Only the Rich can afford Cheap Car Batteries!!!

It is entirely possible to own cars for a complete lifetime without ever bothering to learn anything about looking after batteries. If it's flat, call the emergency service. If it fails, buy a new one. On the other hand, an appreciation of the technicalities may save a lot of money in the long term.

Yes! We all know about batteries don't we? They cost money! But who really knows what batteries are about? I didn't, so I raided the internet and compiled this! First, a word of caution! Lead acid batteries contain sulfuric acid, which is a highly corrosive poison and will produce gasses when recharged and explode if ignited. This hurts! When working with batteries, ventilate area well, remove jewelry, wear protective eyewear and clothing, and exercise caution. Follow maker's instructions for testing, jumping, installing, charging and equalizing batteries. This precis assumes a 12-volt, negative earth, lead acid battery used to start petrol engines in cars like the Rover SD1.

The basics

At first signs of slow starting, headlights dim at idle, dash light warns of discharge with engine running at high idle, loss of electrical performance or after deep discharges or jump starts; Recharge battery, remove surface charge and load test it! Weak batteries cause stress or premature failures of charging systems and starters. Perform regular preventive maintenance. Keep it charged but avoid overcharging. Temperature matters! Heat kills car batteries! Cold reduces capacity!

Why only the rich can afford cheap car batteries?

A car battery is a rechargeable electrochemical device that stores chemical energy and releases it as electrical energy upon demand. When a car battery is connected to a device such as a starter, chemical energy is converted to electrical energy and current flows through the circuit. A good quality car battery will cost between £40 and £100 and, if properly maintained, it should last an average of five years. A cheap battery will cost much less but when it fails prematurely or lets you down, now you have to be rich! Its primary function is to start the engine. Its secondary function is to filter or stabilize the power. It also provides extra power for the lighting, radio, audio system and accessories when their combined load exceeds the capability of the charging system. Finally, a car battery provides power to the electrical system when the charging system is not operating.

A twelve-volt car battery is made up of six cells, each producing 2.1 volts that are connected in series from positive to negative. Each cell is made up of an element containing positive plates that are all connected together and negative plates, also all connected together. They are individually separated with thin sheets of electrically insulating, porous material that are used as spacers between the positive and negative plates to keep them from electrically shorting to each other. The plates within a cell alternate with a positive plate a negative plate and so on. After "curing" the plates are made up into cells, which are inserted into a high-density tough, polypropylene or hard rubber case. They are connected to the terminals and the case is covered and then filled with a dilute sulfuric acid electrolyte and initially charged or "formed". The electrolyte is replaced and the battery is given a finishing charge. Some batteries are "dry charged," meaning that they are shipped without electrolyte and it is added and recharged when they are put into service.

Two important considerations in battery construction are porosity and diffusion. **Porosity** is the pits and tunnels in the plate that allows the sulfuric acid to get to the interior of the plate. **Diffusion** is the spreading, intermingling and mixing of one fluid with another. In use, the fresh acid needs to be in contact with the plate material and the water generated needs to be carried away from the plate. The larger the pores or warmer the temperature, the better the diffusion.

How does a battery work? By alternating two different metals such as Lead Dioxide, the positive plates, and Sponger Lead, the negative plates, immersed in diluted Sulfuric Acid, the electrolyte, a typical lead-acid battery produces approximately 2.1 volts per cell. The chemical action between the

metals and the electrolyte creates the electrical energy. Energy flows from the battery as soon as there is an electrical load that completes a circuit between the positive and negative terminals. The electrical current flows as ions between the battery plates and as electrons through the external circuit. The action of a lead-acid storage battery is determined by the chemicals used, state of charge, temperature, porosity, diffusion and load.

Why do batteries die? In cold climates batteries age as the active positive plate material flakes off due to the expansion and contraction that occurs during the discharge and recharge cycles. Brown sludge builds up in the bottom of the case and can short the cell out. In hot climates, additional causes of failure are positive grid growth, metal corrosion in the electrolyte, negative grid shrinkage, plate buckling or loss of water. Deep discharges, heat, vibration, over charging, under charging or non-use (SORN owners please note!) accelerate this "aging" process. Another major cause of premature battery failure is lead sulfation. Using tap water to refill batteries can produce calcium sulfate that also will coat the plates and fill the pores. Recharging a sulfated battery is like trying to wash your hands with gloves on. When the active material in the plates can no longer sustain a discharge current, the battery "dies". In a hot climate, the harshest environment for a battery, a survey of junk batteries revealed that the average life of a good quality car battery was 37 months. If a car battery is more than three years old, then it is living on borrowed time. Abnormally slow cranking, especially on a cold day, is another good indication that a battery is going bad and should be externally recharged and load tested. Dead batteries almost always occur at the most inopportune times, for example, after jump starting, in the airport after returning home from a long trip, during bad weather, late at night in a dark car park, or when late for an appointment. It's easy to spend the cost of a good quality new battery or more for an emergency jump start, a tow, or a taxi. The majority of "defective" batteries returned to manufacturers during warranty periods are good, suggesting even most sellers of new batteries don't properly load test or recharge them.

Preventive maintenance

Maintaining correct electrolyte levels; tightening loose clamps and terminals; removing corrosion from both ends of each battery cable and both terminals; cleaning battery top and checking the alternator belt tension is normally the only preventive maintenance required for a battery. Frequency is dependent upon climate and battery type, but perform this at least once before cold weather starts and once a month in warm weather. If electrolyte levels are low in non-sealed batteries, allow the battery to cool. Add distilled water to the level indicated by the battery manufacturer or if no recommendation, to within 1/8 to 1/4 inch below the bottom of the filler tube vent wells or splash barrels. The plates need to be covered at all times. Avoid overfilling, especially in hot climates, because heat causes the electrolyte to expand and overflow.

Testing

There are 6 simple steps in testing a car battery - **Inspect, Recharge (1), Remove Surface Charge, Load Test, Bounce Back Test and Recharge (2).** With a non-sealed battery, use of a good quality, temperature-compensated hydrometer, costing slightly more than peanuts, is highly recommended. A hydrometer is a float-type device used to determine the state-of-charge by measuring the specific gravity of the electrolyte in each cell. It is a very accurate way of determining a battery's condition and weak or dead cells. To troubleshoot charging or electrical systems or when using a sealed battery, a basic digital voltmeter with 0.5% or better accuracy is essential. Analog voltmeters are not accurate enough to measure the millivolt differences of a battery's state-of-charge or the output of the charging system. A battery load tester is optional. A more accurate way of testing the starting capacity of a lead acid battery is by using a somewhat expensive conductance tester.

Inspect. Visually inspect for obvious problems: loose or broken alternator belt, electrolyte levels below the top of the plates, dirty battery top, corroded or swollen cables, corroded terminal clamps, loose clamps, loose cable terminals, or a leaking or damaged battery case.

Recharge (1). Recharge the battery to 100% state-of-charge. If the battery has a difference of 0.03 specific gravity reading between the lowest and highest cell, then it should be equalized. (See later)

Remove surface charge. Surface charge is the uneven mixture of sulfuric acid and water along the surface of the plates as a result of charging or discharging. It can make a weak battery appear good or a good battery appear to be bad. Eliminate the surface charge by one of the following methods:

- Allow the battery to sit for between four to twelve hours to allow surface charge to dissipate.
- Turn the headlights on high beam for five mins, shut them off, and wait five to ten mins.
- Using load tester, apply half the battery's CCA load rating for 15 secs; wait five to ten mins.
- Disable ignition, turn the engine over for 15 secs with the starter motor, wait five to ten mins.

Now measure the state-of-charge. If the battery's electrolyte is above 110^{o} F, allow it to cool. Using a temperature compensated hydrometer, determine the battery's state-of-charge from the following table, which assumes that 1.265 specific gravity reading is a fully charged battery: Tables for temperature compensation are on the mentioned web-site.

Digital Voltmeter Open Circuit Voltage	Approximate State-of-Charge	Hydrometer Average Cell Specific Gravity
12.65	100%	1.265
12.45	75%	1.225
12.24	50%	1.190
12.06	25%	1.155
11.89	Discharged	1.120

For non-sealed batteries, check the specific gravity in each cell with a hydrometer and average the readings. For sealed batteries, measure the Open Circuit Voltage across the battery terminals with an accurate digital voltmeter. This is the only way to determine the state-of-charge. Some batteries have a built-in hydrometer, which only measures the state-of-charge in one of its six cells. If the built-in indicator is clear or light yellow, then the battery has a low electrolyte level and should be refilled and recharged before proceeding. If sealed, the battery is toast and should be replaced. If the state-of-charge is below 75% using either the specific gravity or voltage test or the built-in hydrometer indicates "bad" (usually dark), then the battery needs to be recharged before proceeding. Replace the battery, if one or more of the following conditions occur:

- There is a .050 or more difference in the specific gravity reading between the highest and lowest cell indicating a weak or dead cell(s). Applying an equalizing charge may correct this.
- Battery will not recharge to a 75% or more state-of-charge level or if the built-in hydrometer still does not indicate "good" (usually green, which indicates a 65% state-of-charge or better). If a battery has spilled or "bubbled over" and electrolyte has been partially replaced with water, replace old electrolyte with new, which is a mixture of 25% sulfuric acid and distilled water**. Do remember the safety rules.** It is cheaper to replace electrolyte than to buy a new battery.
- Digital voltmeter measures 0 volts, indicating an open cell.
- Digital voltmeter measures 10.45 to 10.65 volts, indicating probable shorted cell. A shorted cell is caused by plates touching, sediment build-up or "treeing" between the plates.

Load test. If the battery's state-of-charge is at 75% or higher or has a "good" built-in hydrometer indication, load test the battery by one of the following methods:

- Turn the headlights on high beam for 5 mins.
- Disable ignition and turn the engine over for 15 secs with the starter motor.

- With battery load tester, apply load of half the nominal CCA rating of the battery for 15 secs.
- With battery load tester apply load of half the nominal cranking amp specification for 15 secs.

During the load test, the voltage on a good battery will not drop below 9.5 volts with the electrolyte at 60 degrees F. Tables for voltage versus temperature are on the mentioned web-site.

Bounce back test. If the battery has passed the load test, skip bounce back, Otherwise after the load is removed, wait ten minutes and measure the state-of-charge. If the battery bounces back to lower than 75% state-of-charge (1.225 specific gravity or 12.45 volts DC), then recharge and load test again. If the battery fails the load test a second time or bounces back to lower than 75% state-of-charge, replace it because it lacks the necessary CCA power.

Recharge (2). If the battery passes the load test recharge it as soon as possible to restore it to peak performance and to prevent lead sulfation.

Charging system

A charging system comprises of an alternator, voltage regulator, battery and indicator light. With engine running, the charging system's primary purpose is to provide power for the car's electrical load, e.g.: - ignition, lighting, audio system, accessories, etc., and to recharge the battery. Its output capacity is directly proportional to engine rpm. Charging systems are normally sized to provide approximately 125% of the worst-case original electrical load, so that the battery can be recharged.

When a charging system fails, an indicator light comes on. The most common charging failure is a loose, worn or broken alternator belt. Check it first. If when the engine is revved up the alternator light becomes **brighter**, then the battery needs to be fully recharged and tested. If the light becomes **dimmer** then the problem is most likely in the charging system, in which case attach a known-to-be-good battery to the engine and run the engine at 2000 or more RPM for two minutes. Depending on the load and ambient temperature, the voltage should increase to between 13.0 and 15.1 volts for a good fully charged battery. Most cars will measure between 14.4 and 14.8 volts on a warm day, depending on the battery type that the charging system was designed for.

Most voltage regulators are temperature compensated to properly charge the battery under different conditions. Charging voltage increases as temperature decreases to overcome higher battery resistance. Conversely, voltage decreases as temperature increases. Other factors affecting the charging voltage are the battery's condition, state-of-charge, electrical load and electrolyte purity.

If a battery's terminal voltage is below 13.0 volts but it still tests good after being recharged, or it won't stay charged then test the charging system output voltage along with the car's electrical load. Also, test the parasitic load. A loose alternator belt or open circuit diode significantly reduces the alternator's current output. If output voltage is above 15.1 volts with temperature above freezing, and the battery's electrolyte level is frequently found to be low or the battery smells of "rotten eggs", then it is probably being overcharged and the charging system requires testing.

If the battery tests OK but the system won't recharge it – what then? The electrical load is satisfied first, by the charging system and any remaining power is then used to recharge the battery, e.g.: - If the total electrical load is 64 amps and the charging system can produce 80 amps. Up to 16 amps is available for recharging and the battery will usually recharge in five minutes. Now, assume that the engine is idling and the charging system is only capable of producing 20 amps then 44 amps are required to make up the difference to satisfy the total electrical load and the battery is being discharged further. This example is why, during short trips or while in stop-and-go traffic, a battery may never get recharged and may even "completely" discharge.

Now assume that 20 amps of accessories are added to the load. With a new total electrical load of 84 amps, even at maximum output the battery will never recharge from an 80-amp system and during operation the battery must make up the 4-amp deficit. The solution is to upgrade the charging system to 125% or more of the new worst-case load. In this example, 105 amps of output.

Jump starting

In cold weather, a good quality booster cable is necessary to provide enough current to the disabled car to start the engine. Larger diameter wire is better. Check the owner's manual for both vehicles before attempting to jump-start. Follow the manufacturers' procedures because some good cars should not be running during a jump-start of a disabled one. However, starting the disabled car with the good car running can prevent having both cars disabled. Avoid the booster cable clamps touching each other or the positive clamp touching anything but the positive (+) post of the battery. Momentarily touching the block or chassis can cause extensive, costly damage. Here is a good plan.

- Below 10^{o} F, insure the electrolyte is not frozen in the dead battery. If frozen, check for cracks and thaw before proceeding. Electrolyte in a dead battery will freeze at approximately 13^{o} F.
- Without the cars touching, turn off all unnecessary accessories and lights on both cars, insure plenty of ventilation, and wear eye protection.
- Start the good car and let it run for 2 or 3 mins at fast idle to recharge its battery.
- Check positive and negative terminal marking on both batteries before proceeding.
- Connect positive booster cable clamp (red) to positive (+) terminal on dead battery. Connect positive clamp on the other end of the booster cable to positive terminal on good battery.
- Connect negative booster cable clamp (black) to negative (-) terminal on good battery and negative booster cable clamp on the other end to a clean, unpainted area on the engine block or chassis well away from the battery on disabled car. This arrangement is used because sparking will occur which must kept away from the battery in order to avoid possible explosion (Boom!).
- Continue to run good car at high idle for five minutes or so to allow dead battery to receive some recharge and to warm its electrolyte. If there is a bad jumper connection, don't wiggle cable clamps connected to battery terminals, because sparks will risk an explosion. Disconnect clamp from engine block before checking battery clamps. Then reconnect clamp to block.
- Some carmakers advise turning off the engine of good car to protect charging systems prior to jump-starting. Check owner's manual; otherwise leave engine running to avoid two dead cars!
- Start disabled car and allow it to run at high idle. If car does not start first time, recheck connections, wait a few minutes and try again.
- Disconnect cables in the reverse order, starting with the negative clamp on the engine block or chassis of the disabled car to minimize possibility of explosion. (Another Boom!)
- As soon as possible, fully recharge, remove the surface charge and load test the dead battery for latent or permanent damage as a result of the deep discharge.

Buying a new battery

Mostly we buy a battery specified by Rover for SD1's but here are some supplemental points.

Cold Cranking Amps (CCA). An important consideration is that the battery CCA meets or exceeds the car's cranking requirement. CCA is the discharge load measured in amps that a new, fully charged battery operating at 0^{o} F can deliver for 30 secs while maintaining voltage above 7.2 volts. To start an 8 cylinder petrol engine requires 750-850 CCA. In hot climates, buying batteries that exceed starting requirement can be a waste of money. In cold climates the higher CCA rating the better, due to increased power required to crank a sluggish engine and the inefficiency of a cold battery. As batteries age, they are also less capable of producing their nominal CCA.

Reserve Capacity (RC). Second in importance is RC because of the effect of increased parasitic loads and of emergencies. RC is the number of minutes a fully charged battery at 80^{o}F can be discharged at 25 amps until the voltage falls below 10.5 volts. Adding RC can be done in two ways. Best is to add a deep cycle battery and a diode isolator to existing car battery. This is standard setup

in most Recreational Vehicles. The advantage of multi-battery setup is that high-power accessories can be run from a deep cycle battery and the car battery is available to start the engine. The second advantage of using a deep cycle battery to power high-power accessories is that it can be discharged and recharged hundreds of times without damage. A car battery is not designed for deep discharges and will have a very short life if it is so abused. A third advantage is that both batteries will be recharged automatically when the charging system has power available. Another way of increasing RC is by replacing the existing car battery with a large, 12-volt deep cycle battery. The deep cycle battery must have enough current capacity to start the engine in the worst-case temperature. More detail on battery capacity is available on the mentioned web-site.

Type. Two common types of car batteries are wet low maintenance (non-sealed) and wet maintenance free (non-sealed or sealed). The advantages of maintenance free batteries are less preventive maintenance, up to 250% less water loss, faster recharging, greater overcharge resistance, reduced terminal corrosion, up to 40% more life cycles, up to 200% less self discharge, and less danger to consumers because there is less to service. However, they are more prone to deep discharge (dead battery) failures due to increased shedding of active plate material and development of a barrier layer between the active plate material and the grid metal. If sealed, a shorter life in hot climates is often experienced because water cannot be replaced. Maintenance free batteries are generally more expensive than low maintenance batteries.

Freshness. Determining the “freshness” of a battery is sometimes difficult. Never buy a non-sealed wet lead acid battery that is more than 3 months old or a sealed wet lead acid battery that is more than 6 months old. This is because it has started to sulfate unless it has periodically been recharged or it is “dry-charged”. The date of manufacture is stamped on the case or printed on a sticker.

Install it yourself

Studies show that non-professional battery installers install 60% of the many millions of batteries currently sold. Car batteries are the fourth most popular auto part purchased. A car battery weighs between 30 and 60 lbs. So! Two Questions! "Do I want to install it myself?" and “What to do with the old battery if not exchanged for the new one?”

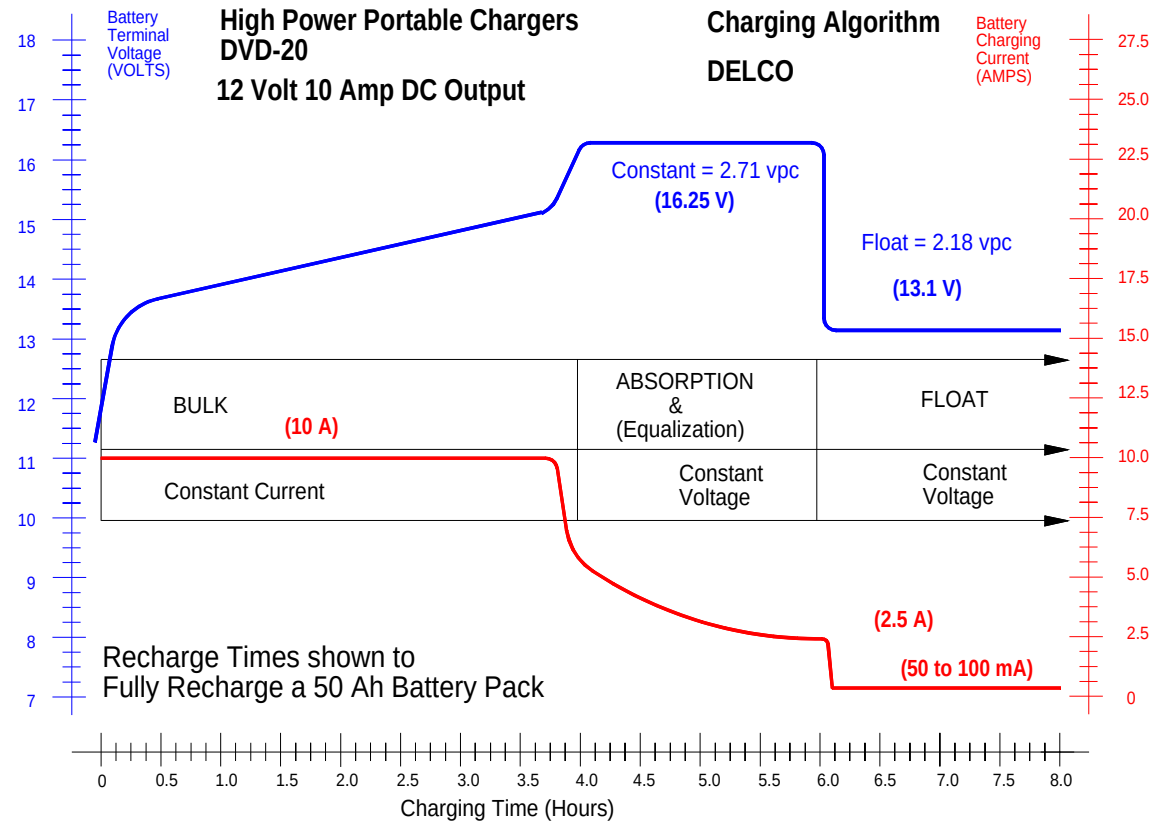
- Ensure a safe record of radio and security codes before disconnecting an old battery. A second battery can be temporarily connected in parallel to the electrical system via an active ignition-off cigarette lighter plug, before disconnection.
- Thoroughly wash and clean the old battery, battery terminals and case or tray with warm water to minimize problems from acid or corrosion. Heavy corrosion can be neutralized with mixture baking soda and warm water. (1 lb. to 1 gallon). Wear safety goggles and using a stiff brush, brush away from self. Also, mark cables so as not to forget how they are connected.
- Remove negative cable first, as this will minimize possibility of shorting the battery when removing the other cable. It is a good idea to secure cables out of the way so they do not make any unwanted contact. Next, remove the positive cable, then the hold-down bracket or clamp. Dispose of the old battery by exchanging it when buying a new one or by taking it to local council recycling center. Typically over 96% of old battery lead is recycled, making batteries the most completely recycled object of all recycled items. (Boring, but important!) Remember that batteries contain large amounts of harmful lead and acid, so take great care with safety and dispose of your old battery properly to protect the fragile environment.
- After removing the old battery, ensure that the battery tray, cable terminals and connectors are clean. Use an inexpensive wire brush to clean terminal clamps and terminals. If terminals, cables or hold down brackets are severely corroded, replace them. Corroded terminals or swollen cables reduce starting capability because of their inability to carry high current.
- Thinly coat the terminal, terminal clamps and exposed metal around the battery with a high temperature grease or petroleum jelly (e.g., Vaseline) to prevent corrosion.

- Check the positive and negative terminal markings on the replacement battery and place it so that the negative cable will connect to the negative terminal. Reversing the polarity of the electrical system will severely damage or destroy it. It can even cause the battery to explode.
- After replacing the hold-down bracket reconnect the positive cable first then negative cable last.
- Before using the battery, check the electrolyte levels and add distilled water to cover the plates. Check the state-of-charge and recharge if necessary. Then re-check the electrolyte levels after the battery has cooled and top off with distilled water as required, but do not overfill.

Recharge (or Equalize) a battery

There are up to four phases of battery charging - Bulk, Absorption, Equalization and Float.

- **Bulk.** Where charger current is constant and battery voltage increases. Give battery whatever current it will take but not exceeding 20% of the amp-hour rating and that avoids overheating.
- **Absorption.** Where the charger voltage is constant and current decreases until battery is fully charged, which occurs when charging current drops to 1% or less of the amp-hour capacity.
- **Equalization.** Optional 5% overcharge to equalize and balance voltage and specific gravity in each cell by increasing the charge voltage. It reverses the build-up of chemical effects and has occurred once specific gravity no longer rises during the gassing stage.
- **Float.** Where a reduced charge voltage is held constant, to indefinitely maintain full charge.
- Graph shows how the above phases relate to a typical maintenance free battery.



- An excellent tutorial on battery charging basics can be found at http://www.batterytender.com: Use battery maker's recommendations for optimum performance and life.

In addition to the earlier cautions, here are some more:

- Never disconnect a battery cable from a car with the engine running because the battery acts like a filter for the electrical system. Unfiltered (pulsating DC*)* electricity may exceed 40 volts and can damage expensive electrical items such as computers, radio, charging system, etc.
- Before recharging, check the electrolyte level covers the plates at all times and is not frozen.
- Don't add distilled water if electrolyte covers the top of plates because it warms and expands during recharging. Recheck the levels after charging.
- Ensure vent caps are clean and fitted before recharging only in well-ventilated areas. Wear eye protection. Do not smoke or cause sparks, as exploding gasses will wake the neighbours.
- For sealed batteries avoid recharging with current above 20% of RC or 50% of amp-hour rating. E.g.: - 24 amps maximum for a 120 minute RC 48-amp hour battery.
- Adhere to battery and charger operating instructions for connecting and disconnecting cables. Work in a manner to minimize possibility of explosion or incorrectly charging the battery. Turn charger off before connecting or disconnecting cables. Do not wiggle cable clamps while the battery is recharging, because of sparks. Disperse charging gasses with good ventilation.
- If battery overheats (>110 ^{o} F), gasses violently or spews liquid, turn off or reduce charge rate.
- If charging on-car with external charger, ensure it won't damage electrical system with high voltage. If even a remote possibility, disconnect both battery cables before connecting charger.
- After jump-starting, a car is usually driven long enough to fully recharge the battery. The time taken depends on amount of discharge, surplus current diverted to battery, how long the engine runs, engine speed and ambient temperature. An alternator is sized to carry the maximum accessory load and to maintain a battery, not to recharge a dead battery
- If car has added lights, audio or high-powered accessories and is also driven in a stop-and-go manner, the charging system might need increased capacity to keep the battery fully charged.
- A better recharge method is to use an external constant current charger set to deliver only 12% of RC rating and also monitors the state-of-charge. A timer will help prevent overcharging.
- The best method is to slowly recharge the battery over a ten-hour period using an external constant voltage (or tapered current) charger. This allows the acid more time to penetrate the plates and causes less mechanical stress. Such a unit applies regulated voltage at approx. 14.4 volts. A 5-amp constant voltage charger will cost between £10 and £30 and is suitable for most simple car charging applications. Expensive three-stage microprocessor-controlled chargers are available that automatically provide bulk, absorption and float charging. A four-stage charger also will provide an equalizing charge in addition to the bulk, absorption and float charging.
- To prevent damage to a fully discharged battery, the current should be less than 1% of the CCA rating during the first 30 minutes of charge.
- Left unattended, cheap, unregulated trickle or manual battery chargers can overcharge a battery because they can "decompose" the water out of the electrolyte. Avoid using fast, high rate or boost chargers on any battery that is sulfated or deeply discharged. The electrolyte should never bubble violently because high currents only create heat and excess explosive gas.

What causes a battery to drain overnight?

Parasitic drain is the cumulative load produced by electrical devices, e.g.: - clocks, computers, alarms, etc. that operate after the engine is stopped and the ignition key has been switched off. Parasitic loads typically run 20 to 120 milliamps. Glove box, boot, and under bonnet lights that don't extinguish after door closure and shorted diodes in alternators are the common faults. Cooling fans, radios, courtesy lights, alarm systems, and electric car antennas also cause batteries to drain.

Leaving headlights on will generally discharge a good battery in 2 hours. Here are 2 common parasitic load tests for use without the engine running, under bonnet lights off and doors shut.

- Connect 12-volt bulb in series between the negative cable and negative battery terminal. If bulb glows brightly, remove fuses one-at-a-time until the offending electrical component is found.
- A better method is use a DC ammeter inserted as per bulb (above). Starting with highest scale, check if load is above 120 milliamps. Remove fuses as above to identify faulty component.

Increasing battery life

- Protect battery from high under bonnet temperatures and keeping it well maintained are best ways to extend its life. In winter, keep battery fully charged and engine warm. In summer, with high under bonnet temperatures, electrolyte levels need frequent checking. Add distilled water if required. Never add electrolyte to battery that is not fully charged. Keep battery top clean.
- Mostly if cold, turn off unneeded accessories and lights to decrease battery load while cranking
- Leaving lights and accessories on and fully discharging a maintenance-free battery can ruin it. If this happens, load test it after full recharge and removed surface charge to identify any damage.
- Reduce parasitic (key-off) load to 120 milliamps or less.

Causes of premature battery failure

Normally, premature battery failure is caused by one of the following. Batteries having been in use for long periods will typically fail from multiple causes. All batteries will fail eventually.

- High under hood heat or overcharging causes a loss of water and accounts for 50% of failures.
- Sulfation from water loss, undercharging, or prolonged periods of non-use
- Deep discharges (such as leaving lights on).
- Misapplication or using an undersized battery.
- Excessive vibration due to a loose hold-down clamp.
- Using tap water causes calcium sulfation.
- Freezing.

Storage.

Batteries naturally discharge while in storage and sulfation will begin when the state-of-charge is 80% or less. Cold slows the process - Heat speeds it up. These steps will help protect stored battery.

- Physically inspect for damaged cases, remove any corrosion, and clean the battery.
- Check electrolyte levels, add distilled water as required, but avoid overfilling.
- Fully charge or equalize.
- Store in a cool dry place, but not below 32^{o} F. Periodically test the state-of-charge. When it is 80% or below, re-charge using a voltage regulated charger
- To avoid overcharging connect an automatic [voltage regulated] “trickle” charger to battery using 13.8 volts and equalize the battery every couple on months.

The above info was extracted and condensed from web site www.uuhome.de/william.darden. It is amazingly detailed and I tailored this essay to favour SD1 V8 applications. Go to the web address for more comprehensive or alternative applications. Let me know of any errors and omissions.

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