Phase 2

Trade of Motor Mechanic

Module 2

Unit 3

The Battery

Produced by

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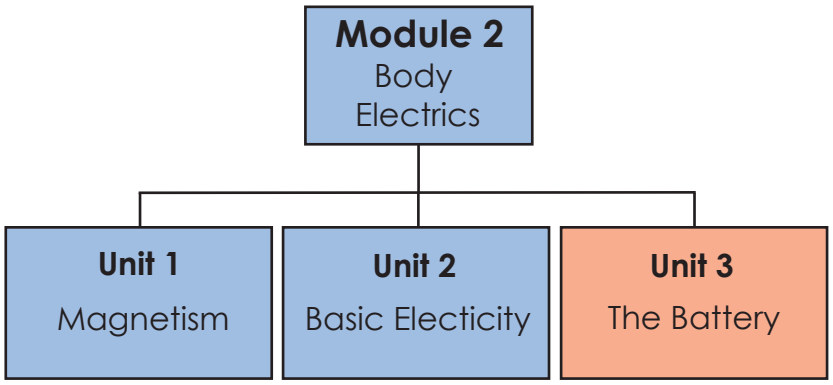
Curriculum Revision 2.2 16-01-07

Table of Contents

Introduction

There are six Units in this Module. In Theory 1 we cover Units 1, 2 and 3 which focuses on the basics of electricity. In Theory 2 we cover Units 4, 5 and 6 which focuses on the fundamental electrical circuits in the vehicle.



On completion of this unit you will be able to describe the basic function, operation of a lead acid battery. Health and safety issues related to this unit will also be covered in this unit.

Unit Objective

By the end of this unit you will be able to:

- Describe the electrical energy supply requirements of 12V petrol and diesel engine vehicles
- Describe the function and basic operation of a lead acid battery
- Describe the dangers and the Health and Safety precautions associated with the lead acid battery
- Service, test and charge batteries
- Use boost pack/jump leads to assist-start a vehicle
- Describe the basic function of the in-vehicle, battery control/ management unit
- State the end-of-life legal requirements of lead acid batteries

1.0 Dangers Associated With the Lead Acid Battery

Key Learning Points

- The strict need for 'polarity observance' when making connections to the vehicle.
- Hazards: Possibility of explosion by arcing/sparking around battery terminals due to Hydrogen and Oxygen presence, from the charging process, acid burns, spillages, overcharging, toxic fumes.
- Health and Safety precautions: ventilated charging area (fume extraction). Personal protection equipment (P.P.E.) i.e. full facial shield, charger always off before making or breaking any connections. Environmental damage due to incorrect 'end of life' disposal of batteries.

1.1 Safety Precautions

Always refer to manufactures specification when working on vehicles with lead acid batteries. Here are some guide lines.

- Always ensure correct polarity before attempting to fit a battery to a vehicle. Connected the wrong way, even for the fraction of a second will burn out alternator diodes and other electronic components.
- Always connect the earth lead last. This way, if the spanner used to tighten the live connection at the live side of the battery shorts off the chassis, there will be no danger of a direct short circuit across the battery.
- Always wear goggles or a face shield.
- Always pour acid slowly into water, not water into acid.
- Never lean over a battery when charging, testing, or jump-starting an engine.
- Charge batteries only in well-ventilated areas (fume extraction).
- Batteries contain hydrogen and oxygen, two flammable and explosive gasses.

- Never smoke or operate anything that may cause a spark when working on a battery. The gasses may ignite and cause the battery to explode.
- A battery which is being overcharged should not be allowed to do so. The regulator should be checked immediately and the fault rectified. This condition will be recognised by a number of symptoms:
    1. The battery will need to be topped up frequently.
    2. Electrolyte may overflow onto the battery cage.
    3. Lights will brighten up abnormally and bulbs may blow at more than the normal rate.

The dangers of allowing this situation to continue are:

- The battery's life will be shortened considerably.
- The overflow of electrolyte will cause serious corrosion.
- The constant failure of bulbs could be a danger.
- The most important of all - a battery which is being charged at an abnormally high rate will give off hydrogen gas in large quantities. Accumulation of this, plus the slightest spark in the vicinity of the battery could cause an explosion and fire.
- Wiring could also burn out as a result of the heavy loads being imposed on it in the charging system.
- Loose or corroded battery connections should be rectified immediately. As the battery would not be charged correctly, and of course the obvious starting problems would also result from any loose or corroded leads. In an alternator system, any break in the connection to the battery while the engine is running will allow the alternator to charge in an open circuit which will cause serious damage to the alternator.
- Never place any tools on the battery as these are in constant danger of shorting across the poles of the battery, or between the live pole and earth. The resulting spark can cause an explosion due to the hydrogen gas being given off by the battery. Such an explosion may cause the battery to disintegrate spraying acid over a wide area and possibly cause a fire as well.

- Never test a battery by placing any metal object across the battery poles. The end result could be the same as in No. 11 above. If the battery is to be tested use a voltmeter, hydrometer or high-discharge tester. Be extremely careful using any of these on a battery that has just been charged or which is being overcharged on the vehicle. The spark caused by placing a discharge tester on a battery which is gassing could cause an explosion. The hydrometer is quite safe at any time.
- If acid is accidentally spilled on the skin wash off with plenty of water. Time is important, seconds matter so do it immediately. If acid gets on one's clothes, washing it off with a solution of an alkali such as bread soda and water will prevent the acid from burning holes in the fabric.
- Using jump leads, always double check polarity before connecting. The spark caused by a wrong connection could cause an explosion or damage to alternator.
- Using a battery booster, or even a normal charger, same as above applies.
- Always disconnect the battery when electric welding
- Always disconnect the battery when:
    1. Working on the electrics, except for testing.
    2. Removing the starter motor.
    3. Removing the engine.
    4. Carrying out any mechanical work in the vicinity of the battery.
    5. Leaving a job where turning over the engine could cause damage e.g. engine partly dismantled.
- Exercise extreme care when removing or fitting battery connections. Never hammer on or off or use undue pressure with connections. When removing clamp type, slacken bolt and spread clamp by inserting screwdriver in the slot and twisting.

2.0 Energy Requirements for 12 V Vehicles

Key Learning Points

- Vehicle electrical current and voltage requirements i.e. consistently fully charged battery and the ever-increasing electrical loads/circuits.

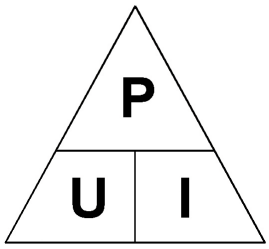
2.1 Typical Electrical Loads

Batteries do not produce electric current but instead store current produced by the generator when the engine is running. This energy is then available for starting the engine (typically 120 amps). In addition, the battery covers the power requirements of electrical equipment when the engine is stationary or only ticking over. These include some of the following (voltage applied 12v):

Short-term load		*Permanent load*	
Per interior lamp	5W	Ignition	20W
Per flasher lamp(indicator)	21W	Electric fuel pump	50–70W
2 stop lamps	42W	Electronic petrol injection	70–100W
Per reversing lamp	21W	*Long-term load*	
Horn	25–40 W	Car radio approx	10–100W
Fog lamp	21W	Per licence-plate lamp	10W
Rear-window wiper	30–65W	Side lamp	5W
Wipers.	80W	2 headlamp dip lights	110W
Cigarette lighter	100W	2 headlamp main beams	120W
Rear-window heater	120W	Per rear tail light	5W

For diesel cars	
Heater plugs for starting (per cylinder)	100W
Power windows	150W
Electric radiator fan	200W
Starter	800-3000W

Note: to change watts to amps use the power triangle. For this calculation the voltage value is 12 volts.



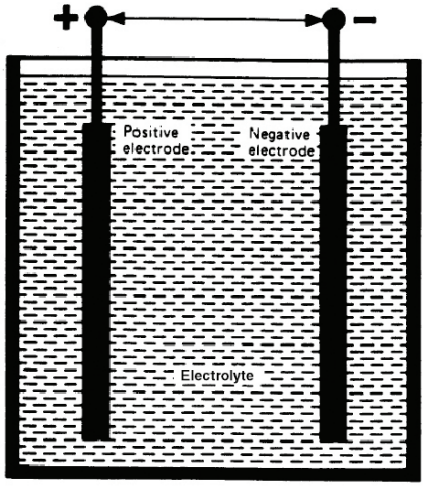
3.0 The Function of a Lead Acid Battery

Key Learning Points

- The battery, an EMF generator by chemical means.
- Basic chemical reaction i.e. lead plates and H2SO4 electrolyte, grid support material; antimony, lead-calcium, lead calcium silver advantages, low maintenance, gassing, durability to higher temperatures, maintenance-free batteries

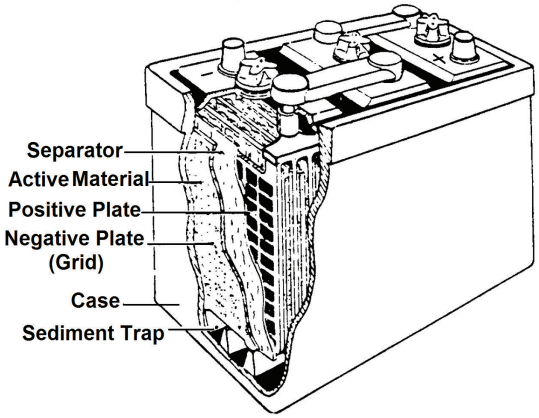
3.1 Function of The Battery

The function of the battery is to store electricity in the form of chemical energy and when required to convert it to electrical energy. Electrical energy can be produced from two plates immersed in a chemical solution. Several linked give a higher capacity.



The Lead Acid Battery is the most popular type used in modern motor vehicles and consists basically of the following parts:

1. Case
2. Plates
3. Electrolyte



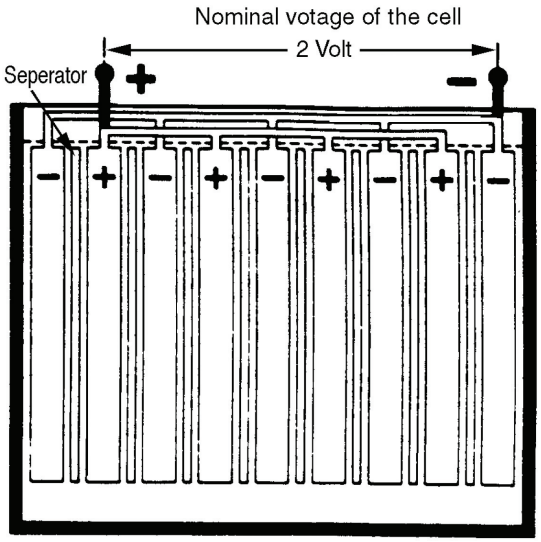
Case

The battery case is constructed of insulating, acid resistant material (hard rubber or plastic) and has a number of compartments or cells. A 12 volt battery has 6 cells. Recesses in the bottom of the cells collect the sediment that falls from the plates. This prevents the sediment from bridging the plates and causing internal short circuiting. The top of the plate assembly is enclosed by a moulded one piece cover which is sealed to the main case. Each cell has a removable plug to facilitate topping up and testing.

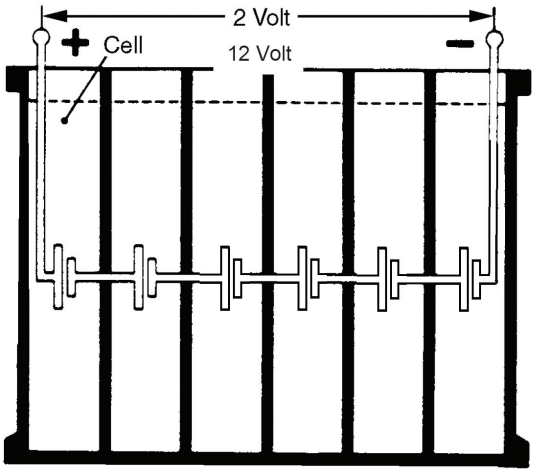
These plugs are vented to allow for the escape of gases produced during charging.

Plates

Each cell has a number of positive and negative plates with separators fitted between them. The total number of plates per cell is normally not less than seven, usually starting and finishing with a negative plate.



The plates are made of lead grids and active material which is coated or pasted onto the grids. Each group of positive plates and each group of negative plates is held together by its own plate strap.



The plate strap joining the positive plates in the first cell is connected to the positive (Plus) terminal pole of the battery. The plate strap joining the negative plates in the last cell is connected to the negative (Minus) terminal pole of the battery.

Electrolyte

The battery is filled with electrolyte which is a mixture of sulphuric acid and water (H2SO4). The separators are porous to permit circulation of the electrolyte and to allow chemical action between the plates to take place. When the cell is functioning, the acid reacts with

the plates, converting chemical energy into electrical energy. Electric current flows from one pole of the battery through the vehicle circuit back to the battery and then through the electrolyte.

The heaviest demand is made on a battery when the engine is being started (approx 120 amps). Once the engine is running, the alternator provides a flow of current to the battery to recharge it and keep it charged.

Discharging

In a fully-charged battery the positive plates are made of lead peroxide and the negative plates are spongy lead. During discharge or use:

- Sulphur in the acid combines with the plates to form lead sulphate.
- The oxygen and hydrogen released combine to form water, which dilutes the electrolyte.

This makes it possible to tell the state of charge by seeing how weak the electrolyte is. A hydrometer is used to measure the strength of the electrolyte.

Both negative and positive plates become lead sulphate as the battery is discharged by use. The resulting lead sulphate is bulkier than spongy lead or lead peroxide, so if the battery is discharged too quickly the plates will buckle and some paste will fall out. This shortens the life of the battery.

Charging

To charge a battery, a current must be forced back through it. So a positive voltage must be applied to the positive terminal and negative to the negative terminal. Also the voltage must be high enough to overcome the battery voltage and drive sufficient current into the battery. About 14 Volts is adequate, for a 12V battery.

During Charging

- Oxygen in the electrolyte combines with the lead sulphate of the positive plate to become lead peroxide;
- Sulphate is released from both plates, which increases the concentration of sulphuric acid in the electrolyte;
- The negative plate becomes spongy lead.

Charging is thus the reverse of discharging, and the plate materials return to their original form lead peroxide for the positive plates and spongy lead for the negative plates.

3.2 Battery Types

There are at least three variations of the lead-acid battery in current automotive use.

In the most common configuration, the car battery has six cells, each producing about 2.1 volts. Thus the total battery output voltage is about 12.6 volts.

The three major contributors to battery chemistry are lead, lead dioxide, and sulphuric acid. Unfortunately pure lead is too soft to withstand the physical abuse of mobile applications, so about 6% antimony was added to strengthen it.

Antimony added to the lead grids acted as a catalyst and made out gassing (loss of hydrogen and oxygen during use) worse, and frequent water replenishing was required. So battery manufacturers looked for another material that could strengthen the lead grids.

Calcium was added to both the positive and negative electrodes it reduced out gassing. Therefore the need for topping up with distilled water is reduced i.e. “maintenance-free batteries”.

However, lead/calcium batteries are not very resistant to “deep-cycling” (deep discharge followed by a full charge). It also required a higher charging voltage at 14.8 volts. Lower settings prevented charging to full capacity. This is too high for lead/antimony batteries and will cause them to lose water rapidly.

The third type of battery frequently used in automotive service uses "hybrid" construction. Its positive grid is strengthened with antimony, and the negative grid with calcium. Water usage is greatly reduced, although regular checking is advisable.

The hybrid battery is more resistant to deep cycling than the lead/calcium, but is still not as good in this respect as the original lead/antimony style.

Older vehicles with voltage regulators set at about 14.0 volts simply will not fully charge lead/calcium or hybrid batteries.

4.0 Service, Test and Charge Batteries

Key Learning Points

- Battery charging, correct use of equipment and rate of charge. Voltage limitation chargers for maintenance free batteries
- Electrolyte specific gravity levels/change during charge/discharge
- Battery: specific gravity test (conventional types) high rate discharge tester, use of electronic battery tester
- Dangers of excessive voltages/voltage peaks produced by the incorrect use of battery chargers/battery charger type causing damage to ECUs or related electronic systems/components

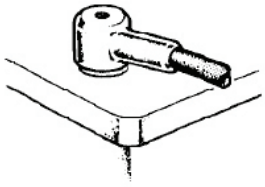
4.1 Battery Maintenance

Positive pole is shown '+'. Usually red in colour and larger diameter.

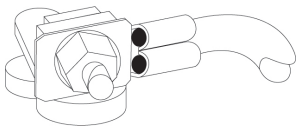
Negative pole is shown '–'. Usually black or green and smaller diameter.

Battery Connectors

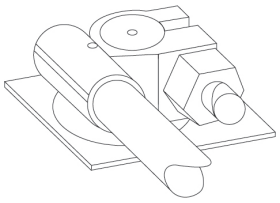
Various types of connectors are shown below:



Die Cast (Helmet) Type

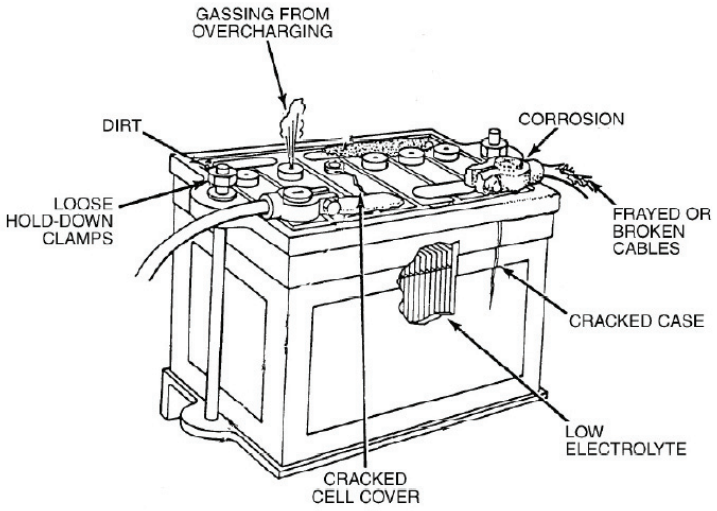


Flat Type



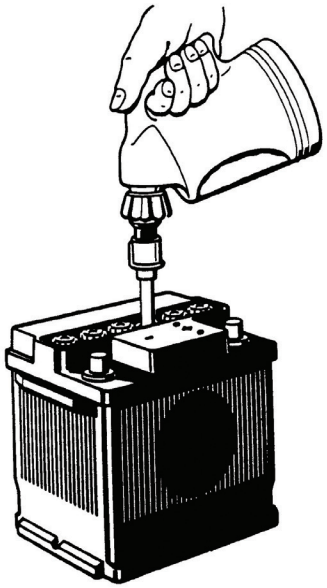
SMMT (Clamp) Type

Battery Visual Checks



1. Electrolyte level. The electrolyte must be maintained at the correct height which is normally level with the tops of the separators.

2. Topping up should be carried out when the electrolyte falls below the correct level. Only distilled water or de-ionised water must be added to electrolyte lost by evaporation.



3. Clean and dry the battery, particularly the top area after topping up.

4. Battery terminal poles and clamps - should be cleaned of oxidation and smeared with petroleum jelly as a precaution against corrosion.

4.2 Battery Recharging

The way that an alternator charges a battery is ideal. It is capable of delivering a large current to a discharged battery when the engine is driving it. Since the alternator has an accurate built-in semiconductor regulator it is unlikely to over-charge the battery.

Workshop chargers and home chargers are not so well regulated and over-charging can occur. This causes gassing, loss of electrolyte, overheating, and positive plate corrosion.

Low-maintenance and maintenance free batteries are easily damaged by using workshop battery chargers use only approved chargers.

Fast Charging

Fast charging or boost charging is only acceptable in an emergency with conventional batteries and should be controlled by a thermostat probe inserted into the electrolyte. Rarely is this precaution taken in practice. Fast charging of low maintenance and maintenance free batteries is not recommended, as most chargers do not have the required control system, Therefore when charging maintenance free batteries the correct charger is to be used.

Charging Rates

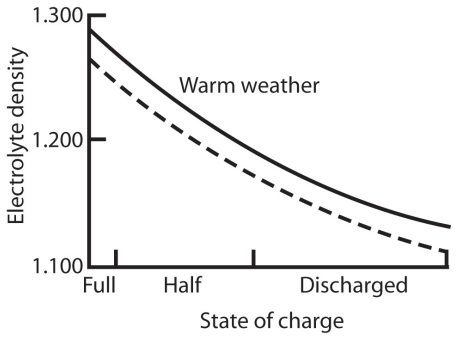
A battery can safely be charged at 1/l0th of its Amp-hr capacity until the terminal voltage reaches 14.4 V: (A 30 Ah battery charged at 1/l0th will require 3 A of direct current). This will take several hours.

Electrolyte

The concentration (strength) of sulphuric acid within the electrolyte varies with the state of charge. This changes the density or specific gravity of the electrolyte, which can be measured with a hydrometer.

State of charge	*Density*
Fully charged	1.280
Half charged	1.200
Discharged	1.120

Since temperature also has a small effect on density the graph below would be a more accurate way of finding the state of charge. Hydrometer scale showing density readings of electrolyte this energy is then available for starting the engine. In addition, the battery covers the power requirements of electrical equipment when the engine is stationary or only ticking over.



Battery Rating

Nowadays batteries have a new method of rating instead of A.H. capacity and it can become very confusing as there are three standards used, namely:

- BS (British Standard)
- DIN (German Standard)
- S.A.E. (Society of Automobile Engineers — American).

However, the main function of a battery used in motor vehicles is to provide a high starting current for a short time. The vehicle loads are thereafter supplied by the alternator. In these circumstances Cold Cranking Amps (CCA) figures are given.

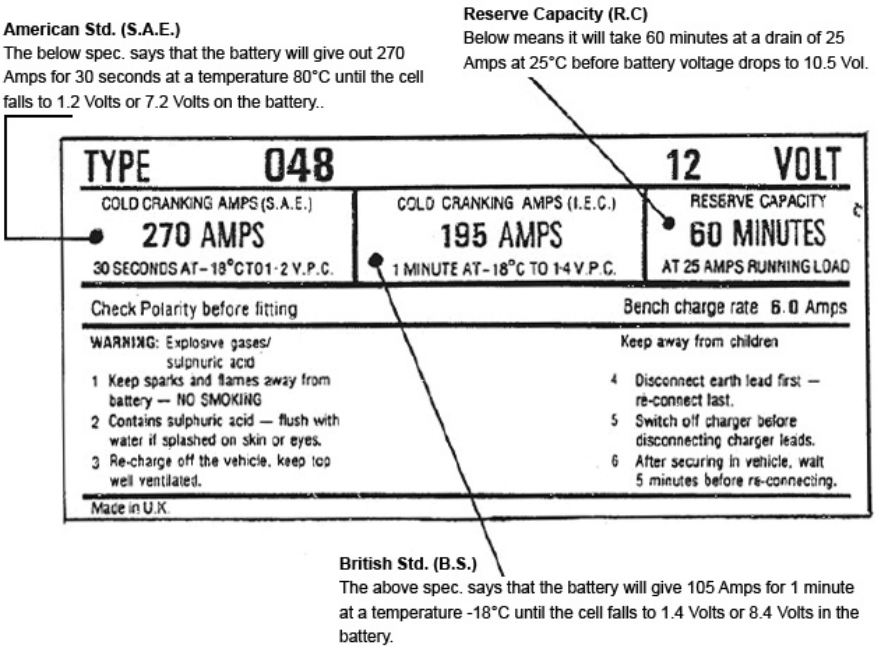
The Cold Cranking rating is, then, the current in Amperes delivered at -18° until the battery voltage fails to:

Standard Duration	*End Voltage*
BS 60 seconds	8.4 volts
DIN 30 seconds	9.0 volts
SAE 30 seconds	7.2 volts

Reserve Capacity (RC)

This is defined as the time in minutes for the battery voltage to fall to 10.5 volts with a constant load of 25 Amps at a temperature of 25°C.

Typical Label on a Battery



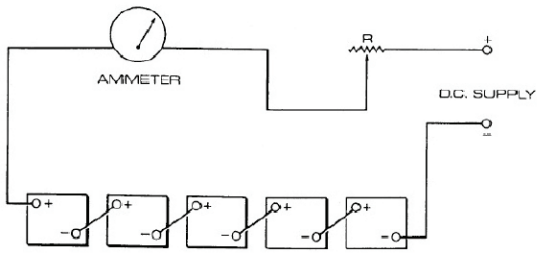
Charging in Series and Parallel

For charging purposes it is possible to put batteries in series or parallel provided the charger can produce the correct voltage and current.

Charging Methods

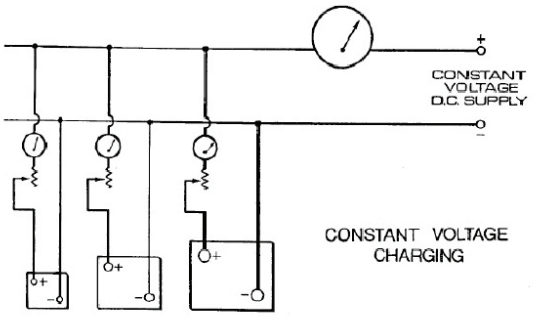
Either the constant current method or the constant voltage method may be employed for recharging. In either case a *Direct Current* supply must be used.

The connections to be made differ with each method as can be seen in the diagram. You will see that, using the constant current method (below), the batteries is in series.



Thus, a limit is set to the number of batteries that may be charged in series, since the voltage of the batteries when fully charged must not exceed the supply voltage.

A constant-voltage charger gives a voltage output equivalent to the voltage of a fully charged battery, e.g. 14.4V for a 12V battery. When a discharged battery is connected to the charger, the initial charge current is high, but this gradually falls until it is practically zero after about 6-8 hours. The batteries are normally connected in parallel with this type of charger.



Charge Rate for Conventional Batteries

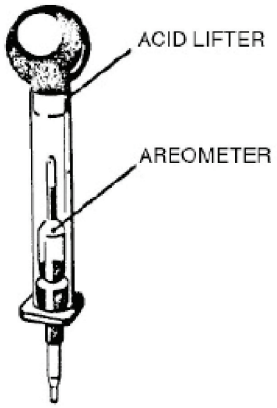
It is recommended that the charge current should be 1/10 of the ampere-hour capacity of the battery. Charging at this rate should continue until the sp. gr. values remain constant for three successive hourly readings and all cells are gassing freely.

During charging, the electrolyte should be maintained at the indicated level by topping-up with distilled water. It takes about 16 hours to recharge a battery at the normal rate from a specific gravity Of 1.190 to its fully-charge state.

Checking Specific Gravity

There is a relationship between the state of battery charge and the strength of the electrolyte. As the battery becomes discharged, the specific gravity (S.G.) of the electrolyte becomes lower.

The S.G. of the electrolyte is measured by means of a hydrometer. This instrument consists of a glass tube, with a rubber bulb fitted on one end. Inside the tube, there is a float, which is calibrated from 1.130 to 1.300.



Indications from specific gravity readings are as follows:

1.260 - 1.280: Battery fully charged

1.190 - 1.210: Battery approximately half charged

1.110 - 1.130: Battery fully discharged

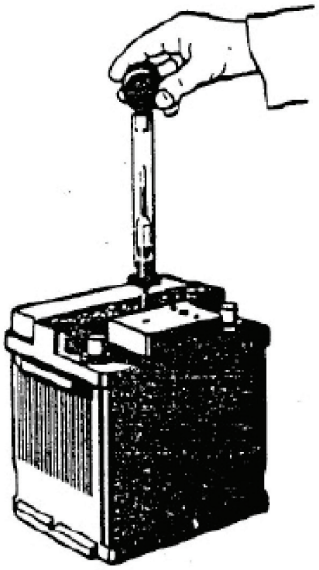
The readings for each cell should be approximately the same.

Note: The hydrometer should always be washed out with clean water after use and stored safely.

This test should be carried out as a further check of the battery condition. A heavy discharge tester should be applied to the battery terminals as shown in the illustration on next page.

The test ensures that the battery is capable of supplying the heavy currents required by the starter at the moment of starting the engine.

The tester should be set to the manufactures specification. This will vary depending on the type and capacity of the battery. An electronic battery tester is to be used to carry out this test.



The results are checked against the manufactures spec and then a report is filled in.

Battery must be 70% charged to obtain correct result.

5.0 Use Boost Pack/Jump Leads

5.1 Battery Boosting Safety Notes

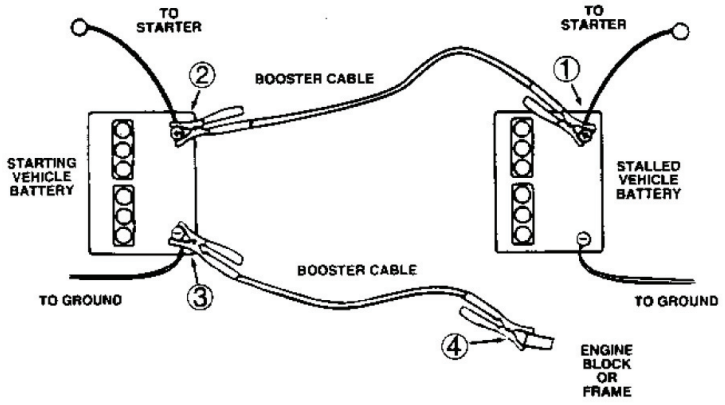
Safe Use of Booster Pack/Jump Leads

- Use a booster pack or jump leads that have a surge protection device.
- Refer to the vehicle manufactures specifications for important specific information on jump starting

General Information

- When jump starting a vehicle, always wear proper eye protection and never lean over battery.
- Inspect both batteries before connecting booster cables. Do not jump start a damaged battery.
- Ensure that the car you are jump starting has the keys out of the ignition and you have them with you outside the vehicle when connecting the leads or booster pack. Some cars will auto lock when you connect a power supply locking keys in the vehicle.
- Be sure vent caps are tight and level.

Sequence for Connecting Leads



1. Connect positive (+) booster cable to positive (+) terminal of discharged battery.
2. Connect other end of positive (+) cable to positive (+) terminal of assisting battery.

3. Connect negative (-) cable to negative (-) terminal of assisting battery.
4. Make final connection of negative (-) cable to engine block of stalled vehicle, away from battery. This helps reduce the risk of sparks occurring around the battery.
5. Start Vehicle and remove cables in reverse order of connections.

5.2 Jump-Starting a Vehicle

Preparation and Safety

Objective

Start a vehicle with a discharged battery using jumper leads and a second vehicle or battery.

Safety Check

- Make sure that the bonnet is secure with a stay rod before going under it.
- A spark created above a battery can cause an explosion. So always follow these precautions:
    1. Keep your face and body as far back as you can while connecting jumper leads.
    2. Connect the leads in the correct order -- positive on discharged battery; then positive on charged battery; then negative on charged battery; then negative to a good ground on the vehicle with the discharged battery away from the battery itself.
    3. Do not connect the negative cable to the discharge battery because this may cause a spark.

4. Only use specially designed heavy-duty jumper cables to start a vehicle with a dead battery. Do not try to connect the batteries with any other type of cable.

- Always make sure that you wear the appropriate personal protection equipment before starting the job. Remember, batteries contain acid and it is very easy to hurt yourself even when the most exhaustive protection measures are taken.
- Always make sure that your work area/environment is as safe as you can make it. Do not use damaged, broken or worn out workshop equipment.
- Always follow any manufacturer's personal safety instructions to prevent damage to the vehicle you are servicing.
- Make sure that you understand and observe all legislative and personal safety procedures when carrying out the following tasks. If you are unsure of what these are, ask your instructor.

Points to Note

- Make sure the battery is not frozen; you cannot jump-start a frozen battery.
- Before you disconnect the service battery from the discharged battery, it is good practice to place a load across the discharged battery (such as turning on the headlamps) to absorb any sudden rise in voltage that may occur as the alternator suddenly increases its output.

Step-by-Step Instruction

1. *Locate the charged battery:* Locate the charged battery close enough to the discharged battery of your vehicle so that it is within comfortable range of your jumper cables. If the charged battery is in another vehicle, make sure the two vehicles are not touching.

2. *Connect jumper leads:* Connect the leads always in this order. First, connect the red, positive, lead to the positive terminal of the discharged battery in the vehicle you are trying to start. The positive terminal is the one with the plus sign. Next, connect the other end of this lead to the positive terminal of the charged battery. Then connect the black, negative, lead to the negative terminal of the charged battery. The negative terminal is the one with the minus sign. Connect the other end of the negative lead to a good ground on the engine block or body of the vehicle with the discharged battery, and as far away as possible from the battery. Do NOT connect the lead to the negative terminal of the discharged battery itself; this may cause a dangerous spark.

3. *Start the vehicle with the discharged battery:* Start the vehicle with the discharged battery. If the booster battery does not have enough charge to do this, start the engine in the second vehicle and try it again with the engine running. Turn the lights on to prevent a possible voltage spike damaging electronic equipment.

4. *Disconnect jumper leads:* Disconnect the leads in the reverse order to connecting them. Remove the negative lead from the good ground. Then from the second battery. Then remove the positive lead from the second battery and lastly, disconnect the other end from the battery in the vehicle you have just started. If the charging system is working correctly and the battery is in good condition, the battery will be recharged while the engine is running.

6.0 Functions of the In-Vehicle Battery Control Unit

Key Learning Points

- Battery control/management unit; on-going evaluation of system voltage, hidden consumer current draw of network/gateway, closing down of lesser priority circuits, requirement of battery charger use

6.1 Battery Control/Management

Many modern vehicles (particularly those using a CANBUS to facilitate the various vehicle electrical systems) have a system that is able to control battery load through a "priority" system. This system is able to determine the most efficient use of the available battery EMF (voltage). Priority is given to the essential vehicle operation systems and less essential systems are effectively put into "sleep or hibernation mode" by the system controller as the available EMF (voltage) runs down.

7.0 End-of-Life Legal Requirements of Lead Acid Batteries

Key Learning Points

- Batteries at 'end of life' stored appropriately for industry approved recycling company collection/us

7.1 Environment Issues

The legal requirements for lead acid battery's in relation to "end of useful life" are that it is disposed in a manner that is appropriate to the current laws and regulations' within the state. The storage of the batteries within the garage environment has to be such that it conforms to the safety rules and regulations. The collection of used batteries has to be by an approved recycling company. Contact your local waste disposal company for further details.

Self Assessment

Q1: In a discharged lead acid cell the active material of both plates is: (Tick one box only)

- ❑ 1. Lead sulphate
- ❑ 2. Lead peroxide
- ❑ 3. Sponge lead
- ❑ 4. Electrolyte

Q2: A hydrometer measures: (Tick one box only)

- ❑ 1. Specific heat
- ❑ 2. Scientific gravity
- ❑ 3. Specific gravity
- ❑ 4. Scientific heat

Q3: The electrolyte in an automotive lead acid battery is: (Tick one box only)

- ❑ 1. Hydrochloric acid
- ❑ 2. Sulphur dioxide
- ❑ 3. Sulphuric acid
- ❑ 4. Nitric acid

Q4: The potentially explosive gas given off when charging a battery is: (Tick one box only)

- ❑ 1. Oxygen
- ❑ 2. Helium
- ❑ 3. Hydrogen
- ❑ 4. Nitrogen

Q5: The Hydrometer reading for a fully charged battery is: (Tick one box only)

- ❑ 1. 1150 - 1200
- ❑ 2. 1200 - 1250
- ❑ 3. 1250 - 1300
- ❑ 4. 1300 – 1350

Q6: During a high rate discharge test, a battery in good condition should maintain a steady voltage that must not drop below: (Tick one box only)

- ❑ 1. 6 volts
- ❑ 2. 8 volts
- ❑ 3. 8.5 volts
- ❑ 4. 10 volts
- ❑ 5. 11 volts

Q7: Battery terminal corrosion can be treated by: (Tick one box only)

- ❑ 1. Pouring cold water on it
- ❑ 2. Using bicarbonate of soda
- ❑ 3. Pouring freezing cold water on it
- ❑ 4. Using salt water

Q8: What is the correct sequence for removing a battery? (Tick one box only)

- ❑ 1. Disconnecting it before removal
- ❑ 2. Disconnecting it after removal
- ❑ 3. Disconnecting the negative terminal and then the positive terminal before removal
- ❑ 4. Disconnecting the positive terminal and then the negative terminal before removal

Q9: What MUST be done when "jump starting" a vehicle fitted with electronic control units? (Tick one box only)

- ❑ 1. Turn ALL systems off before connecting the slave battery
- ❑ 2. Turn the headlights on before connecting the slave battery
- ❑ 3. Turn the headlights on on the slave vehicle before disconnecting the slave battery
- ❑ 4. Turn ALL systems off, on the slave vehicle before connecting the slave battery

Q10: What type of water should you use to top up battery electrolyte levels? (Tick one box only)

- ❑ 1. De-mineralized or distilled
- ❑ 2. Hot de-mineralized or distilled
- ❑ 3. Tap water
- ❑ 4. Mineralized or still water

Q11: Name two types of battery chargers that are used in automotive applications: (Tick one box only)

- ❑ 1. Trickle charger & high rate
- ❑ 2. Trickle charger & low rate
- ❑ 3. Super & high rate
- ❑ 4. Dry cell & high rate

Q12: Which of the following is the most correct when connecting booster leads to start a vehicle with a discharged battery? (Tick one box only)

- ❑ 1. Positive to positive, and negative to engine valve cover
- ❑ 2. Positive to positive, and negative to engine intake manifold
- ❑ 3. Positive to positive, and negative to engine block
- ❑ 4. Positive to positive, and negative to negative

Q13: When disconnecting automotive battery terminals on a vehicle with a negative ground system, which of the following statements are correct? (Tick one box only)

- ❑ 1. Disconnect the positive terminal first
- ❑ 2. Disconnect the negative terminal first

Q14: An assembly consisting of a parallel group of negative plates, a parallel group of positive plates, separators and electrolyte, is referred to as a. (Tick one box only)

- ❑ 1. Series accumulator
- ❑ 2. Unit
- ❑ 3. Battery
- ❑ 4. Cell

Q15: A fully charged battery that has been disconnected has the potential to do work, so it is referred to as a:
(Tick one box only)

- ❑ 1. Source of electrons
- ❑ 2. Source of resistance
- ❑ 3. Source of current
- ❑ 4. Source of energy

Suggested Exercises

1. Use an electronic data facility to procure manufacturer's appropriate data for use with practical exercises
2. Perform specific gravity and high rate discharge tests on a battery
3. Place batteries on charge
4. State the local procedure for battery end of life/recycling
5. Use boost pack/reserve battery/jump leads to 'assist' crank over an engine

Task Sheets

Cleaning & Replacing a Battery

Preparation and Safety

Objective

Clean and replace an automotive battery.

Personal Safety

Whenever you perform a task in the workshop you must use personal protective clothing and equipment that is appropriate for the task and which conforms to your local safety regulations and policies. Among other items, this may include:

- Work clothing - such as coveralls and steel-capped footwear
- Eye protection - such as safety glasses and face masks
- Ear protection - such as earmuffs and earplugs
- Hand protection – such as rubber gloves and barrier cream
- Respiratory equipment – such as face masks and valve respirators

Safety Check

- Make sure that the hood is secure with a bonnet rod before going under it.
- Always make sure that you wear the appropriate personal protection equipment before starting the job. Remember, batteries contain acid and it is very easy to hurt yourself even when the most exhaustive protection measures are taken.
- Always make sure that your work area/environment is as safe as you can make it. Do not use damaged, broken or worn out workshop equipment.
- Always follow any manufacturer's personal safety instructions to prevent damage to the vehicle you are servicing.
- Make sure that you understand and observe all legislative and personal safety procedures when carrying out the following tasks. If you are unsure of what these are, ask your instructor.

Points to Note

- Always remove the negative terminal first when disconnecting the battery and fit the negative terminal last when reconnecting the battery.

- Automotive batteries can look lighter than they really are.
- If replacing a smaller battery with a larger one, replace the restraining device and tray used to secure the new battery.
- Be sure that you do not connect the battery up with reverse polarity because this could send an unwanted voltage spike into the electronic circuit and possibly damage the Electronic Control Unit (ECU).
- Disconnecting the battery will usually clear all the codes that are used to maintain the memory for the vehicle's on-board computer. This may erase all the radio presets and security codes.
- In some cases, the vehicle will even go into a type of "sleep" mode. This can prevent the vehicle from starting after the battery has been reconnected.
- Some manufacturers recommend connecting a 9-volt dry cell battery to the cigarette lighter with an auxiliary plug before the battery is disconnected. This should supply enough power to maintain the memory while the battery is changed over.

Step-by-Step Instruction

1. *Disconnect battery:* Always remove the cable clamp from the negative terminal first. The negative terminal is marked with a minus sign. Then remove the positive terminal, the one with the plus sign. You will later replace them in reverse order, positive cable first and then the negative cable. While they are unconnected, bend the cables back, or if necessary tie them out of the way, so that they cannot fall back and touch the terminals.

2. *Remove battery restraints:* Remove the battery restraints or other hardware holding the battery down. Depending on the type of vehicle, you will need to unbolt or unscrew or unclip the restraint and move it away from the battery. Keeping it upright, remove the battery from its tray and place it on a clean level surface. You are now ready to inspect it.

3. *Visual inspection:* Carefully wipe the battery with a clean cloth. It is best to wear rubber gloves while doing this in case any corrosive electrolyte has leaked from the battery. Then safely dispose of the cloth. If you see major cracks in the battery case or obvious terminal damage, the battery should be replaced regardless of its electrical performance. If the battery is not serviceable, don't just dump it into the trash where it will be a hazard to the environment. Batteries are recyclable, and can be rebuilt and returned into service.

4. *Clean terminals:* If there are powdery deposits on the terminals, clean them off. It may be enough to brush the deposits off the terminal posts and cable clamps with a non-metallic brush and a mixture of baking soda and water. Sprinkle the baking soda onto the terminal, dip the brush in clean water, and scrub the deposits away. If this is not effective, use a battery terminal cleaner and brush to provide a good, solid mechanical and electrical connection.

5. *Clean clamps:* Examine the battery cables to see whether they are badly frayed or corroded. If the damage looks extensive, the cables and clamps should be replaced. Clean the insides of the cable clamps with the clamp cleaner that is usually supplied with a terminal brush. If you don't have the correct brushes, use a steel wool pad instead. Dry the terminals and clamps with a clean, disposable, lint-free rag. To prevent corrosive deposits from forming, coat the terminals with some anti-corrosion terminal grease.

6. *Clean the battery tray:* Clean the battery tray with a mixture of baking soda and water, or some other approved cleaning solutions using a small non-metallic brush. Wipe the tray clean and dry, and then replace the cleaned and serviceable battery. Replace the restraints and make sure they are holding the battery securely in position. If a new battery is to be installed be sure to compare the outside dimensions as well as the type of terminals and their locations prior to installation. These MUST meet the original manufacturer's specifications.

7. *Reconnect the battery terminals:* Reconnect the battery terminals, Positive first, and then Negative. Test that you have a good electrical connection by starting the vehicle.

Charging a Battery

Preparation and Safety

Objective

Correctly charge a battery using battery charging equipment.

Safety Check

- Make all connections between the battery charger and the battery to be charged before connecting to the power supply or turning "ON" any switches.
- Make sure that the voltage used to charge the system never exceeds the system design while charging. For instance if you connect two 12 volt batteries in 'series' for charging you should use the 24 volt setting on the charger, however if you connect the same two batteries in 'parallel' you should only use the 12 volt setting on the charger.

- Never allow a spark or flame to get near the battery.
- Always use the markings on the battery to determine the positive and negative terminals. Never simply use the colour of the cables to determine the positive or negative terminals.
- Make sure that you understand and observe all legislative and personal safety procedures when carrying out the following tasks. If you are unsure of what these are, ask your instructor.

Points to Note

Slow charging a battery is less stressful on a battery than fast charging is.

- Always remove the negative battery terminal while changing a battery to reduce risk to the vehicle, especially with today's electronically intensive cars. Use a 'memory minder' to retain electronic settings.
- After charging the battery and reinstalling it, always clean the battery terminals and posts.

Step-by-Step Instruction

1. *Inspect the battery:* Carry out a visual inspection of the battery to ensure there are no cracks or holes in the casing.
2. *Connect the charger:* Check the charger is unplugged from the wall and turned off. Connect the red lead from the charger to the positive battery terminal. Connect the black lead from the charger to the negative battery terminal. Turn the charger on. Check the charger amperage output to ensure the battery is charging correctly. A slow charger usually charges at a rate of less than 5 amperes. A fast charger charges at a much higher ampere rate depending on the original battery state of charge and should only be carried out under constant supervision.
3. *Disconnect the charger:* Once the battery is charged turn the charger off. Disconnect the black lead from the negative battery terminal, and the red lead from the positive battery terminal.
4. *Test the battery:* Allow the battery to stand for at least 5 minutes before testing the battery. Using a load tester or hydrometer, test the charged state of the battery.

Testing a Battery

Preparation and Safety

Objective

Inspect and test a battery.

Safety Check

- Make sure that the bonnet is secure with a bonnet stay rod.
- Always make sure that you wear the appropriate personal protection equipment before starting the job. Remember that batteries contain acid and it is very easy to hurt yourself even when the most exhaustive protection measures are taken.

- Always make sure that your work area/environment is as safe as you can make it. Do not use damaged, broken or worn out workshop equipment.
- Always follow any manufacturer's personal safety instructions to prevent damage to the vehicle you are working on.
- Make sure that you understand and observe all legislative and personal safety procedures when carrying out the following tasks. If you are unsure of what these are, ask your instructor.

Points to Note

- Batteries come in many sizes and power ratings, so always check the rating of the battery you are servicing. The rating provides a testing benchmark for battery performance.
- The hydrometer used to measure the specific gravity of the electrolyte must be handled carefully and safely.
- Store the hydrometer in a safe receptacle before and after use. Small amounts of electrolyte in the hydrometer can leak out and damage the vehicle paintwork.
- Do not remove electrolyte from one cell to another when testing; this will cause incorrect readings.

Step-by-Step Instruction

1. *General condition checks:* Switch on the ignition. The charge light on the dash should light up, and go out when you start the engine. This indicates that the alternator is charging the battery. Turn the engine off. Switch on the headlights of the vehicle, then start the engine and see if the lights brighten significantly. If they do, then this indicates that the alternator is charging the battery more than it is being drained by the lights. If you do not have someone else to start the engine for you, judge the brightness by shining the lights onto a reflective surface such as a wall. Check that the battery casing and the terminals are in good condition. This can generally be achieved just with a visual inspection; however, since the battery may be located in a position where you cannot see all of it, you may have to remove it to complete the inspection, after performing any other on-car tests.

2. *Check and adjust fluid level:* A sealed or low-maintenance battery has no removable cell covers, so you cannot adjust or test the fluid levels inside However, some of these do have visual indicators that provide information on the status of the charge and condition of the battery cells. Each manufacturer provides details of these visual indicators so refer to these when undertaking an inspection. If the battery is not a sealed unit, it will have removable caps or bars on top. Remove them, and look inside to check the level of the battery fluid, which is called the electrolyte. If the level is below the tops of the plates and their separators inside add distilled water or water with a low mineral content until it just covers them. Be careful not to over-fill the cells as they could "boil" over when charging.

3. *Conduct specific gravity test:* Test the specific gravity of each of the cells by using a hydrometer designed for battery testing. Draw some of the electrolyte into the tester and look at the float inside it. A scale indicates the relative charge state of the battery by measuring how high the float sits in relation to the fluid level. A very low overall reading of 1150 or below indicates a low state of charge. A high overall reading of about 1300 indicates a high state of charge. The reading from each cell should be the same. If one or two cells are very different from the rest that indicates there is something wrong with the battery.

4. *Conduct voltage test with DVOM:* Select the Volts DC position on your DVOM and attach the probes to the battery terminals (red to positive and black to negative). With all vehicle accessories switched off and the battery at 70 degrees Fahrenheit or 21 degrees Celsius, the voltage reading should be 12.6 volts if the battery is fully charged. This will be slightly lower at cooler temperatures.

5. *Conduct load test:* Measure the continuous load capability of the battery with a load tester, use of electronic battery tester is preferred. Refer to the manual of the particular tester for its operating instructions. A load tester induces a high rate of discharge in the battery, like the load created by a cranking starter motor. A battery is rated in ampere hours, which means that it can supply a certain number of amperes for a specified length of time under continuous load. Another measurement used is International Standard Cold Cranking Amps. Check the specifications for the battery you are testing. If it can meet these specifications under a load test then it is in good condition. There are different makes and types of load testers. Always use the equipment manufacturer's recommended testing procedure.

Hazards

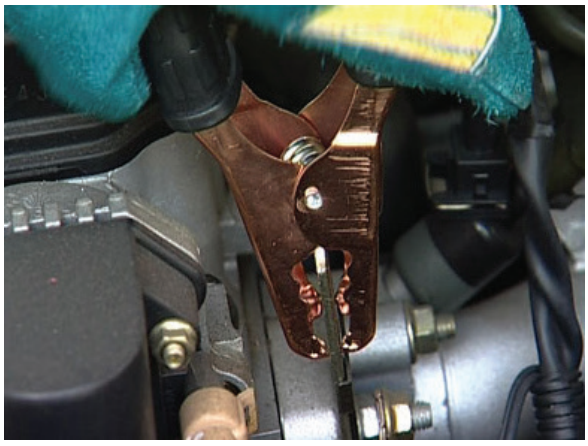
Possibility of explosion by arcing/sparking around battery terminals due to Hydrogen and Oxygen presence from the charging process, acid burns, spillages, overcharging, and toxic fumes.

Jump-Starting a Vehicle

Preparation and Safety

Objective

Start a vehicle with a discharged battery using jumper leads and a second vehicle or battery.



Personal Safety

Whenever you perform a task in the workshop you must use personal protective clothing and equipment that is appropriate for the task and which conforms to your local safety regulations and policies. Among other items, this may include:

- Work clothing - such as coveralls and steel-capped footwear
- Eye protection - such as safety glasses and face masks
- Ear protection - such as earmuffs and earplugs
- Hand protection – such as rubber gloves and barrier cream
- Respiratory equipment – such as face masks

Safety Check

- Make sure that the hood is secure with a stay rod before going under it.
- A spark created above a battery can cause an explosion. So always follow these precautions:

    1. Keep your face and body as far back as you can while connecting jumper leads.
    2. Connect the leads in the correct order -- positive on discharged battery; then positive on charged battery; then negative on charged battery; then negative to a good ground on the vehicle with the discharged battery away from the battery itself.

3. Do not connect the negative cable to the discharge battery because this may cause a spark.

4. Only use specially designed heavy-duty jumper cables to start a vehicle with a dead battery. Do not try to connect the batteries with any other type of cable.

- Always make sure that you wear the appropriate personal protection equipment before starting the job. Remember, batteries contain acid and it is very easy to hurt yourself even when the most exhaustive protection measures are taken.
- Always make sure that your work area/environment is as safe as you can make it. Do not use damaged, broken or worn out workshop equipment.
- Always follow any manufacturer's personal safety instructions to prevent damage to the vehicle you are servicing.
- Make sure that you understand and observe all legislative and personal safety procedures when carrying out the following tasks. If you are unsure of what these are, ask your instructor.

Points to Note

- Make sure the battery is not frozen; you cannot jump-start a frozen battery.
- Before you disconnect the service battery from the discharged battery, it is good practice to place a load across the discharged battery (such as turning on the headlamps) to absorb any sudden rise in voltage that may occur as the alternator suddenly increases its output.

Step-by-Step Instruction

1. *Locate the charged battery*: Locate the charged battery close enough to the discharged battery of your vehicle so that it is within comfortable range of your jumper cables., If the charged battery is in another vehicle, make sure the two vehicles are not touching.

2. *Connect jumper leads*: Connect the leads always in this order. First, connect the red, positive, lead to the positive terminal of the discharged battery in the vehicle you are trying to start. The positive terminal is the one with the plus sign. Next, connect the other end of this lead to the positive terminal of the charged battery. Then connect the black, negative, lead to the negative terminal of the charged battery. The negative terminal is the one with the minus sign. Connect the other end of the negative lead to a good ground on the engine block or body of the vehicle with the discharged battery, and as far away as possible from the battery. Do NOT connect the lead to the negative terminal of the discharged battery itself; this may cause a dangerous spark.

3. *Start the vehicle with the discharged battery:* Start the vehicle with the discharged battery. If the booster battery does not have enough charge to do this, start the engine in the second vehicle and try it again with the engine running. Turn the lights on to prevent a possible voltage spike damaging electronic equipment.

4. *Disconnect jumper leads:* Disconnect the leads in the reverse order to connecting them. Remove the negative lead from the good ground. Then from the second battery. Then remove the positive lead from the second battery and lastly, disconnect the other end from the battery in the vehicle you have just started. If the charging system is working correctly and the battery is in good condition, the battery will be recharged while the engine is running.

Suggested Further Reading

- Advanced Automotive Diagnosis. Tom Denton. ISBN 0340741236
- Automobile Electrical and Electronic Systems (3rd Edition). Tom Denton. ISBN 0750662190
- Automotive Mechanics (10th Edition). William H. Crouse and Donald L. Anglin. ISBN 0028009436
- Bosch Automotive Electrics Automotive Electronics: Systems and Components (4th Edition). Robert Bosch. ISBN 0837610508
- Bosch Automotive Handbook (6th Edition). Robert Bosch. ISBN 1860584748
- Bosch Automotive Technology Technical Instruction booklet series (numerous titles)
- Hillier's Fundamentals of Motor Vehicle Technology: Book One (5th Edition). V.A.W. Hillier and Peter Coombes. ISBN 0748780823
- Hillier's Fundamentals of Motor Vehicle Technology: Book Two (5th Edition). V.A.W. Hillier and Peter Coombes. ISBN 0748780998
- Modern Automotive Technology. James E. Duffy. ISBN 1566376106
- Motor Vehicle Craft Studies - Principles. F.K. Sully. ISBN 040800133X
- National Car Test (NCT) Manual (Department of Transport, Vehicle Testers Manual - DoT VTM). Department of Transport
- Transmission, Chassis and Related Systems (Vehicle Maintenance and Repair Series: Level 3) (3rd Edition) John Whipp and Roy Brooks. ISBN 186152806X
- Vehicle and Engine Technology (2nd Edition). Heinz Heisler. ISBN 0340691867
- http://www.cdxglobal.com/
- http://auto.howstuffworks.com/
- http://www.autoshop101.com/
- http://www.cdxetextbook.com/
- Automotive Encyclopedia and Text Book Resource (CD version of e-textbook), Available from your instructor.

Notes

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