Figure 30-1. The seats and guides for the valves are in the cylinder head as well as the camshaft and the entire valve train if it is an overhead camshaft design.

Figure 30-2. A wedge-shaped combustion chamber showing the squish area where the air-fuel mixture is squeezed, causing turbulence that pushes the mixture toward the spark plug.
Locating the spark plug in the center of the combustion chamber reduces the distance the flame front must travel.

The combustion chamber of the 5.7 liter Chrysler Hemi cylinder head shows the two spark plugs used to ensure rapid burn for best power and economy with the lowest possible exhaust emissions.

The shrouded area around the intake valve causes the intake mixture to swirl as it enters the combustion chamber.
A typical cross flow cylinder head design, where the flow into and out of the combustion chamber is from opposite sides of the cylinder head.

Method for measuring the valve opening space.

FREQUENTLY ASKED QUESTION: What Is Carbon Knock?

Carbon knock was a common occurrence in older engines that were equipped with carburetors and high compression ratios. As carburetors aged, the mixture would tend to be richer than normal due to a leaking needle and seat, as well as a fuel-saturated float. This richer mixture would cause carbon deposits in the combustion chamber. During light load conditions when the spark advance was greatest, this knocking would occur due to a higher compression ratio caused by carbon deposits. This knocking was often very loud, sounding like a rod bearing noise, because in some cases the carbon deposits actually caused physical contact between the piston and the carbon. Many engines were disassembled in the belief that the cause of the knocking sound was a bearing problem, only to find that the actual cause was carbon deposits. Carbon knock can still occur in newer engines, especially if there is a fault in the fuel system that would allow a much richer mixture, causing excessive carbon deposits in the combustion chamber. Often a de-carbonization using chemicals will correct the knocking.
Figure 30-8  Comparing the valve opening areas between a two- and three-valve combustion chamber when the valves are open.

Figure 30-9  Typical four-valve head. The total area of opening of two small intake valves and two exhaust valves is greater than for one or two large valves. The smaller valves also permit the use of shorter intake runners for better low-speed engine response.

Figure 30-10  Four valves in a pentroof combustion chamber.
TECH TIP: Horsepower is Airflow

To get more power from an engine, more air needs to be drawn into the combustion chamber. One way to achieve more airflow is to increase the valve and port size of the cylinder heads along with a change in camshaft lift and duration to match the cylinder heads. One popular, but expensive, method is to replace the stock cylinder heads with high-performance cast-iron or aluminum cylinder heads. Some vehicle manufacturers, such as Audi, go to great expense to design high-flow rate cylinder heads by installing five-valve cylinder heads on some of their high-performance engines. See Figure 30-11.

Figure 30-11: An Audi five-valve cylinder head, which uses three intake valves and two exhaust valves.

TECH TIP: Unshroud the Intake Valve for More Power

If an engine is being rebuilt for high performance, most experts recommend that the shrouded section around the intake valve be removed, thereby increasing the airflow and, therefore, the power that the engine can achieve, especially at higher engine speeds. This process is often called unshrouding.
Figure 30-12  The intake manifold design and combustion chamber design both work together to cause the air-fuel mixture to swirl as it enters the combustion chamber.

Figure 30-13  A port-injected engine showing the straight, free-flowing intake and exhaust ports.

Figure 30-14  A cutaway head showing the coolant passages in green.
Figure 30-15: Coolant flows through the cylinder head, and the passages are sealed by the head gasket.

Figure 30-16: Overhead camshafts may be (a) held in place with bearing caps, (b) supported by towers, or (c) fitted into bearing bores machined directly into the head.

Figure 30-17: Always follow the specified loosening sequence to prevent valve spring tension from bending the camshaft.
Pushrods can be kept labeled if stuck through a cardboard box. Individual parts become and remain separated if they are wrapped in a loose but effective material to keep all valve train parts together and valve train parts so they come back the way they went out.

Cylinder heads should be checked in five planes for warpage, distortion, bend, and twist.

A precision ground straightedge and a feeler gauge are used to check the cylinder head for flatness.
Figure 30-21  Warped overhead camshaft cylinder head. If the gasket surface is machined to be flat, the camshaft bearings will still not be in proper alignment. The solution is to straighten the cylinder head or to align bore the cam tunnel.

Figure 30-22  A cast iron cylinder head being resurfaced using a surface grinder.

TECH TIP: The Potato Chip Problem

Most cylinder heads are warped or twisted in the shape of a typical potato chip: high at the ends and dipped in the center. After a cylinder head is ground, the surface should be perfectly flat. A common problem involves grinding the cylinder head in both directions while it is being held on the table that moves to the left and right. Most grinders are angled by about 4 degrees. The lower part of the stone should be the cutting edge. If grinding occurs along the angled part of the stone, then too much heat is generated. The heat warps the head (or block) upward in the middle. The stone then removes this material, and the end result is a slight depression in the center of the finished surface. To help prevent this from happening, always feed the grinder in the forward direction only (especially during removal of the last 0.003 in. of material).
Figure 30-23 A graph showing a typical rough surface as would be viewed through a magnifying glass. RA is an abbreviation indicating the average height of all peaks and valleys.

Figure 30-24 The material that must be removed for a good manifold fit.

Figure 30-25 Using an intake manifold template to check for the proper angles after the cylinder heads have been machined.
Figure 30-26  An integral valve guide is simply a guide that has been drilled into the cast-iron cylinder head.

Figure 30-27  All aluminum cylinder heads use valve guide inserts.

Figure 30-28  Valve guides often wear to a bell-mouth shape at both ends due to the forces exerted on the valve by the valve train components.
A small-hole gauge and a micrometer are being used to measure the valve guide. The guide should be measured in three places: at the top, middle, and bottom.

The diameter of the valve stem is being measured using a micrometer. The difference between the inside diameter of the valve guide and the diameter of the valve stem is the valve guide-to-stem clearance.

Measuring valve guide-to-stem clearance with a dial indicator while rocking the valve in the direction of normal thrust. The reading on the dial indicator should be compared to specifications because it does not give the guide-to-stem clearance directly. The valve is usually held open to its maximum operating lift.
FREQUENTLY ASKED QUESTION

What Is Valve Guide Knurling?

In an old and now outdated process known as valve guide knurling, a tool is rotated as it is driven into the guide. The tool displaces the metal to reduce the hole diameter of the guide. Knurling is ideally suited to engines with integral valve guides (guides that are part of the cylinder head and are nonremovable). It is recommended that knurling not be used to correct wear exceeding 0.006 in. (0.15 mm). In the displacing process, the knurling tool pushes a small tapered wheel or dull threading tool into the wall of the guide hole. This makes a groove in the wall of the guide, similar to a threading operation without removing any metal.

The metal piles up along the edge of the groove just as dirt would pile up along the edge of a tire track as the tire rolled through soft dirt. (The dirt would be displaced from under the wheel to form a small ridge alongside the tire track.) See Figure 30–32.

The knurling tool is driven by an electric drill and an attached speed reducer that drives the rotating speed of the knurling tool. The reamers that accompany the knurling tool will ream just enough to provide the correct valve stem clearance for commercial reconditioning standards. The valve guides are honed to size in the precision shop when precise fits are desired. Clearances of knurled valve guides are usually one-half of the new valve guide clearances. Such small clearances can be used because knurling leaves so many small oil rings down the length of the guide for lubrication.

Figure 30–32 Sectional view of a knurled valve guide.
TECH TIP: Tight Is Not Always Right

Many engine manufacturers specify a valve stem-to-guide clearance of 0.001 to 0.003 in. (0.025 to 0.076 mm). However, some vehicles, especially those equipped with aluminum cylinder heads, may specify a much greater clearance. For example, many Chrysler 2.2 liter and 2.5 liter engines have a specified valve stem-to-guide clearance of 0.003 to 0.005 in. (0.076 to 0.127 mm). This amount of clearance feels loose to those technicians accustomed to normal valve stem clearance specifications. Although this large amount of clearance may seem excessive, remember that the valve stem increases in diameter as the engine warms up. Therefore, the operating clearance is smaller than the clearance measured at room temperature. Always double-check factory specifications before replacing a valve guide for excessive wear.

**Figure 30-33** Valve guide replacement procedure.

**Figure 30-34** A type of fixture required to bore the valve guide to accept a thin-walled insert sleeve.
Right Side Up
When replacing valve guides, it is important that the recommended procedures be followed. Most manufacturers specify that replaceable guides be driven from the combustion chamber side toward the rocker arm side. For example, big block Chevrolet V-8 heads (396, 402, 427, and 454 cu. in.) have a 0.004 in. (0.05 mm) taper (small end toward the combustion chamber).

Other manufacturers, however, may recommend driving the old guide from the rocker arm side to prevent any carbon buildup on the guide from damaging the guide bore. Always check the manufacturer’s recommended procedures before attempting to replace a valve guide.