Figure 51-1 A visual inspection on this battery shows the electrolyte level was below the plates in all cells.

Figure 51-2 Corrosion on a battery cable could be an indication that the battery itself is either being overcharged or is sulfated, creating a lot of gassing of the electrolyte.
Besides baking soda and water, a sugar-free diet soft drink can also be used to neutralize the battery acid.

**TECH TIP: Dynamic versus Open Circuit Voltage**

Open circuit voltage is the voltage (usually of a battery) that exists without a load being applied. Dynamic voltage is the voltage of the power source (battery) with the circuit in operation. A vehicle battery, for example, may indicate that it has 12.6 volts or more, but that voltage will drop when the battery is put under a load such as cranking the engine. If the battery voltage drops too much, the starter motor will rotate more slowly and the engine may not start. If the dynamic voltage is lower than specified, the battery may be weak or defective or the circuit may be defective.

A voltage reading of 12.28 volts indicates that the battery is not fully charged and should be charged before testing.
Figure 51-4  A battery that measures 12.6 volts or higher after the surface charge has been removed is 100% charged.

Chart 51-1  The estimated state of charge of a 12 volt battery after the surface charge has been removed.

<table>
<thead>
<tr>
<th>BATTERY VOLTAGE (V)</th>
<th>STATE OF CHARGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.6 or higher</td>
<td>100% charged</td>
</tr>
<tr>
<td>12.4</td>
<td>75% charged</td>
</tr>
<tr>
<td>12.2</td>
<td>50% charged</td>
</tr>
<tr>
<td>12.0</td>
<td>25% charged</td>
</tr>
<tr>
<td>11.8 or lower</td>
<td>Discharged</td>
</tr>
</tbody>
</table>

Figure 51-5  When testing a battery using a hydrometer, the reading must be corrected if the temperature is above or below 80°F (27°C).
Chart 51-2 - Measuring the specific gravity can detect a defective battery. A battery should be at least 75% charged before being load tested.

<table>
<thead>
<tr>
<th>Specific Gravity</th>
<th>Battery Voltage (V)</th>
<th>State of Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.265</td>
<td>12.6 or higher</td>
<td>100% charged</td>
</tr>
<tr>
<td>1.25</td>
<td>12.4</td>
<td>75% charged</td>
</tr>
<tr>
<td>1.199</td>
<td>12.2</td>
<td>50% charged</td>
</tr>
<tr>
<td>1.155</td>
<td>12.0</td>
<td>25% charged</td>
</tr>
<tr>
<td>Lower than 1.120</td>
<td>11.9 or lower</td>
<td>Discharged</td>
</tr>
</tbody>
</table>

Figure 51-6 - This battery has cold-cranking amperes (CCA) of 550 A, cranking amperes (CA) of 680 A, and load test amperes of 270 A listed on the top label. Not all batteries have this complete information.

Figure 51-7 - An alternator regulator battery starter tester (ARBST) automatically loads the battery with a fixed load for 15 sec. to reduce the surface charge, then removes the load for 30 sec. to allow the battery to recover, then reapplies the load for another 15 sec. The results of the test are then displayed.
FREQUENTLY ASKED QUESTION: What Is the Three-Minute Charge Test?

A three-minute charge test is used to check if a battery is sulfated, and is performed as follows:

• Connect a battery charger and a voltmeter to the battery terminals.
• Charge the battery at a rate of 40 amperes for three minutes.
• At the end of these minutes, read the voltmeter.

Results: If the voltage is above 15.5 volts, replace the battery. If the voltage is below 15.5 volts, the battery is not sulfated and should be charged and retested.

This is not a valid test of many maintenance-free batteries, such as the Delphi Freedom Due to the high internal resistance, a discharged Delphi Freedom battery may not start to accept a charge for several hours. Always use another alternative battery test before discarding a battery based on the results of the three-minute charge test.

Figure 51-8: Most light-duty vehicles equipped with two batteries are connected in parallel as shown. The two 12-volt 500-A batteries are capable of supplying 1,000 A at 12 volts, which is needed to start many diesel engines.

FREQUENTLY ASKED QUESTION: How Should You Test a Vehicle Equipped with Two Batteries?

Many vehicles equipped with a diesel engine use two batteries. These batteries are usually electrically interconnected in parallel to provide additional current (amperes) at the same voltage. See Figure 51-8. Some heavy-duty trucks and buses connect the two batteries in series to provide about the same current as one battery, but with twice the voltage, as shown in Figure 51-9.

To successfully test the batteries, they should be disconnected and tested separately. If just one battery is found to be defective, most experts recommend that both be replaced to help prevent future problems. Because the two batteries are electrically interconnected, a fault in one battery can cause the good battery to discharge into the defective battery, thereby affecting both even if just one battery is at fault.
Figure 51-9 Many heavy-duty trucks and buses use two 12 volt batteries connected in series to provide 24 volts.

Figure 51-10 A conductance tester is very easy to use and has proved to accurately determine battery condition if the connections are properly made. Follow the instructions on the display exactly for best results.

SAFETY TIP: Never Charge or Jump Start a Frozen Battery
A discharged battery can freeze because the electrolyte becomes mostly water. Never attempt to charge or jump start a vehicle that has a frozen battery. When the battery freezes, it often bulges at the sides because water expands about 9% when it freezes, forming ice crystals that occupy more space than liquid water. The crystals can trap bubbles of hydrogen and oxygen that are created during the chemical processes in a battery. When attempting to charge or jump start the frozen battery, these pockets of gas can explode. Because the electrolyte expands, the freezing action usually destroys the plates and can loosen the active material from the grids. It is rare for a frozen battery to be restored to useful service.
**Chart 51-3** Battery charging guideline showing the charging times that vary according to state of charge, temperature, and charging rate. It may take eight hours or more to charge a fully discharged battery. *Correct for temperature **If colder, it will take longer.*

**Figure 51-11** A typical industrial battery charger. Be sure that the ignition switch is in the off position before connecting any battery charger. Connect the cables of the charger to the battery before plugging the charger into the outlet. This helps prevent a voltage spike and sparks that could occur if the charger happened to be accidentally left on. Always follow the battery charger manufacturer’s instructions.

**TECH TIP: Charge Batteries at 1% of Their CCA Rating**

Many batteries are damaged due to being overcharged. To help prevent damage such as warped plates and excessive release of sulfur small gases, charge batteries at a rate equal to 1% of the battery’s CCA rating. For example, a battery with a 700 CCA rating should be charged at 7 amperes (700 x 0.01 = 7 amperes). No harm will occur to the battery at this charge rate even though it may take longer to achieve a full charge. This means that a battery may require eight or more hours to become fully charged depending on the battery capacity and state of charge (SOC).
Chart 51-4: A summary chart showing where the 12 volt and high-voltage batteries and shut-off switch/plugs are located. Only the auxiliary 12 volt batteries can be serviced or charged.

### Chart 51-4 (continued)

<table>
<thead>
<tr>
<th>Brand</th>
<th>Battery Type</th>
<th>Location</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chrysler</td>
<td>12 Volt</td>
<td>Under the hood, near batteries</td>
<td></td>
</tr>
<tr>
<td>Dodge</td>
<td>12 Volt</td>
<td>Under the hood, near batteries</td>
<td></td>
</tr>
<tr>
<td>Ford</td>
<td>12 Volt</td>
<td>Under the hood, near batteries</td>
<td></td>
</tr>
<tr>
<td>Jeep</td>
<td>12 Volt</td>
<td>Under the hood, near batteries</td>
<td></td>
</tr>
<tr>
<td>Lincoln</td>
<td>12 Volt</td>
<td>Under the hood, near batteries</td>
<td></td>
</tr>
<tr>
<td>Mercury</td>
<td>12 Volt</td>
<td>Under the hood, near batteries</td>
<td></td>
</tr>
<tr>
<td>Nissan</td>
<td>12 Volt</td>
<td>Under the hood, near batteries</td>
<td></td>
</tr>
<tr>
<td>Toyota</td>
<td>12 Volt</td>
<td>Under the hood, near batteries</td>
<td></td>
</tr>
<tr>
<td>Subaru</td>
<td>12 Volt</td>
<td>Under the hood, near batteries</td>
<td></td>
</tr>
<tr>
<td>Toyota (Hybrid)</td>
<td>12 Volt</td>
<td>Under the hood, near batteries</td>
<td></td>
</tr>
<tr>
<td>Toyota (PHEV)</td>
<td>12 Volt</td>
<td>Under the hood, near batteries</td>
<td></td>
</tr>
<tr>
<td>Volkswagen</td>
<td>12 Volt</td>
<td>Under the hood, near batteries</td>
<td></td>
</tr>
</tbody>
</table>

---

Only the auxiliary 12 volt batteries can be serviced or charged.
TECH TIP: Always Use Adapters on Side Post Batteries

Side post batteries require that an adapter be used when charging the battery, if it is removed from the vehicle. Do not use steel bolts. If a bolt is threaded into the terminal, only the parts of the threads that contact the battery terminals will be conducting all of the charging current. An adapter or a bolt with a nut attached is needed to achieve full contact with the battery terminals. See Figure 51-12.

Figure 51-12: Adapters should be used on side terminal batteries whenever charging.

FREQUENTLY ASKED QUESTION: Should Batteries Be Kept Off of Concrete Floors?

All batteries should be stored in a cool, dry place when not in use. Many technicians have been warned not to store or place a battery on concrete. According to battery experts, it is the temperature difference between the top and the bottom of the battery that creates a difference in the voltage potential between the top (warmer section) and the bottom (colder section). It is this difference in temperature that causes self-discharge to occur.

In fact, submarines cycle seawater around their batteries to keep all sections of the battery at the same temperature to help prevent self-discharge. Therefore, always store or place batteries up off the floor and in a location where the entire battery can be kept at the same temperature, avoiding extreme heat and freezing temperatures. Concrete cannot drain the battery directly because the case of the battery is a very good electrical insulator.
A typical battery jump box used to jump start vehicles. These hand-portable units have almost made jumper cables obsolete.

Figure 51-14 Jumper cable usage guide. Notice that the last connection should be the engine block of the disabled vehicle to help prevent the spark that normally occurs from igniting the gases from the battery.

![TECH TIP: Look at the Battery Date Code](image)

All major battery manufacturers stamp codes on the battery case that give the date of manufacture and other information. These battery markings can be a puzzle to help determine the date of manufacture, except the letter I because it can be confused with the number 1. For example:

- A = January
- B = February
- C = March
- D = April
- E = May
- F = June
- G = July
- H = August
- I = September
- J = October
- K = November
- L = December

The shipping date from the manufacturing plant is usually indicated by a sticker on the end of the battery. Almost every battery manufacturer uses just one letter and one number to indicate the month and year. **FIGURE 51–15.**
Figure 51-15. The code on the Delphi battery indicates that it was built in 2005 (5), in February (B), on the eleventh day (11), during third shift (C), and in the Canadian plant (Z).

Figure 51-16. This mini clamp-on digital multimeter is being used to measure the amount of battery electrical drain that is present. In this case, a reading of 20 mA (displayed as 00.02 A) is within the normal range of 20 to 30 mA. Be sure to clamp around all of the positive battery cable or all of the negative battery cable, whichever is easiest to get the clamp around.

Figure 51-17. After connecting the shut-off tool, start the engine and operate all accessories. Stop the engine and turn off everything. Connect the ammeter across the shut-off switch in parallel. Wait 20 minutes. This time allows all electronic circuits to "time out" or shut down. Open the switch —all current now will flow through the ammeter. A reading greater than specified (usually greater than 50 mA, or 0.05 A) indicates a problem that should be corrected.
The battery was replaced in this Acura and the radio displayed "code" when the replacement battery was installed. Thankfully, the owner had the five-digit code required to unlock the radio.

FREQUENTLY ASKED QUESTION: The Chevrolet Battery Story

A 2005 Chevrolet Impala was being diagnosed for a dead battery. Testing for a battery drain (parasitic draw) showed 2.25 A, which was clearly over the acceptable value of 0.050 or less. At the suggestion of the shop foreman, the technician used a Tech 2 scan tool to check if all of the computers and modules went to sleep after the ignition was turned off. The scan tool display indicated that the instrument panel (IP) showed that it remained awake after all of the others had gone into sleep mode. The IP cluster was unplugged and the vehicle was tested for an electrical drain again. This time, it was only 0.32 mA (0.00032 A), well within the normal range. Replacing the IP cluster solved the excessive battery drain.

TECH TIP: It Could Happen to You!

The owner of a Toyota replaced the battery. After doing so, the owner noted that the "airbag" amber warning lamp was lit and the radio was locked out. The owner did not know the four-digit security code needed to unlock the radio. Determined to fix the problem, the owner tried three four-digit numbers, hoping that one of them would work. However, after three tries, the radio became permanently disabled.

Frustrated, the owner went to a dealer. It cost over $300 to fix the problem. A special tool was required to reset the airbag system. The radio had to be removed and sent out of state to an authorized radio service center and then reinstalled into the vehicle.

Therefore, before disconnecting the battery, check to be certain that the owner has the security code for a security-type radio. A memory saver may be needed to keep the radio powered up when the battery is being disconnected.
Memory saver. The part numbers represent components from Radio Shack.

Figure 51-19 (a): Battery replacement strap #270-325

Figure 51-19 (b): A schematic drawing of the memory saver. Some experts recommend using a 12 volt lantern battery instead of a small 9 volt battery to help ensure that there will be enough voltage in the event that a door is opened while the vehicle battery is disconnected. Interior lights could quickly drain a small 9 volt battery.

FREQUENTLY ASKED QUESTION

Where Is the Battery?

Many vehicle manufacturers today place the battery under the backseat, under the front fender, or in the trunk. See Figure 51-20.

Often, the battery is not visible even if it is located under the hood. When testing or jump starting a vehicle, look for a battery access point.
Figure 51-20  Many newer vehicles have batteries that are sometimes difficult to find. Some are located under plastic panels under the hood, under the front fender, or even under the rear seat or storage area.

**TECH TIP: Check the Battery Condition First**

A discharged or defective battery has lower voltage potential than a good battery that is at least 75% charged. This lower battery voltage cannot properly power the starter motor. A weak battery could also prevent the charging voltage from reaching the voltage regulator cutoff point. This lower voltage could be interpreted as indicating a defective alternator and/or voltage regulator. If the vehicle continues to operate with low system voltage, the stator winding in the alternator can be overheated, causing alternator failure.