CHAPTER 29

PREPARATION FOR ASSEMBLY

OBJECTIVES

After studying Chapter 29, the reader will be able to:

1. Describe the steps that should be followed in preparation for assembly.
2. Explain clamping force.
3. Discuss the advantages of performing a trial assembly of the engine.

KEY TERMS

Clamping Force (p. 563)
Cylinder Head Cover Gasket (p. 562)
Fogging Oil (p. 561)
Fretting (p. 564)
Head Gaskets (p. 562)

DETAILS, DETAILS, DETAILS

Successful engine assembly depends on getting all of the details right. Where to start? Start when all parts have been purchased or prepared for assembly.

When starting to assemble the engine, be sure to have all of the instructions from all of the parts used.

- **Read**—Read *all* instructions. Often very important information or suggested specifications are included and may be at the end.
- **Understand**—Be sure to fully understand everything that is stated in the instructions. If unsure as to what is meant, ask a knowledgeable technician or call the company to be sure that all procedures are clearly understood. This is especially important if working on an engine that is not very common, such as the Audi/Volkswagen W-8. This engine has seven rotating shafts, including four overhead camshafts, two counterrotating balance shafts, and the crankshaft. See Figure 29-1.
- **Follow**—Be sure to follow *all* of the instructions. Do not pick the easy procedures and skip others.

SHORT BLOCK PREPARATION

The details that should be checked on the block include:

- All passages should be clean and free of rust and debris.
- All cups and plugs should be installed.
- The final bore dimension is correct for the piston.
- The surface finish of the cylinder bore matches with the specified finish required for the piston rings that are going to be used.
- All sharp edges and burrs have been removed. See Figure 29-2.
- The main bearing bore (saddle) is straight and inline.
- The lifter bores have been honed and checked for proper dimension.

Surface Finish

The surface finish is important for the proper sealing of any gasket.

- Surface too rough—If the surface finish is too rough, the gasket will not be able to seal the deep grooves in the surface.
- Surface too smooth—If the surface finish is too smooth, the gasket can move out of proper location, causing leakage.

Surface finish is measured in microinches, usually abbreviated by using the Greek letter *mu* (µ) and the abbreviation for inches together (µin.).

- The higher the µin. finish, the rougher the surface.
- The lower the µin. finish, the smoother the surface. The specification for surface finish is usually specified in roughness average or Ra.

Engine Part Material	Gasket Material	Acceptable Surface Finish (Ra)
Cast iron/cast iron	Composite	60 to 80 µin.
Aluminum/ cast iron	Composite	20 to 30 µin.
Aluminum/ cast iron	Rubber-coated multilayered steel	20 to 30 µin.

Check the instruction sheet that comes with the gasket for the specified surface finish.

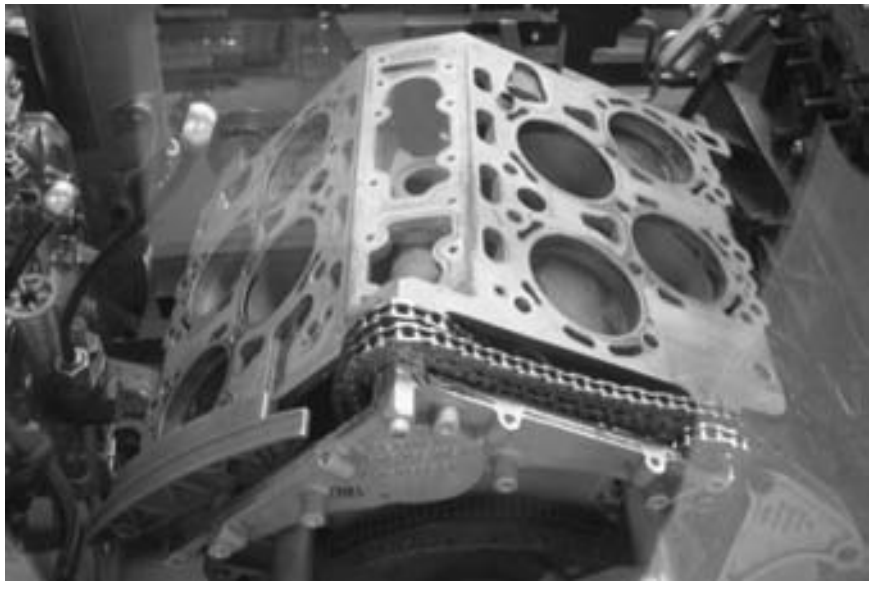

FIGURE 29-1 A uniquely designed W-8 engine installed in some Audi and Volkswagen vehicles. Rebuilding the engine would require detailed service information to be sure that all steps are taken to ensure proper assembly.

FIGURE 29-2 Deburring all sharp edges is an important step that has to be done to achieve proper engine assembly.

Checking Surfaces Before Assembly

All surfaces of an engine should be clean and straight and have the specified surface finish and flatness. Flatness is a measure of how much the surface varies in any 6-inch span. An industry standard maximum limit for flatness is usually 0.002 inch. If the surface is not flat, the gaskets will not be able to seal properly.

Preparing for Installation of Cylinder Head Studs

Similar to using studs for the main bearing caps, studs for cylinder heads are recommended for all high-performance applications. However, studs should not be used on a street-driven vehicle engine because the studs would prevent the cylinder heads from being removed unless the engine is first removed from the vehicle. Most vehicles do not have enough room under the hood to allow the cylinder heads to be moved upward far enough for removal.

Similar to main bearing caps, studs do provide for more accurate and consistent torque loading and clamping force. For example, when a bolt is used to attach a cylinder head, it is being twisted and pulled at the same time. In comparison, a stud is only being stretched. Also, a stud uses a fine thread for the retaining nut and this allows for more precise torque readings.

Preparing for Installation of Main Cap Studs

Purpose of Studs. For high-performance use, most experts recommend the use of studs instead of bolts. Studs are able to obtain more accurate torque values because studs do not twist during tightening like bolts. See Figure 29-3.

The use of studs for the main bearing saddles helps main cap alignment because the torque applied is more consistent and there is less chance of the bearing cap moving during the tightening operation.

TECH TIP

BE AWARE OF BMW ENGINE PROCEDURES

If rebuilding a BMW engine, check service information carefully because most require that threaded inserts be installed in all head bolt threads. Performing this operation can increase the cost and time needed. Always follow all recommended service procedures on the engine being serviced.

FIGURE 29-3 Main bearing studs installed on a V-8 block.

Preparing Threaded Holes

Step 1 All threads in the block should be thoroughly cleaned. Use a thread chaser and not a tap as a tap could cut and remove metal. A chaser will restore the threads without removing metal.

Step 2 Use a calibrated torque wrench. Torque applied by a torque wrench can change over time due to temperature changes and how it is stored.

TECH TIP

CREEP UP ON THE TORQUE VALUE

Do not jerk or rapidly rotate a torque wrench. For best results and more even torque, slowly apply force to the torque wrench until it reaches the preset value or the designated torque. Jerking or rapidly moving the torque wrench will often cause the torque to be uneven and not accurate.

Step 3 Screw the studs into the block *finger-tight only*. Do not tighten a stud more than finger-tight. A nut should not be used to double nut a stud to keep it in position.

NOTE: The tightening torque in the installation instructions is for the *nut* and not the stud itself.

In most cases, a thread locker such as Loctite 242 can be used on the threads of the stud being inserted into the block to make the installation of the stud more permanent.

CAUTION: If a thread locker is used, be sure to immediately install the main bearing caps before the compound cures to help avoid misalignment.

CYLINDER HEAD PREPARATION

The details that should be checked on the cylinder head(s) include:

- The surface finish of the fire deck is as specified for the head gasket type to be used.
- All valves should be checked for leakage by pouring mineral spirits into the intake and exhaust ports and looking for leakage past the valves.
- All valve springs should be checked for even spring pressure and installed height.
- Check for proper pushrod length. If the cylinder head(s) has been machined and/or the block deck machined, the pushrods may be too long. If the pushrods are too long, the rocker arm geometry will not be correct. One problem that can occur with incorrect rocker arm geometry is spring bind, which can cause severe engine damage.
- If replacement rocker arms are used, be sure that the geometry and total lift will be okay.

REAL WORLD FIX

VALVE SPRINGS CAN VARY

A technician was building a small-block Chevrolet V-8 engine at home and was doing the final detailed checks and found that many of the valve springs did not have the same tension. Using a borrowed valve spring tester, the technician visited a local parts store and measured all of the valve springs that the store had in stock. The technician selected and purchased the 16 that were within specification and were also within a very narrow range of tension. While having all valve springs equal may or may not affect engine operation, the technician was pleased that all of the valve springs were equal.

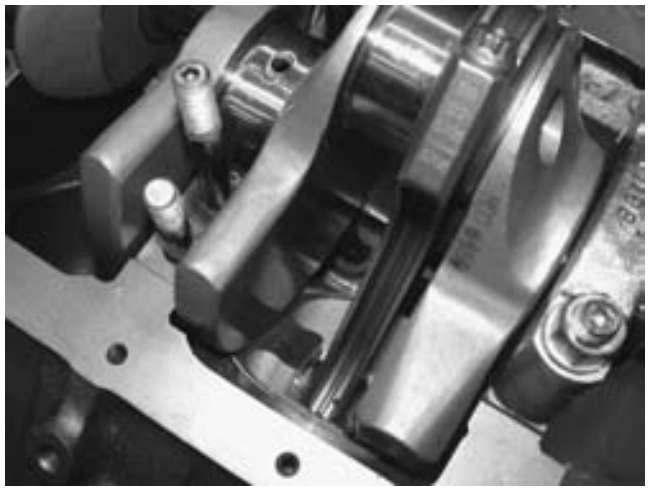

FIGURE 29-4 A trial assembly showed that some grinding of the block will be needed to provide clearance for the counterweight of the crankshaft. Also, notice that the engine has been equipped with studs for the four-bolt main bearing caps.

TRIAL ASSEMBLY

Short Block

Before performing final engine assembly, the wise technician checks that all parts will fit and work. This is especially important if using a different crankshaft that changes the stroke. See Figure 29-4 for an example of a 400-cu. in. Chevrolet crankshaft being fitted to a 350-cu. in. Chevrolet engine.

Valve Train

Another place where a trial fit is needed is in the valve train. Some timing chain mechanisms require more space than the stock component so some machining may be needed.

If the rocker arms have been upgraded to roller rockers, these should be installed and checked that the tip of the roller rests at the center of the valve stem. See Figure 29-5.

If there is a problem, further investigation will be needed because the pushrods may be too long due to machining of the block deck and/or cylinder head. Rotate the engine and check for proper clearance throughout the entire opening and closing of the valves. Use a feeler gauge between the coils of the valve spring to check for coil bind. If coil bind occurs, a different camshaft should be used.

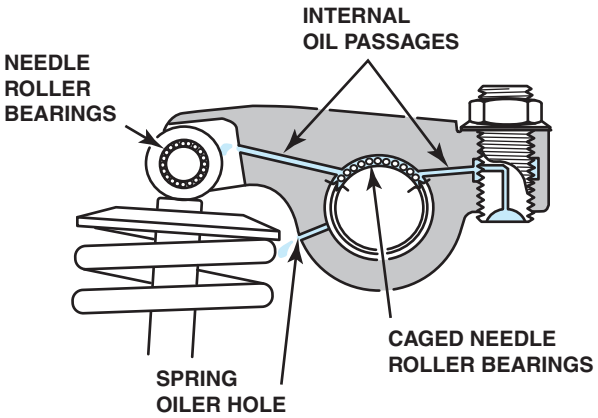

FIGURE 29-5 A typical high-performance aftermarket rocker arm that is equipped with needle roller bearings at the valve stem end and caged needle bearings at the pivot shaft end to reduce friction, which increases engine horsepower and improves fuel economy.

FIGURE 29-6 Fogging oil is used to cover bare metal parts to prevent corrosion when the engine is being stored.

TECH TIP

FOGGING OIL AND ASSEMBLY FLUID

When assembling an engine, the parts should be coated with a light oil film to keep them from rusting. This type of oil is commonly referred to as **fogging oil** and is available in spray cans. See Figure 29-6.

During engine assembly, the internal parts should be lubricated. While engine oil or grease could be used, most experts recommend the use of a specific lubricant designed for engine assembly. This lubricant is designed to remain on the parts and not drip or run and is called assembly lube. See Figure 29-7.

FIGURE 29-7 Engine assembly lube is recommended to be used on engine parts during assembly.

TECH TIP

KEEP THE ENGINE COVERED

Using a large plastic trash bag is an excellent way to keep the engine clean when storing it between work sessions. See Figure 29-8.

FIGURE 29-8 Placing a plastic trash bag over the engine and tying it shut is an excellent way to keep the engine clean.

CHECK THE ANGLE BETWEEN HEADS

During the trial assembly, use a gauge to check that the heads are at the correct angle to ensure proper intake manifold gasket sealing. See Figure 29-9.

PAINTING THE ENGINE

While most technicians wait until the engine has been assembled, started, and tested before painting, others prefer to paint each component or assembly individually. If components are being painted before assembly, be sure to keep the paint off of the mating surfaces. Only use paint that can withstand the temperature of an operating engine.

GASKETS AND CLAMPING FORCE

Purpose and Function

A gasket is a device used to fill a space or gap between two objects to prevent leakage from occurring either from the inside outward or outside inward. In an engine, gaskets are used between the cylinder head and engine block, which are called *head gaskets.* A gasket is also used between the valve cover and the cylinder head. These gaskets are called *valve cover gaskets, cylinder head cover gaskets,* or *rocker arm cover gaskets,* depending on the make and model of engine. Other gaskets are used between the intake and exhaust manifolds and the cylinder head(s) as well as on the oil pan and front covers of the engine.

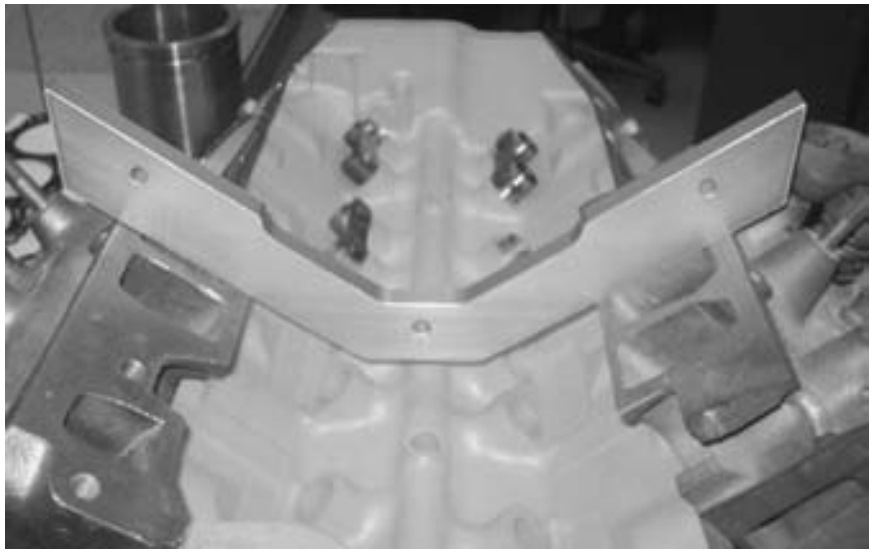

FIGURE 29-9 An angle gauge being used to check the angle between the cylinder heads on this small-block Chevrolet V-8 engine.

Types of Gaskets

Gaskets are made from a variety of materials and construction types based mainly on the need. Gaskets can be made from sheet or solid materials, such as paper, rubber, cork, felt, or fiberglass and combined with other materials, if necessary, such as neoprene and plastic. Some newer-style gaskets combine two or more gaskets into one easy-to-use unit. Consider using one of these gaskets to eliminate gaps and thereby reduce the chance of leakage. See Figure 29-10.

Clamping Force

Clamping force is the amount of force exerted on a gasket. The clamping force is not the same as the torque applied to the fastener. When tightening a bolt or nut, about 80% of the applied torque is used to overcome friction between the threads. Therefore, it is very important that the threads be clean and lubricated with the proper (specified) lubricant.

Fastener Consideration

Because most of the torque applied to a fastener is absorbed by friction, it is extremely important that the following steps be performed:

Step 1 Clean the threads of all fasteners before using.

Step 2 Check service information for the specified thread lubricant. Many vehicle manufacturers recommend the use of 30 weight engine oil (SAE 30).

FIGURE 29-10 An oil pan gasket assembly which includes the windage tray is an aftermarket part that can be used to simplify assembly.

CAUTION: SAE 5W-30 or SAE 10W-30 is not the same as SAE 30 engine oil. A multiviscosity oil such as SAE 5W-30 is actually SAE 5 oil with additives to provide the protection of a SAE 30 oil when it gets hot. Always use the exact oil specified by the vehicle manufacturer.

If using aftermarket bolts or studs, such as ARP (American Racing Products®), use the lubricant the company specifies

FREQUENTLY ASKED QUESTION

WHY DO BOTH HEAD GASKETS HAVE "FRONT" MARKED?

A common question asked by beginning technicians or students is how to install head gaskets on a V-6 engine that is mounted transversely (sideways) in the vehicle. The technician usually notices that "front" is marked on one gasket and therefore installs that gasket on the block on top of the forward facing cylinder bank. Then, the other gasket is picked up and the technician notices that "front" is also marked on this gasket. How could both be marked front? There must be some mistake. The mistake is in the terminology used. In the case of head gaskets, the "front" means toward the accessory belt end of the engine and *not* on the cylinder bank toward the front of the vehicle.

TECH TIP

ALWAYS "EXERCISE" NEW BOLTS

New bolts and studs are manufactured by rolling the threads and heat treating. Due to this operation, the threads usually have some rough areas, which affect the clamping force on the gasket. Many engine building experts recommend that all new bolts be installed in the engine using a new or used gasket and torqued to specifications at least five times, except for torque-to-yield bolts. This process burnishes the ramps of the threads and makes the fastener provide a more even clamping force. The bolts should be torqued and removed and then torqued again, using the recommended lubricant.

TECH TIP

RUBBER OR CONTACT CEMENT

One of the reasons why gaskets fail is due to being moved during installation. Some gaskets, such as cork or rubber valve cover gaskets or oil pan gaskets, can be held onto the cover using a rubber or contact cement.

To use a rubber or contact cement, perform the following steps:

Step 1 Apply a thin layer to one side of the gasket and to the cover where the gasket will be placed.

Step 2 Allow the surfaces to air-dry until touch free.

Step 3 Carefully place the gaskets onto the cover being sure to align all of the holes.

CAUTION: Do not attempt to remove the gasket and reposition it. The glue is strong and the gasket will be damaged if removed. If the gasket has been incorrectly installed, remove all of the gasket, clean the gasket surface, and repeat the installation using a new gasket.

and the torque they recommend. Do not use ARP lubricant and the factory torque specifications or the fasteners will be greatly overtightened. The same applies if using thread sealant to the threads of fasteners being installed in wet holes (holes that extend into the cooling passages). See Figure 29-11.

FIGURE 29-11 Special lubricant is specified when using ARP fasteners. This lubricant reduces the friction of the threads and therefore a lower-than-factory-specified torque specification is mandated when using the special lubricant.

Gasket Failures

Gaskets can fail to seal properly, but the root cause is often a severe condition. For example, a head gasket can fail due to detonation (spark knock or ping), which causes extreme pressure to be exerted on the armor of the head gasket, causing it to deform. Improper installation such as incorrect torquing sequence can cause gasket failure.

Fretting is a condition that can destroy intake manifold gaskets and is caused by the unequal expansion and contraction of two different engine materials. For example, if the intake manifold is constructed of aluminum and the cylinder heads are cast iron, the intake manifold will expand more than the cylinder heads. This causes a shearing effect, which can destroy the gasket. See Figure 29-12. Therefore, before assembling an engine, check for newer gasket designs that are often different from the type originally used in the engine.

FIGURE 29-12 This intake manifold gasket was damaged due to fretting. Newer designs allow for more movement between the intake manifold and the cylinder head.

SUMMARY

1. Gaskets are used to fill a space or gap between two objects to prevent leakage from occurring.
2. There are many types of gaskets including cylinder head cover gaskets, valve cover gaskets, and timing cover gaskets.
3. The clamping force which keeps the gaskets compressed is achieved by torquing the fastener to a specified torque and/or angle.
4. Rubber or contact cement is used to hold a gasket in place.
5. Sealers are used to help gaskets seal.

REVIEW QUESTIONS

1. What is the purpose of a gasket?
2. Why is clamping force different from bolt torque?
3. What is the difference between a bolt and a stud?

CHAPTER QUIZ

1. About how much of the turning torque applied to a head bolt is lost to friction?
   a. 20%
   b. 40%
   c. 60%
   d. 80%
2. Service information states that SAE 30 engine oil should be used on the threads of the head bolts before installation and torquing. Technician A says that SAE 5W-30 will work. Technician B says that SAE 10W-30 will work. Which technician is correct?
   a. Technician A only
   b. Technician B only
   c. Both Technicians A and B
   d. Neither Technician A nor B
3. Technician A says that the torque applied to the head bolts is the same as the clamping force on the gasket. Technician B says that the clamping force is the force actually applied to the surfaces of the gasket. Which technician is correct?
   a. Technician A only
   b. Technician B only
   c. Both Technicians A and B
   d. Neither Technician A nor B
4. A coating that is used to keep an engine from rusting during assembly is called _____?
   a. Engine oil
   b. Assembly lube
   c. Flogging oil
   d. Penetrating oil
5. Head gasket installation is being discussed. Technician A says that the surface finish of the cylinder head or block deck is very important for proper sealing to occur. Technician B says that if "front" is marked on a head gasket, the mark should be installed near the accessory belt end of the engine. Which technician is correct?
   a. Technician A only
   b. Technician B only
   c. Both Technicians A and B
   d. Neither Technician A nor B
6. Technician A says that studs should be installed finger tight. Technician B says that thread locker must be used if installing studs. Which technician is correct?
   a. Technician A only
   b. Technician B only
   c. Both Technicians A and B
   d. Neither Technician A nor B
7. What can be used to check that the heads are at the proper angle for the intake manifold?
   a. A metal rule
   b. An angle gauge
   c. A tape measure
   d. A dial indicator
8. What should be used to check for coil bind?
   a. dial indicator
   b. feeler gauge
   c. micrometer
   d. angle gauge

9. If a stoker crankshaft is being installed, what additional work may be required?

a. The crankshaft may have to be shortened to fit the block

b. The crankshaft main bearing journals will need to reground

c. The block may need to be ground for clearance

d. Both a and b

10. The movement of engine parts that are constructed from two different materials, such as aluminum and cast iron, is called _____.

a. Cracking

b. Fretting

c. Shearing

d. Stretching