Figure 31-1  Identification of the parts of a valve.

Figure 31-2  Typical valve spring and related components. Dual valve springs are used to reduce valve train vibrations and a spring seat is used to protect aluminum heads.
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Figure 31-3  The intake valve is larger than the exhaust valve because the intake charge is being drawn into the combustion chamber at a low speed due to differences in pressure between atmospheric pressure and the pressure (vacuum) inside the cylinder. The exhaust is actually pushed out by the piston and, therefore, the size of the valve does not need to be as large, leaving more room in the cylinder head for the larger intake valve.

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TECH TIP: Hot Engine + Cold Weather = Trouble
Serious valve damage can occur if cold air reaches hot exhaust valves soon after the engine is turned off. An engine equipped with exhaust headers and/or straight-through mufflers can allow cold air a direct path to the hot exhaust valve. The exhaust valve can warp and/or crack as a result of rapid cooling. This can easily occur during cold windy weather when the wind can blow cold outside air directly up the exhaust system. Using reverse-flow mufflers with tailpipes and a catalytic converter reduces the possibilities of this occurring.

Figure 31-4  Inertia welded valve stem and head before machining.
A sodium-filled valve uses a hollow stem, which is partially filled with metallic sodium—a liquid when hot—to conduct heat away from the head of the valve.

**WARNING:** If a sodium-filled valve is damaged and the sodium leaks out, it can cause a fire if exposed to water. Sodium reacts violently when exposed to water and burns uncontrollably.

Integral valve seats are machined directly into the cast-iron cylinder head and are operation-hardened for precise wear.
Figure 31-7 Insert valve seats are a separate part that is interference fitted to a counterbore in the cylinder head.

Figure 31-8 Typical intake valve seat wear.

Figure 31-9 Carbon deposits on the intake valve are often caused by oil getting past the valve stems or fuel deposits.
Figure 31-10  Excessive wear of the valve stem or guide can cause the valve to seat in a cocked position.

Figure 31-11  Valve face guttering caused by thermal shock.

Figure 31-12  Note the broken piston caused by a valve breaking from the stem.
TECH TIP: Valve Seat Recession and Engine Performance

If unleaded fuel is used in an engine without hardened valve seats, valve seat recession is likely to occur over time. Without removing the cylinder heads, how can a technician identify valve seat recession?

As the valve seat wears up into the cylinder head, the valve itself rises and locates farther up in the head. As this wear occurs, the valve clearance (lash) decreases. If hydraulic lifters are used, this wear will go undetected until the reduction in valve clearance bottoms out in the lifter. When this occurs, the valve does not seat fully, and compression, power, and fuel economy are drastically reduced. If valve lash is adjustable, the valve cannot reach its seat and will begin to seat, but the valve becomes hotter.

When this happens, the valve will stick and not seat smoothly.

If solid lifters are used, the decrease in valve clearance will show up as a rough idle only when the engine is hot. As the valve seat recesses farther into the head, the engine will exhibit low power, rough idle, poor performance, lower fuel economy, and lower fuel economy will be noticed sooner than if the engine were equipped with hydraulic lifters.

To summarize, refer to the following symptoms as valve seat recession occurs.

1. Valve lash (clearance) decreases (valves are not noisy).
2. The engine idles roughly when hot as a result of reduced valve clearance.
3. Missing occurs, and the engine exhibits low power and poor fuel economy, along with a rough idle, as the valve seat recesses farther into the head.
4. As valves burn, the engine continues to run poorly; the symptoms include difficulty in starting hot and cold engines, backfiring, and low engine power.

HINT: If valve lash is adjustable, valve burning can be prevented by adjusting the valve lash regularly. Remember, as the seat recesses, the valve itself recesses, which decreases the valve stem clearance. Many technicians do not think to adjust valve clearances if they are noisy. If, during the valve adjustment procedure, a decrease in valve lash is noticed, then valve seat recession could be occurring.

Figure 31-13 A retainer and two split keepers hold the spring in place on the valve. A spring seat is used on aluminum heads. Otherwise, the spring seat is a machined area in the head.
FREQUENTLY ASKED QUESTION

What Is Valve Float?

Valve float occurs when the valve continues to stay open after the camshaft lobe has moved from under the lifter. This happens when the inertia of the valve train overcomes the valve spring tension at high engine speeds.

SEE FIGURE 31–15.

Figure 31-14  Valve spring types (left to right): coil spring with equally spaced coils; spring with damper inside spring coil; closely spaced spring with a damper; taper wound coil spring.

Figure 31-15  Valve springs maintain tension in the valve train when the valve is open to prevent valve float, but must not exert so much tension that the cam lobes and lifters begin to wear.
Figure 31-16 All valve springs should be checked for squareness by using a square on a flat surface and rotating the spring while checking. The spring should be replaced if more than 0.016 in. (0.4 mm) is measured from the top of the spring and the square.

Figure 31-17 One popular type of valve spring tester used to measure the compressed force of valve springs. Specifications usually include (1) free height (height without being compressed), (2) pressure at installed height with the valve closed, and (3) pressure with the valve open to the height specified.

Figure 31-18 Valve keepers (also called locks) are tapered so they wedge into a tapered hole in the retainer.
Notice that there is no gap between the two keepers (ends butted together). As a result, the valve is free to rotate because the retainer applies a force, holding the keepers in place but not tight against the stem of the valve. Most engines, however, do not use free rotators and, therefore, have a gap between the keepers.

Figure 31-20 - Types of valve rotator operation. Roll-type operation is on the left and spring-type operation is on the right.

Figure 31-21 - Resurfacing the face of a valve. Both the valve and the grinder stone or disc are turned to ensure a smooth surface finish on the face of the valve.
Never use a valve that has been ground to a sharp edge. This weakens the valve and increases the chance of valve face burning.

**TECH TIP: Grinding the Valves for More Power**

A normal “valve job” includes grinding the face of the valve to clean up any pits and grinding the valve stems to restore the proper stem height. However, a little more airflow in and out of the cylinder head can be accomplished by performing two more simple grinding conditions:

- Use the valve grinder and adjust to 30 degrees (for a 45-degree valve) and grind a transition between the valve face and the valve stem area of the valve. While this step may reduce some desirable swirling of the air-fuel mixture at lower engine speeds, it also helps increase cylinder filling, especially at times when the valve is not fully open.
- Chamfer or round the head of the valve between the tip of the valve and the margin on the side. By rounding this surface, additional airflow into the cylinder is achieved. SEE FIGURE 31–23.

After grinding the 45-degree face angle, additional airflow into the engine can be accomplished by adding a transition between the face angle and the stem, and by angling or rounding the transition between the margin and the top of the valve.
Figure 31-24 Grinding a 45-degree angle establishes the valve seat in the combustion chamber.

Figure 31-25 Some vehicle manufacturers recommend that the valve face be resurfaced at a 44-degree angle and the valve seat at a 45-degree angle. This 1-degree difference is known as the interference angle.

Figure 31-26 The seat must contact evenly around the valve face. For good service life, both margin and overhang should be at least 0.03 in. (0.8 mm).
Figure 31-27 Grinding a 60-degree angle removes metal from the bottom to raise and narrow the seat.

Figure 31-28 Grinding a 30-degree angle removes metal from the top to lower and narrow the seat.

Figure 31-29 A typical three-angle valve job using 30-, 45-, and 60-degree stones or cutters.
Figure 31-30  A valve guide pilot being used to support a valve seat cutter.

Figure 31-31  Checking valve seat concentricity using a dial indicator.

Figure 31-32  Typical dial indicator type of micrometer for measuring valve seat concentricity.
Figure 31-33 After the valve face and the valve seat are ground (reconditioned), lapping compound is used to smooth the contact area between the two mating surfaces. Notice that the contact is toward the top of the face. For maximum life, the contact should be in the middle of the face.

Figure 31-34 A cutter is used to remove metal and form the valve seat angles.

Figure 31-35 All aluminum cylinder heads use valve seat inserts. If an integral valve seat (cast-iron seat) is worn, it can be replaced with a replacement valve seat by machining a pocket (counterboring) to make a place for the new valve seat.
TECH TIP: The MIG Welder Seat Removal Trick
A quick and easy method to remove insert valve seats is to use a metal inert gas (MIG) welder, also called a gas metal arc welder (GMAW). After the valve has been removed, use the MIG welder and lay a welding bead around the seat area of the insert. As the weld cools, it shrinks and allows the insert to be easily removed from the cylinder head. The weld bead also provides a surface that can be used to pry the seat from the cylinder head.

TECH TIP: Use the Recommended Specifications
A technician replaced valve seat inserts in an aluminum cylinder head. The factory specification called for a 0.002 in. interference fit; the insert should be 0.002 in. larger in diameter than the seat pocket in the cylinder head. Shortly after the engine was started, the seat fell out, ruining the engine.

The technician should have used the interference fit specification supplied with the replacement seat insert. Interference fit specifications depend on the type of material used to make the insert. Some inserts for aluminum heads require as much as 0.007 in. interference fit. Always refer to the specification from the manufacturer of the valve inserts when replacing valve seats in aluminum cylinder heads.
Figure 31-37  Valve stem height is measured from the spring seat to the tip of the valve after the valve seat and valve face have been refinished. If the valve stem height is too high, up to 0.02 in. can be ground.

Figure 31-38  Installed height is determined by measuring the distance from the spring seat to the bottom of the valve spring retainer.

Figure 31-39  Valve spring inserts are used to restore proper installed height.
Engine vacuum can draw oil past the valve guides and into the combustion chamber. One of the main causes of oil smoke is the amount of oil that is drawn into the engine if the seals are defective. Excessive oil (blue) smoke or oil in the exhaust during engine start-up is evidence of this problem.

Engine oil can also be drawn past the exhaust valve guide because of a small vacuum created by the flow of exhaust gases. Any oil drawn past the guide would simply be forced out through the exhaust system and not enter the engine. Some engine manufacturers do not use valve stem seals on the exhaust valves.

Umbrella seals install over the valve stems and cover the guides.
A small square cut O-ring is installed under the retainer in a groove in the valve under the groove(s) used for the keepers (locks).

**TECH TIP:** Purchase Engine Parts from a Known Manufacturer

It is interesting to note that an automotive service technician cannot tell the difference between these synthetic rubber valve stem seals if they have come out of the same mold for the same engine. Often suppliers that package gasket sets for sale at a low price will include low-temperature Nitrile, even when the engine needs higher-temperature polyacrylate. The best chances of getting the correct valve stem seal material for an engine is to purchase gaskets and seals packaged by a major brand gasket company.

Positive valve stem seals are the most effective type because they remain stationary on the valve guide and wipe the oil from the stem as the valve moves up and down.
Figure 31-45. The positive valve stem seal is installed on the valve guide.

Figure 31-46. An assortment of shapes, colors, and materials of positive valve stem seals.

Figure 31-47. A metal valve spring seat must be used between the valve spring and the aluminum cylinder head. Many Chrysler aluminum cylinder heads use a combination valve spring seat and valve stem seal.
Figure 31-48 Assembling a race engine using a heavy-duty valve spring compressor.

TECH TIP: Check Before Bolting It On

Using new assembled cylinder heads, whether aluminum or cast iron, is a popular engine buildup option. However, experience has shown that metal shavings and casting sand are often found inside the passages. Before bolting on these "ready to install" heads, disassemble them and clean all passages. Often machine shavings are found under the valves. If this debris were to get into the engine, the results would be extreme wear or damage to the pistons, rings, block, and bearings. This cleaning may take several hours, but how much is your engine worth?

INSTALLING A NEW VALVE SEAT

After the valve guide has been replaced or checked for being within specification, insert a pilot into the valve guide.
INSTALLING A NEW VALVE SEAT 2
Level the bubble on the pilot by moving the cylinder head, which is clamped to a milling machine.

INSTALLING A NEW VALVE SEAT 3
Select the proper guide for the application. Consult guide manufacturer’s literature for recommendations.

INSTALLING A NEW VALVE SEAT 4
Select the correct cutter and check that the cutting bits are sharp.
Carefully measure the exact outside diameter (O.D.) of the valve seat.

Adjust the depth of the cutter bit to achieve the specified interference fit for the valve seat.

Install the pilot into the valve guide to support the seat cutter.
INSTALLING A NEW VALVE SEAT

Install the seat cutter onto the pilot.

Adjust the depth of cut, using the new valve seat to set it to the same depth as the thickness of the seat.

With the cylinder head still firmly attached to the seat and guide machine, start the cutter motor and cut the head until it reaches the stop.
INSTALLING A NEW VALVE SEAT 11

The finish cut valve seat pocket. Be sure to use a vacuum to remove all of the metal shavings from the cutting operation.

INSTALLING A NEW VALVE SEAT 12

Place the chilled valve seat over the pilot being sure that the chamfer is facing toward the head as shown.

INSTALLING A NEW VALVE SEAT 13

Install the correct size driver onto the valve seat.
INSTALLING A NEW VALVE SEAT

Using the air hammer or press, press the valve seat into the valve pocket.

A new valve seat is now ready to be machined or cut.