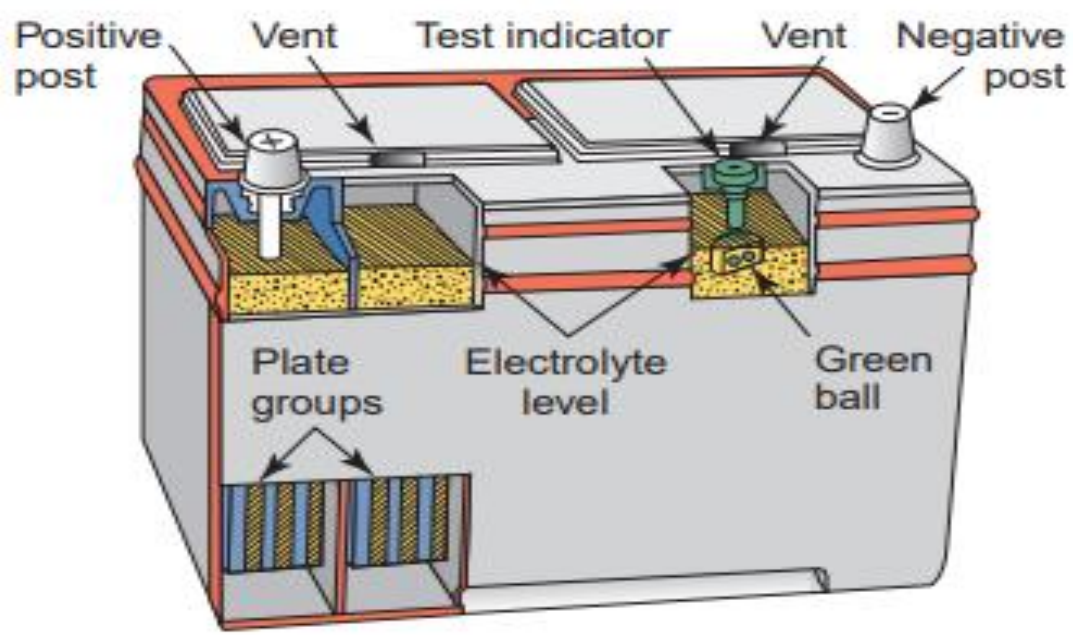
Atomotive Mechanics

Level – I

Based on June 2021, Curriculum Version 1



Module Title: - Testing, Charging and Replacing Batteries

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Acronyms

- ✓ WHS ====Workplace Health and Safety
- ✓ PPE =====Personal Protective Equipment
- ✓ NiCad ===Nickel-Cadmium
- ✓ NiMH ===Nickel-Metal Hydride
- ✓ Li-Ion === Lithium-Ion
- ✓ DVM === digital volt meter
- ✓ SOC ==== state-of-charge

Introduction to the Module

In automotive mechanics filed; the Test, Charge and Replace Batteries helps to know to test, inspect and service battery; to charge battery, to carry out jump-start procedures to vehicle and remove and replace battery; to identify WHS required; in automotive mechanics filed.

This module covers the knowledge, skill and attitude required to test, charge, jump-start, and remove and replace automotive batteries. **Test, Charge and Replace Batteries**

This module covers the units

- Test and inspect battery
- Battery charge
- Vehicle jump-start
- Remove and replace battery
- Retest battery

Learning Objective of the Module

- Prepare to test and inspect battery
- Test and service battery
- Charge battery
- Carry out jump-start procedures to vehicle
- Remove and replace battery
- Retest battery and prepare vehicle and equipment for delivery

Module Instruction

For effective use this modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the "LAP test" giver at the end of each unit and
5. Read the identified reference book for examples and exercise

Unit One: Test and Inspect Battery

This module is developed to provide you the necessary information regarding the following content coverage and topics:

- Workplace Health and Safety (WHS)
- Principles of electro/chemical Process of Battery
- Battery Characteristics and Construction
- Battery Rating and code

This module will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Know Workplace Health and Safety (WHS)
- Know Principles of electro/chemical Process of Battery
- Understand Battery Characteristics and Construction
- Determine Battery Rating and code

2.1 Workplace Health and Safety (WHS)

Safety must be a prime consideration when anyone is working around and with batteries. Remove all jewelry. After all you don't want to melt your watchband while you are wearing the watch. The hydrogen gas that batteries make when charging is very explosive. Batteries have been known to explode and drench people in sulfuric acid. This is a good time to use safety goggles because sulfuric acid eats up clothing and you may want to select Polyester clothing to wear, as it is naturally acid resistant. When doing electrical work on vehicles it is best to disconnect the ground cable. Just remember you are messing with corrosive acid, explosive gases and 100's amps of electrical current.

The primary source for electrical power in all automobiles is the battery. The battery has undergone many changes through the years. The introduction of hybrid vehicles and the promise of fuel cell vehicles have drastically changed the basic design of an automotive battery. Many different types of batteries are available or under development to exceed the needs of hybrid or fuel cell vehicles. Lead-acid batteries have been, and continue to be, the power source for conventional vehicles.

2.2 Personal safety

Whenever perform a task in the work shop you must personal protective cloth and equipment that is appropriate the task and which conforms to your local safety regulation s and Policies.

A Personal Protective Equipment (PPE) is clothing or equipment designed to reduce employee exposure to chemical, biological, and physical hazards when on a worksite. It is used to protect employees when engineering and administrative controls are not feasible to reduce the risks to acceptable levels.

Among other items, this may include.

- **Working clothes** =such as cover all and steel capped foot wear.



Figure 2-1clothing

- **Eye protection**=such as safety glasses and face masks.



Figure 2-2 various types of eye protection: safety (splash) goggles, face shield, and safety glasses

- **Ear protection**=such as earmuffs and ear plugs.



Figure 2-3While working in a noisy environment, your ears can be protected with earmuffs or earplugs.

- **Hand protection**=such as rubber gloves and barrier respiratory equipment-such as face masks and valve respirators
- **Respiratory protection:** There are two types, disposable dust mask and respiratory. A disposable dust mask is made from paper with a wire reinforced edge that is held to your face with an elastic stripe it covers your mouth and nose, and is disposed of at completion of the task.

2.3 Handling of potentially hazardous material and substances

a). Gasoline is a highly flammable volatile liquid. Something that is flammable catches fire and burns easily. A volatile liquid is one that vaporizes very quickly. Flammable volatile liquids are potential fire bombs. Always keep gasoline, ethanol, or diesel fuel in an approved safety can and never use gasoline to clean your hands or tools.

b). Ethanol Most commonly found as E85 (15% gasoline mixed with 85% ethanol), ethanol is a very volatile liquid. Ethanol is a non-petroleum-based fuel and is used as an alternative fuel to gasoline. Ethanol is also used as an additive to increase the octane rating of gasoline. Handle and store E85 in the same way as gasoline.

c). Diesel fuel is not as volatile as gasoline but should be stored and handled in the same way.

d). Solvents cleaning solvents are also not as volatile as gasoline, but they are still flammable. These should be stored and treated in the same way as gasoline.

e). Fire Extinguishers You should know the location of all fire extinguishers and fire alarms in the shop and you should also know how to use them before you need one.



Figure 2-4 Know the location and types of fire extinguishers that are available in the shop.

a). Battery Precautions

Because the vehicle's electrical power is stored in a battery or battery pack, special handling precautions must be followed when working with or near batteries. Hybrid and other electric vehicles have very high voltages; therefore, special precautions apply to these vehicles and are given following the general precautions for batteries.

- ✓ Make sure you are wearing safety glasses (preferably a face shield) and protective clothing when working around and with batteries.
- ✓ Keep all flames, sparks, and excessive heat away from the battery at all times, especially when it is being charged.
- ✓ Never smoke near the top of a battery and never use a lighter or match as a flashlight.
- ✓ Never lay metal tools or other objects on the battery because a short circuit across the terminals can result.
- ✓ All batteries have an electrolyte, which is very corrosive. It can cause severe injuries if it comes in contact with your skin or eye. If electrolyte gets on you, immediately wash with baking soda and water. If the acid gets in your eyes, immediately flush them with cool water for a minimum of 15 minutes and get immediate medical attention.
- ✓ Lead-acid batteries use sulfuric acid as the electrolyte. Sulfuric acid is poisonous, is highly corrosive, and produces gases that can explode in high heat.
- ✓ Acid from the battery damages a vehicle's paint and metal surfaces and harms shop equipment. Neutralize any electrolyte spills during servicing.
- ✓ The most dangerous battery is one that has been overcharged. It is hot and has been, or still may be, producing large amounts of hydrogen. Allow the battery to cool before working with or around it. Also never use or charge a battery that has frozen electrolyte.
- ✓ Always use a battery carrier or lifting strap to make moving and handling batteries easier and safer.
- ✓ Always charge a battery in well-ventilated areas.
- ✓ Never connect or disconnect charger leads when the charger is turned on. This generates a dangerous spark.
- ✓ Never recharge the battery when the system is on.
- ✓ Turn off all accessories before charging the battery and correct any parasitic drain problems.

- ✓ Make sure the charger's power switch is off when you are connecting or disconnecting the charger cables to the battery.
- ✓ Always double-check the polarity of the battery charger's connections before turning the charger on. Incorrect polarity can damage the battery or cause it to explode.
- ✓ Never attempt to use a charger as a boost to start the engine

2.4 Types of storage batteries

In addition to their use in automobiles, batteries are used in many other applications. As a result, there are many different types and designs of batteries available. Batteries differ in size, from small single cells to large battery packs, comprised of many cells. They also have different ratings (not always dependent on size) and service lives. The primary difference between batteries is the chemicals used in the cells.

The following battery types can be or are being used in automobiles.

2.4.1 Lead-Acid

Lead-acid batteries are the most commonly used starting battery. This type of battery is rechargeable. Several lead-acid batteries are connected in series to provide high voltage in some electric vehicles. There are many variations to the basic design, but all work and are constructed in the same way. The lead-acid cell has electrodes made of lead and lead-oxide with an electrolyte that is a strong acid. The lead-acid battery is one of the oldest battery designs.

2.4.2 Nickel-Cadmium (NiCad)

NiCad batteries are mostly used in portable radios, emergency medical equipment, professional video cameras, and power tools. They provide great power and are normally the battery of choice for power tools. The electrodes in a NiCad cell are nickel hydroxide and cadmium. The electrolyte is potassium hydroxide. NiCad batteries are economical and have a long service life. However, cadmium is an environmentally unfriendly metal, which is why NiCad batteries are being replaced by other designs.

2.4.3 Nickel-Metal Hydride (NiMH)

Nickel-metal hydride batteries are rapidly replacing NiCad batteries because they are more environmentally friendly and are more capable of receiving a full recharge. NiMH batteries also have more capacity than a NiCad but have a reduced service life and a lower current capacity under load. These batteries are commonly used in today's hybrid vehicles. The cells have electrodes made of a metal hydride and nickel hydroxide. The electrolyte is potassium hydroxide.

2.4.4 Lithium-Ion (Li-Ion)

The electrodes in lithium-ion cells are made of a carbon compound (graphite) and a metal oxide. The electrodes are submersed in lithium salt. Overheating these cells may produce pure lithium in the cells. This metal is very reactive and can explode when hot. To prevent overheating Li-ion cells have built-in protective electronics and/or fuses to prevent reverse polarity and overcharging.

2.5 Principles of electro/chemical Process of Battery

The principle of how a battery works is based on a scientific principle that states: When two dissimilar metals are placed in an acid, electrons flow between the metals if a circuit is connected between them.

A battery consists of one or more electrochemical cells. Each cell contains two metal electrodes and at least one electrolyte solution (a solution containing ions that can conduct electricity). The battery operates through electrochemical reactions called oxidation and reduction. These reactions involve the exchange of electrons between chemical species. If a chemical species loses one or more electrons, this is called oxidation. The opposite process, the gain of electrons, is called reduction.

The automobile battery, or lead storage battery, consists of six electrochemical cells connected in series. The anode of each cell is lead, while the cathode is lead dioxide.

Lead dioxide is represented as: PbO_2

The electrodes are immersed in a sulfuric acid solution. Sulfuric acid is represented as: H_2SO_4.

When you start your car, the following cell reactions take place:

$$Pb(s) + H_2SO_4(aq) \rightarrow PbSO_4(s) + 2\,H^+ + 2\,e^-\ (anode)$$

$$2\,e^- + 2\,H^+ + PbO_2(s) + H_2SO_4(aq) \rightarrow PbSO_4(s) + 2\,H_2O(l)\ (cathode)$$

$$Pb(s) + PbO_2(s) + 2\,H_2SO_4(aq) \rightarrow 2\,PbSO_4 + 2\,H_2O(l)\ (overall\ reaction)$$

When this reaction takes place, both electrodes become coated with solid lead (II) sulfate, and the sulfuric acid is used up.

After the automobile has been started, the alternator or generator takes over the job of producing electricity (for spark plugs, lights, and so on) and also recharges the battery. The alternator reverses both the flow of electrons into the battery and the original redox reactions, and regenerates the lead and lead dioxide:

$$2\,PbSO_4(s) + 2\,H_2O(l) \rightarrow Pb(s) + PbO_2(s) + 2\,H_2SO_4(aq)$$

During charging, the automobile battery acts like a second type of electrochemical cell, an *electrolytic cell*, which uses electricity to produce a desired redox reaction.

2.5.1 Electrochemical Action

A lead-acid storage battery can be partially discharged and recharged many times. There are four stages in this discharging/charging cycle.

- ✓ Charged
- ✓ Discharging
- ✓ Discharged
- ✓ Charging

A). Charged

A fully charged battery contains:

- ✓ Negative plate of sponge lead (Pb)
- ✓ positive plate of lead dioxide (PbO_2)
- ✓ Electrolyte of sulphuric acid (H_2SO_4)

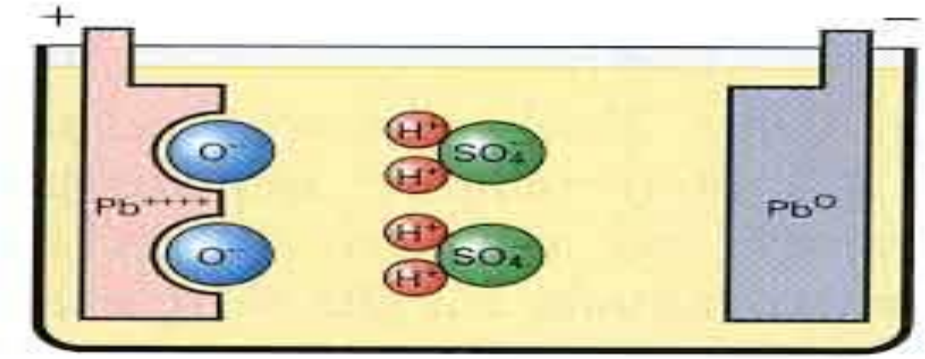
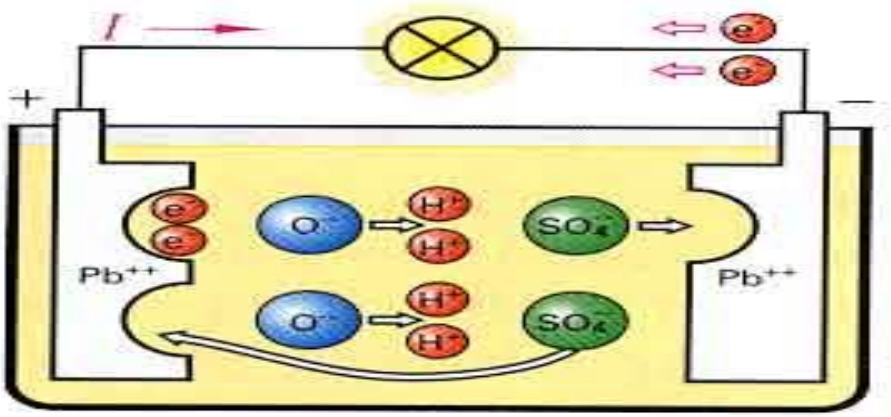


Figure 2-5 charged battery

B). Electro-chemical process during Discharging

- ➢ The electrolyte divides into hydrogen (H_2) and sulfate ($S0_4$).
- ➢ The hydrogen (H_2) combines with Oxygen (O) from the positive plate to form more water (H_2O).
- ➢ The sulfate combines with the lead (Pb) in both plates to form lead sulfate ($PbSO_4$)



2-6 Battery discharging process

C). Electro-chemical process during discharged: In a fully discharged battery both Plates are covered with lead sulfate ($PbSO_4$) and the Electrolyte is diluted to mostly water (H_2O).

D). Electro-chemical process during charging

In a discharged lead storage cell, the active materials of both, the positive and the negative electrodes consist of lead sulphate ($PbSO_4$) which is a white colour.

If the lead storage cell is to be charged, its two electrodes connected to a suitable source of direct current. The source of the charging current draws electrons from the positive electrode and forces them in to the negative electrode and zero volt lead is formed at the negative electrode from the bivalent positive lead atoms, breaking down the lead sulphate So4-2 molecule ($PbSO_4$). As a result the negatively charged are released from the negative electrode to the electrolyte. At the positive electrode the bivalent positive lead is transformed in to tetravalent positive lead through removal of electrons. In this process the lead sulphate is separated in to lead ion and sulphate ion and the lead peroxide as a result the sulphate ion and the hydrogen ion pass in to the electrolyte and the positive hydrogen and the negative sulphate ion increases in the solution.

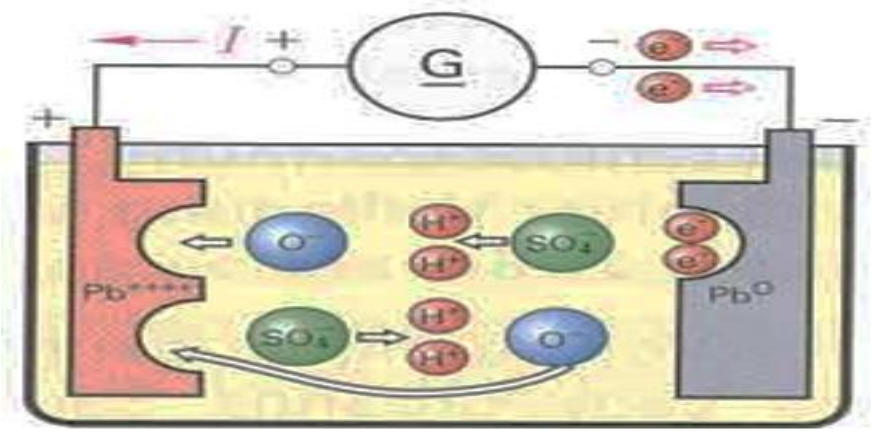


Figure 2-7 Electro-chemical process during charging

2.5.2 Battery Gassing

As part of the chemical reactions during charging, hydrogen gas is liberated at the negative plates and Oxygen gas is liberated at the positive plates. This is known as gassing and it causes water loss in the Battery. The higher the rate of charge, the greater the gassing occurs. Vent holes are provided to prevent pressure build up in the battery and hence prevent battery explosion.

2.6 Battery Characteristics and Construction

Batteries are devices that convert chemical energy into electrical energy. Chemical reactions that produce electrons are called electrochemical reactions. A battery stores DC voltage and releases it when it is connected to a circuit. Inside the battery are two electrodes or plates surrounded by an electrolyte. These three elements make up an electrochemical cell. Batteries are normally made up of electrochemical cells connected together.

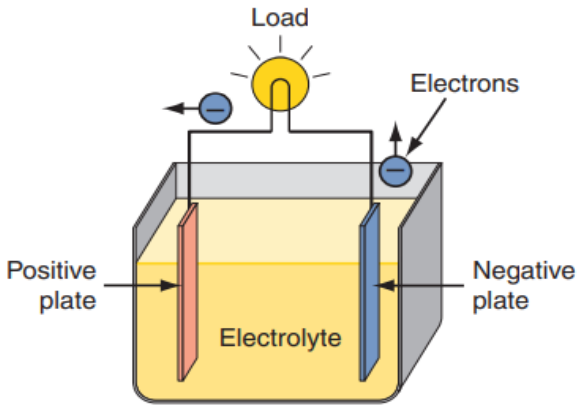


Figure 2-8 A simple electrochemical cell.

All Automotive storage batteries are similar in construction and operation but their difference lies in the number of cells, the arrangement of the cells, the number of plates in each cell, the size and thickness of the plates and the type of separated used.

2.6.1 Characteristics of car battery

The main characteristics of car batteries are:

- Self- discharge
- Accumulator capacity
- Cold cracking ampere
- Polarity
- Level of charge
- Internal resistance
- Electromotive force

2.6.2 Construction of battery

- **Case:** Container which holds and protects all battery components and electrolyte, separates cells, and provides space at the bottom for sediment (active materials washed off plates).Translucent plastic cases allow checking electrolyte level without removing vent caps.
- **Cover:** Permanently sealed to the top of the case; provides outlets for terminal posts, vent holes for venting of gases and for battery maintenance (checking electrolyte, adding water).
- **Plates:** Positive and negative plates have a grid framework of antimony and lead alloy. Active Material is pasted to the grid ... brown-color lead dioxide ($Pb0_2$) on positive plates, gray-cooled sponge lead (Pb) on negative plates. The number and size of the plates determine current capability ... batteries with large plates or man plates produce more current than batteries with small plates or few plates.
- **Separators:** Thin, porous insulators (woven glass or plastic envelopes) are placed between positive and negative plates. They allow passage of electrolyte, yet prevent the plates from touching and shorting out.

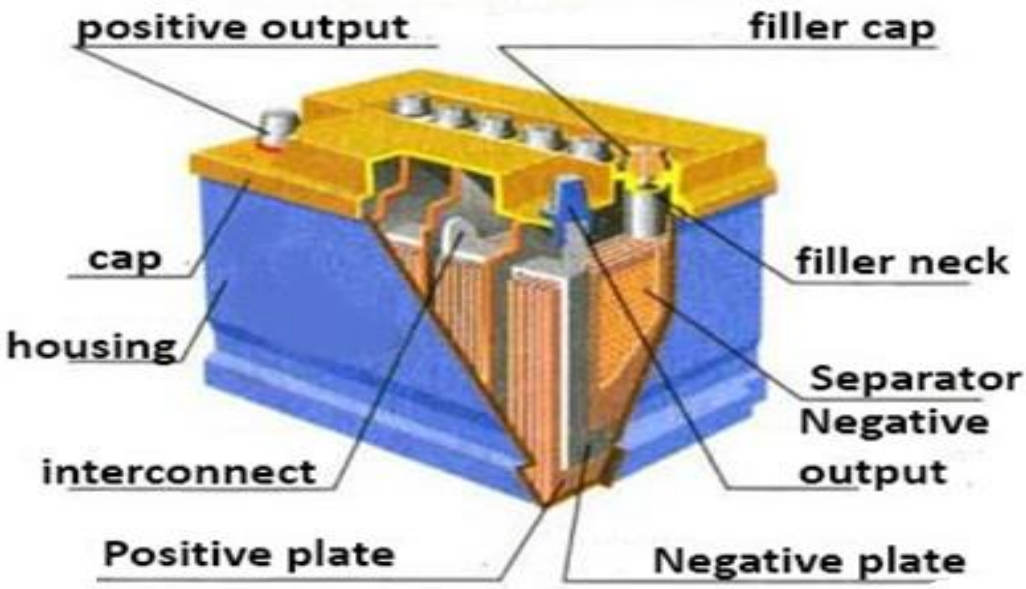


Figure 2-9 Battery construction

- **Cells:** An assembly of connected positive and negative plates with separators in between is called a cell or element. When immersed in electrolyte, a cell produces about 2.1 volts (regardless of the number or size of plates).
- Battery cells are connected in series, so the number of cells determines the battery voltage. A"1 2 - volt" battery has six cells.
- **Cell connectors:** Heavy, cast alloy metal straps are welded to the negative terminal of one Cell and the positive terminal of the adjoining cell until all six cells are connected in series.
- **Cell partitions:** Part of the case, the partitions separate each cell.
- **Terminal posts:** Positive and negative posts (terminals) on the case top have thick, heavy cables connected to them. These cables connect the battery to the vehicle's electrical system (positive) and to ground (negative).
- **Vent caps:** Types include individual filler plugs, strip-type, or box-type. They allow controlled release of hydrogen gas during charging (vehicle operation). Removed, they permit checking electrolyte and, if necessary, adding water.
- **Electrolyte:** A mixture of sulphuric acid (H_2SO_4) and water (H_2O). It reacts chemically with the active materials in the plates to create an electrical pressure (voltage). And, it

conducts the electrical current produced by that pressure from plate to plate. A fully charged battery will have about 36% acid and 64% water.

2.7 Battery Rating and code

2.7.1 Battery ratings

The current that is delivered by battery depends on the area and volume of the active plate materials, on the amount and strength of the electrolyte.

The factors that influence battery capacity include the number of plates per cell, the size and thickness of plates, and the quantity of electrolyte. The ratings most commonly used are:-

- **Reserve capacity:** is the length of time in minute that a fully charged battery at 80^0F can deliver 25 amperes for 125 minutes. This shows for how long the battery can deliver the electrical operating load, if the alternator fails to supply current.
- **Ampere hour capacity:** This is the amount of current that a battery can deliver for 20 hours without the cell voltage dropping below 1.75 volts with an electrolyte temperature 80^0F.
- **Cold cranking rate:** It is the number of amperes that a battery delivers for 30 seconds at 0^0F without the cell voltage falling below 12volt. A typical rating for a battery with a 125 minute reserve capacity would be 430 ampere. The second cold cranking rate is measured at negative 20^0F. In this case the final voltage is allowed to drop 1 volt. For same reserve hour capacity its rating is 320 ampere.
- **Over charging:** Batteries that are completely charged need not be charged furthermore. Because the current that is applied to charge the battery makes electrolysis of water and the water will be converted in to oxygen and hydrogen gasses which bubbles out of the electrolyte.

  H_2O Current $1/2\ O_2 + H_2$

  As a result of these process particles of the active materials break from the plates. The hot acid also attacks the life of the plates and separators which shortness the life of the battery.

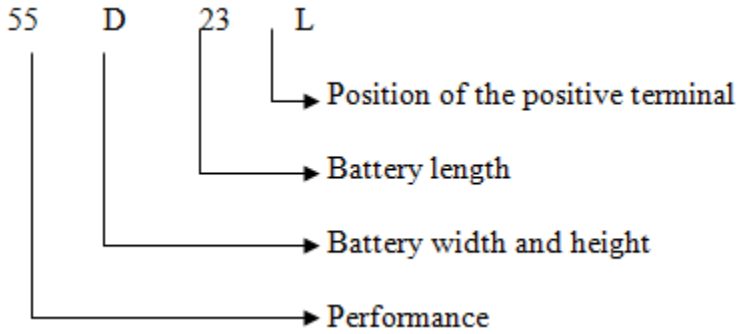
2.7.2 Battery Code

Battery that is made in different countries has identification codes. To suit an example, batteries that are made in Japan are given a battery identification code according to the Japan industrial standard. The battery code indicates the battery capacity, dimension& the position of the positive terminal whether it is right or left

Table 2-1 some of the battery identification codes in relation with their battery capacity are shown in the table.

Battery ID. Code	Battery capacity(5hrs rate)	Battery ID. Code	Battery capacity (5hrs rate)
28B17R/L	25	65D26R/L	52
28B19R/L	24	95D31R/L	64
36B20R/L	28	95E41R/L	80
46B24R/L	36	150F51	108

Example of battery code



- ✓ The performance of the battery indicates the battery capacity indirectly.
- ✓ Battery width and length

Battery length

The length of the battery is indicated roughly in centimetre (cm) for instance ‘’23’’ in a battery indicates that the battery is 23cm long or (230mm) long.

- ✓ Position of the positive terminal the position of the positive terminal is indicated either by ‘R’ (right side), ‘L’ (left side) or blank

Terminal Diameters: There are two sizes of terminal diameters

Table 2-2 terminal diameters of battery

Positive terminal	Negative terminal
➢ 14.7mm	➢ 13mm
➢ 19.5mm	➢ 17.9mm

In the battery width and length combination is indicated by one of the eight letters ‘’A’’ through ‘’H ‘’ as follows.

Table 2-3 Battery width and length combination

	Width	Height
A	162	127
B	203	127 OR 129
C	207	135
D	204	137
E	213	176
F	213	182
G	213	222
H	220	278

2.8 Battery Capacity ratings

The voltage rating of a battery may be expressed as open circuit or operating voltage. Open circuit voltage is the voltage measured across the battery when there is no load on the battery. Operating voltage is the voltage measured across the battery when it is under a load.

The available current from a battery is expressed as the battery's capacity to provide a certain amount of current for a certain amount of time and at a certain temperature.

Basically, a capacity rating expresses how much electrical energy a battery can store. Batteries are rated according to the amount of current they can produce under specific conditions.

2.8.1 Ampere-Hour

A commonly used capacity rating is the ampere-hour rating. In the past, this was the common rating method for lead-acid batteries. However, these batteries are now rated otherwise. Other battery designs are still rated in ampere-hours or milliamp-hours.

The ampere-hour (AH) rating is the amount of steady current that a fully charged battery can supply for 20 hours at 80°F (26.7°) without the cell's voltage dropping below a predetermined level. For example, if a 12-volt battery can be discharged for 20 hours at a rate of 4.0 amperes before its voltage drops to 10.5 volts, it would be rated at 80 AH (20 hours x 4 amps = 80 AH). A 100 AH battery will provide 1 amp for 100 hours, or 100 amps for 1 hour.

2.8.2 Watt-Hour Rating

Some battery manufacturers rate their batteries in watt-hours. The watt-hour rating is determined at 0°F (–17.7°C) because the battery's capacity changes with temperature. The rating is calculated by multiplying a battery's AH rating by the battery's voltage. The watt-hour rating of a battery may be listed in units of kilowatts. If a battery can deliver 5 AH at 200 volts, it would be rated at 1 kilowatt-hour (5 AH 200 volts =1,000 watt-hour or 1 kilowatt-hour).

2.8.3 Cold Cranking Amps

The cold cranking amps (CCA) rating is the common method of rating most automotive starting batteries. It is determined by the load, in amperes, that a battery is able to deliver for 30 seconds at 0°F (–17.7°C) without its voltage dropping below a predetermined level. That voltage level for a 12-volt battery is 7.2 volts. The normal range for passenger car and light truck batteries is between 300 and 600 CCA; some batteries have a rating as high as 1,100 CCA.

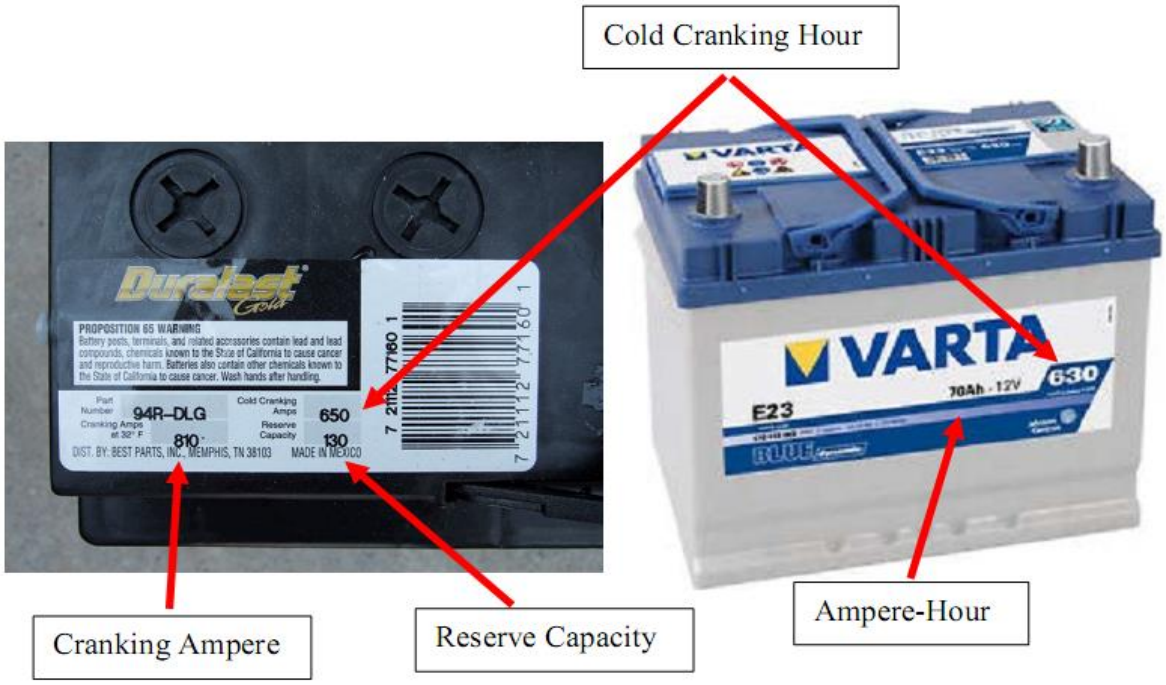


Figure 2-10 Battery capacity

2.8.4 Cranking Amps

The cranking amps (CA) rating is similar to CCA and is a measure of the current a battery can deliver at 32°F (0°C) for 30 seconds and maintain voltage at a predetermined level. Again, this level is 1.2 volts per cell (7.2 volts) for a 12-volt battery. This rating is more commonly used in climates that are not subject to extremely cold weather. Typically, the CCA rating of a battery is about 20% less than its CA rating.

2.8.5 Reserve Capacity

The reserve capacity (RC) rating is determined by the length of time, in minutes, that a fully charged starting battery at 80°F (26.7°C) can be discharged at 25 amperes before battery voltage drops below 10.5 volts. This rating gives an indication of how long the vehicle can be driven with the headlights on if the charging system fails. A battery with a reserve capacity of 120 would be able to deliver 25 amps for 120 minutes before its voltage drops below 10.5 volts.

Self-check-1

Part I. Choose the correct answer

1. _____ is the amount of steady current that a fully charged battery can supply for 20 hours at 80°F without the cell's voltage dropping below a predetermined level.

A. Ampere-Hour
B. Watt-Hour Rating
C. Cold Cranking Amps
D. Cranking Amps

2. Electrolyte is a mixture of sulfuric acid and _____ :

A. Hydrogen
B. Carbon
C. Sulfuric carbon
D. Water

3. The capacity of a battery is expressed in terms

A. Current rating
B. Voltage rating
C. Ampere hour rating
D. None of the above

4. The storage battery generally used in electric power station is

A. Nickel-cadmium battery
B. Zinc carbon battery
C. Lead-acid battery
D. None of the above

5. The electrode for a battery must be

A. A semi-conductor
B. An insulator
C. A good conductor of electricity
D. A bad conductor of electricity

Part II. Write true if the statement is correct and false if it is incorrect.

1. All electrochemical batteries have three major parts: an anode, a cathode, and an electrolyte.

2. A fully charged new battery will have a low conductance reading.

3. Always disconnect the ground cable first when doing any electrical work on vehicles and use the reverse procedure for connecting the

PartIII. Give short answer

1. List down the main hazards associated with batteries?

2. Compare and contrast commonly used automotive battery types?

3. Write and explain some of personal protective equipment.

Unit Two: Test and Service Battery

This module is developed to provide you the necessary information regarding the following content coverage and topics:

- Cleaning battery and its compartment
- Visual inspection of battery
- Battery on-vehicle inspection
- Battery circuit testing

This module will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Cleaning battery and its compartment
- Clean battery and its compartment
- Visually inspecting battery
- Perform battery on-vehicle inspection
- Apply battery circuit testing

3.1 Cleaning Battery and Its Compartment

Before removing the battery connectors or the battery, always neutralize any accumulated corrosion on terminals, connectors, and other metal parts. Apply a solution of baking soda and water or ammonia and water. Do not splash the corrosion onto the vehicle's paint, metal or rubber parts, or onto your hands and face. Be sure the solution cannot enter the battery cells. A stiff-bristle brush is ideal for removing heavy buildup. Dirt and accumulated grease can be removed with a detergent solution or solvent. After cleaning, rinse the battery and cable connections with clean water. Dry the components with a clean rag or low pressure compressed air

To clean the inside surfaces of the connectors and the battery terminals, remove the cables. Always begin with the ground cable. Spring-type cable connectors are removed by squeezing the ends of their prongs together with wide-jaw, vise-gripping, channel lock, or battery pliers. This pressure expands the connector so it can be lifted off the terminal post

Battery testing has changed in recent years; although the three areas are basically the same, the equipment has improved.

1. Visual Inspection;
2. State of Charge;
    - Specific Gravity;
    - Open Circuit Voltage;
3. Capacity or Heavy Load Test.

Tools and equipment for testing battery:

- ✓ Voltmeter
- ✓ Special battery tester
- ✓ Acid resistant metal
- ✓ Ammeter
- ✓ Peak load tester
- ✓ Hydrometer

The following are some of the tests for the automotive battery:

- ❖ Battery leakage test
- ❖ Battery terminal test
- ❖ Battery voltage test
- ❖ Cell voltage test
- ❖ Battery Drain test
- ❖ Battery capacity test
- ❖ Peak load test
- ❖ Battery test without testing instruments

3.2 Visual Inspection

Battery service should begin with a thorough visual inspection. This inspection may reveal simple, easily corrected problems.

- ❖ Check for cracks in the battery case and broken terminals. Either may allow electrolyte leakage, which requires battery replacement.
- ❖ Check for cracked or broken cables or connections. Replace, as needed.
- ❖ Check for corrosion on terminals and dirt or acid on the case top. Clean the terminals and case top with a mixture of water and baking soda. A battery wire brush tool is needed for heavy corrosion on the terminals.
- ❖ Check for a loose battery hold-down or loose cable connections. Clean and tighten, as needed.
- ❖ Check the electrolyte fluid level. The level can be viewed through the translucent plastic case or by removing the vent caps and looking directly into each cell.

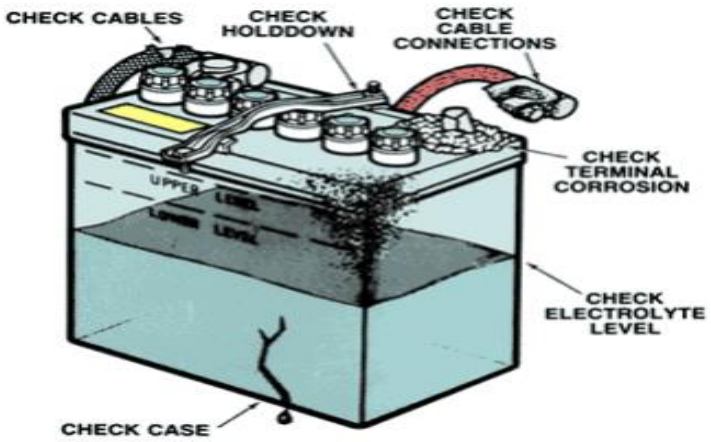


Figure 3-1 Battery visual inspection

3.3 Battery on-vehicle inspection

3.3.1 Load Test

While a State of Charge test determines the battery's state of charge, it does not measure the battery's ability to deliver adequate cranking power. A capacity or heavy-load test measures the battery's ability to deliver current. A battery load tester such as a Volt, Amp Tester (VAT) (Figure 12) is used. (Note: the battery must be at least 75% charged before a heavy test can be performed.)

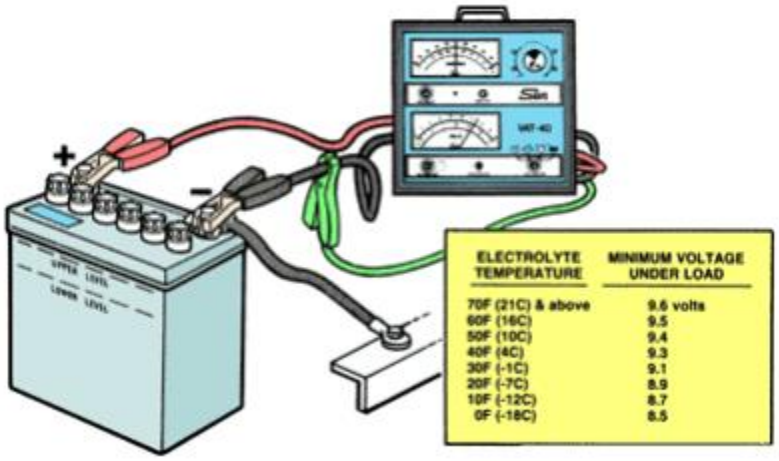


Figure 3-2 Battery load testing

3.3.2 Drain/parasitic Test

Parasitic drains are the small current drains required to operate various electrical systems, such as the clock, computer memory, or alarms that continue to work when the car is parked and the ignition is off. All vehicles today have parasitic drains and over time will drain all batteries if not driven or charged periodically. The problem is when the parasitic drain becomes excessive, usually over 35 milliamps. Unwanted battery drain can also be the reason why a battery keeps discharging. Unwanted battery drain can be a result of excessive parasitic drain, or if the top of the battery is wet or has excessive corrosion, it could create a path between the two battery posts, causing a current drain; usually 0.5 volt potential or higher will result in a battery discharge.

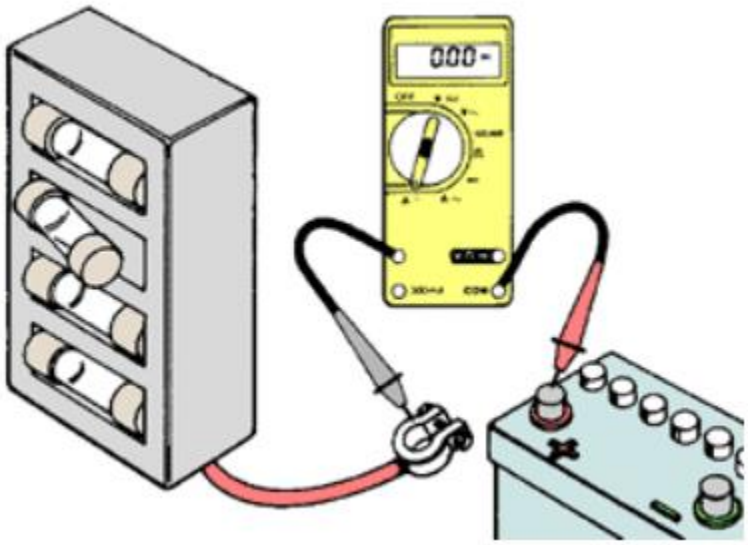


Figure 3-3 Drain/parasitic testing

3.3.3 Drop test

A voltage drop test is the only effective way to find excessive resistance in high amperage circuits. It's a quick and easy test that doesn't require any disassembly and will quickly show you whether or not you've got a good connection or a bad one.

To do a voltage drop test, you create a load in the circuit that's being tested. Then you use a digital volt meter (DVM) to measure the voltage drop across the live connection while it is under the load. Voltage always follows the path of least resistance, so if the circuit or connection being tested has too much resistance some of the voltage will flow through the DVM and create a voltage reading.

3.4 State Of Charge

The state of charge of a battery can be easily checked in one of two ways:

- Specific Gravity Test; and
- Open Circuit Voltage Test

3.4.1 Specific Gravity Test

The electrolyte of a fully charged battery is usually about 64% water and 36% sulfuric acid. This corresponds to a specific gravity of 1.270. Specific gravity is the weight of a given volume of any liquid divided by the weight of an equal volume of water. Pure water has a specific gravity of 1.000, whereas battery electrolyte should have a specific gravity of 1.260 to 1.280 at 80°F (26.7°C). In other words, the electrolyte should be 1.260 to 1.280 times heavier than water.

The specific gravity of the electrolyte decreases as the battery discharges. This is why measuring the specific gravity of the electrolyte with a hydrometer can be a good indicator of how much charge a battery has lost. Hydrometer readings should not vary more than 0.05 differences between cells. More variance is an indication that the battery is bad.

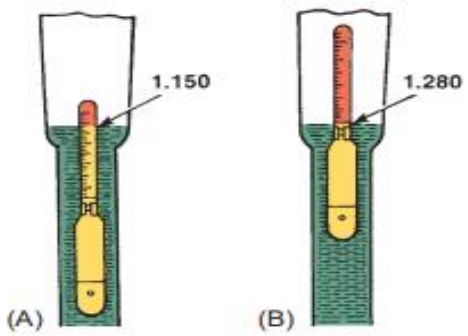


Figure 3-4 (A) When the scale sinks in the electrolyte, the specific gravity is low; (B) when it floats high, the specific gravity is high

The electrolyte's specific gravity can be measured on unsealed batteries to give a fairly good indication of the battery's state-of-charge (SOC). A basic battery hydrometer uses a glass float or hydrometer in a glass tube to measure the electrolyte's specific gravity. Squeezing the hydrometer's bulb pulls electrolyte into the tube. When filled with test electrolyte, the hydrometer float bobs in the electrolyte. The depth at which the float sinks in the electrolyte indicates its relative weight compared to water. The reading is taken off the scale by sighting along the level of the electrolyte. If the hydrometer floats deeply in the electrolyte, the specific gravity is low (Figure 2–4A). If the hydrometer floats high in the electrolyte, the specific gravity is high (Figure 2–4B).

3.4.2 Open Circuit Voltage Test

An open circuit voltage check can be used as a substitute for the hydrometer specific gravity test on maintenance-free sealed batteries with no built-in hydrometer. As the battery is charged or discharged, slight changes occur in the battery's voltage. Therefore, battery voltage with no load applied can give some indication of the SOC. The battery's temperature should be between 60° and 100°F (15.5° and 37.7°C). The voltage must be allowed to stabilize for at least 10 minutes with no load applied. On vehicles with high drains (computer controls, clocks, and accessories that always draw a small amount of current), it may be necessary to disconnect the battery ground cable. On batteries that have just been recharged, apply a heavy load for 15 seconds to remove the surface charge, and then allow the battery to stabilize. Once voltage has stabilized, use a digital voltmeter to measure the battery voltage to the nearest one-tenth of a volt (Figure 2–5). A fully charged 12-volt battery should have a terminal voltage of 12.6 volts. However, sealed AGM and gel cell batteries may have a slightly higher voltage (12.8–12.9 volts). Use Figurec2–5 to interpret the results. As you can see, minor changes in battery open circuit voltage can indicate major changes in SOC. If the test indicates an SOC below 75%, recharge the battery and perform the capacity test to determine battery condition

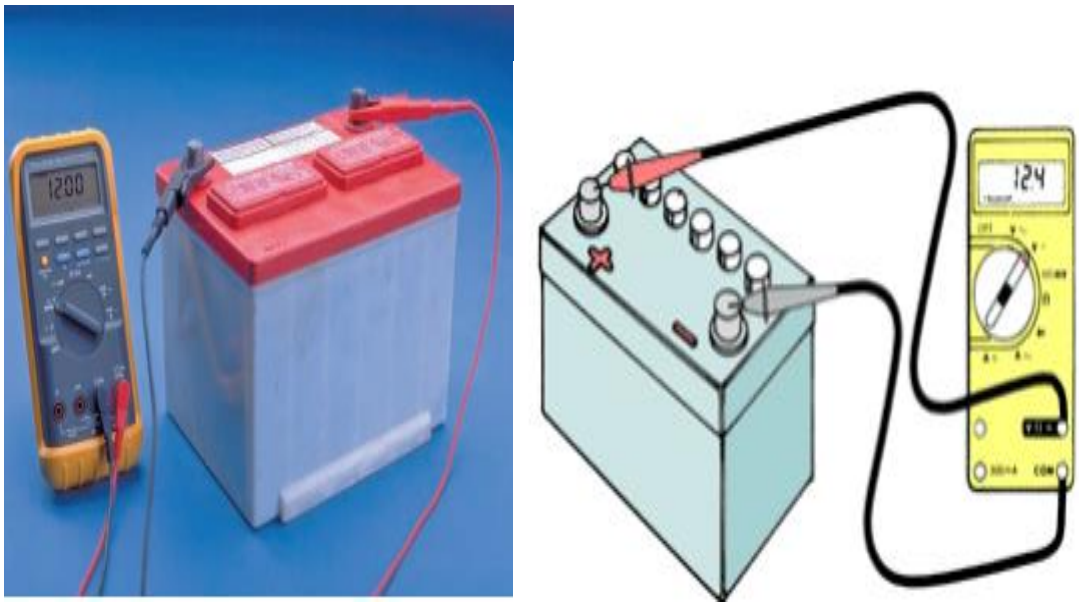


Figure 3-5 Measuring open circuit voltage across battery terminals using a voltmeter

3.4.3 Battery Leakage Test

To perform a battery leakage test, set a voltmeter to a low DC volt range. Connect the negative lead to the battery's negative post. Then move the meter's positive lead across the top and sides of the battery case. If some voltage is read on the meter, current is leaking out of the battery. The battery should be cleaned and then rechecked. If voltage is again measured, the battery should be replaced; the case is porous or cracked.

3.4.4 Battery Peak-load

If the battery's state-of-charge is at 75 percent or higher or has a "good" built-in hydrometer indication, then you can load test a car battery by one of the following methods.

1. With a battery load tester, apply a load equal to one-half of the CCA rating of the battery for 15 seconds. (Recommended method).
2. With a battery load tester, apply a load equal to one-half the vehicle's CCA specification for 15 seconds.
3. Disable the ignition and turn the engine over for 15 seconds with the starter motor.



Figure 3-6 Peak load tester

Table 3-1 during the load test, the voltage on a good battery will NOT drop below the following table's indicated voltage for the electrolyte at the temperatures shown:

Electrolyte Temperature F	Electrolyte Temperature C	Minimum Voltage Under LOAD
100°	37.8°	9.9
90°	32.2°	9.8
80°	26.7°	9.7
70°	21.1°	9.6
60°	15.6°	9.5
50°	10.0°	9.4
40°	4.4°	9.3
30°	-1.1°	9.1
20°	-6.7°	8.9
10°	-12.2°	8.7
0°	-17.8°	8.5

Table 3-2 the load chosen to be placed on the battery is shown in the following table.

Battery capacity	Battery voltage	Resistors connected	Load applied
Up to 40 Ah	6v, 12v	1 1	50amp 100amp
40 to 80 ah	6v, 12v	2 2	100amp 200amp
80 and above	6v, 12v	3 3	150amp 300amp

During this test, the voltmeter reading should not drop below 9.6volt

V ≥ 9.6 volt is good

V ≤ 9.6 volt is defective

3.4.5 Cell voltage test

The cell voltage test will let you know if the battery is discharged or defective like a hydrometer cell test, if the voltage reading on one or more cell is 2 volts or more lower than the other cells, the battery must be replaced.

To perform a cell voltage test use a low voltage reading voltmeter with special cadmium (acid resistant metal) tips.

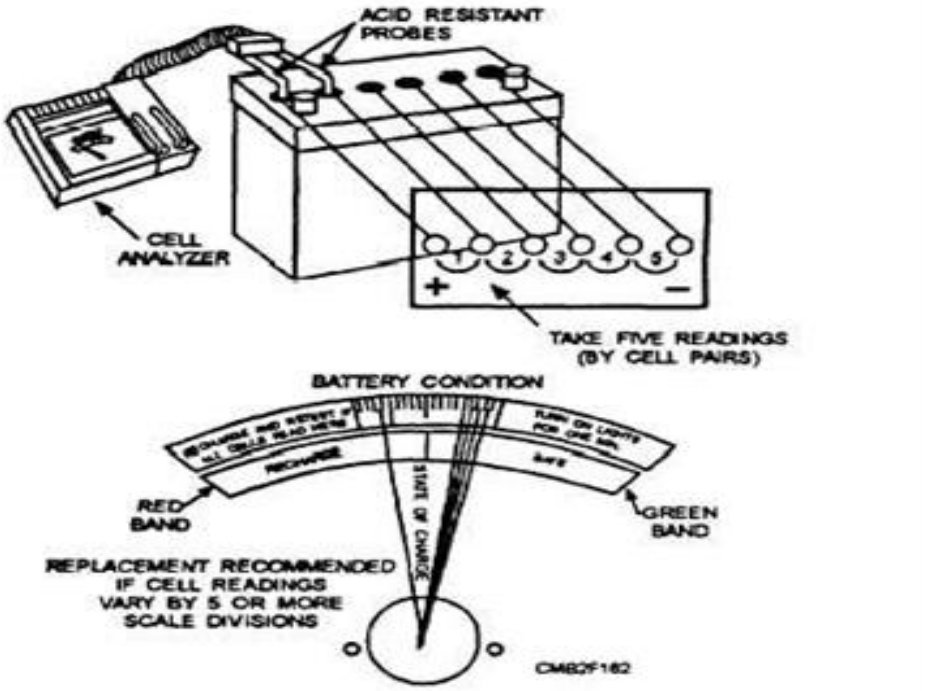


Figure 3-7 Battery cell test

Self-check 2

Part I. <u>Among the given alternatives choose the best answer.</u>

1. To check for battery drain, you would connect an ammeter between the

A. battery and alternator

B. battery and (-) terminals

C. battery terminal and ground cable

D. battery terminal and ground cable

2. A battery heavy-load test discharges the battery for:

A. 5 seconds B. 10 seconds C. 15 seconds D. 20 seconds

3. When performing a battery capacity test on a 12-volt battery, the voltage should not fall below:

A. 12.0 volts B. 10.6 volts C. 9.6 volts D. 8.6 volts

4. Following will happen if battery charging rate is too high

A. Excessive gassing will occur

B. Temperature rise will occur

C. Bulging and buckling of plates we occur

D. All of the above

6. Which test is used to ascertain whether the battery plates are defective or not ?

A. Open volt test

B. Cadmium test

C. High discharge test

D. Specific gravity test

Part II. <u>Write the correct answers for the following questions (1point)</u>

1. What is the maximum time a Heavy Load Test should be performed?

2. Describe the "open circuit voltage" test procedure.

3. Explain the term "specific gravity" and how it is measured

Operation sheet 2.1: Battery terminal testing

Operation Title: Testing battery terminal

Purpose: To check of poor electrical connection between the terminals and the battery cables.

Conditions or situations for the operations:

- ✓ Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Equipment, Tools and Materials:

- ✓ Multi-meter
- ✓ Battery
- ✓ Vehicle

Steps in doing the task

1. Connects the negative voltmeter lead to the battery cable end.
2. Touch the positive lead to the battery terminal
3. The ignition or injection system disabled so that the engine will not start
4. Crank the engine while watching the voltmeter reading.

Quality Criteria: Assured performing of all the activities according to the procedures

Precautions:

- ➢ Wearing proper clothes, eye glass, glove
- ➢ Make working area hazard free
- ➢ Read and interpret manual which guide you how to use tools and equipments

Operation sheet 2.2: Battery voltage testing

Operation Title: Testing Battery voltage

Purpose: To determines the general state of charge and battery condition quickly

Conditions or situations for the operations:

- ✓ Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Equipment Tools and Materials:

- ✓ Voltmeter or special battery tester
- ✓ Battery

Steps in doing the task

1. Connects the voltmeter or battery tester across the battery terminals.
2. Turn of the vehicle headlights or heater blower to provide a light load.
3. Now read the meter or tester. A well charged battery should have over 12 volts.

Quality Criteria: Assured performing of all the activities according to the procedures

Precautions:

- ➢ Wearing proper clothes, eye glass, glove
- ➢ Make working area hazard free
- ➢ Read and interpret manual which guide you how to use tools and equipment

Operation sheet 2.3: Battery Drain testing

Operation Title: Testing Battery Drain

Purpose: To checks for abnormal current draw with the ignition off

Conditions or situations for the operations:

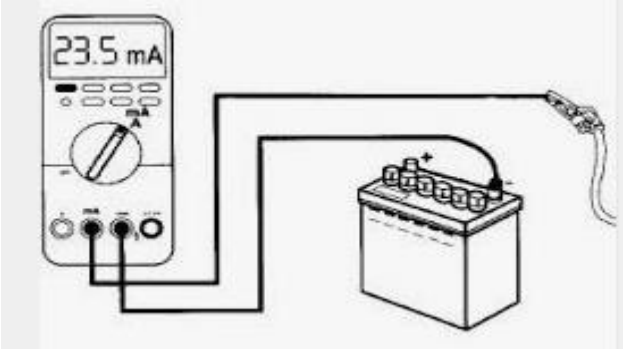
- ✓ Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Equipment Tools and Materials:

- ✓ Voltmeter
- ✓ Battery with vehicle Battery

Steps in doing the task

1. set up an ammeter, as shown in figure



2. pull the fuse if the vehicle has a dash clock
3. Close all doors and trunk (if applicable).
4. read the ammeter

Quality Criteria: Assured performing of all the activities according to the procedures

Precautions:

- ➢ Wearing proper clothes, eye glass, glove
- ➢ Make working area hazard free
- ➢ Read and interpret manual which guide you how to use tools and equipment

Operation sheet 2.4: Battery capacity testing

Operation Title: Testing Battery capacity

Purpose: To check the battery's capacity and safe operating. To check battery condition or to measure the current output and performance of the battery under full current load.

Conditions or situations for the operations:

- ✓ Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Equipment Tools and Materials:

- ✓ Hand tools
- ✓ battery load tester
- ✓ Battery with vehicle Battery

Steps in doing the task

1. set up an ammeter, as shown in figure,
2. pull the fuse if the vehicle has a dash clock
3. Close all doors and trunk (if applicable).
4. read the ammeter

Quality Criteria: Assured performing of all the activities according to the procedures

Precautions:

- ➢ Wearing proper clothes, eye glass, glove
- ➢ Make working area hazard free
- ➢ Read and interpret manual which guide you how to use tools and equipment

Operation sheet 2.5: Battery Cell voltage test

Operation Title: Testing Battery Cell voltage

Purpose: to know if the battery is discharged or defective

Conditions or situations for the operations:

- ✓ Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Equipment Tools and Materials:

- ✓ **Hand tools**
- ✓ voltmeter special cadmium (acid resistant metal) tip

Steps in doing the task:

1. Insert the tips into each cell.
2. Starting at one end of the battery and work your way to the other.
3. Test each cell carefully.

Quality Criteria: Assured performing of all the activities according to the procedures

Precautions:

- ➢ Wearing proper clothes, eye glass, glove
- ➢ Make working area hazard free
- ➢ Read and interpret manual which guide you how to use tools and equipment

Lab- Test

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 5 hours.

Task 1- Battery Specific Gravity testing

Task 2- Open Circuit voltage testing.

Task 3- Battery terminal testing.

Task 4- Battery voltage testing.

Task 5- Battery Drain testing.

Task 6- Battery capacity testing.

Task 7- Cell voltage test.

Task 9- Preparation of electrolyte

Unit Three: Battery Charging

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Charging
- Charging current and time
- Fast charging
- Slow charging

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Apply charging
- Determine charging current and time
- Apply fast charging
- Apply slow charging

4.1 Battery Charging

A battery in good condition may occasionally fail to crank the engine fast enough to start. In such a case the battery requires charging. The storage battery can be recharged in to its original state by a battery charger, which delivers a direct current and a proper voltage. The battery charger has a control switch and an ammeter, which is used to adjust the charging rate.

Charging a battery means causing electrons to flow into the negative terminal. On the car, this job is performed by the alternator. Usually the batteries do not require charge from the external source provided the charging system of the vehicle is working efficiently. In the case of less charging or fault in the system, it becomes necessary to recharge the battery by means of battery chargers. Since most commercially available electricity is alternating current (AC) the charger consists of a transformer to reduce the voltage to a usable value and a rectifier to change the alternating current to direct current. The battery charger has a control switch and an ammeter so the charging rate can be adjusted. The battery chargers are categorized as slow charger and fast charger.

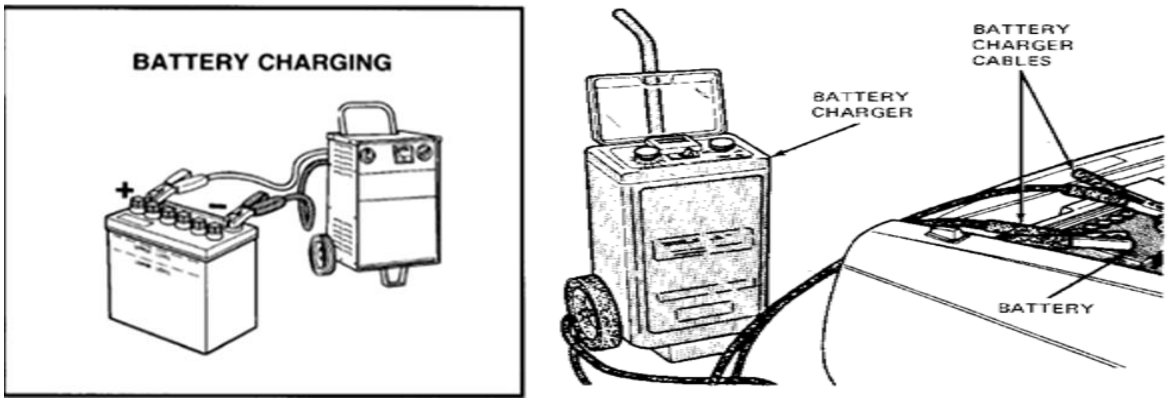


Table 4-1 Battery charging

A battery in good condition may occasionally fail to crank the engine fast enough to make it start.

All battery chargers operate on the same principle:

- ✓ An electric current is applied to the battery to reverse the chemical action in the cells.
- ✓ Never connect or disconnect leads with the charger turned ON.

- ✓ Follow the battery charger manufacturer's instructions.
- ✓ And, do not attempt to charge a battery with frozen electrolyte.

4.2 Types of Battery Connections (Methods of charging)

There are three basic types of batteries connection.

- ❖ Series Connection
- ❖ Parallel Connection
- ❖ Series-Parallel Connection

4.2.1 Series Connection of Batteries

If we connect the positive (+) terminal of battery to negative (-) and negative to positive terminal as shown in the below fig, then the batteries configuration would be in series.

In series connection of batteries, current is same in each wire or section while voltage is different i.e. voltages are additive e.g.

$$V_T = V_1 + V_2 + V_3 + ...V_n$$

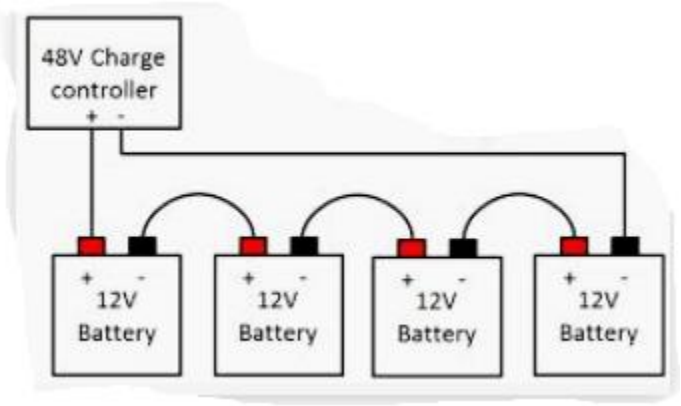


Figure 4-1Series Connection of Batteries

4.2.2 Parallel Connection of Batteries

- If we connect the positive terminal (+) of battery to positive and negative (-) to negative terminal, then the batteries configuration would be in parallel.
- In parallel connection, voltage will be same in each wire or section, while current will be different i.e. current is additive.

$$I_T = I_1 + I_2 + I_3 + ...I_n$$

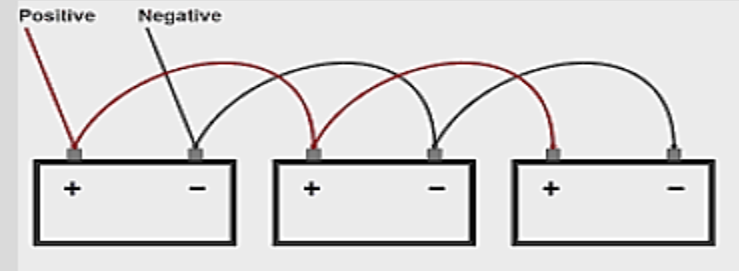


Figure 4-2Parallel Connection of Batteries

The battery chargers are categorized as slow and fast chargers.

4.2.3 Series-Parallel Connection of Batteries

If we connect two pairs of two batteries in series and then connect these series connected batteries in parallel, then this configuration of batteries would be called series-parallel connection of batteries.
In other words, It is series, nor parallel circuit, but known as series-parallel circuit. Some of the components are in series and other are in parallel or complex circuit of series and parallel connected devices and batteries.

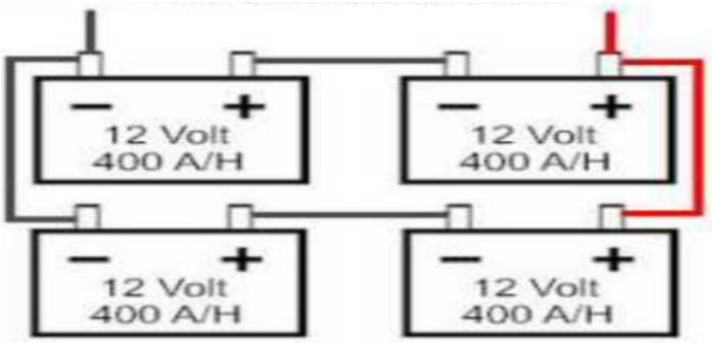


Figure 4-3 Series-Parallel Connection of Batteries

The battery chargers are categorized as slow and fast chargers**.**

4.3 Fast charging

Fast charging is usually constant voltage with a high capacity in which their common charging rates are 80-100 amperes from 6 volt battery and 40-50 amperes for 12 volt battery. Twenty to thirty minutes of charging time will normally charge the battery. So that the starting motor will crank the engine and the battery will not be over heated. Fast chargers do not fully charge a battery in the time allotted for charging. Batteries are 40-60 percent charged when the temperature reaches 110^0F. Some fast chargers have controls for finishing the charging cycle at low rate so the battery can be brought up to a full charge.

4.4 Slow Charging

Slow battery chargers operate at low rate and take a longer time to charge a battery. The charging rate is one ampere for each positive plate in a cell. Batteries of different size can be charged at the same time. But the charging rate is determined by the smallest battery. Batteries are safely charged at a high rate if the temperature is below 125^0F

During slow charging the maximum charging current should be less than $1/10^{th}$ of the battery capacity.

4.5 Charging current and time

Determination of the allowable charging amperage and time is very essential if the battery chargers have no a test device.

Determination of charging amperage determination the state of the battery from the specific gravity, using the below graph, then calculate the correct charging amperage using the following formula. The charging time for quick charging is usually from half to one hour.

$$\text{Correct charging amperage (A)} = \frac{\text{State of discharge Capacity (Ah)}}{1 + \text{Charging Time}}$$

Example

1. Calculate the suitable charging current in Amps and the needed charging time in hrs for a 12V, 120Ah battery.

Battery Charging Current:

First of all, we will calculate charging current for 120 Ah batteries. As we know that charging current should be 10% of the Ah rating of battery.

Therefore,

Charging current for 120Ah Battery = 120 Ah x (10 ÷ 100) = 12 Amperes.

But due to some losses, we may take 12-14 Amperes for batteries charging purpose instead of 12 Amps.

2. Suppose we took **13 Amp** for charging purpose, then,

Charging time for 120Ah battery = 120 ÷ 13 = 9.23 Hrs.

But this was an ideal case…

Practically, it has been noted that **40% of losses** occurs in case of battery charging.

Then 120 x (40 ÷ 100) = 48 …… (120Ah x 40% of losses)

Therefore, 120 + 48 = 168 Ah (120 Ah + Losses)

Now Charging Time of battery = Ah ÷ Charging Current

=168 ÷ 13 = 12.92 or 13 hrs.

Therefore, a **120Ah battery** would take **13 Hours** to fully charge in case of the required **13A** charging current.

Self-check 3

Part I. <u>Among the given alternatives choose the best answer.</u>

1. The following indicate that battery on charge has attained full charge

A. Color of electrode
C. Specific gravity
B. Gassing
D. All of the above

2. When two batteries are connected in parallel, it should be ensured that

A. They have same e.m.f
B. They have same make
C. They have same ampere hour capacity
D. They have identical internal resistance

3. Cells are connected in series in order to

A. Increase the voltage rating
C. Increase the life of the cells
B. Increase the current rating
D. None of the above

4. If the battery is wrongly connected on charge which one of following will happen?

A. Current delivered by the battery will be high
B. Current drawing will be Nil
C. Currently drawing will be very small
E. Currently drawing will be very high

Part II. <u>Write the correct answers for the following questions (1point)</u>

1. What battery charging?
2. Describe the difference between series and parallel connection of batteries?
3. What is similarity and difference between fast and slow, charging?

OPERATION SHEET 3.1: Preparation of electrolyte

PURPOSE: For the purpose of top-upping the battery.

Conditions or Situations for the Operations:

- ⇨ Safe working area
- ⇨ properly operated tools and equipment
- ⇨ appropriate working cloths fit with the body

Equipments, Tools and Materials:

H_2SO_4, distill water, Hydrometer, serviceable battery, wire brush, plier, backing soda plastic container, plastic stick etc.

Procedure:-

1. Prepare plastic container
2. Added distilled water in plastic container
3. Add sulfuric acid on water ass a droplet
4. Steer with plastic stick
5. After 12 hour added electrolyte inside battery case [each cell]

PRECAUTIONS:

- ⇨ Wearing proper clothes, eye glass, glove
- ⇨ Make working area hazard free
- ⇨ Read and interpret manual which guide you how to use tools and equipments

QUALITY CRITERIA:

Assured performing of all the activities according to the procedures

OPERATION SHEET 3.2: Preparing batteries for charging.

PURPOSE: For the purpose of Checking the electrolyte level and fill it if necessary.

CONDITIONS OR SITUATIONS FOR THE OPERATIONS:

- ✓ Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

EQUIPMENT TOOLS AND MATERIALS:

Hydrometer, serviceable battery**,** wire brush**,** plier**,** backing soda etc..

Procedure

1. Clean and wash dirt from the battery terminals.
2. Inspect the case, cell covers, sealing compounds and vent plugs and make repairs if damaged.
3. Check the electrolyte level and fill it if necessary.

PRECAUTIONS:

- ➢ wearing proper clothes, eye glass, glove
- ➢ Make working area hazard free
- ➢ Read and interpret manual which guide you how to use tools and equipments

QUALITY CRITERIA:

Assured performing of all the activities according to the procedures

Operation sheet 3.3: Battery Charging (Slow Charging)

Operation Title: Battery Charging (Slow Charging)

Purpose: To maintain battery fully charged

Conditions or situations for the operations:

- ✓ Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Equipment Tools and Materials:

- Battery charger
- Battery

Steps in doing the task

- Remove all vent plugs.
- Check electrolyte and add distilled water if the level is low.
- Connect the battery to the charger. Connect the positive charger cable to the positive battery terminal post and the negative cable to the negative terminal post.
- If more than one battery are to be charged, **connect the batteries in series** up to the capacity of the charger.
- Switch on the charger and adjust the charging rate.
- Check specific gravity of the electrolyte by means of hydrometer after every two hours until there is no further rise in specific gravity.
- When the battery shows no further rise in specific gravity (should not be less than 1.280) for more than one hour, it will be considered as fully charged.
- Watch the battery temperature, as there is possibility of overheating in this method.

- If the battery boils or overheats, remove it from the line

Quality Criteria: Assured performing of all the activities according to the procedures

Precautions:

- Wearing proper clothes, eye glass, glove
- Make working area hazard free
- Read and interpret manual which guide you how to use tools and equipments

Operation sheet 3.4: Battery Charging (Fast Charging)

Operation Title: Battery Charging (Slow Charging)

Purpose: for quick battery charging

Conditions or situations for the operations:

- ✓ Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Equipment Tools and Materials:

- Battery charger
- Battery

Steps in doing the task

- Remove all vent plugs.
- Check electrolyte and add distilled water if the level is low.
- If the battery is to be charged while on the vehicle, be sure to disconnect both negative and positive battery cables from the terminals to prevent damage to the alternator rectifiers and/or other solid state devices.
- Determine the allowable charging current and time.

- Connect the battery to the charger. Connect the positive charger cable to the positive battery terminal post and the negative cable to the negative terminal post.
- If more than one battery is to be charged, **connect the batteries in parallel** up to the capacity of the charger.
- Switch on the charger and adjust the voltage to specified value.
- Watch the battery temperature, as there is possibility of overheating in this method. If the battery boils or overheats, remove it from the line.
- Stop charging when the gravity shows no further rise after an hour of charging.

Quality Criteria: Assured performing of all the activities according to the procedures

Precautions:

- Wearing proper clothes, eye glass, glove
- Make working area hazard free
- Read and interpret manual which guide you how to use tools and equipments

Lap Test

Instructions: Given necessary templates, workshop, tools and materials you are required to perform the following tasks within 2 hours.

Task 1. Prepare electrolyte

Task 2. Charging Battery

Task 3. Perform slow charge based on the circuit

Task 4. Perform fast charge based on the circuit

Unit Four: Vehicle jump-start

This module is developed to provide you the necessary information regarding the following content coverage and topics:

- Jump start
- Jump start using another vehicle's battery
- Jump start using battery charger

This module will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Know Jump start
- Apply Jump start using another vehicle's battery
- Apply Jump start using battery charger

5.1 Jump start

A jump start, also called a boost, is a procedure of starting a motor vehicle (most commonly cars or trucks) that has a discharged or depleted battery. A temporary connection is made to the battery of another vehicle, or to some other external power source. The external supply of electricity recharges the disabled vehicle's battery and provides some of the power needed to crank the engine. Once the vehicle has been started, its normal charging system will recharge, so the auxiliary source can be removed. If the vehicle charging system is functional, leaving the engine running will restore the charge of the battery, although it is usually recommended to drive the vehicle for a few minutes after starting to speed up the recharging process.

Jump starting safety tips

- When jump starting, make sure you are not smoking.
- Make sure the vehicle is in park.
- Do not let the cables dangle from the car.
- Do not use poor- and low-quality cables. Use high-quality ones.
- Keep a wire brush handy for proper cable-to-terminal connection in case cleaning battery terminals is appropriate

5.2 Using jump starting with another battery

If the starter battery is discharged then the car can be started with current from another battery

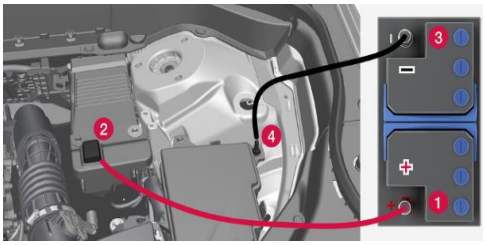


Table 5-1 Using jump starting with another battery

5.3 Jump starts using another vehicle’s battery

Connecting your car's battery to another car's battery with jumper cables is a common way to recharge a battery. Park the vehicles so their batteries are as close as possible. Leave enough room between the vehicles to attach the jumper cables. Put both cars in park or neutral and shut off the ignitions.

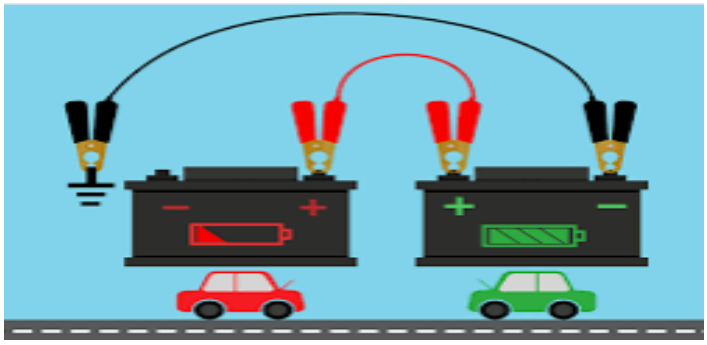


Table 5-2 Jump starts using another vehicle’s battery

5.4 Jump start using battery charger

If your car has a dead battery, you can use a battery charger to jump start the car.





Table 5-3 Battery chargers

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Self-check 4

Part I. <u>Write the correct answers for the following questions (1point)</u>

1. What is jump starting?
2. Describe jump starting with another battery?
3. What is similarity and difference between Jump start using battery charger and jump starting with another battery?

OPERATION SHEET 4.1: Jump starts using another vehicle's battery

PURPOSE: For the purpose of performing the jump start using another vehicle's battery to start the vehicle with dead battery.

Conditions or Situations for the Operations:

- ✓ Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Equipment Tools and Materials:

- ✓ Vehicle equipped with full battery
- ✓ Jumper cables**,**
- ✓ Vehicle equipped with dead battery

Procedure

1. If possible, bring the two cars together nose to nose, about 18" apart. Be sure you're parked well away from traffic. Make sure both cars have their parking brakes on.
2. Make sure both cars are turned off. Put automatic transmission cars in Park. Put manual transmission cars in Neutral. Set the parking brake firmly so the vehicle cannot move.
3. Determine which terminals are positive and negative on both batteries. Look for "+" sign or red indicator for positive, "-" sign or black indicator for negative. The positive terminal is usually wider than the negative.
4. The jumper cables are marked with colors or stripes to help you keep track of the two separate wires. Attach one end of the positive cable clamp to the positive terminal of the dead battery (the positive cable may have a stripe, or if the cables are marked with red and black, the red cable is positive).
5. Attach the other end of the positive cable to the positive terminal of the good battery.
6. Attach one end of the negative cable to the negative terminal of the good battery. *Your cables are now live! Do not touch the remaining cable clamp metal portion to yourself or any part of the car except the negative terminal of the dead battery.*

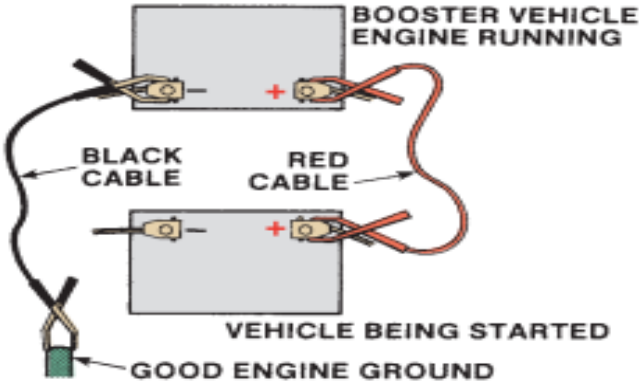


Table 0-1 Jump start using another vehicle's battery

7. Make certain everyone is clear of the engine compartments - don't allow hands or clothing to be caught by moving engine parts.
8. Start the engine of the good car. Allow it to run for 1-2 minutes. Rev the engine slightly by pressing on the gas pedal lightly.
9. Start the engine of the dead car. It may take more than one try, but do not try to restart it more than three or four times.

   ***Caution**: Some car's electrical and computer systems may be damaged by running the engine with a dead battery. Check your owner's manual or service provider for guidance.*

PRECAUTIONS:

- Do not touch the metal portion of the jumper cable clamps to each other or any part of the car except the proper battery terminal. Make working area hazard free
- Read and interpret manual which guide you how to use tools and equipments

QUALITY CRITERIA:

Assured performing of all the activities according to the procedures

OPERATION SHEET 4.2: Jump starts using battery charger.

PURPOSE: For the purpose of performing the jump start using battery charger to start the vehicle with dead battery.

Conditions or Situations for the Operations:

- ✓ Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Equipment Tools and Materials:

- ✓ Vehicle equipped with dead battery
- ✓ Battery charger

Procedure

1. First, make sure that the charger is rated for the voltage of your battery. Most car batteries are 12 volt.
2. Next, attach the positive lead from the charger to the positive terminal on the battery, and the negative lead from the charger to the negative terminal on the battery.
3. Finally, plug in the charger and turn it on. The charger will charge the battery and the car should start.

PRECAUTIONS:

- ➢ Do not touch the metal portion of the jumper cable clamps to each other or any part of the car except the proper battery terminal.
- ➢ Make working area hazard free.
- ➢ Read and interpret manual which guide you how to use tools and equipments

QUALITY CRITERIA:

Assured performing of all the activities according to the procedures

Lap Test

Instructions: Given necessary templates, workshop, tools and materials you are required to perform the following tasks within 2 hours.

Task 1. Apply jump starts using another vehicle's battery

Task 2. Jump starts using battery charger

6 Unit Five: Removing and Replacing Automotive Battery

This module is developed to provide you the necessary information regarding the following content coverage and topics:

- Battery Removing
- Battery Replacing

This module also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Apply Battery Removing Procedures
- Perform Battery Replacing Procedures

6.1 Removing battery from the vehicle

Batteries are a vital component of your vehicle's functionality, ensuring that all the electronic parts in your car run smoothly during operation. Sometimes, however, you'll need to remove your car's battery to perform general maintenance or replace an old battery with a new one.

An automotive battery is a rechargeable battery that supplies electric energy to an automobile. Traditionally, this is called an SLI, for starting, lighting, ignition, and its main purpose is to start the engine. Once the engine is running, power for the car is supplied by the alternator.

Engine starting discharges less than three per cent of the battery capacity. SLI batteries are designed to release a high burst of current, measured in amperes, and then be quickly recharged. They are not designed for deep discharge, and a full discharge can reduce the battery's lifespan.

- Ways in Identifying the Signs of the Battery Terminal.
    - *By Color* – usually the color-coding for the positive terminal is Red and Negative is Green or Black.
    - By Markings – the symbol for the positive terminal is Plus (+) sign and for the Negative terminal is Minus (-) sign.
    - By Size – normally the positive terminal is bigger in size than the negative terminal.

6.2 Installing battery on the vehicle

Batteries are installed on the vehicle for the purpose of starting engine and to give electric power to accessories.

Self-check

Part II. **Write the correct answers for the following questions (1point)**

1. What is battery removal?
2. What is battery replacing/installation?

OPERATION SHEET 5.1: Removing battery from the vehicle

OPERATION TITLE: Removing battery from the vehicle

PURPOSE: for the purpose of servicing battery.

CONDITIONS OR SITUATIONS FOR THE OPERATIONS

- ✓ Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

EQUIPMENT TOOLS AND MATERIALS: open-end wrench, cart, player

Procedure

1. Stop the car in level place
2. Remove ground terminal first and positive last
3. Remove battery guard [if there is]
4. Remove battery from the vehicle
5. place battery on cart and move to maintenance area

PRECAUTIONS:

- ➢ wearing proper clothes, eye glass, glove
- ➢ Make working area hazard free
- ➢ Read and interpret manual which guide you how to use tools and equipments

QUALITY CRITERIA: assured performing of all the activities according to the procedure

OPERATION SHEET 5.2: Replace/Installing Battery on Vehicle

OPERATION TITLE: replace/installing battery on vehicle.

PURPOSE: for the purpose of starting engine and to give electric power to accessories.

Conditions or Situations for the Operations

- ✓ Safe working area
- ✓ Properly operated tools and equipment.
- ✓ Appropriate working cloths fit with the body

Equipment, Tools and Materials: open-end wrench, cart, player etc...

Procedure

1. Clean the battery terminals to remove corrosion.
2. Buy the correct replacement battery.
3. Secure the new battery to the bracket and grease the terminals i.e. coat each of the terminals in a thin layer of lithium grease to prevent corrosion.
4. Reconnect the positive cable first.
5. Reconnect the negative cable next.
6. Close the hood and start your vehicle.

Precautions:

- ➢ wearing proper clothes, eye glass, glove
- ➢ Make working area hazard free
- ➢ Read and interpret manual which guide you how to use tools and equipments

Quality Criteria: Assured performing of all the activities according to the procedures

7 Unit Six: Retest battery and Prepare vehicle and equipment for delivery

This module is developed to provide you the necessary information regarding the following content coverage and topics:

- Retest battery
- Work place documentation

This module also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Apply retest battery
- Prepare work place documentation

7.1 Retest battery

If the result is 'charge – retest', to determine why the battery is in a low state of charge, the battery must first be charged. If after charging the result is 'good, recharge' the battery should be charged further. If, however, the result is 'charge – retest' **the battery is sulphated and will not take a charge**.

7.2 Work place documentation

When a vehicle owner enters the service center, he or she is attended by the supervising engineer. The customer informs about the vehicle defect. After getting feedback from the vehicle owner or driver regarding defects of the vehicle, the supervising engineer in a service station or workshop inspects it. The defects pointed out or listed are noted down in a standard format, which is called the job card or work order. In order to indicate his satisfaction with the diagnosis made by the supervising engineer, the customer of the vehicle signs the job card before the repairs on the vehicle are started. Work is then assigned to the concerned person to carry out repairs and the supervisor signs the job card too. The work order or job card is prepared in duplicate.

Contents of a Standard Job Card

- ✓ Job card number
- ✓ Name, address and phone number of the service center
- ✓ Name, address and phone number of the customer
- ✓ Details of vehicle, such as make, model, registration number, chassis number, engine number, date of sale, kilometers' reading, receiving date and time, delivery date and time by the service center
- ✓ Estimated cost in rupees for the customer and insurance company
- ✓ Checklist before trial
- ✓ Customer's observation
- ✓ Job to be done
- ✓ Labor required
- ✓ Name of the mechanic
- ✓ Name and signature of the supervisor
- ✓ Customer's authorization for repair and their signature

Self-check

1. Defects pointed out are noted down in a standard format which is known as _____.

   A. Complaint book
   C. Job card
   B. Rule book
   D. Register

2. What type of vehicle information is required to be mentioned in a job card?

   A. Chassis No.
   C. Model No.
   B. Engine No.
   D. All of the above

3. The acknowledgement form must have the signature of the _____.

   A. Supervising engineer
   C. Owner of service center
   B. Mechanic
   D. None of the above

Part II. **Write the correct answers for the following questions (1point)**

1. What is a job card?
2. What all is done during the service of a vehicle?

Reference

1. Advanced Automotive Fault Diagnosis. Automotive Technology. Vehicle Maintenance and Repair2017, Tom Denton
2. Automotive Wiring and Electrical Systems, 2009, Tony Candela
3. Automotive Engines: Diagnosis, Repair, Rebuilding, 2010,Tim Gilles

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