condition of any battery is the load test. Most starting and charging testers use a carbon pile to create an electrical load on the battery. The amount of the load is determined by the original capacity of the battery being tested.
Apply the load for a full 15 seconds and observe the voltmeter at the end of the 15-second period
while the battery is still under load.
Wait 30 seconds between tests to allow time for the battery to recover. If the battery fails the load test, recharge the battery and retest. If the load test is failed again, replacement is required.
A good battery should indicate above 9.6 V. Many manufacturers recommend performing the test twice, using the first load period to remove the surface charge on the battery and the second test to provide a truer indication of the condition of the battery.

4. BATTERY ELECTRICAL DRAIN TEST: ***(Read Practical 1)***

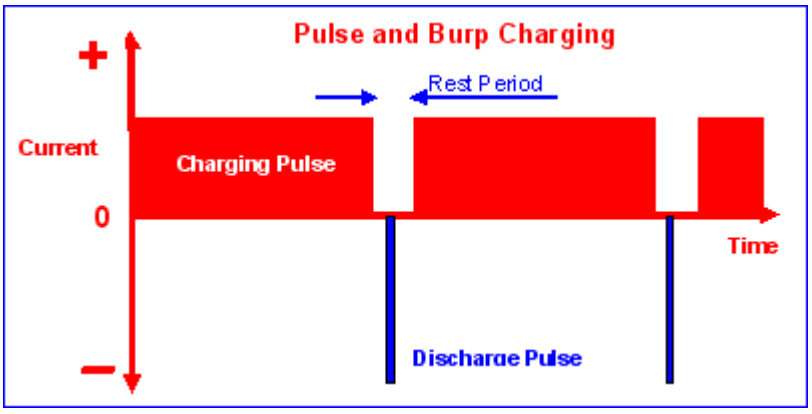
The battery electrical drain test determines if some component or circuit in a vehicle is causing a drain on the battery when everything is off. This test is also called the ignition off draw (IOD) or parasitic load test. This test should be performed whenever one of the following conditions exists:

1. Whenever a battery is being charged or replaced (a battery drain could have been the cause for charging or replacing the battery)
2. The fastest and easiest method to measure battery electrical drain is to connect an inductive DC ammeter that is capable of measuring low current (10 mA). Here is an example of a clamp-on digital multimeter being used to measure battery drain.
3. Make certain that all lights, accessories, and ignition are off.
4. Check all vehicle doors to be certain that the interior courtesy (dome) lights are off.
5. Disconnect the negative (–) battery cable and install a parasitic load tool .
6. Start the engine, drive vehicle about 10 min, using lights, accessories and radio.

7. Turn off the engine and all accessories including the under-hood light.
8. Connect an ammeter across the parasitic load tool switch and wait 10 minutes for all computers and circuits to shut down.
9. Open the switch on the load tool and read the battery electrical drain on the meter display.
10. Normal—10 to 30 mA (0.02 to 0.03 A) Maximum allowable—50 mA (0.05 A)

Basic Charging Methods

- **Constant Voltage** A constant voltage charger is basically a DC power supply which in its simplest form may consist of a step down transformer from the mains with a rectifier to provide the DC voltage to charge the battery. Such simple designs are often found in cheap car battery chargers. The lead-acid cells used for cars and backup power systems typically use constant voltage chargers. In addition, lithium-ion cells often use constant voltage systems, although these usually are more complex with added circuitry to protect both the batteries and the user safety.
- **Constant Current** Constant current chargers vary the voltage they apply to the battery to maintain a constant current flow, switching off when the voltage reaches the level of a full charge. This design is usually used for nickel-cadmium and nickel-metal hydride cells or batteries.
- **Taper Current** This is charging from a crude unregulated constant voltage source. It is not a controlled charge as in V Taper above. The current diminishes as the cell voltage (back emf) builds up. There is a serious danger of damaging the cells through overcharging. To avoid this the charging rate and duration should be limited. Suitable for SLA batteries only.
- **Pulsed charge** Pulsed chargers feed the charge current to the battery in pulses. The charging rate (based on the average current) can be precisely controlled by varying the width of the pulses, typically about one second. During the charging process, short rest periods of 20 to 30 milliseconds, between pulses allow the chemical actions in the battery to stabilise by equalising the reaction throughout the bulk of the electrode before recommencing the charge. This enables the chemical reaction to keep pace with the rate of inputting the electrical energy. It is also claimed that this method can reduce unwanted chemical reactions at the electrode surface such as gas formation, crystal growth and passivation. (See also Pulsed Charger below).



The optimum current profile depends on the cell chemistry and construction.

- **Burp charging** Also called **Reflex** or **Negative Pulse Charging** Used in conjunction with pulse charging, it applies a very short discharge pulse, typically 2 to 3 times the charging

current for 5 milliseconds, during the charging rest period to depolarise the cell. These pulses dislodge any gas bubbles which have built up on the electrodes during fast charging, speeding up the stabilisation process and hence the overall charging process. The release and diffusion of the gas bubbles is known as "burping". Controversial claims have been made for the improvements in both the charge rate and the battery lifetime as well as for the removal of dendrites made possible by this technique. The least that can be said is that "it does not damage the battery".

- **Trickle charge** Trickle charging is designed to compensate for the self discharge of the battery. Continuous charge. Long term constant current charging for standby use. The charge rate varies according to the frequency of discharge. Not suitable for some battery chemistries, e.g. NiMH and Lithium, which are susceptible to damage from overcharging. In some applications the charger is designed to switch to trickle charging when the battery is fully charged.
- **Float charge**. The battery and the load are permanently connected in parallel across the DC charging source and held at a constant voltage below the battery's upper voltage limit. Used for emergency power back up systems. Mainly used with lead acid batteries.
- **Random charging** All of the above applications involve controlled charge of the battery, however there are many applications where the energy to charge the battery is only available, or is delivered, in some random, uncontrolled way. This applies to automotive applications where the energy depends on the engine speed which is continuously changing. The problem is more acute in EV and HEV applications which use regenerative braking since this generates large power spikes during braking which the battery must absorb. More benign applications are in solar panel installations which can only be charged when the sun is shining. These all require special techniques to limit the charging current or voltage to levels which the battery can tolerate.

Charging Rates

Batteries can be charged at different rates depending on the requirement. Typical rates are shown below:

- Slow Charge = Overnight or 14-16 hours charging at 0.1C rate
- Quick Charge = 3 to 6 Hours charging at 0.3C rate
- Fast Charge = Less than 1 hour charging at 1.0C rate

Slow charging

Slow charging can be carried out in relatively simple chargers and should not result in the battery overheating. When charging is complete batteries should be removed from the charger.

- Ni-cads are generally the most robust type with respect to overcharging and can be left on trickle charge for very long periods since their recombination process tends to keep the voltage down to a safe level. The constant recombination keeps internal cell pressure high, so the seals gradually leak. It also keeps the cell temperature above ambient, and higher temperatures shorten life. So life is still better if you take it off the charger.
- Lead acid batteries are slightly less robust but can tolerate a short duration trickle charge. Flooded batteries tend to use up their water, and SLAs tend to die early from grid corrosion. Lead-acids should either be left sitting, or float-charged (held at a constant voltage well below the gassing point).
- NiMH cells on the other hand will be damaged by prolonged trickle charge.

- Lithium ion cells however can not tolerate overcharging or overvoltage and the charge should be terminated immediately when the upper voltage limit is reached.

Fast / Quick Charging

As the charging rate increases, so do the dangers of overcharging or overheating the battery. Preventing the battery from overheating and terminating the charge when the battery reaches full charge become much more critical. Each cell chemistry has its own characteristic charging curve and battery chargers must be designed to detect the end of charge conditions for the specific chemistry involved. In addition, some form of Temperature Cut Off (TCO) or Thermal Fuse must be incorporated to prevent the battery from overheating during the charging process.

Keep in mind, jump-starting the car should only be done in an emergency.