TRADE OF HEAVY VEHICLE MECHANIC

PHASE 2

Module 2

Basic Electricity/Batteries

UNIT: 3

Battery Construction & Maintenance

Table of Contents

1. Learning Outcome

By the end of this unit each apprentice will be able to:

- Described the construction, function and operation of a lead acid battery
- Service test and change battery-(slow and rapid charge)
- Describe the dangers and the Health and Safety precautions associated with the lead acid battery, its service, use and component materials
- Correctly and safety connect a jumper leads to start the vehicle
- Check and replace the generator drive belts
- Use of voltmeter across the battery and a grip on amp-meter to carry out basic charging test under load

1.1 Key Learning Points

- Battery construction: cells, positive/negative plates, electrolyte, casing i.e. plastic/rubber, terminal shapes, size, position, positive/ negative polarity
- Definition of battery capacity i.e. 'Amp Hour Rate' or 'Reserve Capacity' voltage
- Battery function i.e. to store electricity in the form of chemical energy and when required to convert it to electrical energy
- Battery maintenance i.e. testing and topping up electrolyte, pole maintenance
- Battery testing: specific gravity test and high rate discharge test procedure
- Battery charging: correct use of equipment and rate of charge
- Hazards: explosive gases, acid burns, fumes, spillages, overcharging
- Safety precautions: ventilated charging area (fume extraction). Facial and clothing procedures, never allow poles to be bridged by metal object i.e. spanner
- Battery fitment: correct procedure used when fitting, clamping down, connecting and disconnecting, battery specification for vehicle
- Correct boosting and jump starting procedure - precautions against damage to engine management system Basic charging test procedure
- Checking of drive belt condition and adjusting tension
- Internal resistance of a battery: method of calculation
- Battery acid and end of life disposal

2.0 Lead-acid battery

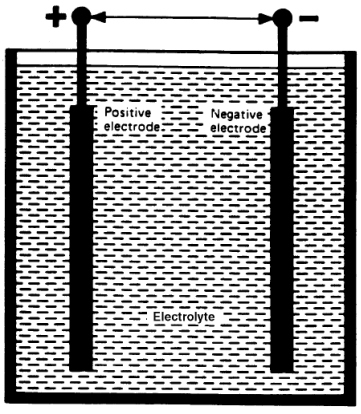
Lead-acid vehicle batteries consist of six cells; each has a nominal voltage of 2 V.

Each charged cell contains electrodes of lead metal (Pb) and lead peroxide (PbO2), in an electrolyte of about 35% sulphuric acid mixed with 65%water = (H2SO4). Modern designs have gelified electrolytes. In a discharged state both electrodes turn into lead sulphate and the electrolyte turns into water. **(This is why discharged lead-acid batteries can freeze.)** Lead acid batteries for automotive use are not designed for deep discharge and should always be kept at maximum charge, using constant voltage at 13.8 V (for six element vehicle batteries). Their capacity will severely suffer from deep cycling. Specially designed deep-cycle cells are much less susceptible to this problem, and are required for applications where the batteries are regularly discharged.

Because of the open cells with liquid electrolyte in most cheap vehicle batteries, overcharging with excessive charging voltages will generate oxygen and hydrogen gas, forming an extremely explosive mix. This should be avoided. Caution must also be observed because of the extremely corrosive nature of sulphuric acid.

2.1 Function of the Battery

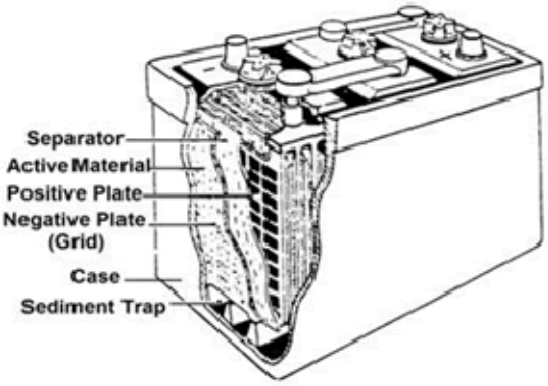
The function of the battery is to store electricity in the form of chemical energy and when required to convert it to electrical energy. Electrical energy can be produced from two plates immersed in a chemical solution. Several linked give a higher capacity.



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

1. Case.
2. Terminals
3. Plates.
4. Electrolyte

Case



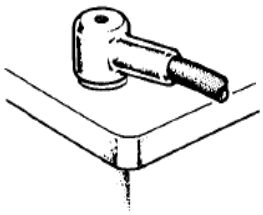
The battery case is constructed of insulating, acid resistant material (hard rubber or plastic) and has a number of compartments or cells. A 12 volt battery has 6 cells. Recesses in the bottom of the cells collect the sediment that falls from the plates. This prevents the sediment from bridging the plates 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.

Terminals

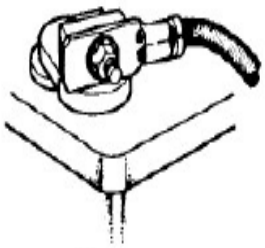
Positive pole: shown '+' usually red in colour and is the larger of the two.

Negative pole: shown '–' usually black or green and is the smaller of the two.

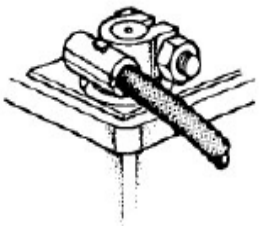
Battery connectors: Various types of connectors are shown below:



Die Cast (Helmet) Type



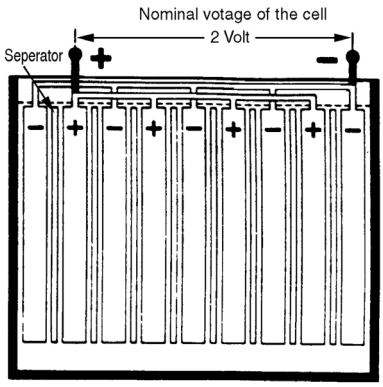
Flat Type



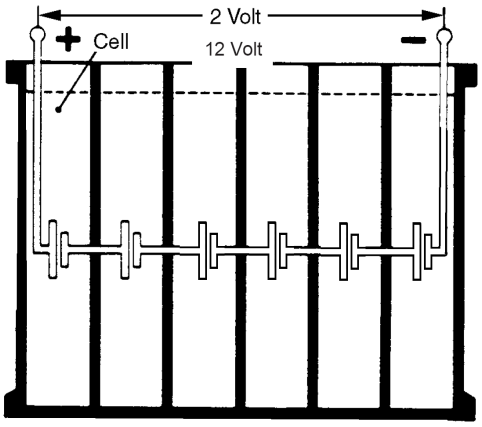
SMMT (Clamp) Type

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 35% sulphuric acid and 65% de-ionised water. The separators between the plates are porous to allow the circulation of the electrolyte, and the chemical action to take place. When the cell is functioning, the acid reacts with the plates, converting chemical energy into electrical energy. Electrical current flows from one pole of the battery, through the circuit back to the battery. The heaviest demand is made on a battery when the engine is being started. Once the engine is running, the alternator provides a flow of current to the battery to recharge it and keep it in a good state of readiness.

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.

- 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 forming lead peroxide for the positive plates and spongy lead for the negative plates.

2.2 Environmental 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.

2.3 Batteries and cells

Vehicle battery

Most Vehicle batteries are lead-acid batteries. The lead acid battery is made up of plates, lead, and lead oxide (various other elements are used to change density, hardness, porosity, etc.)

Basically there are two types of batteries; starting (cranking), and deep cycle(marine/golf cart). The starting battery is designed to deliver quick bursts of energy (such as starting engines) and have a greater plate count. The plates will also be thinner and have somewhat different material composition. The deep cycle battery has less instant energy, but greater long-term energy delivery. Deep cycle batteries have thicker plates and can survive a number of discharge cycles. Starting batteries should not be used for deep cycle applications. The so-called Dual Purpose Battery is only a compromise between the 2 types of batteries.

2.4 Battery Types

There are at least three variations of the lead-acid battery in current automotive use. In the most common configuration, the vehicle 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 is 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 enough to allow manufacturers to claim they building "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.

2.5 Battery Capacity

While a battery that can deliver 10 A for 10 hours can be said to have a capacity of 100 AH, that is not how the rating is determined by the manufacturers. A 100 AH rated battery most likely will not deliver 10 A for 10 hours. Battery manufacturers use a standard method to determine how to rate their batteries. Their rating is based on tests performed over 20 hours with a discharge rate of 1/20 (5%) of the expected capacity of the battery an hour. So a 100 ampere-hour battery is rated to provide 5 A for 20 hours. The efficiency of a battery is different at different discharge rates. When discharging at 5% an hour, the battery's energy is delivered more efficiently than at higher discharge rates. To calculate the 5% discharge rate of a battery, take the manufacturer's ampere-hour rating and divide it by 20.

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.

Later methods of 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:

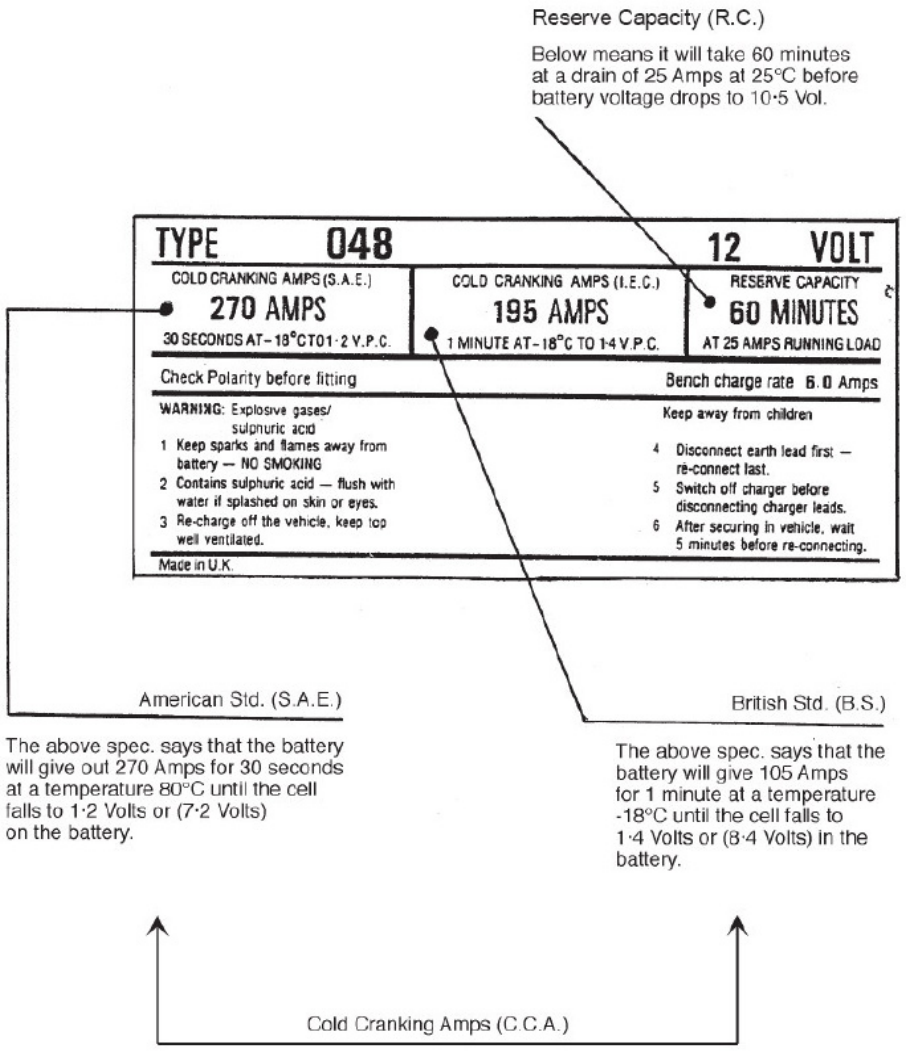
- BS (British Standard)
- DIN (German Standard)
- SAE (Society of Automobile Engineers —American).

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

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

Standard Duration	End Voltage
BS 60 seconds	8·4 volts
DIN 30 seconds	9·0 volts
SAE 30 seconds	7·2 volts

Typical label on a battery



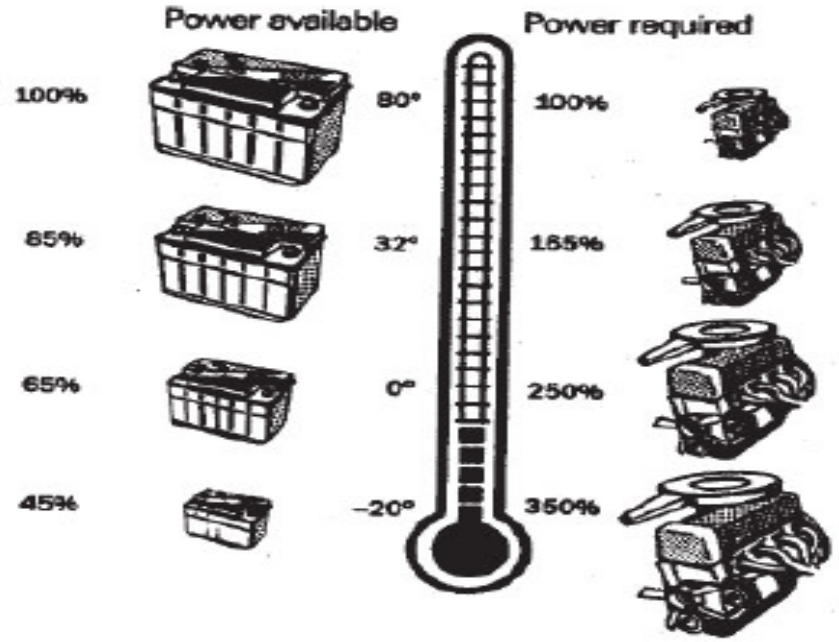
How the battery works Batteries do not produce electric current but instead store current produced by the generator when the engine is running. This energy is then available for starting the engine. In addition, the battery covers the power requirements of electrical equipment when the engine is stationary or only ticking over.

State of charge:

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. Hydrometer scale showing density readings of electrolyte

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.



2.6 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.

2.7 Testing a battery

Part 1. Preparation and safety

Objective

· Inspect and test a battery.

Safety check

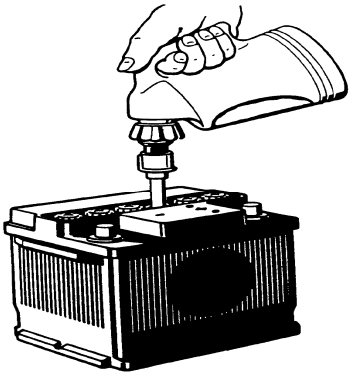
- Make sure that the access is good and any covers or cab are secure and can not fall.
- Always make sure that you wear the appropriate personal protection equipment before starting the job.
- Remember that batteries contain acid and it is very easy to hurt yourself even when the most exhaustive protection 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 supervisor.

Points to note

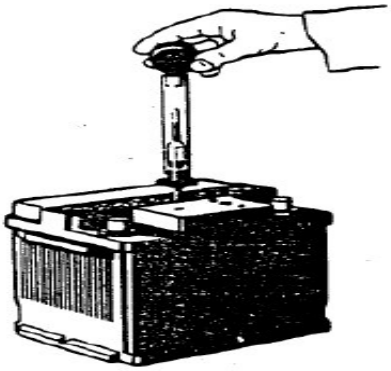
- Batteries come in many sizes and power ratings, so always check the rating of the battery you are servicing. The rating provides a testing benchmark for battery performance.
- The hydrometer used to measure the specific gravity of the electrolyte must be handled carefully and safely.
- Store the hydrometer 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.

Part 2: 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-vehicle 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:** 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. To carry out a specific gravity test on a battery the hydrometer must be designed for battery testing. First step should be to put on all the required personal protection equipment (PPE). Remove all vent caps from the battery to be tested. Draw some of the electrolyte into the hydrometer until the float is floating clear of the bottom of the outer tube. Take a reading from the scale on the float. This reading indicates the density of the electrolyte in that cell. Replace the electrolyte in the same cell, and repeat the process for all the remaining cells. The readings for each cell should be approximately the same.



Add all the readings together and divide by the number of cells. The figure you have now is an overall state of charge for the battery. A very low overall reading of 1150 or below indicates a low state of charge. A high overall reading of about 1280 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.

Indications from specific gravity readings are as follows:

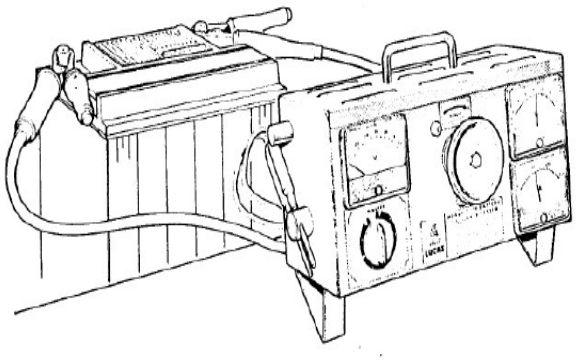
- 1.260 - 1.280: Battery fully charged
- 1.190 - 1.210: Battery approximately half charged
- 1.110 - 1.130: Battery fully discharged

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

The Hydrometer indicates the sate of charge of the battery and a further check using a Hi-rate Discharge Tester should be carried out to ensure 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 discharge the battery at three times the ampere hour capacity (20 hr. rate) for 15 seconds, or matched to the R/C rating of the battery.

Example: If a battery has a capacity of 50 Ah, the tester should be set to 150 amps on the ammeter. Observe the voltmeter during the battery discharge. If the voltmeter reading is 9·6V or above, the battery is considered satisfactory. If the voltage falls below 9·6V, the battery is suspect and should be removed for further testing.



Heavy Discharge Test

Conduct load test:

NOTE: A Battery must be above 70% charged to obtain a correct result.

Measure the continuous load capability of the battery with a load tester, use of electronic battery tester with a printer attached is preferred as this will issue a record of the test.

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. Some testers use the ampere hours, while others use reserve capacity or cold cranking amps to test the battery. There are different makes and types of load testers. Always use the equipment manufacturer's recommended testing procedure. 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.

Hazards: Make sure that the Hi-rate tester is switched off before connecting or disconnecting to a battery.

Warning: before carrying out a heavy discharge test it is important to blow gently across the top of the battery (with the caps removed if possible). This will disperse any explosive hydrogen gas, which may otherwise be ignited by the spark.

2.8 Battery Charging

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.

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.

Electrochemical cells transform chemical energy into electrical energy. There are two types, primary and secondary.

In a primary cell, this transformation is not reversible, and the cell is discarded at the end of its life. In the secondary cell, the transformation is reversible, and it can be re-charged.

There are two types of secondary cell, wet and dry. In automotive use, the usual main-storage device is the wet cell of a lead acid battery. It has two plates of dissimilar materials immersed in an electrolyte - a solution that conducts electricity by using ions.

The accepted, or nominal, voltage of a cell does not depend on the size of the cell, however, current capacity does. The surface area of the plates in a cell determines its current capacity. In a lead acid battery, the plates are assembled so there is always 1 extra negative plate. The plates are close to each other but do not touch, which would cause a short circuit.

The nominal voltage of a cell is 2 volts. Cells connected in series make a battery, and the number of cells determines its nominal voltage. The cells are sealed from each other and filled with dilute sulphuric acid. The battery case is usually plastic or hard rubber.

One set of plates is connected to the negative side of a DC source, the other to the positive side. Direct current is applied to the plates, changing them chemically, until the battery is ready for service.

Caution Danger of Battery Explosion

Under extreme conditions, certain types of batteries can explode violently. A battery explosion is usually caused by the misuse or malfunction of a battery (such as the recharging of a non-rechargeable battery or shorting out of a Vehicle battery).

With vehicle batteries, explosions are most likely to occur when a short circuit generates currents of very high magnitude. A short circuit malfunction in a battery placed in parallel with other batteries ("jumped") can cause its neighbour to discharge its maximum current into the faulty cell, leading to overheating and possible explosion. In addition, vehicle batteries liberate hydrogen when they are overcharged even slightly (because of hydrolysis of the water in the electrolyte). Normally the amount of overcharging is very small and so is the amount of highly explosive gas developed, and the light gas dissipates very quickly. However, when "jumping" a vehicle battery, the high current can cause the rapid release of large volumes of hydrogen, which could be ignited by a spark nearby (for example, when removing the jumper cables).

When a non-rechargeable battery is recharged at a high rate, an explosive gas mixture of hydrogen and oxygen may be produced faster than it can escape from within the walls of the battery, leading to pressure build-up and a possible explosion. In extreme cases, the battery acid may spray violently from the casing of the battery and cause injury. Additionally, disposing of a battery in fire may cause an explosion as steam builds up within the sealed case of the battery. Overcharging, which is charging a battery beyond its electrical capacity, can also lead to a battery explosion, leakage, or irreversible damage to the battery. It may also cause damage to the charger or device in which the overcharged battery is later used.

2.9 Charging a Battery

Part 1. 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 supervisor.

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 vehicles. Use a 'memory minder' to retain electronic settings.
- After charging the battery and reinstalling it, always clean the battery terminals and posts.
- Battery charging, correct use of equipment and rate of charge.
- Voltage limitation chargers for maintenance free batteries.
- Dangers of excessive voltages/voltage peaks produced by the incorrect use of battery chargers/battery charger type causing damage to Electronic Control Units or related electronic components.

Part 2: Step-by-step instruction

- Inspect the battery: carry out a visual inspection of the battery to ensure there are no cracks or holes in the casing.
- 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.
- 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.
- Test the battery: Allow the battery to stand for at least 15 minutes before testing the battery. Using a load tester or hydrometer, test the charged state of the battery.
- 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 S.G. reading of 1.190 to its fully-charge state.

2.10 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. Overcharging causes gassing, this in turn results in loss of electrolyte, due to overheating. Low-maintenance and maintenance free batteries are easily damaged by using workshop battery 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.

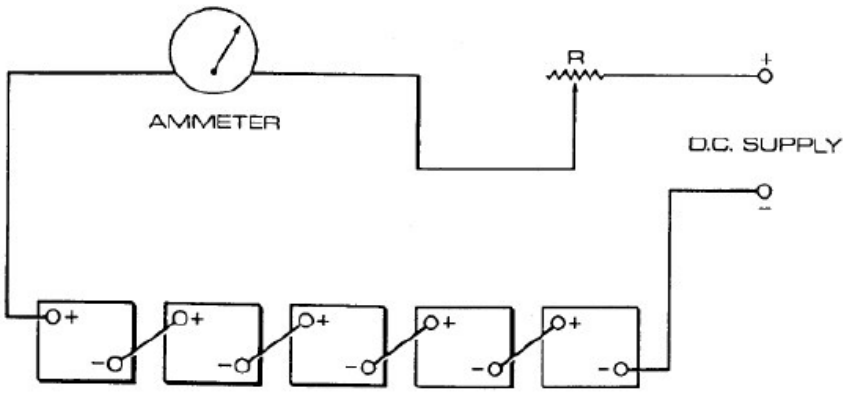
Charging Rates

A battery can safely be charged at a tenth of its Amp-hr capacity until the terminal voltage reaches 14.4 V: (A 30 Ah battery max rate of charge is 3 Amps of direct current).

Charging in series and parallel

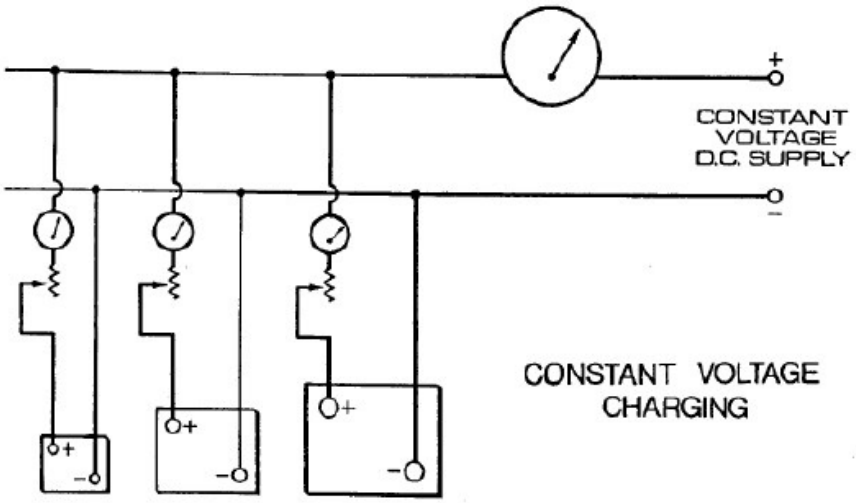
For charging purposes it is possible to put batteries in series or parallel provided the charger can produce the correct voltage and current. There are two charging methods used, these are constant current method or the constant voltage method. In either case a **Direct Current** supply must be used. The connections that are made differ, depending on the method used.

You will see that, using the constant current method (below), the batteries are connected in **series**.



The limit on the number of batteries that may be charged in series 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 8 to 10 hours. The batteries are normally connected in **parallel** with this type of charger.



2.11 Battery Boosting Safety Notes

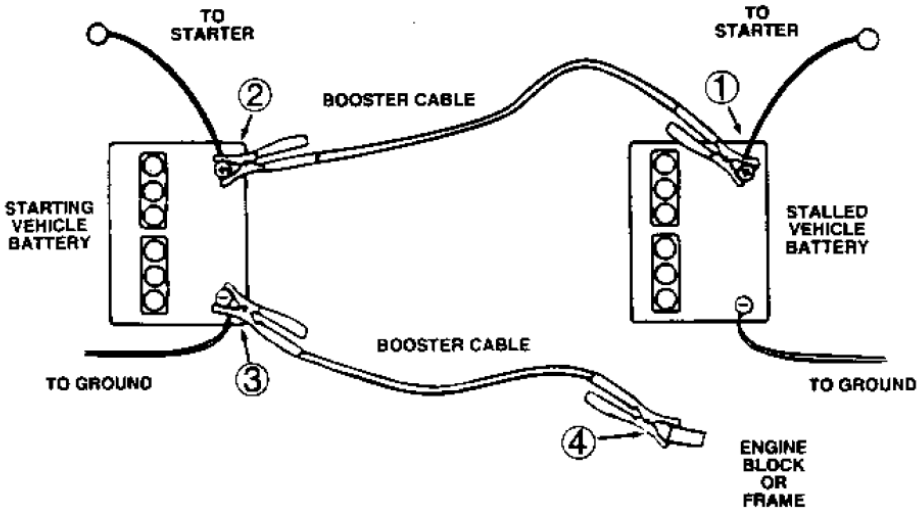
Safe Use of Booster Pack/Jump Leads to assist start a vehicle

- 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 vehicle 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 vehicles will auto lock when you connect a good 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.

Start Vehicle and remove cables in reverse order of connections.

2.12 Jump-starting a Vehicle

Part 1. 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 access is clear from obstruction and loose covers before working on connections.
- 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 supervisor.

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.

Part 2: 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.

Precautions

Batteries in Service:

1. 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.
2. 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.
3. 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:

    - The battery will need to be topped up frequently.
    - Electrolyte may overflow onto the battery cage.
    - Lights will brighten up abnormally and bulbs may blow at more than the normal rate.

4. 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.

5. 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.
6. 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.
7. Never, test a battery by placing any metal object across the battery poles. The end result could be the same as in No. 5 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.
8. 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.
9. Using jump leads, or battery booster always double check polarity before connecting:

    - The spark caused by a wrong connection could cause an explosion or damage to alternator.

10. Always disconnect the battery when:

    - electric welding
    - Working on the electrics, except for testing.
    - Removing the starter motor.
    - Removing the engine.
    - Carrying out any mechanical work in the vicinity of the battery.
    - Leaving a job where turning over the engine could cause damage.

11. Exercise extreme care when removing or fitting battery connections. Never hammer on or off.
12. Do not use undue pressure when removing clamps. (Slacken bolt and spread clamp)
13. When refitting ensure polarity is correct and tighten securely but do not over tighten.

SOLAS

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