

# Chapter 35

## ENGINE INSTALLATION AND BREAK-IN

### LEARNING OBJECTIVES:

After studying this chapter, the reader should be able to:

- Discuss the preinstallation checklist.
- Explain the procedure for transmission installation.
- Explain the process of dressing the engine.
- Discuss engine installation.
- Explain engine start.
- Discuss the break-in precautions of an overhauled engine.

### KEY TERMS:

Lugging 412 • Normal operating temperature 411

### PREINSTALLATION CHECKLIST

**NEED FOR A CHECKLIST** Engine installation must be thoroughly checked to ensure that it is in proper condition to give the customer dependable operation for a long time. Using a checklist guarantees that all accessories are correctly reinstalled on the engine.

**ENGINE INSTALLATION CHECKLIST** Before installing or starting a new or rebuilt engine in a vehicle, be sure all of the following items have been checked:

1. Be sure the battery is fully charged.
2. Prelube the engine and check for proper oil pressure.
3. Check that all electrical wiring connectors and harnesses are properly installed. ● **SEE FIGURE 35-1.**
4. Check that all of the vacuum lines are correctly installed and routed.



**FIGURE 35-1** A partially melted electrical connector indicates that excessive current flow was present. The cause of the excessive current should be located and corrected before the engine is started.

5. Check that all fuel lines are properly connected and free from leaks.
6. Make sure all engine fluids are at the proper operating level, such as coolant, engine oil, and power steering fluid.
7. Check that fresh fuel is in the fuel tank.
8. Be sure that the radiator has been tested, is free from leaks, and flows correctly.
9. Check that all accessory drive belts are routed and tensioned correctly.

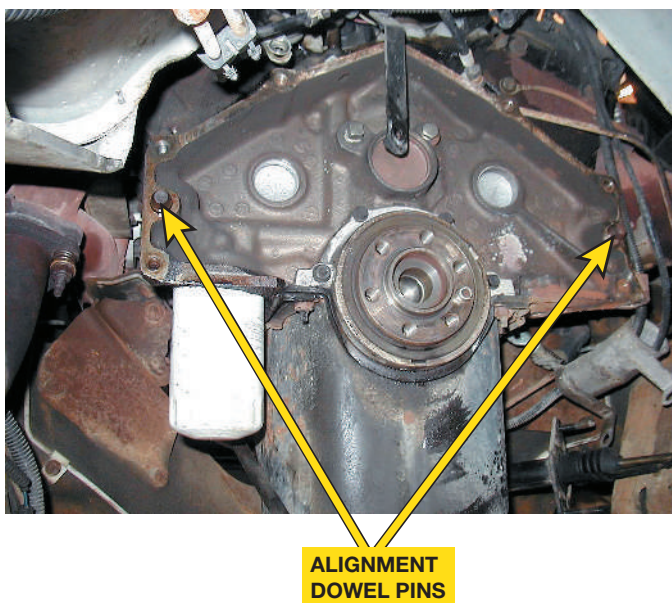
**CAUTION:** Be sure to have a fire extinguisher nearby when the engine is first started.

## TRANSMISSION INSTALLATION

**MANUAL TRANSMISSION INSTALLATION** If the engine was removed with the transmission attached, the transmission should be reinstalled on the engine before other accessories are added. The flywheel is installed on the back of the crankshaft. Often, the attaching bolt holes are unevenly spaced so that the flywheel fits in only one way to maintain engine balance. The pilot bearing or bushing in the rear of the crankshaft is usually replaced with a new one to minimize the possibility of premature failure of this part.

The clutch is installed next and the installation usually includes the following steps:

- STEP 1** Most experts recommend that a new clutch assembly or, at the least, a new clutch friction disc, be installed.
- STEP 2** The clutch friction disc must be held in position using an alignment tool that is secured in the pilot bearing. This holds the disc in position while the pressure plate is being installed.
- STEP 3** The engine bell housing is put on the engine, if it was not installed before. The alignment of this type of bell housing is then checked. ● **SEE FIGURE 35-2.**



**FIGURE 35-2** Bell housing alignment dowel pins are used to ensure proper alignment between the engine block and the transmission.

**CAUTION:** Perfectly round cylinders can be distorted whenever another part of the engine is bolted and torqued to the engine block. For example, it has been determined that after the cylinders are machined, the rear cylinder bore can be distorted to be as much as 0.006 inch (0.15 mm) out-of-round after the bell housing is bolted onto the block! To help prevent this distortion, always apply the specified torque to all fasteners going into the engine block and tighten in the recommended sequence.

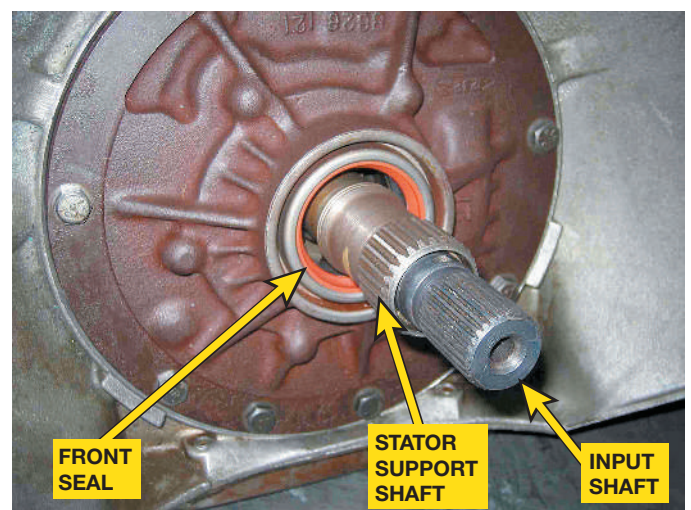
**STEP 4** The clutch release yoke should be checked for free movement. Usually, the clutch release bearing is replaced to ensure that the new bearing is securely attached to the clutch release yoke.

**STEP 5** The transmission is installed by carefully guiding the transmission input (clutch) shaft straight into the clutch disc and pilot bearing. Rotate the transmission output shaft as needed to engage the splines of the clutch disc. The assembly bolts are secured when the transmission fully mates with the bell housing.

**CAUTION:** Always adjust the clutch free play before starting the engine to help prevent engine thrust bearing or clutch release bearing damage.

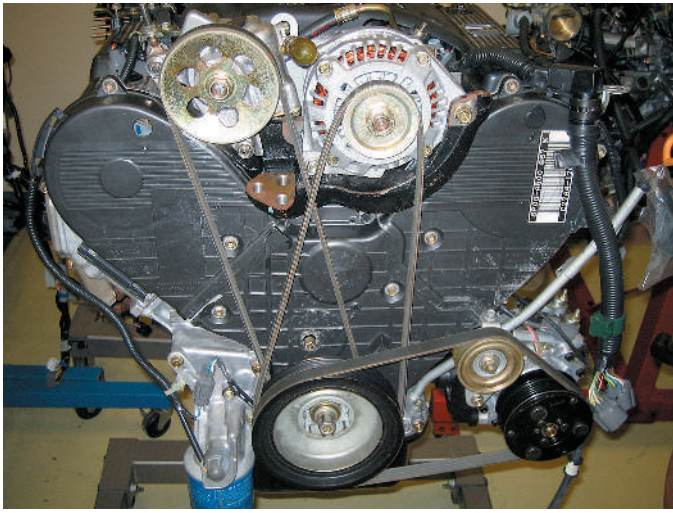
**AUTOMATIC TRANSMISSION INSTALLATION** On engines equipped with an automatic transmission, the drive (flex) plate is attached to the back of the crankshaft. Its assembly bolts are tightened to the specified torque. The bell housing is part of the transmission case on most automatic transmissions. Installing an automatic transmission usually includes the following steps:

- STEP 1** The torque converter should be installed on the transmission before the transmission is put on the engine.
- STEP 2** Rotate the torque converter while it is pushed onto the transmission shafts until the splines of all shafts are engaged in the torque converter. ● **SEE FIGURE 35-3.**
- STEP 3** The torque converter is held against the transmission as the transmission is fitted on the back of the engine. The transmission mounting bolts are attached finger tight.
- STEP 4** The torque converter should be rotated to make sure that there is no binding. The bell housing is secured to the block and then the torque converter is fastened to the drive plate.

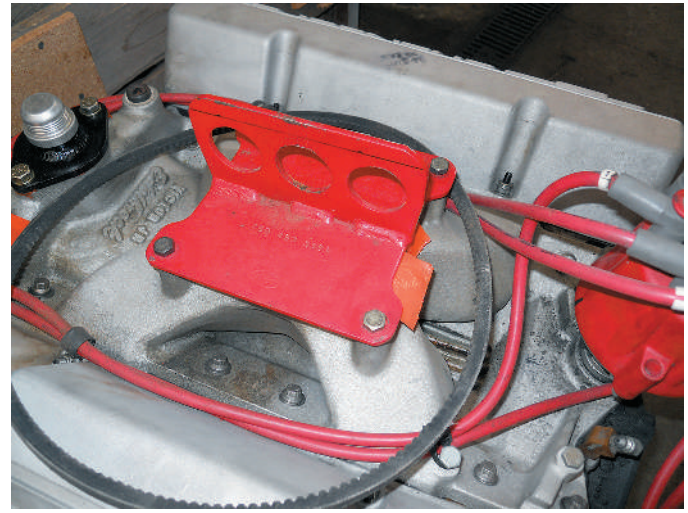


**FIGURE 35-3** The internal splines inside the torque converter must be properly aligned with all of the splines of the automatic transmission.





**FIGURE 35-4** It is often easier to install all of the accessory drive belts before the engine is installed in the vehicle.



**FIGURE 35-5** A fixture installed that is used as a place to attach the hoisting chains.

## DRESSING THE ENGINE

“Dressing the engine” is a term used to describe the process of attaching all of the auxiliary items to the engine. The items include

- Starter motor
- Fuel rail and related fuel system components
- New oxygen sensor(s), to ensure that the engine is operating at the correct air–fuel ratio
- Engine/transmission wiring harness
- Ignition components, such as the ignition coil(s) and spark plug wires, if equipped
- All belt-driven engine accessories, mounted on the front of the engine (Some engines drive all these accessories with one belt. Other engines use as many as four belts. Check service information or decals under the hood to determine the specific belt routing for the accessories used on the engine.) ● **SEE FIGURE 35-4.**
- Front accessories, such as the power steering pump, alternator, and air-conditioning compressor (These accessories may be installed before the engine is installed in the vehicle. On some vehicles, it is easier to put the engine in the chassis before installing the front accessories.)

Always check service information for the exact procedure to follow.

## ENGINE INSTALLATION

**SECURING THE ENGINE** A sling, either a chain or lift cable, is attached to the manifold, head bolts, or lifting brackets on the top of the engine. A hoist is attached to the sling and snugged up to take the weight and to make sure that the engine is supported and balanced properly. ● **SEE FIGURE 35-5.**

### INSTALLING THE ENGINE

- **Rear-wheel drive.** The engine must be tipped as it was during removal to let the transmission go into the engine compartment first. The transmission is worked under the

floor pan on rear-wheel-drive vehicles as the engine is lowered into the engine compartment. The front engine mounts are aligned and the rear cross-member and rear engine mount are installed. The engine mount bolts are installed, and the nuts are torqued. Then the hoist is removed.

- **Front-wheel drive.** Many engines for front-wheel-drive vehicles are installed from underneath the vehicle. Often the entire drivetrain package is placed back in the vehicle while it is attached to the cradle. The vehicle is positioned on a hoist and is lowered onto the engine cradle assembly to install. Always check the recommended procedure for the vehicle being serviced.

**RECONNECTING COMPONENTS AND CONNECTORS** The following items should be connected to the engine assembly:

- Throttle and cruise control linkages or cables.
- Exhaust system to the exhaust manifolds.
- If any of the steering linkage was previously disconnected, it can be reattached while work is being done under the vehicle.
- After the engine is in place, the front engine accessories can all be installed, if they were not installed before the engine was put in the chassis.
- The air-conditioning compressor is reattached to the engine, with care being taken to avoid damaging the air-conditioning hoses and lines.

**COOLING SYSTEM** The radiator is installed and secured in place, followed by the cooling fan and shroud. The fan and new drive belts are then installed and adjusted. New radiator hoses, including new heater hoses, and new coolant should be installed.

**ELECTRICAL SYSTEM** Under the hood, the following electrical components need to be mounted and connected:

- Connect all wiring to the starter and alternator as required.
- Connect the instrument and computer sensor wires to the sensors on the engine.



## FREQUENTLY ASKED QUESTION

### What Is Break-In Engine Oil?

Many years ago, vehicle manufacturers used straight weight oil, such as SAE 30 nondetergent engine oil, as break-in oil. Today, the engine oil recommended for break-in (running in) is the same type of oil that is recommended for use in the engine. No special break-in oil is recommended or used by the factory in new vehicles. Always use the specified viscosity oil as recommended by the vehicle manufacturer.

- Double-check the condition and routing of all wiring, being certain that wires have not been pinched or broken, before installing a fully charged battery.
- Attach the positive cable first and then the ground cable.
- Ensure that the starter cranks the engine.
- Install and time the distributor (if equipped), then connect the ignition cables to the spark plugs, again being sure that they are routed according to service information.

## ENGINE START

**PRECAUTIONS** The engine installation should be given one last inspection to ensure that everything has been put together correctly before the engine is started. If the engine overhaul and installation are done properly, the engine should crank and start on its own fully charged battery without the use of a fast charger or jumper battery. As soon as the engine starts and shows oil pressure, it should be brought up to a fast idle speed and *kept there* to ensure that the engine gets proper lubrication. The fast-running oil pump develops full pressure, and the fast-turning crankshaft throws plenty of oil on the cam and cylinder walls.

**NOTE:** In camshaft-in-block engines, the only lubrication sent to the contact point between the camshaft lobes and the lifters (tappets) is from the splash off the crankshaft and connecting rods. At idle, engine oil does not splash enough for proper break-in lubrication of the camshaft.

Maintaining engine speed above 1,500 RPM for the first 10 minutes of engine operation must be performed to break in a flat-bottom lifter camshaft. If the engine speed is decreased to idle (about 600 RPM), the lifter (tappet) is in contact with and exerting force *on* the lobe of the cam for a longer period of time than occurs at higher engine speeds. The pressure and volume of oil supplied to the camshaft area are also increased at the higher engine speeds. Therefore, to ensure long camshaft and lifter life, make certain that the engine starts quickly after reassembly to prevent long cranking periods and subsequent low engine speeds after a new camshaft and lifters have been installed.

**NOTE:** Many molydisulfide greases used during assembly can start to clog oil filters within 20 minutes after starting the engine. Most engine rebuilders recommend changing the oil and filter after 30 minutes of running time.

After the engine has started, the following items should be checked:

1. Is the valve train quiet? Some engines require several minutes to quiet down.
2. Record the engine vacuum. It should be 17 to 21 inch Hg (sea level).
3. Check for any gasoline, coolant, or oil leaks. Stop the engine and repair the leaks as soon as possible.
4. Check the charging system for proper operation. The charging voltage should be 13.5 to 15 volts.

As soon the engine is at operating temperature and running well, the vehicle should be driven to a road having minimum traffic. Perform the following during the test drive:

- The vehicle should be accelerated, full throttle, from 30 to 50 mph (48 to 80 km/h).
- Then, the throttle is fully closed while the vehicle is allowed to return to 30 mph (48 km/h). This sequence is repeated 10 to 12 times.
- The acceleration sequence puts a high load on the piston rings to properly seat them against the cylinder walls. The piston rings are the only part of the modern engine that needs to be broken in. Good ring seating is indicated by a dry coating inside the tailpipe at the completion of the ring-seating drive.

The vehicle is returned to the service area, where the engine is again checked for visible fluid leaks. If the engine is dry, it is ready to be turned over to the customer.

The oil and filter should be changed at 500 miles (800 km) to remove any dirt that may have been trapped in the engine during assembly, and to remove the material that has worn from the surfaces during the break-in period.

A well-designed engine that has been correctly reconditioned and assembled using the techniques described should give reliable service for many miles.

**NORMAL OPERATING TEMPERATURE** Normal operating temperature is the temperature at which the upper radiator hose is hot and pressurized. Another standard method used to determine when normal operating temperature is reached is to observe the operation of the electric cooling fan, when the vehicle is so equipped. Many manufacturers define normal operating temperature as being reached when the cooling fan has cycled on and off at least once after the engine has been started. Some vehicle manufacturers specify that the cooling fan should cycle twice. This method also helps assure the technician that the engine is not being overheated. ● SEE FIGURE 35-6.

**HOW TO WARM UP A COLD ENGINE** The greatest amount of engine wear occurs during start-up. The oil in a cold engine is thick, and it requires several seconds to reach all the moving parts of an engine. After the engine starts, allow the engine to idle until the oil pressure peaks. This takes from 15 to 60 seconds, depending on the outside temperature. *Do not allow the engine to idle for longer than five minutes.* Because an engine warms up faster under load, drive the vehicle in a normal manner until the engine is fully warm. Avoid full-throttle acceleration until the engine is completely up to normal operating temperature. This method of engine warm-up also warms the rest of the powertrain, including transmission and final drive-component lubricants.





**FIGURE 35-6** Even though the dash gauge may show normal operating temperature, a scan tool or an infrared pyrometer can also be used to verify proper coolant temperature.

## BREAK-IN PRECAUTIONS

Any engine overhaul represents many hours of work and a large financial investment. Precautions should be taken to protect the investment, including the following:

1. Never add cold water to the cooling system while the engine is running.
2. Never lug any engine. **Lugging** means increasing the throttle opening without increasing engine speed (RPM). An example where lugging an engine can occur is when the vehicle is driven at a low speed, such as 15 mph, with the manual transmission in third or fourth gear instead of in second gear, as per the recommended speed for that gear, as published in the owner manual.
3. Applying loads to an engine for *short periods* of time creates higher piston ring pressure against the cylinder walls and assists the breaking-in process by helping to seat the rings.
4. Change the oil and filter at 500 miles (800 km) or after 20 hours of operation.
5. Check for leaks after the engine has gone through several warm-up and cooling down periods.

## REVIEW QUESTIONS

1. How are the clutch and bell housing installed?
2. What should be done to help prevent rear cylinder distortion when the bell housing is being installed on the engine?
3. Why should the clutch, if equipped, be adjusted before starting the engine?
4. What is involved in "dressing the engine"?
5. What is meant by lugging an engine?

## CHAPTER QUIZ

1. Before installing or starting a new or rebuilt engine, all of the following items should have been checked, EXCEPT \_\_\_\_\_.
  - a. battery fully charged
  - b. pre-lube engine and check for proper oil pressure
  - c. check that all of the vacuum lines are correctly installed and routed
  - d. rear axle is topped off
2. "Dressing the engine" means \_\_\_\_\_.
  - a. installing all of the exterior engine components
  - b. cleaning the engine
  - c. changing the oil and oil filter
  - d. Both b and c
3. If the bell housing is not properly torqued to the engine block, \_\_\_\_\_.
  - a. the bell housing will distort
  - b. the engine block will crack
  - c. the rear cylinder can be distorted (become out-of-round)
  - d. the crankshaft will crack
4. Break-in engine oil is \_\_\_\_\_.
  - a. of the same viscosity and grade as that specified for normal engine operation
  - b. SAE 40
  - c. SAE 30
  - d. SAE 20W-50
5. Normal operating temperature is reached when \_\_\_\_\_.
  - a. the radiator cap releases coolant into the overflow
  - b. the upper radiator hose is hot and pressurized
  - c. the electric cooling fan has cycled at least once (if the vehicle is so equipped)
  - d. Both b and c
6. Which computer sensor should be replaced to help ensure that the engine is operating at the correct air-fuel ratio?
  - a. Throttle position sensor
  - b. Oxygen sensor
  - c. Manifold absolute pressure sensor
  - d. Engine coolant temperature sensor
7. How should the vehicle be driven to best break in a newly overhauled engine?
  - a. At a steady low speed
  - b. At varying speeds and loads
  - c. At high speed and loads
  - d. At idle speed and little or no load
8. Which type of vehicle is the engine most likely to be installed from underneath the vehicle?
  - a. Rear-wheel drive (RWD)
  - b. Front-wheel drive (FWD)
  - c. Four-wheel drive (4WD)
  - d. Both a and c
9. Engine vacuum on a normal stock rebuilt engine should be \_\_\_\_\_.
  - a. 10 to 15 inch Hg
  - b. 12 to 16 inch Hg
  - c. 17 to 21 inch Hg
  - d. 19 to 23 inch Hg
10. Why must flat-bottom camshafts be broken in at a fast idle?
  - a. The cam in a cam-in-block engine is only lubricated by splash oil
  - b. The flat-bottom of the lifters must become slightly concave in order to rotate
  - c. Both a and b are correct
  - d. Neither a nor b are correct