VEHICLE SERVICING AND REPAIRING

NTQF Level - II

Learning Guide -42

Unit of Competence: -Test and Repair Engine Electrical Systems

Module Title: -Testing and Repairing Engine Electrical Systems

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LO3: Service engine electrical systems

Instruction Sheet	Learning Guide - 41

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics –

- Analyse service options
- Select and prepare appropriate tools
- Carry-out Service adjustments
- Carry-out post-service testing

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, **you will be able to –**

- Analyse service options
- Select and prepare appropriate tools
- Carry-out Service adjustments
- Carry-out post-service testing

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described in number 3 to 20.
3. Read the information written in the “Information Sheets 1”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the “Self-check 1” **in page -.**
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
6. If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
7. Submit your accomplished Self-check. This will form part of your training portfolio.

Information Sheet-1	Analyse service options

THE AUTOMOTIVE SERVICEPROCEDURE

When something is wrong with a car, the technician must perform four basic steps to find and correct the problem. These are:

1. **Inspection,**which answers the question "Is somethingwrong?" or " Is there a problem?" The answer is usually**a "yes" or "no."**
2. **Diagnosis,**also called *trouble-diagnosis* and *troubleshooting.*This answers the question "What is wrong?"or "What caused or is causing the problem?"
3. **Repair,**which includes the steps necessary to fix the problem or repair both the problem and its cause,
4. **Quality check,**or performing step I again. If the properrepair has been made, the original problem no longerexists.

1.1 Charging system

Inspection

Many charging system concerns are caused by easilyrepairable problems that reveal themselves during avisual inspection of the system. Remember to alwayslook for the simple solution before performing moreinvolved diagnostic procedures. Use the followinginspection procedure when a problem is suspected.

ON-VEHICLE INSPECTION

1. CHECK BATTERY ELECTROLYTE LEVEL

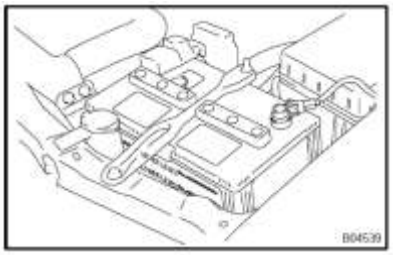
- Check the electrolyte quantity of each cell.
- Maintenance-Free Battery:
  - If under the lower level, replace the battery (or add distilled water if possible). And check the charging system.
- Except Maintenance-Free Battery:

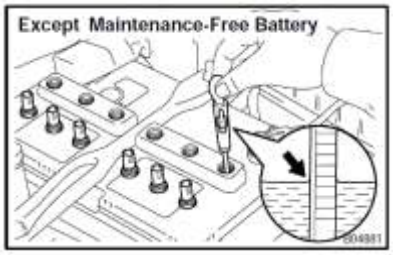
- If under the lower level, add distilled water.

2. Except Maintenance-Free Battery:

CHECK BATTERY SPECIFIC GRAVITY

- Check the specific gravity of each cell.
- **Standard specific gravity: 1.25 - 1.29 at 20°C (68°F)**
- If the specific gravity is less than specification, charge the battery.





3. Maintenance-Free Battery:

- **CHECK BATTERY VOLTAGE**

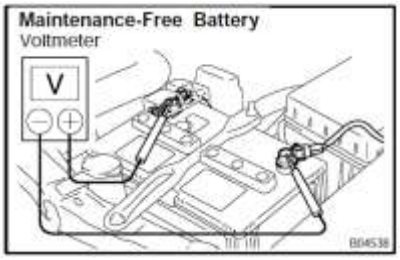
a) After having driven the vehicle and in the case that 20minutes have not passed after having stopped the engine,turn the ignition switch ON and turn on the electricalsystem (headlight, blower motor, rear defogger etc.) for60 seconds to remove the surface charge.

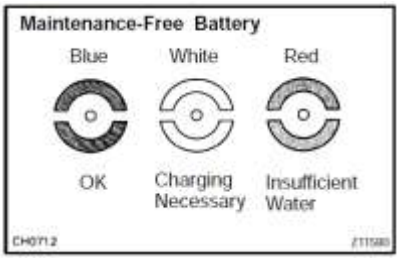
b) Turn the ignition switch OFF and turn off the electrical systems.

c) Measure the battery voltage between the negative (-)and positive (+) terminals of the battery.

- **Standard voltage: 12.5 - 12.9 V at 20°C (68°F)**
- If the voltage is less than specification, charge the battery.

HINT:Check the indicator as shown in the illustration.





4. CHECK BATTERY TERMINALS, FUSIBLE LINK AND FUSES

a) Check that the battery terminals are not loose or corroded.

b) Check the fusible link and fuses for continuity.

5. INSPECT DRIVE BELT

HINT:A belt tensioner is used, so checking the belt tension is not necessary.

a) Visually check the drive belt for excessive wear, frayedcords etc.

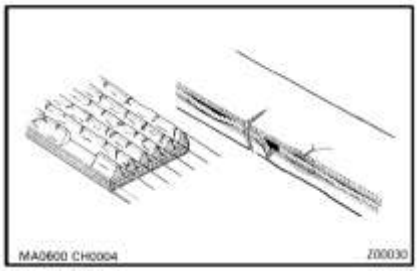
- If necessary, replace the drive belt.

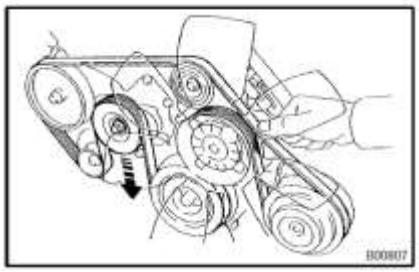
HINT:

- Cracks on the rib side of a drive belt are considered acceptable. If the drive belt has chunks missing from the ribs, it should be replaced.
- The drive belt tension can be released by turning the belttensioner counterclockwise. The pulley bolt for the belttensioner has a left-hand thread.

b) Check the belt tensioner operation.

- Check that the belt tensioner moves downwardwhen the drive belt is pressed down at the points indicatedin the illustration with approx. 98 N (10 kgf,22.0 lbf) of force.
- Check the alignment of the belt tensioner pulley tomake sure the drive belt has not slipped off thepulley.



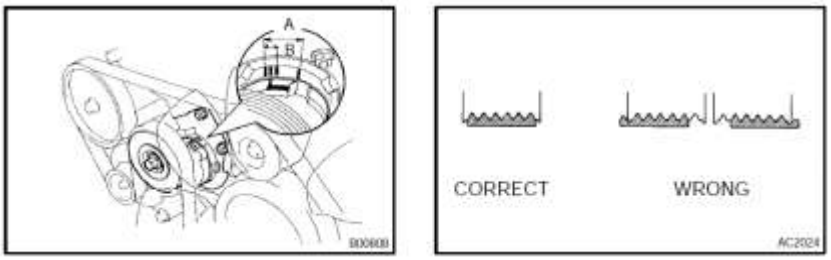


- If necessary, replace the belt tensioner.
  - Check that the arrow mark on the belt tensioner fallswithin area A of the scale.

- If it is outside area A, replace the drive belt.

HINT:

- When a new belt is installed, it should lie within area B. Ifnot, the drive belt is not correct.
- After installing a belt, check that it fits properly in theribbed grooves.
- Check by hand to confirm that the belt has not slipped outof the groove on the bottom of the pulley.



6. REMOVE ENGINE UNDER COVER NO.1

7. VISUALLY CHECK GENERATOR WIRING AND LISTENFOR ABNORMAL NOISES

a) Check that the wiring is in good condition.

b) Check that there is no abnormal noise from the generatorwhile the engine is running.

8. CHECK CHARGE WARNING LIGHT CIRCUIT

a) Warm up the engine and then turn it off.

b) Switch off all accessories.

c) Turn the ignition switch ON, and check that the chargewarning light is lit.

d) Start the engine, and check that the light goes off.

- If the light does not go off as specified, troubleshoot the chargelight circuit.

9. INSPECT CHARGING CIRCUIT WITHOUT LOAD

HINT:

- If a battery/generator tester is available, connect the tester tothe charging circuit as per manufacturer’s instructions.

a) If a tester is not available, connect a voltmeter and ammeterto the charging circuit as follows:

- Disconnect the wire from terminal B of the generator,and connect it to the negative (-) tester probeof the ammeter.
- Connect the positive (+) tester probe of the ammeterto terminal B of the generator.
- Connect the positive (+) tester probe of the voltmeterto terminal B of the generator.
- Ground the negative (-) tester probe of the voltmeter.

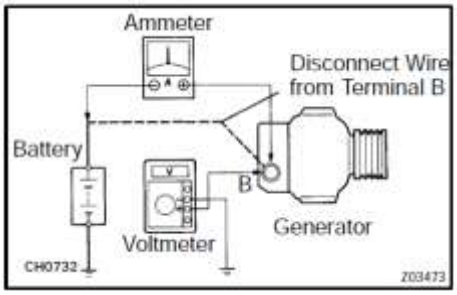
b) Check the charging circuit as follows:

- With the engine running from idling to 2,000 rpm, checkthe reading on the ammeter and voltmeter.

➢ **Standard amperage: 10 A or less**

➢ **Standard voltage: 13.2 - 14.8 V**

▪ If the value is not specified, check the generator.



10. INSPECT CHARGING CIRCUIT WITH LOAD

a) With the engine running at 2,000 rpm, turn on the highbeam headlights and place the heater blower switch at HI.

b) Check the reading on the ammeter.

▪ **Standard amperage: 30 A or more**

▪ If the ammeter reading is less than the standard amperage, repair the generator.

HINT:

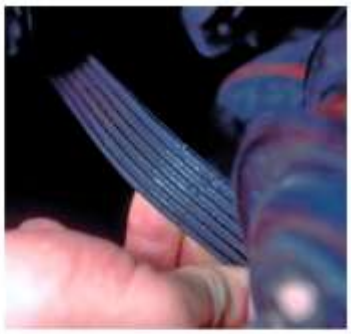
▪ If the battery is fully charged, the indication will sometimes beless than standard amperage.

11. REINSTALL ENGINE UNDER COVER NO.1

PHOTO SEQUENCE 1 - Typical Procedure for Inspecting, Removing, Replacing, and Adjusting a Drive Belt

1 *Inspect the belt by looking at both sides.*

2 *Look for signs of glazing.*



3 *Look for signs of tearing or cracking.*

4 *To replace a worn belt, locate the tensioner or generator pulley.*

5 *Loosen the hold-down fastener for the tensioner or generator pulley.*

6 *Pry the tensioner or generator pulley inward to release the belt t ension and remove the belt.*

7 *Match the old belt up for size with the new replacement belt.*

8 *Observe the belt routing diagram in the engine compartment.*

9 *Install the new belt over eachof the drive pulleys. Often the manufacturer recommends a sequence for feeding the belt around the pulleys.*

10 *Pry out the tensioner or generator pulley to put tension on the belt.*

11 *Install the belt squarely in the grooves of each pulley.*

12 *Measure the belt deflection in its longest span. If a belt tension gauge is available, use it and compare the tension to specifications.*

13 *Pry the tensioner or generator pulley to adjust the belt to specifications.*

14 *Tighten the tensioner or generator pulley fastener.*

15 *Start the engine and check the belt for proper operation.*

Oscilloscope Checks

AC generator output can also be checked using an oscilloscope.Illustrate common AC generator voltage patterns for good and faulty generator. The correct pattern looks like the rounded top of a picket fence. A regular dip in the pattern indicates that one or more of the coil windings is grounded or open, or that a diode in the rectifier circuit of a diode trio circuit has failed. One or more bad or leaking diodes will decrease the output of a generator.

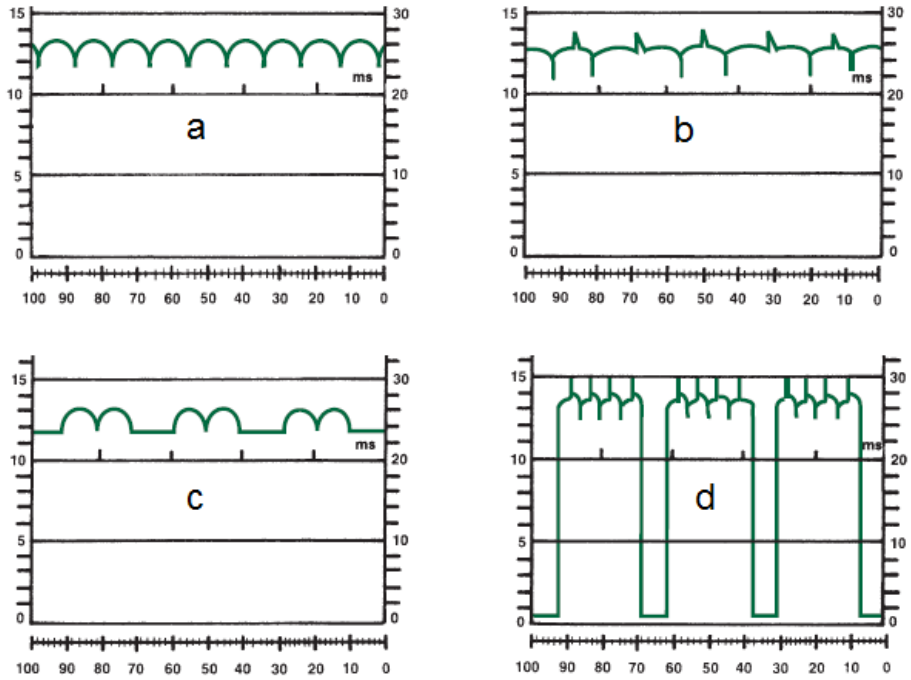


Figure 1.1-1AC generator oscilloscope patterns: (A) good AC generator under full load, (B) good AC generator under no load, (C) shorted diode and/or stator winding under full load, and (D) open diode in diode trio.

PRECAUTION

- **Check that the battery cables are connected to the correct terminals.**
- **Disconnect the battery cables when the battery is given a quick charge.**
- **Do not perform tests with a high voltage insulation resistance tester.**
- **Never disconnect the battery while the engine is running.**

1.2 STARTING SYSTEM

STARTING SYSTEM TESTING

The starter motor is a specialtype of electrical motor designed for intermittentuse only. During testing, it should never be operatedfor more than 15 seconds without resting for2 minutes in between operation cycles to allow itto cool.

Preliminary Checks

- **BATERRY -** The cranking output obtained from the motor is affected by the condition and charge of the battery, the circuit's wiring, and the engine's cranking requirement. The battery should be checked and charged as needed before testing the starting system.

- **CABLES -**Check the wiring and cables for clean, tight connections. Loose or dirty connections will cause excessive voltage drops. Cables can be corroded by battery acid, and contact with engine parts and other metal surfaces can fray the cable insulation. Frayed insulation can cause a dead short that can seriously damage some of the electrical units of the vehicle.

  Cables should also be checked to make sure theyare not undersized or too long. When checking cablesand wiring, always check the maxi-fuses and/or fusiblelinks for the system. When one has failed, alwaystroubleshoot the system and locate the cause beforereplacing the fuse or link.

- **OIL -**Make certain that the engine is filled with proper weight oil as recommended by the vehicle manufacturer. Heavier-than-specified oil when coupled with low operating temperatures can drastically lower cranking speed to the point where the engine does not start and excessively high current is drawn by the starter.

IGNITION SWITCH -Check the ignition switch for loose mounting,damaged wiring, sticking contacts, and loose connections.

- **SAFETYSWITCH -** Check the wiring and mounting of the safetyswitch, if so equipped, and make certain the switch isproperly adjusted.
- **MAGNETIC SWITCH AND STARTER MOTOR -** Check the mounting, wiring, andconnections of the magnetic switch and starter motor.
- **PINION GEAR -** Also, be sure the starter pinion is properly adjusted.

Cranking Voltage Test

The **cranking voltage test** measures the availablevoltage to the starter during cranking. To perform thetest, disable the ignition or use a remote starter switchto bypass the ignition switch. Normally, the remotestarter switch leads are connected to the positive terminalof the battery and the starter terminal of thesolenoid or relay.

- Refer to the servicemanual for specific instructions on the model car being tested.
  1. Connect the voltmeter's negative lead toa good chassis ground.
  2. Connect the positive lead tothe starter motor feed at the starter relay or solenoid.
  3. Activate the starter motor and observe the voltagereading.
  4. Compare the reading to the specificationsgiven in the service manual.
- Normally, 9.6 volts is theminimum required.

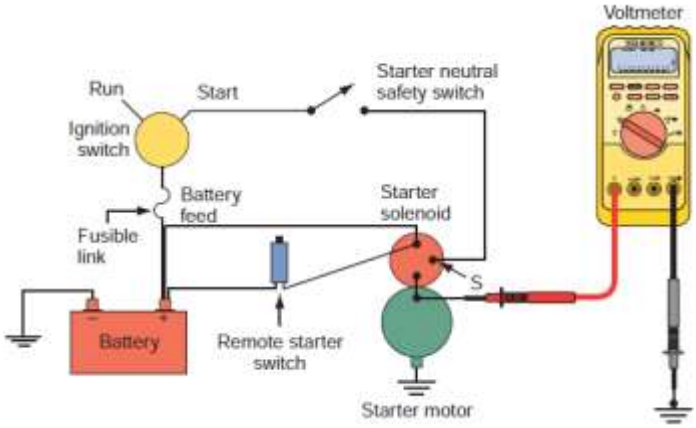


Figure 1.1-2 Use a remote starter switch to bypass the control circuit and ignition system.

❖ **Test Conclusions:**

- If the reading is above specifications but the starter motor still cranks poorly, the starter motor is faulty.
- If the voltage reading is lower than specifications, a cranking current test and circuit resistance test should be performed to determine ifthe problem is caused by high resistance in the startercircuit or an engine problem.

Cranking Current Test

The **cranking current test** measures the amount ofcurrent the starter circuit draws to crank the engine.Nearly all starter current testers use an inductivepickupto measure the current draw.

Figure 1.1-3 It is important to remember to move the inductive lead to the vehicle's system after checking the battery.

To conduct the cranking current test,

1. Connect aremote starter switch or disable the ignition prior totesting.
2. Follow the instructions given with the testerwhen connecting the test leads.
3. Crank the engine forno more than 15 seconds.
4. Observe the voltmeter.

- Ifthe voltage drops below 9.6 volts, a problem is indicated.

1. Also, watch the ammeter and compare thereading to specifications.

Table 1summarizes the most probable causesof too low or high starter motor current draw. If the problem appears to be caused by excessive resistancein the system, conduct an insulated circuitresistance test.

Concern	Probable Cause
Low current draw	Undercharged or bad battery Excessive resistance in the starter circuit Excessive resistance in the starter or solenoid Excessive resistance at the various connections to the starter and/or solenoid
High current draw	The starter motor is shorted A short-to-ground in the starter circuit High mechanical resistance due to engine problems Misalignment of starter drive

TABLE 1.1-1interpreting the results of a cranking current test

Insulated Circuit Resistance Test

The starter circuit is made up of the insulated circuitand the ground circuit. The insulated circuit includesall of the high current cables and connections fromthe battery to the starter motor.

To test the insulated circuit for high resistance,

1. Disable the ignition or bypass the ignition switch with a remote starter switch.
2. Connect thepositive (+) lead of the voltmeter to the battery'spositive (+) terminal post or nut.
3. Connect thenegative (-) lead of the voltmeter to the starter terminalat the solenoid or relay.
4. Crank the engine andrecord the voltmeter reading.

- If the reading is within specifications (usually 0.2 to 0.6 voltage drop), theinsulated circuit does not have excessive resistance.

Proceed to the ground circuit resistance test outlinedin the next section.

- If the reading indicates a voltageloss above specifications,
  1. Move the negative lead ofthe tester progressively closer to the battery,
  2. Crankingthe engine at each test point.

Normally, a voltagedrop of 0.1 volt is the maximum allowed across alength of cable.

PHOTOSEQUENCE – 2 Voltage Drop Testing of a Starter Circuit

1 *The tools required to measure voltage drop at various points within the starter circuit are fender covers, a DMM, and a remote starter switch. Make sure to apply the parking brake and set the t ransmission into neutral or park.*

2 *Connect the meter's positive lead to the positive battery post. If at all possible, do not connect it to the battery clamp.*

3 *Connect the negative lead to the battery connection at the starter*

4 *Set the voltmeter to the scale that is close to, but greater than, battery voltage.*

5 *Disable the ignition and fuel injection and/or connect a remote starter switch.*

6 *Crank the engine and read the voltmeter. This reading shows the voltage drop on the positive side of the starter circuit.*

7 *This reading shows excessive resistance. To locate the resistance, move the meter's negative lead to the next location toward the battery. In this case it is the starter side of the starter relay.*

8 *Crank the engine and observe the reading on the meter. This is the voltage drop across the positive circuit from the battery to the output of the relay.*

9 *There is still too much voltage drop; continue the test by moving the negative lead to the battery side of the relay*

10 *Crank the engine and observe the reading on the meter. This is the voltage drop across the cable from the battery to the relay. Notice that hardly any voltage was dropped. This cable is okay*

11 *Now connect the meter across the relay: the red lead on the battery side and the black lead on the starter side.*

12 *Crank the engine and observe the reading on the meter. This is the voltage drop across the contacts inside the relay.*

13 *The reading is higher than normal; therefore, the starter relay has high resistance and needs to be replaced.*

- **Test Conclusions -**When excessive voltage drop isobserved, the trouble is located between that pointand the preceding point tested. It is a damagedcable or poor

connection, an undersized wire, or possiblya bad contact assembly within the solenoid.Repair or replace any damaged wiring or faultyconnections.

Starter Relay By-Pass Test

The starter relay by-pass test is a simple way to determine if the relay is operational.

1. First, disable the ignition.
2. Connect a heavy jumper cable between the batteries's positive (+) terminal and the starter relay's starter terminal. This bypasses the relay.

When the connection is made, the engine should crank.

C A U T I O N !

Make sure the vehicle's transmission is in park or neutral before doing this test. The starter motor can move the vehicle, which could injure you and others around you.

- **Test Conclusions -** If the engine cranks with the jumper installed and did not before the relay was bypassed, the starter relay is defective and should be replaced.

Ground Circuit Resistance Test

The ground circuit provides the return path to thebattery for the current supplied to the starter by theinsulated circuit. This circuit includes the **starter-to-engine**,**engine-to-chassis**, and **chassis-to-battery**ground terminal connections.

To test the ground circuit for high resistance,

1. Disable the ignition, or bypass the ignition switch with aremote starter switch. Refer to **Figure 1.1-4**for theproper test connection. Crank the engine and recordthe voltmeter reading.

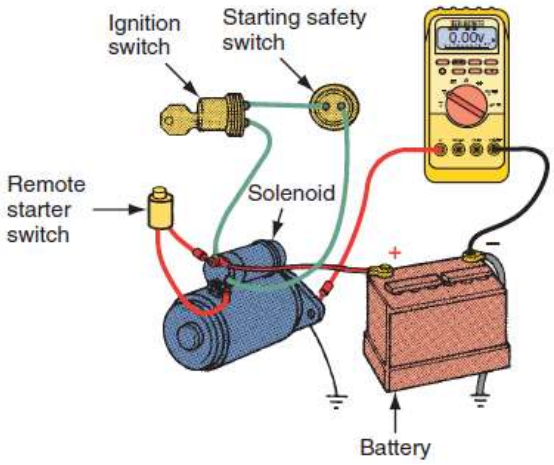


Figure 1.1-4 Setups for checking voltage drop across the ground circuit.

- **Test Conclusions -** Good results would be less than a0.2 volt drop for a 12-volt system. A voltage drop inexcess of this indicates the presence of a poor groundcircuit connection, resulting from a loose startermotor bolt, a poor battery ground terminal post connector,or a damaged or undersized ground systemwire from the battery to the engine block.

  Isolate thecause of excessive voltage drop in the same manneras recommended in the insulated circuit resistancetest by moving the positive (+) voltmeter lead progressivelycloser to the battery. If the ground circuittests out satisfactorily and a starter problem exists,move on to the control circuit test.

Voltage Drop Test of the Control Circuit

The control circuit test examines all the wiring andcomponents used to control the magnetic switch,whether it is a relay, a solenoid acting as a relay, or astarter motor-mounted solenoid.

High resistance in the solenoid switch circuitreduces current flow through the solenoid windings,which can cause improper functioning of the solenoid.In some cases of high resistance, it may notfunction at all.

Improper functioning of the solenoidswitch generally results in the burning of the solenoidswitch contacts, causing high resistance in the startermotor circuit.

2. Check the vehicle wiring diagram, if possible, toidentify all control circuit components. These normallyinclude the ignition switch, safety switch, thestarter solenoid winding, or a separate relay.

To perform the test,

1. Disable the ignition system.
2. Connect the positive meter lead to the battery's positive terminal and the negative meter lead to the starter switch terminal on the solenoid or relay.
3. Crank the engine and
4. Record the voltmeter reading.

❖ **Test Conclusions -**Generally, good results would beless than 0.5 volt, indicating that the circuit conditionis good.

- If the voltage reading exceeds 0.5 volt, it isusually an indication of excessive resistance.

However, on certain vehicles, a slightly higher voltage lossmay be normal.

Identify the point of high resistance by moving thenegative test lead back toward the battery's positive terminal,eliminating one wire or component at a time.

- A reading of more than 0.1 volt across any one wire or switch is usually an indication of trouble.
- If a highreading is obtained across the safety switch used onan automatic transmission, check the adjustment ofthe switch according to the manufacturer's servicemanual. Clutch-operated safety switches cannot beadjusted. They must be replaced.

Test Starter Drive Components

This test detects a slipping starter drive withoutremoving the starter from the vehicle.

1. First, disablethe ignition system or bypass the ignition switch witha remote starter switch.
2. Turn the ignition switch tostart and hold it in this position for several seconds.
3. Repeat the procedure at least three times to detect anintermittent condition.

❖ **Test Conclusions –**

- If the starter cranks the enginesmoothly, that is an indication that the starter drive isfunctioning properly.
- If the engine stops crankingand the starter spins noisily at high speed, the drive isslipping and should be replaced.
- If the drive is not slipping, but the engine is notbeing cranked, inspect the flywheel for missing ordamaged teeth.
  1. Remove the starter from the vehicleand check its drive components.
  2. Inspect the pinion gear teeth for wear and damage.
  3. Test the overrunning clutch mechanism.
- If good, the overrunning clutchshould turn freely in one direction but not in theother. A bad clutch will turn freely in the overrundirection or not at all.
- If a drive locks up, it can destroythe starter by allowing the starter to spin at more than15 times engine speed.

1.3 IGNITION SYSTEM

GENERAL IGNITION SYSTEM

DIAGNOSIS

The ignition system should be tested whenever you know or suspect there is no spark, not enough spark, or when the spark is not being delivered at the correct time to the cylinders.

1.3.1 SERVICING IGNITION SYSTEMS

No ignition system is maintenance free. All have parts that deteriorate, wear, and sometimes fail. Various inspections, tests, and services are performed on the ignition system to help prolong normal engine operation. Many of these procedures are the same for both contact-point and electronic ignition systems.

When performing ignition-system service, look for the **vehicle emission control information(VECI)** label in the engine compartment. The VECI label has specifications and tune-up instructions for the engine in the vehicle. The information includes firing order, how to set ignition timing, recommended spark plug, and spark-plug gap.

VISUAL INSPECTION OFIGNITION SYSTEMS

Begin all diagnosis by gathering as much information as possible from the customer. Then conduct a careful visual inspection. The system should be checked for obvious problems. Although no-start problems and incorrect ignition timing are caused by the primary circuit, the secondary circuit can be the cause of driveability problems and should be carefully checked. In addition to the ignition system, inspect all related electrical connectors or fuses, vacuum lines, air intake system, and cooling system.

Also check available service information that may relate to the symptoms. Symptoms commonly caused by ignition system problems include (keep in mind that the ignition system is not the only thing that can cause these):

- **Hard starting -**The engine requires an excessiveamount of time to start.
- **Rough idle -**The engine idles poorly and maystall.
- **Engine stalling -**The engine quits unexpectedly.It may occur right after engine startup, while idling,or during deceleration.
- **Hesitation -** The engine does not immediatelyrespond to opening of the throttle.
- **Stumble -** The engine temporarily loses powerduring acceleration.
- **Poor acceleration -** The vehicle accelerates slowerthan expected.
- **Surge -** The engine's speed fluctuates with a constantthrottle during idle, steady cruise, acceleration,or deceleration.
- **Bucking -** The vehicle jerks shortly after accelerationor deceleration.
- **Knocking (pinging) -** The engine makes a sharpmetallic noise during acceleration.
- **Backfire and after-fire -** Backfire is a loud pop comingfrom the intake system, usually during rapid throttleopening. After-fire is a popping that occurs in theexhaust system, usually during quick deceleration.

IGNITION-SYSTEM TESTING

SPARK TEST

When an engine cranks normally but does not start, make aspark test **(Figure 1.1-5)**. This quick check of the ignition system determines if high-voltage surges from the coil secondary winding reach the spark plugs.

1. Disconnect the spark-plug cable from a spark plug.
2. Insert a metal extender into the terminal at the end of thecable.
3. Using *insulated pliers,* hold the extender about3/8 inch [10 mm] from the cylinder head or block **(Figure 1.1-5A).** Or attach the cable terminal to a *spark tester* **(Figure1.1-5B).**
4. Then fasten the tester to a good ground on theengine.

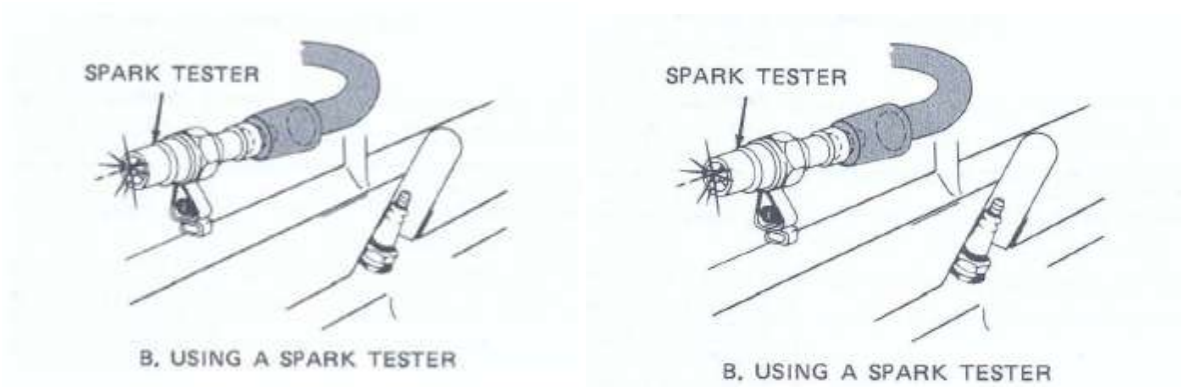


Figure 1.1-5 making a spark test (A) using insulated pliers and (B) using a spark tester.

CAUTION~

Hold secondary cables with insulated pliers made of nonconductive material. Do not use metal pliers with insulated handles. The spark in a high-energy ignition system can jump an inch [25.4 mm] or more. It could jump around or through the insulation and give you a dangerous shock. Be sure there is no fuel or fuel vapor near where the spark will occur. The spark could ignite the fuel causing a fire or explosion.

5. Be sure the battery is charged.
6. Crank the engine and watch for sparking across the gap.

- If blue sparks jump thegap when the engine cranks, the trouble is probably in thefuel system. No sparking indicates trouble in the ignitionsystem. Make a *triggering test*of the primarycircuit. This will show if the primary circuit is opening andclosing.

TRIGGERING TEST

All ignition systems have a switch (contact points or electronic) that turns the primary current on and off. This switching action sends pulses of dc current through the coil primary

winding. If the primary current does not pulse on and off, the magnetic field in the coil does not build up and collapse. Then no high-voltage surge appears in the secondary circuit.

When no spark occurs during a spark test, use an *electronic circuit tester* or a *digital logic probe*to make a triggering test of the primary circuit.

Follow the connecting procedure in the manufacturer's operating instructions. Then:

1. Contact the coil negativeterminal or lead with the probe tip.
2. Crank the engine.
3. The*pulse LED* should flash on and off.

This shows the triggeringof the primary circuit as it switches the primary current on and off.

- If the LED does not flash, the triggeringsystem is not working.

Carful!

A 12-volt test lightcan be used to make a primary-triggering test on a contact-point ignition system. However, this test light must not be used on some electronic ignition systems. The test light connects in parallel. This can cause excessive current flow which damages the ignition module and electronic control module (ECM).

OSCILLOSCOPE PATTERNS

The *oscilloscope* or *scope* is used to analyze ignition-system operation;the scope patterns showignition-system troubles and help pinpoint their causes.**Figure 1.1-6** shows the basic secondary-voltage pattern for one spark-plug firing cycle. The scope shows other ignition-system patterns which may vary slightly from system to system. These include patterns that show the firing of all spark plugs in the engine **(Figure 1.1-7)**. Frequently-used patterns are the *parade* or *display* pattern, the *stacked* or *raster* pattern, and the *superimposed* pattern.

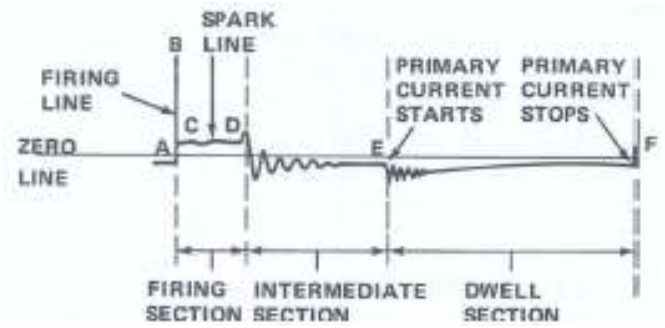


Figure 1.1-6 Oscilloscope waveform, or trace, showing onecomplete spark-plug firing cycle in the secondary circuit. The dwell section is the time period during which current flows through the primary circuit.

The parade or display pattern **(Fig. 1.1-7a)** shows all plugs firing in a single line. The pattern reads from left to right in the firing order. The firing line for cylinder 1 is on the right. In the stacked or raster pattern **(Fig. 1.1-7b)**, each spark-plug firing cycle appears one above the other in the firing order. This allows a comparison among the traces to show any abnormal conditions in one or more cylinders. The superimposed pattern **(Fig. 1.1-7c)**places all traces on top of each other. Then the variation among cylinders can be seen.

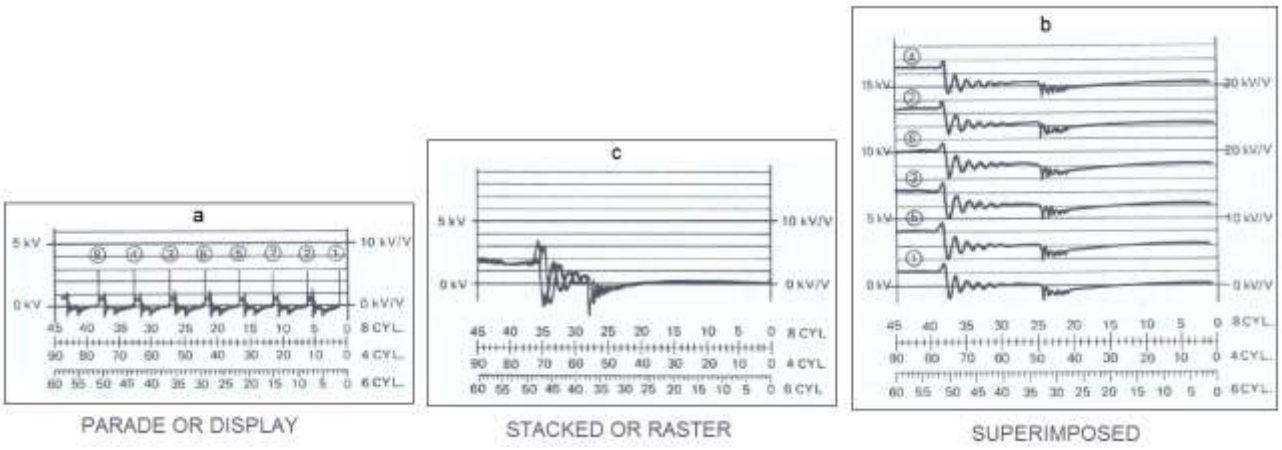


Fig. 1.1-7 Three ways to display ignition secondary voltages for all cylinders in an engine.

CHECKING IGNITION-SYSTEM COMPONENTS

IGNITION-SYSTEM MAINTENANCE

Many parts in the ignition system should be inspected or replaced at the time or mileage given in the vehicle maintenance schedule. These include the spark plugs, spark-plug cables, and distributor cap and rotor (if used).

VISUAL INSPECTION

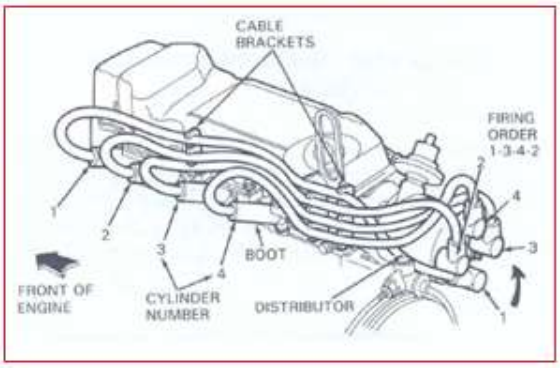
Make a visual inspection if parts fail or other problems occur in the ignition system. This will locate and identify many troubles and potential troubles.

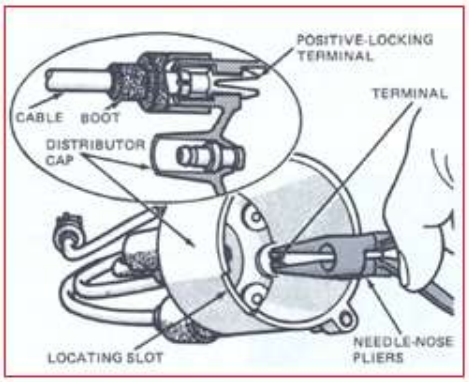
Checking secondary wiring

Secondary cables should be:

- Clean and attached tightly to the distributor cap or coils and the spark plugs.

- Terminals should be fully seated. Loose connections corrode and increase in resistance.
- Boots should be in good condition and fit tightly on the cap or coils and spark plugs. Loose or punctured boots allow water to enter the towers. Erosion, arc-over, and other ignition problems may result.





- To disconnect a cable, grasp the boot, twist and pull at the same time. Do not pull on the cable. Pull on the boot, or use a *spark-plug boot puller.* It has fingers that fit behind the boot. Some Hall-effect distributors have push-in cable terminals that lock in place in the cap.
- To detach the cables, remove the cap. Use needle-nose pliers to release the terminals.
- Clean dirty cables and boots with *waterless hand cleaner* or liquid detergent (soap). Then wipe dry. Examine the boots and cable insulation for brittleness, bums, cracks, and other damage.

- Bend each cable or wrap it around your finger. Cracks will open and be easily seen.

Any of these conditions allows high-voltage leakage and causes engine miss. Some manufacturers recommend coating the inside of each boot with *silicone grease* before installation.

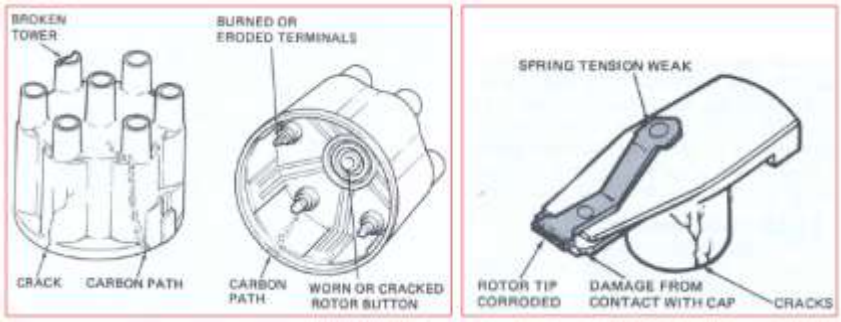
- To install new secondary cables or a new cap, replace one cable at a time.
- Grasp the boot and push the terminal and boot into the proper tower until the terminal seats.
- Then position each cable correctly in the cable brackets and looms. This helps prevent cable damage and cross-firing.
- Be sure each cable is in its specified position. Improperly positioned cables may allow an induced voltage to affect a nearby sensor or the ECM. This can set trouble codes and cause drive ability problems.

Checking distributor cap and rotor

To check the cap and rotor,

- Remove the cap. It is held in place by screws, spring clips, or retaining latches.
- Examine the cap for cracks, arc-over and carbon paths, cracked and worn rotor button, burned or eroded terminals, and broken cap towers.
- Clean off light scaling with a knife blade. Heavy scaling requires replacing the cap. The inside of the cap may be dirty, greasy, or coated with a powdery substance.
- Disconnect the cables from the cap and wash it with warm water and detergent. Scrub the deposits with a soft brush. Thoroughly rinse the cap and dry with a clean soft cloth.

Inspect the rotor for cracks, weak spring tension, signs of contacting the cap, and a burned or corroded tip on the rotor blade.



- Replace a rotor that has any of these conditions.

When replacing the cap, transfer the spark-plug cables to the new cap or install new cables.

Install the cap on the distributor. Be sure the cap is properly positioned and seated. A *locating slot* or lug in the cap fits a matching section of the distributor housing. If the cap is not seated when the engine cranks, the rotor will hit the cap and probably break.

Testing ignition coil

Inspect the coil and coil cable.

- Wipe away any dirt from the coil tower using a clean cloth and soap and water.
- Look for cracks, carbon tracking, and arcing and burning of the tower. Replace a coil that has any of these conditions.
- Check for damage to the boot on the coil end of the secondary cable. Replace the cable if the boot is damaged. Arcing at the tower damages the boot. Placing a damaged boot on a new coil will cause coil failure. Replace the coil cable if it is damaged or shows carbon tracking.
- Continued use will also cause a new coil to fail. Coil operation can be checked on the engine by making a spark test.
- Disconnect the coil wire from the distributor. Insert a metal extender into the terminal. Using insulated pliers, hold the extender about 3/8 inch [10 mm] from a good ground. Or attach a spark tester to the coil high-voltage terminal and a jumper wire from the spark tester to ground.
- Crank the engine and watch for sparking across the gap. If blue sparks jump the gap when the engine cranks, the coil is probably good.

Ignition Coil Resistance

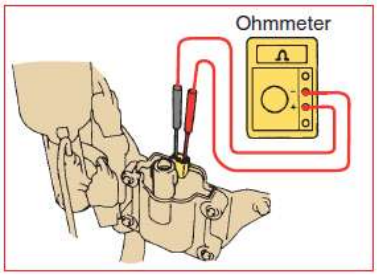
Ignition coils, like all parts that contain electrical windings, can be checked with an ohmmeter. In an ignition coil there are two separate windings and each has a different resistance value. This is due to the wire size and the number of windings. Always refer to the specifications prior to testing a coil. If a measurement is not within specifications, the coil or coil assembly should be replaced.

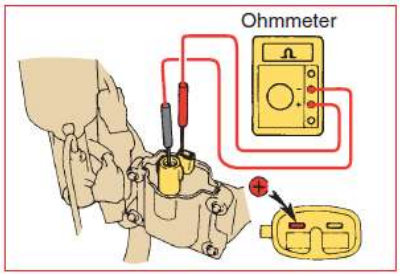
To check the primary windings,

- Set the ohmmeter to the auto-range mode and connect the meter across to the primary coil (BAT and TACH) terminals.
- An infinite ohmmeter reading indicates an open winding.
- Higher-than-normal readings indicate the presence of excessive resistance.
- If the measurement is less than the specified resistance, the windings are shorted.

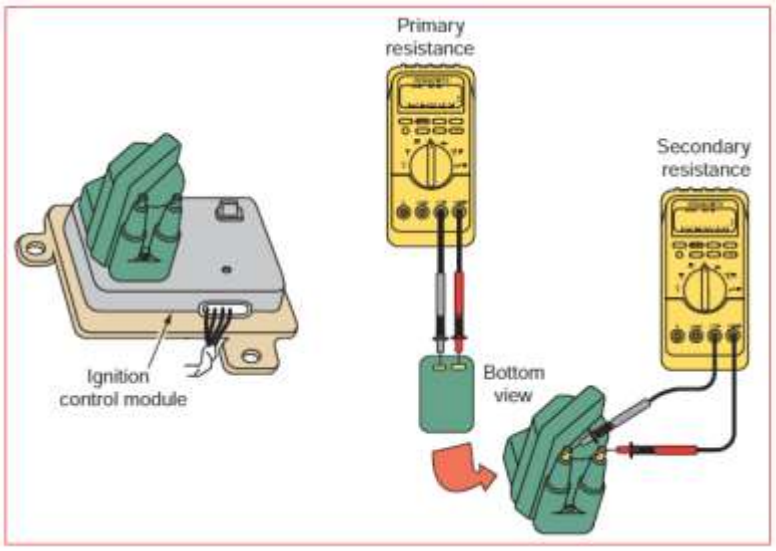
To check the secondary winding,

- Connect the meter between the coil's secondary terminal and the positive (BAT) terminal of the coil.
- A meter reading below the specified resistance indicates a shorted secondary winding.
- An infinite meter reading indicates that the winding is open.
- Higher-than-normal readings indicate the presence of excessive resistance.





The secondary windings of a **waste spark ignition coil** are not checked in the same way as other coils. Each coil has two secondary terminals. The coil is checked by connecting the meter across the two secondary terminals. As with other coils, compare the readings to specifications. COP coils are checked in the same way as other coils.



❖ Replace the coil if it is not within specifications.

In the electronic ignition system:

- If the ignition coils check out with an ohmmeter but still does not spark, Check the voltage from the ignition relay. There should be 12 volts.
- If this voltage is not present, check for battery voltage to the relay.
- If this voltage is there, check the relay control wires from the PCM.
- If the circuit is good, the relay should be replaced.
- If no voltage is available to the relay, check the relay control circuit from the PCM and the ignition switch.
- If the wires and the ignition switch are good, test the PCM.

Spark Plugs

Spark plug replacement is part of the preventive maintenance program for all vehicles. The recommended replacement interval depends on a number of factors but ranges from 20,000 to 100,000 miles (32,000 to 160,000 km).

Removal of an engine's spark plugs is pretty straightforward. Remove the cables from each plug, being careful not to pull on the cables. Instead, grasp the boot and gently twist it off. (To save time and avoid confusion later, use masking tape to mark each of the cables with the number of the plug it attaches to.)

Using a spark plug socket and ratchet, loosen each plug a couple of turns. A spark plug socket should be used because it has an internal rubber bushing to prevent plug insulator breakage. Spark plug sockets can have either a 3⁄8- or 1⁄2- inch drive, and most have an external hex so that they can be turned using an open end or box wrench.

Once the plugs are loose; use compressed air to blow dirt away from the base of the plugs. Then remove the plugs, making sure their gaskets have also been removed (if applicable). When the spark plugs are removed,

- They should be set in order so the spark plug from each cylinder can be examined.
- Check the threads in the cylinder head for damage. Normally you can do this by feel as you remove a spark plug.
- If the plug does not turn out smoothly after it is loose, the threads may be damaged. Often the threads can be cleaned up with a spark plug thread chaser.
- Also, check the threads on the spark plug. Look for damage or metal embedded in the threads, as these are sure signs of problems.
- If the cylinder head is aluminum, it may be necessary to install a threaded insert into the spark plug bore.

Inspecting Spark Plugs

Once the spark plugs have been removed, it is important to “read” them. In other words, inspect them closely, noting in particular any deposits on the plugs and the degree of electrode erosion.

PHOTOSEQUENCE - 3

1. Normal spark plug.
2. A worn spark plug.
3. A cold- or carbon-fouled spark plug.
4. A wet- or oil-fouled spark plug.


5. A splash-fouled spark plug.


6. There is no longer a gap on this spark plug.

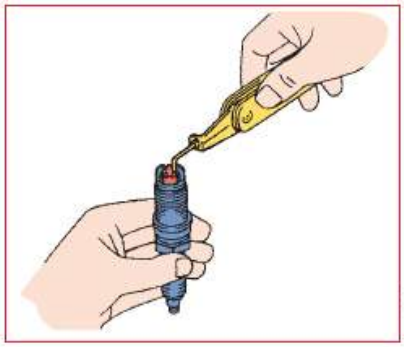

7. This spark plug shows signs of overheating.

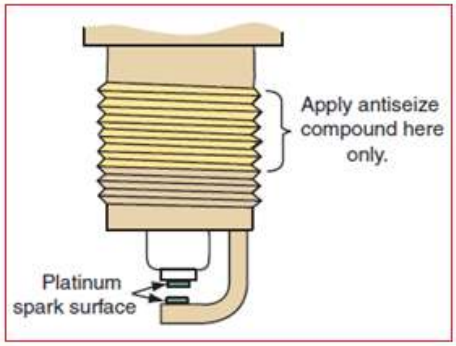

8. A spark plug with preignition damage.

Re-gapping Spark Plugs

Both new and used spark plugs should have their air gaps set to manufacturer's specifications.

- Always use round wire gauges when checking and setting the gap.
- After the gap has been adjusted, make sure that the ground electrode is as horizontal as it can be.
- Always check the air gap of a new spark plug before installing it. Never assume the gap is correct just because the plug is new.
- Do not try to reduce a plug's air gap by tapping the side electrode on a bench. Use a spark plug gapping tool to bend the ground electrode to its correct height. When doing this, be careful not to contact or put pressure on the center electrode.
- Some engines are equipped with spark plugs that have more than one ground electrode. The gap between the center electrode and each ground electrode should be checked. If the gap between the center electrode and one of the ground electrodes is less than that of the others, spark will occur only at the smallest gap.





Timing the distributor to the engine

During installation, the distributor must be timed to the engine if the crankshaft has turned while the distributor was out. Locate the firing order and cylinder numbering illustration for the engine. This is in the vehicle service manual and auto repair manuals. **Note** the position of the cap latches or screws.

- Install the distributor in the engine in the same position. Also **note** the location of the number I terminal on the distributor cap. When the number 1 piston is at TDC ending the compression stroke, the rotor tip should point to the number 1 terminal in the cap.

To time the distributor to the engine,

1. Remove the number I spark plug. Locate the *timing marks*. Most engines have a rotating mark that aligns with a specified stationary mark when ignition timing is correct. The timing marks are usually on the crankshaft vibration damper and the engine front cover. Some are on the flywheel and the housing.
2. Place a shop towel over your finger and cover the sparkplug hole. Do not allow your finger to enter the spark-plug hole! Crank the engine with the starting motor until you feel compression pressure push against your finger.
3. Continue bumping the engine with the starting motor until the timing marks align. This shows that the number I piston is in firing position.
4. Install the distributor, making sure the rotor tip aligns with the cap terminal for the number 1 spark plug.
5. Install but do not tighten the distributor clamp and bolt.
6. Rotate the distributor until the primary trigger opens the primary circuit. This occurs when:
   a. The contact points start to open.
   b. The reluctor tip passes alignment with the pole piece.
   c. The shutter leaves the air-gap in the Hall-effect switch.
   d. The rotating disk interrupts the light beam striking the photodiode.
7. Hold the cap in its mounting position above the distributor.
8. Check that the rotor tip aligns with the number I terminal on the cap. Install the cap.

9. Connect the primary lead.
10. Start the engine and check that the oil light in the instrument panel goes out.
- If not, stop the engine and check for proper seating of the distributor.
11. Set the ignition timing.
12. Tighten the hold down bolt.
13. Connect the vacuum hose and install any parts removed.

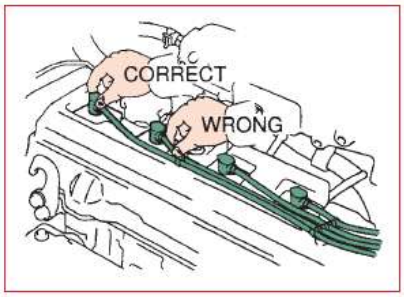
COMMON CYLINDER NUMBERING AND FIRING ORDER

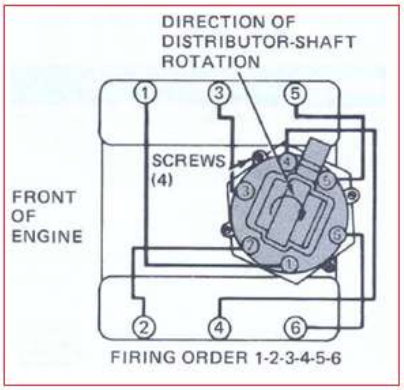
IN-LINE

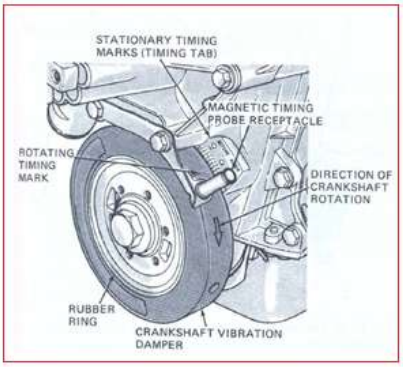
4-Cylinder		6-Cylinder	
① ② ③ ④		① ② ③ ④ ⑤ ⑥	
Firing Order	1–3–4–2 1–2–4–3	Firing Order	1–5–3–6–2–4

V CONFIGURATION

V6		V8	
⑤ ③ ①	Right Bank	① ② ③ ④	Right Bank
⑥ ④ ②	Left Bank	⑤ ⑥ ⑦ ⑧	Left Bank
Firing Order	1–4–5–2–3–6	Firing Order	1–5–4–8–6–3–7–2
② ④ ⑥	Right Bank	① ② ③ ④	Right Bank
① ③ ⑤	Left Bank	⑤ ⑥ ⑦ ⑧	Left Bank
Firing Order	1–6–5–4–3–2	Firing Order	1–5–4–2–6–3–7–8
① ② ③	Right Bank	② ④ ⑥ ⑧	Right Bank
④ ⑤ ⑥	Left Bank	① ③ ⑤ ⑦	Left Bank
Firing Order	1–2–3–4–5–6	Firing Order	1–8–4–3–6–5–7–2
① ② ③	Right Bank	② ④ ⑥ ⑧	Right Bank
④ ⑤ ⑥	Left Bank	① ③ ⑤ ⑦	Left Bank
Firing Order	1–4–2–3–5–6	Firing Order	1–8–7–2–6–5–4–3







SETTING IGNITION TIMING

The engine requires two types of ignition timing:

1. One is the **basic** or **initial timing** for starting and idling. This timing is determined by the relationship between piston position and the opening of the primary circuit.

2. The other **timing**, or **spark advance**, advances and retards the spark from the basic-timing setting, primarily as engine speed and load change. On some distributors, it is mechanically controlled by centrifugal- and vacuum-advance mechanisms. Other ignition systems have electronic spark advance. It is used on many electronic distributors and in all distributor-less ignition systems.

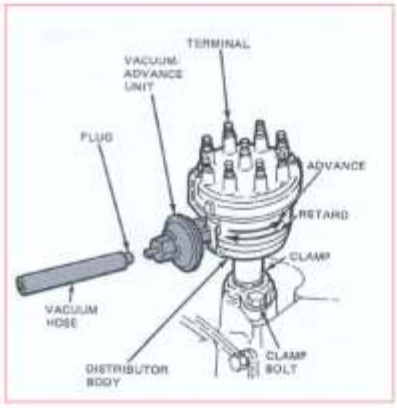
Contact-point distributors should have the timing checked periodically. Always check and adjust the dwell first. As the contact points and rubbing block wear, ignition timing and dwell change. Electronic ignition systems normally do not require periodic timing adjustments once the timing is set.

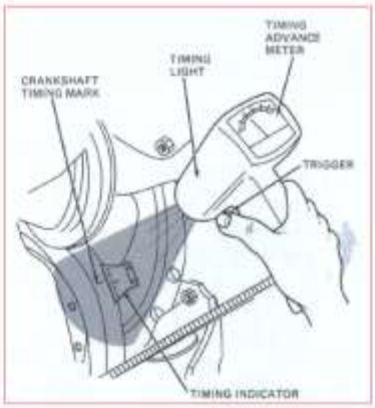
Adjusting the basic timing so the spark occurs at the correct instant with the engine idling is called setting the ignition timing. On most engines with a distributor, this is performed by turning the distributor slightly. Some engines have a distributor that mounts in a fixed position. The timing may be adjusted by installing a different reluctor. Ignition timing is usually not adjustable in a distributor-less ignition system.

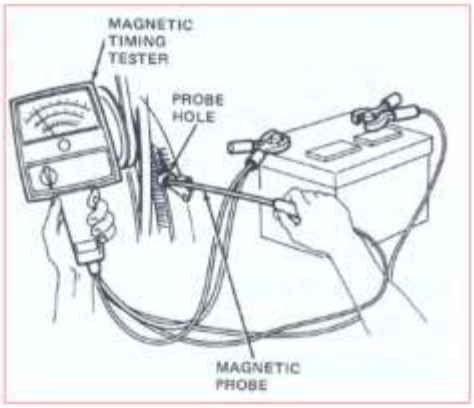
- Check the timing with the engine at normal operating temperature and idling at the specified speed.
- Eliminate all spark advances mechanical and electronic, so the engine is running on only basic timing. The low engine speed prevents spark advance from the centrifugal-advance mechanism in the distributor.
- Removing the vacuum hose from the vacuum-advance unit disables the vacuum advance. Plug the hose to prevent an air leak into the intake manifold.

Turning the distributor in its mounting adjusts the basic timing.

- Rotating the distributor in the direction opposite to shaft rotation advances the timing. This opens the primary circuit earlier.
- Turning the distributor in the same direction as shaft rotation retards the timing. The spark occurs later.
- Determining when the timing is properly adjusted requires the use of timing light or a magnetic timing tester. Initial timing and spark advance may also be read from a scan tool, computerized engine analyzer, or service-bay diagnostic computer.







SETTING TIMING WITH TIMING LIGHT

You cannot see the rapid periodic alignment of the timing marks in normal light. However, the stroboscopic timing light produces instant flashes that match engine speed. This makes the marks appear to stand still.

- The timing light usually has a set of power leads that connect to the car battery.
- Another lead with an inductive pickup clamps around the number 1 spark-plug cable.
- Pressing the trigger causes the light to flash every time the number 1 spark-plug fires.
- To adjust the timing, slightly loosen the distributor hold-down clamp bolt.
- Aim the timing light at the timing marks.
- Turn the distributor in its mounting. The rotating timing mark will move ahead or back. When the timing is correct, the specified timing marks align.
- Tighten the distributor clamp bolt.
- Then recheck the timing to ensure it did not change as the clamp was tightened.
- Remove the timing light and restore spark advance operation.

CAUTION!

Keep your hands and the timing-light leads away from the fan and drive belts. Never stand in line With the fan. A blade might fly off and strike you.

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Some batteries have a built-in _____ thatindicates battery condition.
2. Key-off or _____ draw occurs when a systemor component stays active and drains the battery.
3. A faulty drive belt _____ can cause lowcharging system output.
4. Typical starter current draw is between _____ and _____ amps.
5. A vehicle with a maintenance-free battery hasa slow cranking complaint. Technician "A" saysbattery condition can be determined by testingthe specific gravity of the electrolyte. Technician"B"says starter current draw and voltage drop testsshould be performed. Who is correct?
   a) Technician A
   b) Technician B
   c) Both A and B
   d) Neither A nor B
6. A starter turns very slowly and has excessivecranking current draw. When removed fromthe vehicle and bench tested, the starterspins normally, and current draw is withinspecifications. Technician "A" says poor batteryconnections may be the cause. Technician "B"says an internal engine problem may be thecause. Who is correct?
   a) Technician A
   b) Technician B
   c) Both A and B
   d) Neither A nor B
7. The engine cranks normally but will not start. There is a good spark on the spark test. Technician "A" says the trouble is probably in the fuel system. Technician "B" says it probably is in the ignition system. Who is right?
   a) A only
   b) B only
   c) both A and B
   d) neither A nor B
8. Cross-firing may be caused by all the following EXCEPT:
   a) wet distributor cap or rotor
   b) defective insulation on secondary cables
   c) improper routing of spark-plug cables
   d) a fouled spark plug

Note: **Satisfactory rating - 7 points** **Unsatisfactory - below 7 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

Information Sheet- 2	**Select and prepare appropriate tools**

2.1 Starting and Charging System Tools

Many of the tools used when servicing, diagnosing, and repairing the starting and charging systems are used for general electrical system service, such as the digital multimeter (DMM). Other tools as shown here are needed to measure the high amperage found in starting and charging circuits.

1. A starting/charging system tester, is used to measure voltage and current flow. This type of tester can be used to test battery capacity, starting, and charging system performance. Often referred to as VAT tester for volt/amp tester.
2. Conductance testers are used to test batteries, starters, and generator output. A conductance tester is used to send a small AC current through the battery. This tester is small, easy to use, and inexpensive compared to the larger VAT-type testers.
3. Current clamps can be used with a DMM or scope when you are testing the starting and charging systems. An inductive current clamp is used to measure cranking and charging current.
4. Hydrometer
5. Multimeter
6. circuit tester
7. lab scopes
8. scan tool
9. Various scan tool connectors for OBD-II systems
10. timing light
11. spark plug socket
12. pair of lineman's gloves
13. screwdrivers
14. Battery terminal puller
15. Battery brushes
16. Remote starter switches

Operation Sheet 1	Carry-out Service adjustments

CHARGING, STARTING AND IGNITION SYSTEMS INSPECTING PROCEDURE

Follow these steps while inspecting a charging system:

1. Inspect the battery. It might be necessary to charge the battery to restore it to a fully charged state. If the battery cannot be charged, it must be replaced. Also, make sure that the posts and cable clamps are clean and tight, because a bad connection can cause reduced current flow.
2. Inspect all system wiring and connections. Many systems contain fusible links or maxi-fuses to protect against overloads; check them.
3. Inspect the generator and regulator mountings for loose or missing bolts. Replace or tighten as needed. Remember, most generators and regulators complete their ground through their mounting. If the mountings are not clean and tight, a high resistant ground will result.
4. Inspect the AC generator drive belt. Loose drive belts are a major source of charging problems.
5. Before adjusting belt tension, check for proper pulley alignment.

- **Basic No-Start Diagnosis**

STEP 1- Connect a test spark plug to the spark plug wire and ground the spark plug case.

STEP 2- Crank the engine and observe the spark plug. If there is a bright, snapping, blue spark, the ignition is working properly.

STEP 3- If the test spark plug does not fire, check for coil output at the coil terminal.

STEP 4- If there is no spark, connect a test-light or DMM from the negative side of the coil to ground. Turn on the ignition switch. In most cases, the test-light should light. If the test-light is “off,” there is an open circuit in the coil primary winding or in the circuit from the ignition switch to the coil battery terminal.

STEP 5- With the test-light or DMM still connected, crank the engine. If the light flashes, the primary circuit is okay and the problem is a bad coil.

STEP 6- If the light does not flash, check the voltage from the ignition switch to the positive side of the coil. If there is no voltage, the problem is in that circuit or the switch. If there is voltage at the positive side of the coil, the problem is the pickup unit or the control module.

STEP 7- Keep in mind that on some vehicles, the PCM will not send power to the coil until it receives a CKP signal. A magnetic pulse generator can be checked with an ohmmeter,

DMM, or scope. A Hall-effect sensor should be checked with a DMM or scope. Compare your findings to specifications.

STEP 8- If the pickup unit is good, suspect the ignition module. Make sure all wiring to and from the module are good.

- **No-Start Diagnosis for EI Systems:**

STEP 1- Connect a test spark plug to the spark plug wire and ground the spark plug case.

STEP 2- Crank the engine and observe the spark plug. If there is a bright, snapping, blue spark, the ignition is working properly.

STEP 3- If the spark is weak or there is no spark; check the wiring to and from the PCM.

STEP 4- If the power and ground circuits for the PCM are okay, connect a voltmeter from the input (battery) terminal on each coil pack to ground. With the ignition switch on, the voltmeter should read 12 volts. If the voltage is less than that, check the system's wiring diagram to determine what is included in the coil's power feed circuit.

STEP 5- If battery voltage is present, check the voltage drop across each of the components and wires to identify the location of an open or high resistance.

STEP 6- If none is found, check the crankshaft and camshaft position sensors. Both of these sensor circuits can be checked with a voltmeter, ohmmeter, or DSO. If the sensors are receiving the correct amount of voltage and have good low-resistance ground circuits, their output should be a digital or a pulsing voltage signal while the engine is cranking. Compare their resistance readings to specifications. If any readings are abnormal, the circuit needs to be repaired or the sensor needs to be replaced.

- **To remove a distributor:**

1. Disconnect the electrical connector and the vacuum advance hose, if the distributor has them.
2. Remove the distributor cap and note the position of the rotor. On some vehicles, it may be necessary to remove the spark plug wires from the cap prior to cap removal.
3. Note the position of the vacuum advance, then remove the distributor hold-down bolt and clamp.

4. Pull the distributor from the engine. Most distributors will need to be twisted as they are pulled out of their bore. Note the direction of rotation.
5. Once the distributor is removed, install a shop towel in the distributor opening to keep foreign material out of the engine block.

- **The following procedure may be followed to install the distributor and time it to the engine:**

1. Lubricate the O-ring on the distributor shaft.
2. Position the rotor so that it is aligned with the mark made to the distributor housing prior to removal.
3. Align the distributor to the mark made on the engine block during removal.
4. Lower the distributor into the engine block.
5. Remove the distributor and move the rotor backward the same amount.
6. Make sure the distributor housing is fully seated against the engine block.
7. Rotate the distributor a small amount so the timer core teeth and pickup teeth are aligned.
8. Install the distributor hold-down clamp and bolt and leave the bolt slightly loose.
9. Install the spark plug wires in the direction of distributor shaft rotation and in the correct cylinder firing order.
10. Connect the wiring for the distributor. The vacuum advance hose is usually left disconnected until the timing is set with the engine running.

- **Check that the spark occurs**

1. Select and prepare appropriate tools
2. Remove the ignition coils (with igniter)
3. Remove the spark plugs.
4. Install the spark plugs to each ignition coil (with igniter), and connect the ignition coil (with igniter) connector.
5. Disconnect the 8 injector connectors.
6. Ground the spark plug.
7. Check if spark occurs while engine is being cranked.

- **Spark Plug Installation**

STEP 1- Wipe dirt and grease from the plug seats with a clean cloth.

STEP 2- Verify that the replacement spark plugs are the correct ones for the engine by matching the part number to its application. Never assume that the plugs that were removed from the engine are the correct type.

STEP 3- Adjust the air gap, as needed.

STEP 4- Check the service manual to see if anti-seize compound should be applied to the plug's threads.

STEP 5- Install the plugs and tighten them with your hand. If the plugs cannot be installed easily by hand, the threads in the cylinder head may need to be cleaned with a thread-chasing tap. Be especially careful not to cross-thread the plugs when working with aluminum heads.

STEP 6- Tighten the plugs with a torque wrench, following the vehicle manufacturer's specifications or the values.

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

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

Task 1.

Task 2.

Task N.

List of Reference Materials

1- BOOKS

2- WEB ADDRESSES (PUTTING LINKS)