Electrical System

There will be three questions on the ASE P2 test that deal with electrical systems, parts and products.

Electrical system parts include large rotating electrical components such as alternators and starters, solenoids, relays, batteries, battery cables, wiring, fuses, bulbs and small electrical motors for things such as power windows and seats.

Of all these parts, batteries are probably the most often replaced component. The average battery life is about four to five years in most areas of the country and only about three years in really hot climates.

Heat is hard on batteries because it increases evaporation of water from the cells. Maintenance-free batteries normally do not require make-up water, but in hot climates water loss can be a problem. Most people don't check their batteries anymore and on sealed-top batteries there are no caps to remove. Consequently, battery life suffers.

If a customer needs a new battery, you might recommend upgrading to a gel-type battery that contains no liquid water. The electrolyte is a gel-like substance sandwiched between absorbent fiberglass mats in the cells. This makes the batteries spill-proof and much more resistant to heat damage. High-density, spiral-wound batteries also use this same type of gel electrolyte.

Each cell inside a battery produces a little more than two volts of electricity. Automotive batteries contain a total of six cells, so the total voltage is about 12 volts. A fully charged battery will actually read about 12.65 volts if you place a voltmeter across the terminals.

Post configurations will vary depending on the application. Most General Motors batteries have flat terminals on the side to which the positive and negative cables are attached with bolts. Everybody else uses batteries with two top posts (one negative and one positive). Some aftermarket "universal" replacement batteries have both types of posts (top and side) to reduce the number of different batteries needed to cover vehicle applications.

Batteries come in different lengths, heights, widths and post configurations, which are classified according to group sizes. A replacement battery must be a compatible group size to physically fit the battery tray and cable locations on the vehicle.

Another difference in batteries is power ratings. The most commonly used number is the "Cold Cranking Amp" (CCA) capacity, which is the maximum number of amps the battery can deliver when cranking the engine. The higher the number, the more amps the battery can provide for reliable cold starting.

Another power rating number that's important, but may be less familiar, is the battery "Reserve Capacity" (RC) rating. This is how many amp hours of current the battery can provide should the charging system fail. A replacement battery should have CCA and RC that meet or exceed OEM battery requirements.

Battery date codes are also important. Batteries age on the shelf, so the oldest ones should always be sold first to keep the stock fresh. The number/letter date code on the battery reveals when it was manufactured. The number indicates the year, and the letter corresponds to the month (A = January, B = February, C = March, etc.)

To prevent comebacks, new and used batteries should be tested to confirm their state of charge and condition. A low battery that still has good cell plates can be recharged and returned to service. But if a battery fails a "load test" or will no longer accept a charge, it must be replaced. Batteries contain lead and should always be recycled. Handle all batteries with care because they contain acid.

ROTATING ELECTRICAL

The alternator is part of the charging system and generates voltage to keep the battery charged and to operate the ignition system, computer and other electrical accessories on the vehicle. The alternator is belt driven and produces an alternating current (AC) that is converted into 12 volts of direct current (DC) by diodes (the rectifier assembly) on the back of the alternator. The output voltage is controlled by the engine computer or an internal or external voltage regulator according to demand. The higher the load on the electrical system and battery, the higher the charging output of the alternator. Most charging systems that

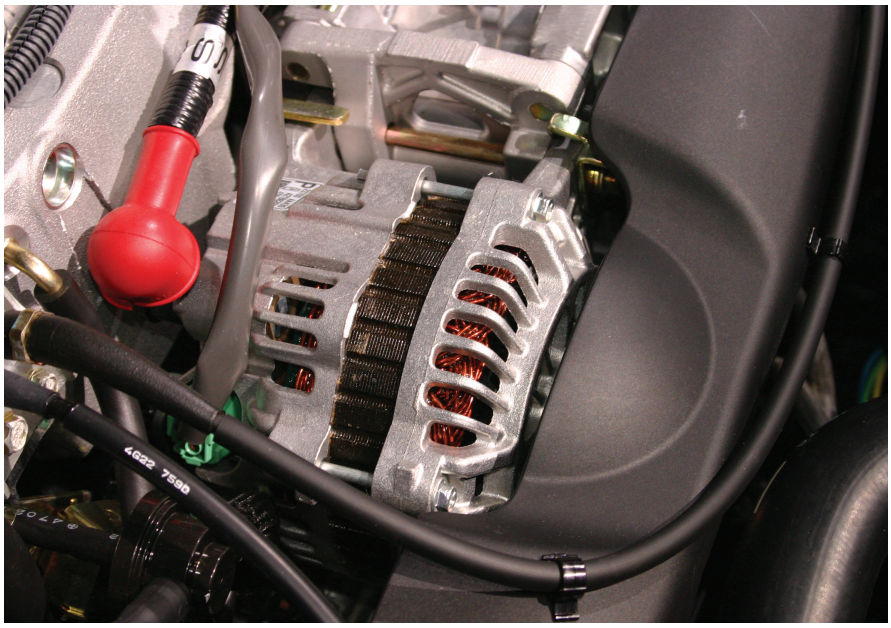
are working properly produce a charging voltage of about 13.8 to 14.5 volts at idle with the lights and accessories off.

Alternator output can be tested with a voltmeter, ammeter or special test equipment. Noisy shaft bearings may also require alternator replacement. Alternators often fail because of excessive heat and electrical overloads. The higher electrical loads that are common in many vehicles today can tax many OEM alternators to the limit, especially those that are equipped with high-output aftermarket audio systems, auxiliary lighting and other electrical accessories that increase the amp load on the charging system.

Replacement alternators should always have the same or higher amp rating as the original. Some of these premium-priced units have twice the output of a stock alternator and can greatly extend alternator life in demanding applications. Most are bolt-on replacements for the stock alternator, but heavier gauge cables are also required to handle the higher output.

On hybrid vehicles, the alternator may be built into the flywheel. *Caution*: Hybrid vehicles have high-voltage batteries (up to 300 volts or higher) in addition to a conventional 12-volt battery. The high-voltage hybrid battery is covered by an extended factory warranty (eight years or 100,000 miles on most hybrids), and is typically used for starting, full-electric driving modes, and power assisted acceleration. The high-voltage electrical circuits in these vehicles are usually color-coded orange. To avoid shock hazards on these vehicles, the high-voltage battery must be disconnected before electrical repairs are made. The high-voltage hybrid battery usually has a special disconnect switch in the rear of the vehicle where the battery is located.

Starters are replaced less often than alternators because they are only used to start the engine. Fuel-injected engines usually require little cranking to start, so the starter doesn't have to work very hard, except during cold weather when the oil in the engine thickens and makes it harder to crank. Prolonged cranking is what kills many starters because heavy cranking causes the starter to overheat.



The starter is mounted on the engine or transmission bellhousing and engages teeth on the flywheel to crank the engine. A one-way, overrunning clutch is used to protect most starters against damage should the starter remain engaged after the engine starts.

There are several different types: direct-drive starter motors, gear-reduction starter motors and permanent-magnet starter motors (reduced-size starters with permanent magnets inside instead of wire coils). It's important to handle permanent-magnet starters with care because banging them on the counter or floor may break the magnets inside.

Because of the high load on the starter, good electrical connections are extremely important. Loose, corroded or undersized battery cables may not deliver enough amperage to crank the engine at normal speed, causing hard starting. Starter drives (which can be replaced separately on many starters) can also fail, preventing the motor from engaging the flywheel. A bad solenoid or relay will prevent the starter motor from cranking at all. Accurate diagnosis of a starter problem is important to prevent unnecessary parts replacements and returns.

OTHER ELECTRICAL

Battery cables should be replaced if loose, damaged or too small for the application. Engine ground straps are equally important and are an often-overlooked cause of charging and starting problems.

Fuses protect against electrical overloads and are designed to blow if there's too much current in a circuit. Overloads shouldn't normally occur, so if a fuse has failed, there may be a short in the circuit. Replacement fuses must have the same amp rating as the originals. Relays are switching devices used to route power to other components such as the fuel pump, ABS system, lights and so on. Relays may be located in the engine compartment, in the fuse panel under the dash or almost anywhere in the vehicle (locating a particular relay often requires referring to the vehicle's wiring diagram).

Lamps and bulbs for interior and exterior illumination come in various sizes and styles. Replacement lamps and bulbs must have the same mounting and electrical connections as the original (compare the old and new bulbs or refer to an application chart), but headlamps can often be upgraded for more light output with higher output bulbs. ◉