chapter 23 STARTING AND CHARGING SYSTEMS

OBJECTIVES: After studying Chapter 23, the reader should be able to: • Prepare for ASE Engine Performance (A8) certification test content area "F" (Engine Electrical Systems Diagnosis and Repair). Discuss methods that can be used to check the condition of a battery. • Discuss battery rating system. • Conduct a battery state-of-charge (SOC) test. • Conduct a battery load test. • Perform a charging voltage test. • Perform a battery conductance test. • Describe starting circuit components. • Perform routine battery service procedures. • Describe how to properly charge a battery. • Describe how to safely jump-start a vehicle. • Explain how to test the alternator.

KEY TERMS: • Alternator 217 • Ampere-hour 218 • Battery 217 • CA 217 • Capacity test 220 • CCA 217 • Charging circuit 222 • Conductance tester 220 • Cranking circuit 221 • DE 222 • Load test 220 • Marine cranking amperes (MCA) 218 • Neutral safety switch 222 • Open-circuit battery voltage test 219 • Reserve capacity 218 • SRE 222 • State of charge 219

BATTERIES

PURPOSE AND FUNCTION

The primary purpose of an automotive **battery** is to provide a source of electrical power for starting the vehicle and to meet electrical demands that exceed alternator output.

Just as in the old saying "If Mother isn't happy—no one is happy," the battery, the starter, and the charging system have to function correctly for the engine performance to be satisfactory.

The battery also acts as a voltage stabilizer for the entire electrical system. The battery is a voltage stabilizer because it acts as a reservoir where large amounts of current (amperes) can be removed quickly during starting and replaced gradually by the **alternator** during charging. The battery *must* be in good (serviceable) condition before the charging system and the cranking system can be tested. For example, if a battery is discharged, the **cranking circuit** (starter motor) could test as being defective because the battery voltage might drop below specifications.

The **charging circuit** could also test as being defective because of a weak or discharged battery. It is important to test the vehicle battery before further testing of the cranking or charging system.

BATTERY RATINGS

Batteries are rated according to the amount of current they can produce under specific conditions.

- **Cold-Cranking Amperes** The cold-cranking power of a battery is the number of amperes that can be supplied at 0°F (−18°C) for 30 seconds while the battery still maintains a voltage of 1.2 volts per cell or higher. The cold-cranking performance rating is called **cold-cranking amperes (CCA).** **SEE FIGURE 23–1.**
- **Cranking Amperes Cranking amperes (CA)** are not the same as CCA, but are often advertised and labeled on batteries. The designation "CA" refers to the number of amperes that can be supplied by the battery at 32°F (0°C).

FIGURE 23–1 The cold-cranking amperes (CCA) is the rating that is most commonly used to rate batteries.

This rating results in a higher number than the more stringent rating of CCA.

- **Marine Cranking Amperes Marine cranking amperes (MCA)** rating is similar to the CA rating and is tested at 32°F (0°C).
- **Ampere-Hour Rating** The **ampere-hour (Ah)** is how many amperes can be discharged from the battery over a 20-hour period before the battery voltage drops to 10.5 volts. A battery that is able to supply 3.75 amperes for 20 hours has a rating of 75 ampere hours (3.75 × 20 = 75).
- **Reserve Capacity** The **reserve capacity (RC)** rating for batteries is *the number of minutes* for which the battery can produce 25 amperes and still have a battery voltage of 1.75 volts per cell (10.5 volts for a 12 volt battery). This rating is actually a measurement of the time for which a vehicle can be driven in the event of a charging system failure.

? 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 causes 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.

BATTERY SERVICE

SAFETY Batteries contain acid and release explosive gases (hydrogen and oxygen) during normal charging and discharging cycles. To help prevent physical injury or damage to the vehicle, always adhere to the following safety procedures.

1. Whenever working on any electrical component of a vehicle, disconnect the negative battery cable from the battery. When the negative cable is disconnected, all electrical circuits in the vehicle will be open, which will prevent accidental electrical contact between an electrical component and ground. Any electrical spark has the potential to cause an explosion and personal injury.
2. Wear eye protection whenever working around any battery.
3. Wear protective clothing to avoid skin contact with battery acid.

SYMPTOMS OF A BAD BATTERY There are several warning signs that may indicate that a battery is near the end of its useful life, including:

- **Excessive corrosion on battery cables or connections.** Corrosion is more likely to occur if the battery is sulfated, creating hot spots on the plates. When the battery is being charged, the acid fumes are forced out of the vent holes and get onto the battery cables, connections, and even on the tray underneath the battery.
- **Slower-than-normal engine cranking.** When the capacity of the battery is reduced due to damage or age, it is less likely to supply the necessary current for starting the engine, especially during cold weather.

VISUAL INSPECTION The battery, battery tray, hold-down assembly, and battery cables should be included in the list of items checked during a thorough visual inspection. Check the battery cables for corrosion and tightness. **SEE FIGURE 23–2.**

NOTE: On side-post batteries, grasp the battery cable near the battery and tighten the cable in a clockwise direction in an attempt to tighten the battery connection.

If possible, remove the covers and observe the level of the electrolyte. **SEE FIGURE 23–3.**

ROUTINE BATTERY SERVICE Check and service the following items as necessary.

1. Neutralize and clean any corrosion from the battery terminals with a solution of baking soda and water.
2. Conduct a careful visual inspection of the battery cables.

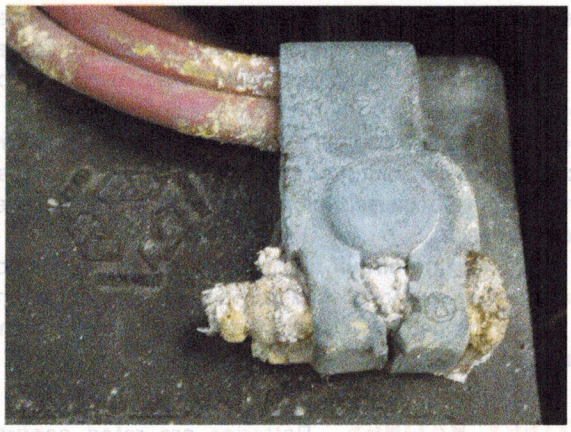

FIGURE 23–2 Corrosion on a battery cable could be an indication that the battery itself is either being overcharged or is sulfated, creating a lot of gassing of the electrolyte.

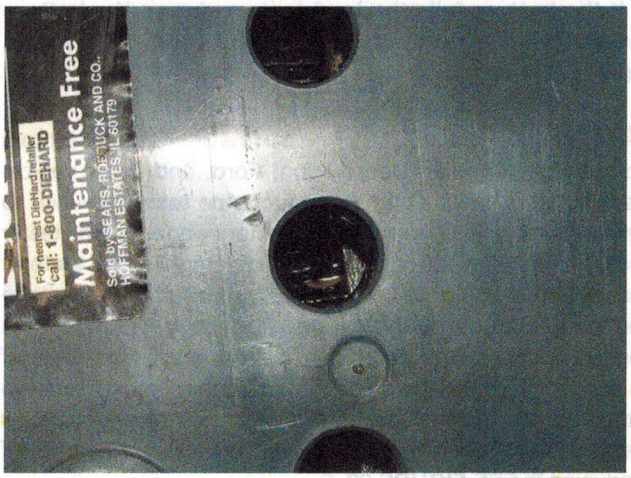

FIGURE 23–3 A visual inspection on this battery shows the electrolyte level was below the plates in all cells.

3. Check that the hold-down brackets or assembly and battery tray are secure and corrosion-free.
4. Check the tightness and cleanliness of all ground connections.

BATTERY VOLTAGE TEST Testing the battery voltage with a voltmeter is a simple method for determining the **state of charge (SOC)** of any battery. **SEE FIGURE 23–4.**

The voltage of a battery does not necessarily indicate whether the battery can perform satisfactorily, but it does indicate to the technician more about the battery's condition than a simple visual inspection. A battery that *looks* good may not be good. A commonly used test to determine the SOC is called an **open-circuit battery voltage test.** It is called an open circuit test because it is conducted with an open circuit—with no current flowing and no load applied to the battery.

1. Set the digital voltmeter to read DC volts. Connect a voltmeter to the positive (+) and negative (−) terminals of the battery.
2. If the battery has just been charged or the vehicle has recently been driven, it is necessary to remove the surface charge from the battery before testing. A surface charge is a charge of higher-than-normal voltage that is only on the surface of the battery plates. The surface charge is quickly removed whenever the battery is loaded and, therefore, does not accurately represent the true state of charge of the battery.
3. To remove the surface charge, turn the headlights on high beam (bright) for one minute, then turn the headlights off and wait two minutes.
4. Read the voltmeter and compare the results with the following state-of-charge chart. The voltages shown are for a battery at or near room temperature (70°F to 80°F, or 21°C to 27°C). **SEE CHART 23–1.**

(a)

(b)

FIGURE 23–4 (a) A voltage reading of 12.28 volts indicates that the battery is not fully charged and should be charged before testing. (b) A battery that measures 12.6 volts or higher after the surface charge has been removed is 100% charged.

BATTERY VOLTAGE (V)	STATE OF CHARGE (%)
12.6	100
12.4	75
12.2	50
12.0	25

CHART 23–1

Battery voltage can indicate the state of charge (SOC) of a battery after the surface charge has been removed.

BATTERY LOAD TEST One method to determine the condition of any battery is the **load test,** also known as a **capacity test.** Most automotive starting and charging testers use a carbon pile to create an electrical load on the battery. The amount of the load is determined by the original capacity of the battery being tested. The capacity is measured in CCA.

The proper electrical load to be used to test a battery is one-half of the CCA rating or three times the ampere-hour rating, with a minimum of a 150-ampere load. Apply the load for a full 15 seconds and observe the voltmeter at the end of the 15-second period while the battery is still under load. A good battery should indicate above 9.6 volts.

NOTE: This test is sometimes called the one-minute test, because many battery manufacturers recommend performing the load test twice, using the first load period (15 seconds) to remove the surface charge on the battery, then waiting for 30 seconds to allow time for the battery to recover, and then loading the battery again for 15 seconds. Total time required is 60 seconds (15 + 30 + 15 = 60 seconds or 1 minute). This method provides a true indication of the condition of the battery. ● **SEE FIGURE 23–5.**

FIGURE 23–5 An alternator regulator battery starter tester (ARBST) automatically loads the battery with a fixed load for 15 seconds to remove the surface charge, then removes the load for 30 seconds to allow the battery to recover, and then reapplies the load for another 15 seconds. The results of the test are then displayed.

If the battery fails the load test, recharge the battery and retest. If the battery fails the load test again, replace the battery.

BATTERY CONDUCTANCE TESTING General Motors Corporation, Chrysler Corporation, Ford, and other vehicle manufacturers specify that a **conductance tester** be used to test batteries in vehicles still under factory warranty. The tester uses its internal electronic circuitry to determine the state of charge and capacity of the battery by measuring the voltage and conductance of the plates. A huge advantage of a conductance tester is that it can test a battery regardless of its state of charge whereas a "Load Tester," must have the battery at least 75% charged. Conductance testers will give a stated readout of how many CCAs the battery is capable of producing. ● **SEE FIGURE 23–6.**

Connect the unit to the positive and negative terminals of the battery, and after entering the CCA rating (if known), push the arrow keys. The tester determines one of the following:

- **Good battery.** The battery can return to service.
- **Charge and retest.** Fully recharge the battery and return it to service.
- **Replace the battery.** The battery is not serviceable and should be replaced.
- **Bad cell—replace.** The battery is not serviceable and should be replaced.

CAUTION: Test results can be incorrectly reported on the display if proper, clean connections to the battery are not made. Also, be sure that all accessories and the ignition switch are in the off position. Inaccurate readings will occur if the tester is attached to the steel-side terminal battery bolts. Only lead connections must be used. The tester comes with lead-side terminal battery adapters, which must be used.

FIGURE 23–6 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.