CHAPTER 14

LUBRICATION SYSTEM OPERATION AND DIAGNOSIS

OBJECTIVES

After studying Chapter 14, the reader will be able to:

1. Prepare for Engine Repair (A1) ASE certification test content area "D" (Lubrication and Cooling Systems Diagnosis and Repair).
2. Explain engine oil ratings.
3. Describe how an oil pump and engine lubrication work.
4. Discuss how and when to change the oil and filter.
5. Explain how to inspect an oil pump for wear.

KEY TERMS

ACEA (p. 211)
Additive Package (p. 212)
American Petroleum Institute (API) (p. 209)
Antidrainback Valve (p. 216)
Boundary Lubrication (p. 208)
Bypass Valve (p. 216)
Cavitation (p. 219)
Dry Sump (p. 224)
Gallery (p. 221)
Hydrodynamic Lubrication (p. 208)
ILSAC (p. 210)
JASO (p. 211)
Miscible (p. 209)
Pour Point (p. 209)
Pour Point Depressants (p. 212)
Pressure Regulating Valve (p. 219)
SAE (Society of Automotive Engineers) (p. 209)
Viscosity (p. 208)
Viscosity Index (VI) (p. 209)
Wet Sump (p. 224)
Windage Tray (p. 223)
ZDDP (p. 212)

LUBRICATION PURPOSE AND FUNDAMENTALS

Engine oil is the lifeblood of any engine. The purposes of engine oil include the following:

1. *Lubricating* all moving parts to prevent wear.
2. Helping to *cool* the engine.
3. Helping to *seal* piston rings.
4. *Cleaning,* and holding dirt in suspension in the oil until it can be drained from the engine.
5. *Neutralizing* acids that are formed as the result of the combustion process.
6. *Reducing* friction.
7. *Preventing* rust and corrosion.

LUBRICATION PRINCIPLES

Lubrication between two moving surfaces results from an oil film that separates the surfaces and supports the load. See Figure 14-1.

Although oil does not compress, it does leak out around the oil clearance between the shaft and the bearing. In some cases, the oil film is thick enough to keep the surfaces from seizing, but can allow some contact to occur. This condition is called **boundary lubrication.** The specified oil viscosity and oil clearances must be adhered to during service to help prevent boundary lubrication and wear from occurring, which usually happens when the engine is under a heavy load and low speeds. The movement of the shaft helps prevent contact with the bearing. If oil were put on a flat surface and a heavy block were pushed across the surface, the block would slide more easily than if it were pushed across a dry surface. The reason for this is that a wedge-shaped oil film is built up between the moving block and the surface, as illustrated in Figure 14-2.

This wedging action is called **hydrodynamic lubrication** and the pressure depends on the force applied to how fast the speed between the objects and the thickness of the oil. Thickness of oil is called the **viscosity** and is defined as the ability of the oil to resist flow. High-viscosity oil is thick and low-viscosity oil is thin. The prefix *hydro-* refers to liquids, as in hydraulics, and *dynamic* refers to moving materials. Hydrodynamic lubrication occurs when a wedge-shaped film of lubricating oil develops between two surfaces that have relative motion between them. See Figure 14-3.

The engine oil pressure system feeds a continuous supply of oil into the lightly loaded part of the bearing oil clearance. Hydrodynamic lubrication takes over as the shaft rotates in the bearing to produce a wedge-shaped hydrodynamic oil film that is curved around the bearing. This film supports the bearing and reduces the turning effort to a minimum when oil of the correct viscosity is used.

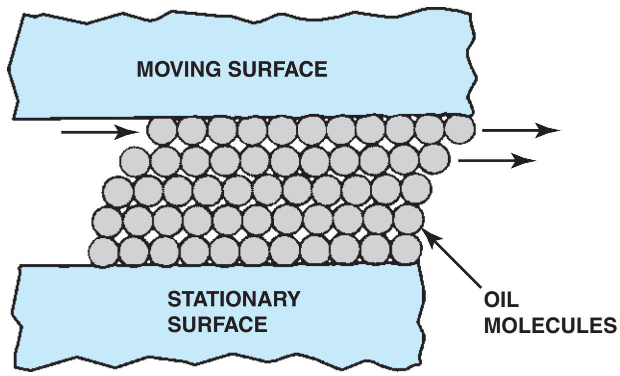


FIGURE 14-1 Oil molecules cling to metal surfaces but easily slide against each other.

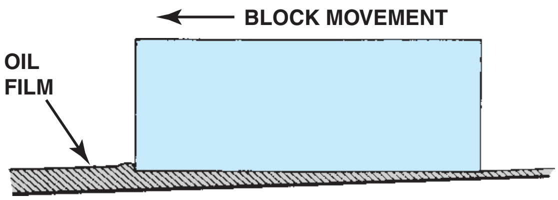


FIGURE 14-2 Wedge-shaped oil film developed below a moving block.

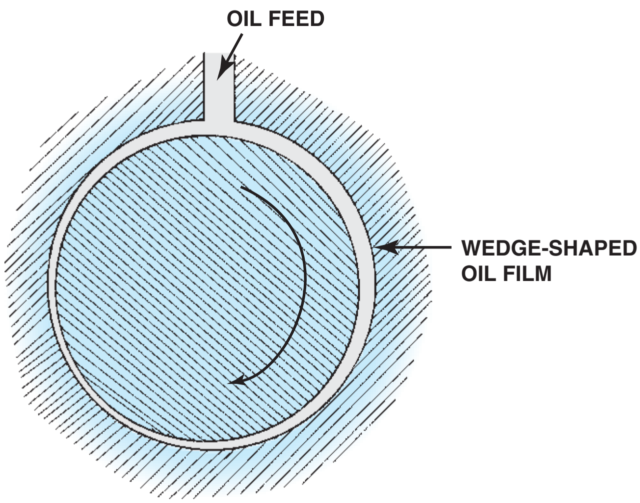


FIGURE 14-3 Wedge-shaped oil film curved around a bearing journal.

Most bearing wear occurs during the initial start-up. Wear continues until a hydrodynamic film is established.

ENGINE LUBRICATION SYSTEMS

The primary function of the engine lubrication system is to maintain a positive and continuous oil supply to the bearings.

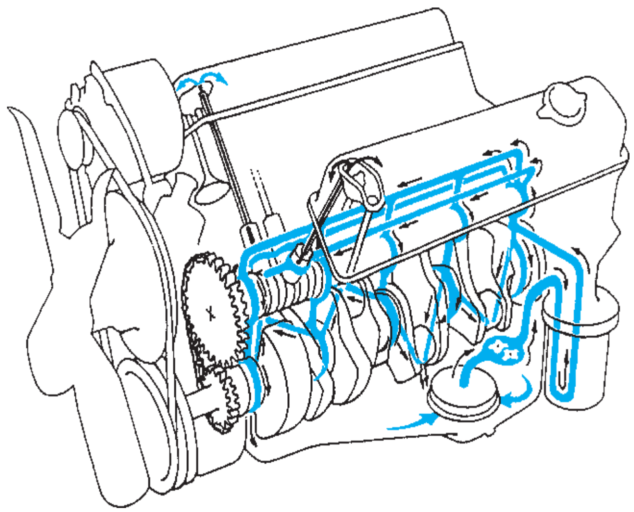


FIGURE 14-4 Typical V-8 engine lubrication system. Oil is stored in the oil pan (sump), drawn into the oil pump, and moves through the oil filter and on through the oil passages (oil galleries).

Engine oil pressure must be high enough to get the oil to the bearings with enough force to cause the oil flow that is required for proper cooling. The normal engine oil pressure range is from 10 to 60 PSI (200 to 400 kPa) (10 PSI per 1000 engine RPM). However, hydrodynamic film pressures developed in the high-pressure areas of the engine bearings may be over 1,000 PSI (6,900 kPa). The relatively low engine oil pressures obviously could not support these high bearing loads without hydrodynamic lubrication. See Figure 14-4.

PROPERTIES OF ENGINE OIL

The most important engine oil property is its thickness or viscosity. As oil cools, it thickens. As oil heats, it gets thinner. Therefore, its viscosity changes with temperature. The oil must not be too thick at low temperatures to allow the engine to start. The lowest temperature at which oil will pour is called its **pour point.** An index of the change in viscosity between the cold and hot extremes is called the **viscosity index (VI).** All oils with a high viscosity index thin less with heat than do oils with a low viscosity index. Oils must also be **miscible,** meaning they are capable of mixing with other oils (brands and viscosities, for example) without causing any problems such as sludge.

SAE RATING

Engine oils are sold with an **SAE (Society of Automotive Engineers)** grade number, which indicates the viscosity range into which the oil fits. Oils tested at 212°F (100°C) have a number with no letter following. For example, SAE 30 indicates that the oil has only been checked at 212°F (100°C). This oil's viscosity falls within the SAE 30 grade number range when the oil is hot. Oils tested at 0°F (−18°C) are rated with a number and the letter *W*, which means *winter* and indicates that the viscosity was tested at 0°F, such as SAE 20W. An SAE 5W-30 multigrade oil is one that meets the SAE 5W viscosity specification when cooled to 0°F (−18°C) and meets the SAE 30 viscosity specification when tested at 212°F (100°C).

Most vehicle manufacturers recommend the following multiviscosity engine oils:

- SAE 5W-30
- SAE 10W-30

An oil with a high viscosity has a higher resistance to flow and is thicker than lower-viscosity oil. A thick oil is not necessarily a good oil and a thin oil is not necessarily a bad oil. Generally, the following items can be considered in the selection of an engine oil within the recommended viscosity range.

- Thinner oil
  1. Improved cold-engine starting
  2. Improved fuel economy
- Thicker oil
  1. Improved protection at higher temperatures
  2. Reduced fuel economy

API RATING

The **American Petroleum Institute (API)**, working with the engine manufacturers and oil companies, has established an engine oil performance classification. Oils are tested and rated in production automotive engines. The oil container is printed with the API classification of the oil. The API performance or service classification and the SAE grade marking are the only information available to help determine which oil is satisfactory for use in an engine. See Figure 14-5 for a typical API oil container "doughnut."

Gasoline Engine Rating

In gasoline engine ratings, the letter *S* means *service*, but it can be remembered as being for use in spark ignition engines. The rating system is open-ended so that newer, improved ratings can be readily added as necessary (the letter *I* is skipped to avoid confusion with the number one).

SA Straight mineral oil (no additives), not suitable for use in any engine
SB Nondetergent oil with additives to control wear and oil oxidation
SC Obsolete (1964)
SD Obsolete (1968)

FIGURE 14-5 API doughnut for a SAE 5W-30, SM engine oil. When compared to a reference oil, the "energy conserving" designation indicates a 1.1% better fuel economy for SAE 10W-30 oils and 0.5% better fuel economy for SAE 5W-30 oils.

SE	Obsolete (1972)
SF	Obsolete (1980)
SG	Obsolete (1988)
SH	Obsolete (1993–1997)
SJ	Obsolete (1997–2001)
SL	2001–2003
SM	2004+

NOTE: Older-model vehicles can use the newer, higher-rated engine oil classifications where older, now obsolete ratings were specified. Newly overhauled antique cars or engines also can use the newer, improved oils, as the appropriate SAE viscosity grade is used for the anticipated temperature range. The new oils have all the protection of the older oils, plus additional protection.

Diesel Engine Rating

Diesel classifications begin with the letter *C*, which stands for *commercial*, but can also be remembered as being for use in compression ignition or diesel engines.

CA	Obsolete
CB	Obsolete
CC	Obsolete
CD	Minimum rating for use in a diesel engine service
CE	Designed for certain turbocharged or supercharged heavy-duty diesel engine service
CF	For off-road indirect injected diesel engine service
CF-2	Two-stroke diesel engine service
CF-4	High-speed four-stroke cycle diesel engine service
CG-4	Severe-duty high-speed four-stroke diesel engine service
CI-4	Severe-duty high-speed four-stroke diesel engine service

ILSAC OIL RATING

The **International Lubricant Standardization and Approval Committee (ILSAC)** developed an oil rating that consolidates the SAE viscosity rating and the API quality rating. If an engine oil meets the standards, a "starburst" symbol is displayed on the front of the oil container. If the starburst is present, the vehicle owner and technician know that the oil is suitable for use in almost any gasoline engine. See Figure 14-6.

The original GF-1 (gasoline fueled) rating was updated to GF-2 in 1997, GF-3 in 2000, and GF-4 in 2004.

TECH TIP

THREE OIL CHANGE FACTS

The three facts needed to know when changing oil include:

1. *Recommended SAE viscosity* (thickness) for the temperature range that is anticipated before the next oil change (usually SAE 5W-30)
2. *API quality rating* as recommended by the engine or vehicle manufacturer (usually SL or SM)
3. *Recommended oil change interval* (time or mileage) (usually every 5,000 miles or every six months)

FIGURE 14-6 The International Lubricant Standardization and Approval Committee (ILSAC) starburst symbol. If this symbol is on the front of the container of oil, then it is acceptable for use in almost any gasoline engine.

FREQUENTLY ASKED QUESTION

WHY IS SAE 10W-30 RECOMMENDED INSTEAD OF SAE 10W-40?

Engine oils are manufactured in various viscosity grades. Vehicle manufacturers usually recommend that SAE 5W-30 and/or SAE 10W-30 be used. General Motors Corporation specifies that SAE 10W-40 not be used in any engine. These different viscosity grades are formulated by using a viscosity index improver, which is a polymer designed to induce thickening of a thin base oil at higher temperatures. For example, a 10W-30 oil starts as an SAE 10W oil, and viscosity index improver polymers are added to bring the high-temperature viscosity up to SAE 30 standards. These polymers react with heat to restrict the rate of flow of the oil at higher temperatures. The greater the amount of VI improver, the broader the viscosity range. For example, typical multiviscosity oils and the percentages of viscosity index improver that they use are as follows:

SAE 5W-30 7–8% VI
SAE 10W-30 6–8% VI
SAE 10W-40 12–15% VI

Even though a 10W-40 oil will resist high-temperature thinning better than a 10W-30 oil, the increased amount of VI can contribute to some problems. As oil is used in an engine, it tends to thicken. This thickening occurs because of the following:

- *Oxidation.* When oil combines with oxygen, it becomes thicker.
- *Breakdown of polymer additives.* After 1,000 to 2,000 miles, the polymer additives can shear (break down) during use, which causes the oil to become thinner. The increased oxidation causes the oil to thicken and form sludge.

EUROPEAN OIL RATINGS

The **Association des Constructeurs European d'Automobiles (ACEA)** represents most of the Western European automobile and heavy-duty truck market. The organization uses different engines for testing than those used by API and SAE, and the requirements necessary to meet the ACEA standards are different yet generally correspond with most API ratings. ACEA standards tend to specify a minimum viscosity rating and certain volatility requirements not specified by API.

Gasoline Engine Oils

ACEA A1	Low-friction, low-viscosity oil (not suitable for some engines).
ACEA A2	General-purpose oil intended for normal oil change intervals. Not suitable for some engines or extended oil drain intervals in any engine.
ACEA A3	Oil is designed for high-performance engines and/or extended oil drain intervals and under all temperature ranges.
ACEA A4	Designed to meet the requirements for gasoline direct injection (GDI) engines.
ACEA A5	A low-viscosity, low-friction oil not suitable for some engines.

Diesel Engine Oils

ACEA B1	This diesel engine oil is designed for use in a passenger vehicle diesel engine that is equipped with an indirect injection system. This low-viscosity oil is not suitable for some diesel engines.
ACEA B2	Oil meeting this designation is designed to be used in passenger vehicle diesel engines using indirect injection and using normal oil drain intervals.
ACEA B3	Oil meeting this designation is intended for use in a high-performance, indirect injected passenger vehicle diesel engine and used under extended oil drain interval conditions.
ACEA B4	Oils meeting this standard are intended to be used in direct-injected passenger vehicle diesel engines and used year-round and can be used in an indirect-injected diesel engine.
ACEA B5	A low-viscosity oil designed for extended oil drain intervals and not suitable for some engines.
ACEA C1	The ACEA C ratings are specifications for C2, C3 catalyst compatible oils, which have limits on the amount of sulfur, zinc, and other additives that could harm the catalytic converter. Starting in 2004, the ACEA began using combined ratings such as A1/B1, A3/B3, A3/B4, and A5/B5.

JAPANESE OIL RATINGS

The **Japanese Automobile Standards Organization (JASO)** also publishes oil standards. The JASO tests use small Japanese engines, and their ratings require more stringent valve train wear standards than other countries' oil ratings.

ENGINE OIL ADDITIVES

Additives are used in engine oils for three different reasons: (1) to replace some properties removed during refining, (2) to reinforce some of the oil's natural properties, and (3) to provide the oil with new properties it did not originally have. Oils from some petroleum oil fields require more and different additives than oils from other fields. Additives are usually classified according to the property they add to the oil.

- *Antioxidants* reduce the high-temperature contaminants. They prevent the formation of varnish on the parts, reduce bearing corrosion, and minimize particle formation.
- *Corrosion preventives* reduce acid formation that causes bearing corrosion.
- *Detergents* and *dispersants* prevent low-temperature sludge binders from forming and keep the sludge-forming particles finely divided. The finely divided particles will stay in suspension in the oil to be removed from the engine as the oil is removed at the next drain period.
- *Extreme pressure* and *antiwear additives* form a chemical film that prevents metal-to-metal seizure any time boundary lubrication exists.
- *Viscosity index (VI) improvers* are used to reduce viscosity change as the oil temperature changes. See Figure 14-7.
- **Pour point depressants** coat the wax crystals in the oil so that they will not stick together. The oil will then be able to flow at lower temperatures.

A number of other oil additives may be used to modify the oil to function better in the engine. These include rust preventives, metal deactivators, water repellents, emulsifiers, dyes, color stabilizers, odor control agents, and foam inhibitors.

Oil producers are careful to check the compatibility of the oil additives they use. A number of chemicals that will help each other can be used for each of the additive requirements. The balanced additives are called an **additive package.**

FIGURE 14-7 VI improver is a polymer and feels like finely ground foam rubber. When dissolved in the oil, it expands when hot to keep the oil from thinning.

OIL BRAND COMPATIBILITY

Many technicians and vehicle owners have their favorite brand of engine oil. The choice is often made as a result of marketing and advertising, as well as comments from friends, relatives, and technicians. If your brand of engine oil is not performing up to your expectations, then you may wish to change brands. For example, some owners experience lower oil pressure with a certain brand than they do with other brands with the same SAE viscosity rating.

Most experts agree that the oil changes are the most important regularly scheduled maintenance for an engine. It is also wise to check the oil level regularly and add oil when needed. According to SAE Standard J-357, all engine oils must be compatible (miscible) with all other brands of engine oil. Therefore, any brand of engine oil can be used as long as it meets the viscosity and API standards recommended by the vehicle manufacturer. Even though many people prefer a particular brand, be assured that, according to API and SAE, any *major* brand-name engine oil can be used.

FREQUENTLY ASKED QUESTION

CAN NEWER ENGINE OILS BE USED IN OLDER VEHICLES?

No. In the past using a newer standard oil in an older engine was not a concern until the mandated reduction of zinc from the oil. The zinc (commonly referred to as zinc dialkyl dithiophosphate—**ZDDP** or ZDP) can cause damage to the catalytic converter. Even though engines consume very little oil, if the oil contains zinc, the efficiency of the catalytic converter is reduced. The use of ZDDP was intended to reduce sliding friction in an engine. Sliding friction is usually found in engines that use flat-bottom lifters. Most, if not all, engines produced over the past 10 years have used roller lifters or followers, so using the new oil without ZDDP is not a concern. Even diesel oils have reduced amounts of the zinc so many camshaft manufacturers are recommending the use of an additive. Older oils had up to 0.15% ZDDP and now SM-rated oils list the zinc at just 0.08% or 800 parts per million.

If driving a vehicle with flat-bottom lifters, use engine oil specifically designed for older engines or use an additive, such as General Motors engine oil supplement (EOS), Part number 1052367 or 88862586. Check with camshaft manufacturers for their recommended oil or additive to use.

SYNTHETIC OIL

Synthetic engine oils have been available for years for military, commercial, and general public use. The term *synthetic* means that it is a manufactured product and not refined from a naturally occurring substance, as engine oil (petroleum base) is refined from crude oil. Synthetic oil is processed from several different base stocks using several different methods.

According to the American Petroleum Institute, engine oil is classified into groups as follows.

Group I. Mineral, nonsynthetic, base oil with few if any additives.
This type of oil is suitable for light lubricating needs and rust protection and is not to be used in an engine.
Group II. Mineral oils with quality additive packages.
Most of the conventional engine oils are Group II.
Group III. Hydrogenated (hydroisomerized) synthetic compounds commonly referred to as hydrowaxes or hydrocracked oil.
This is the lowest cost of synthetic engine oils. Castrol Syntec is a Group III oil.
Group IV. Synthetic oils made from mineral oil and monomolecular oil called polyalpholefin or POA.
Mobil 1 is an example of a Group IV synthetic oil. See Figure 14-8.
Group V. Nonmineral sources such as alcohol from corn called diesters or polyolesters.
Red Line synthetic oil is an example of a Group V oil.

Groups III, IV, and V are all considered to be synthetic because the molecular structure of the finished product does not occur naturally and is man-made through chemical processes. All synthetic engine oils perform better than Group II (mineral) oils, especially when tested according to the Noack Volatility Test ASTM D-5800. This test procedure measures the ability of an oil to stay in grade after it has been heated to 300°F (150°C) for one hour. The oil is then measured for percentage of weight loss. As the lighter components boil off, the oil's viscosity will increase. If you start with an SAE 5W oil, it could test as an SAE 15W or even an SAE 20W at the end of the test. It is important that the oil you buy stay in grade for the proper lubrication of your engine.

Some types of synthetic oil are not compatible with other types. Some synthetic oils are mixed with petroleum-based engine oils, but these must be labeled as a *blend*.

The major advantage of using synthetic engine oil is in its ability to remain fluid at very low temperatures. See Figure 14-9.

This characteristic of synthetic oil makes it popular in colder climates where cold-engine cranking is important. The major disadvantage is cost. The cost of synthetic engine oils can be four to five times the cost of petroleum-based engine oils.

FIGURE 14-8 Container of oil with the ILSAC starburst symbol on the front. The tri-synthetic label indicates that it contains Group IV (POA) as well as Group V (diesters) to swell seals, and some Group III (hydrocracked oil).

OIL TEMPERATURE

Excessive temperatures, either too low or too high, are harmful to any engine. If the oil is too cold, it could be too thick to flow through and lubricate all engine parts. If the oil is too hot, it could become too thin to provide the film strength necessary to prevent metal-to-metal contact and wear. Estimated oil temperature can be determined with the following formula:

Estimated oil temperature = Outside air temperature + 120°F

For example,

90°F outside air temperature + 120°F = 210°F estimated oil temperature

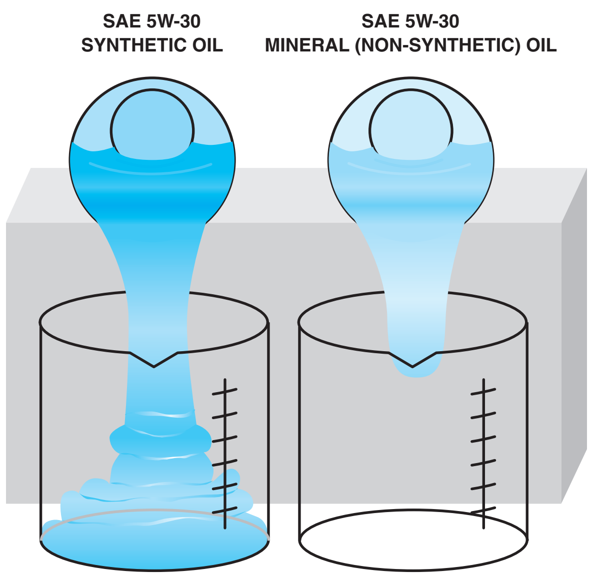


FIGURE 14-9 Both oils have been cooled to −20°F (−29°C). Notice that the synthetic oil on the left flows more freely than the mineral oil on the right even though they are both SAE 5W-30.

TECH TIP

USE SYNTHETIC ENGINE OIL IN LAWN AND GARDEN EQUIPMENT

Most 4-cycle lawn and garden equipment engines are air cooled and operate hotter than many liquid-cooled engines. Lawnmowers and other small engines are often operated near or at maximum speed and power output for hours at a time. These operating conditions are hard on any engine oil. Try using a synthetic oil. The cost is not as big a factor because most small 4-cycle lawnmower engines require only about 1/2 quart (1/2 liter) of oil. The synthetic oil is able to perform under high temperatures better than conventional mineral oils.

TECH TIP

MAKE SURE THE OIL MEETS SPECIFIC VEHICLE SPECIFICATIONS

Some oils can meet the industry specifications, such as SAE, API, and/or ILSAC ratings, but not pass the tests specified by the vehicle manufacturer. The oil used should meet those of the vehicle manufacturer, which include the following:

BMW—Longlife 98 and Longlife-01 (abbreviated LL-01), LL-04

General Motors—GM 6094M, GM 4718M (synthetic oil specification), GM LL-A-25 (gasoline engines), and GM LL-B-25 for GM diesels and vehicles equipped with European-built engines.

Ford—WSS-M2C153-H, WSS-M2C929-A (low viscosity rating—SAE 5W-20), WSS-M2C930-A, WSS-M2C931-A, and WSS-M2C934-A

Chrysler—MS-6395 (2005+ vehicles), MS-10725

Honda—HTO-06

Mercedes—229.3, 229.5, 229.1, 229-31, and 229.51

Volkswagen (VW and Audi)—502.00, 505.00, 505.01, 503, 503.01, 505, 506 diesel, 506.1 diesel, and 507 diesel

TECH TIP

FOLLOW THE SEASONS

Vehicle owners often forget when they last changed the oil. This is particularly true of the person who owns or is responsible for several vehicles. A helpful method for remembering when the oil should be changed is to change the oil at the start of each season of the year.

- Fall (September 21)
- Winter (December 21)
- Spring (March 21)
- Summer (June 21)

Remembering that the oil needs to be changed on these dates helps owners budget for the expense and the time needed.

During hard acceleration (or high-power demand activities such as trailer towing), the oil temperature will quickly increase. Oil temperature should not exceed 300°F (150°C).

OIL CHANGE INTERVALS

All vehicle and engine manufacturers recommend a maximum oil change interval. The recommended intervals are almost always expressed in terms of mileage or elapsed time (or hours of operation), whichever milestone is reached first.

Most vehicle manufacturers recommend an oil change interval of 7,500 to 12,000 miles (12,000 to 19,000 kilometers) or every six months. If, however, *any one* of the conditions in the following list exists, the oil change interval recommendation drops to a more reasonable 2,000 to 3,000 miles (3,000 to 5,000 kilometers) or every three months. The important thing to remember is that these are recommended *maximum* intervals and they should be shortened substantially if any one of the following operating conditions exists.

1. Operating in dusty areas
2. Towing a trailer
3. Short-trip driving, especially during cold weather (The definition of a short trip varies among manufacturers, but it is usually defined as 4 to 15 miles [6 to 24 kilometers] each time the engine is started.)
4. Operating in temperatures below freezing (32°F, 0°C)
5. Operating at idle speed for extended periods of time (such as normally occurs in police or taxi service)

Because most vehicles driven during cold weather are driven on short trips, most technicians and automotive experts recommend changing the oil every 2,000 to 3,000 miles or every two to three months, whichever occurs first.

OIL CHANGE PROCEDURE

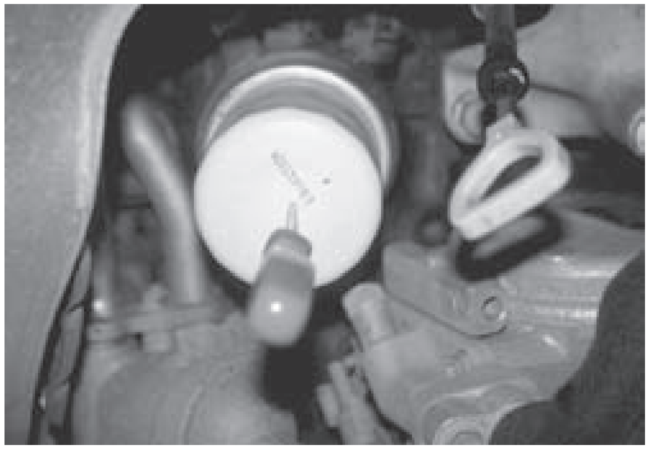
The oil will drain more rapidly from a warm engine than from a cold one. In addition, the contaminants are more likely to be suspended in the oil immediately after running the engine. Position a drain pan under the drain plug; then remove the plug with care to avoid contact with hot oil.

CAUTION: **Used engine oil has been determined to be harmful. Rubber gloves should be worn to protect the skin. If used engine oil gets on the skin, wash thoroughly with soap and water.**

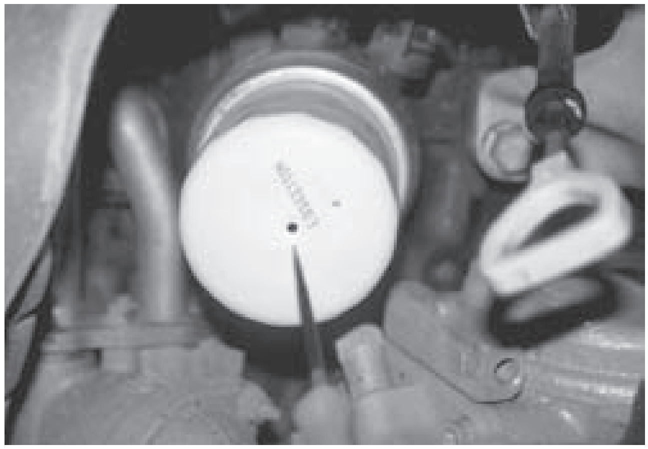
Allow the oil to drain freely so that the contaminants come out with the oil. It is not critically important to get every last drop of oil from the engine oil pan, because a quantity of used oil still remains in the engine oil passages and oil pump. While the engine oil is draining, the oil plug gasket should be examined. If it appears to be damaged, it should be replaced.

NOTE: **Honda/Acura recommends that the oil drain plug gasket be replaced at every oil change on many of their vehicles. The aluminum sealing gasket does not seal once it has been tightened. Always follow the vehicle manufacturer's recommendations.**

When the oil stops running and starts to drip, reinstall and tighten the drain plug. Replace the oil filter if that is to be done during this oil change. Refill the engine with the proper type, grade, and quantity of oil. Restart the engine and allow the engine to idle until it develops oil pressure; then check the engine for leaks, especially at the oil filter.



(a)



(b)

FIGURE 14-10 (a) A pick is pushed through the top of an oil filter that is positioned vertically. (b) When the pick is removed, a small hole allows air to get into the top of the filter which then allows the oil to drain out of the filter and back into the engine.

TECH TIP

THE PICK TRICK

Removing an oil filter that is installed upside down can be a real mess. When this design filter is loosened, oil flows out from around the sealing gasket. To prevent this from happening, use a pick to poke a hole in the top of the filter, as shown in Figure 14-10. This small hole allows air to get into the filter, thereby allowing the oil to drain back into the engine rather than remain in the filter. After punching the hole in the filter, be sure to wait several minutes to allow time for the trapped oil to drain down into the engine before loosening the filter.

TECH TIP

BYPASS FLOW OIL FILTER

Early engines that did have oil filters had them connected to an oil pressure gallery in parallel. This meant that the oil *could,* but did not have to, flow through the filter. Filters in the 1930s through the early 1950s did not have a bypass valve and therefore, if the filter became clogged, the flow of all oil to the engine would stop unless connected in parallel.

The first small block Chevrolet V-8 in 1955 had a bypass-type oil filter. See Figure 14-11.

FIGURE 14-11 This early Chevrolet V-8 has what was an optional oil filter, which is connected to an oil gallery and return oil flows into the oil pan.

FIGURE 14-12 A rubber diaphragm acts as an antidrainback valve to keep the oil in the filter when the engine is stopped and the oil pressure drops to zero.

CAUTION: Always wear protective rubber gloves when changing oil to help protect your hands.

OIL FILTERS

The oil within the engine is pumped from the oil pan through the filter before it goes into the engine lubricating system passages. The filter is made from either closely packed cloth fibers or a porous paper. Large particles are trapped by the filter. Microscopic particles will flow through the filter pores. These particles are so small that they can flow through the bearing oil film and not touch the surfaces, so they do no damage.

Many oil filters are equipped with an **antidrainback valve** that prevents oil from draining out of the filter when the engine is shut off. See Figure 14-12. This valve keeps oil in the filter and allows the engine to receive immediate lubrication as soon as the engine starts.

Either the engine or the filter is provided with a **bypass valve** that will allow the oil to go around the filter element. See Figure 14-13. The bypass allows the engine to be lubricated with dirty oil, rather than having no lubrication, if the filter becomes plugged. The oil also goes through the bypass when the oil is cold and thick. Most engine manufacturers recommend filter changes at every other oil change period. Oil filters should be crushed and/or drained of oil before discarding. See Figure 14-14.

After the oil has been drained, the filter can usually be disposed of as regular metal scrap. Always check and follow local, state, or regional oil filter disposal rules, regulations, and procedures.

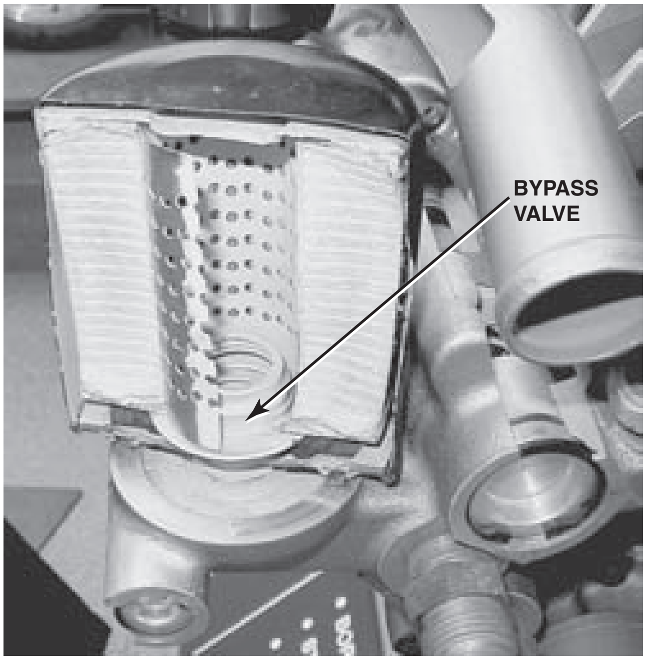


FIGURE 14-13 A cutaway of an oil filter showing the location of a typical bypass valve. When the oil filter becomes clogged, the bypass valve opens, allowing the engine to receive oil even though it is not filtered.

CHANGING OIL IN A TURBOCHARGED ENGINE

One of the most difficult jobs for engine oil is to lubricate the extremely hot bearings of a turbocharger. After a turbocharger

FIGURE 14-14 A typical oil filter crusher. The hydraulic ram forces out most of the oil from the filter. The oil is trapped underneath the crusher and is recycled.

FREQUENTLY ASKED QUESTION

WHY CHANGE OIL IF THE OIL FILTER CAN TRAP ALL THE DIRT?

Many people believe that oil filters will remove all dirt from the oil being circulated through the filtering material. Most oil filters will filter particles that are about 10 to 20 microns in size. A micron is one-millionth of a meter or 0.000039 inch. Most dirt and carbon particles that turn engine oil black are less than a micron in size. In other words, it takes about 3 million of these carbon particles to cover a pinhead. To help visualize the smallness of a micron, consider that a typical human hair is 60 microns in diameter. In fact, anything smaller than 40 microns is not visible to the human eye.

The dispersants added to engine oil prevent dirt from adhering together to form sludge. It is the same dispersant additive that prevents dirt from being filtered or removed by other means. If an oil filter could filter particles down to one micron, it would be so restrictive that the engine would not receive sufficient oil through the filter for lubrication. Oil recycling companies use special chemicals to break down the dispersants, which permit the dirt in the oil to combine into larger units that can be filtered or processed out of the oil.

has been in operation, it is always wise to let the engine idle for about a minute to allow the turbocharger to slow down before shutting off the engine. This allows the turbo to keep receiving oil from the engine while it is still revolving fast.

TECH TIP

EVERY FRIDAY?

A vehicle less than one year old came back to the dealer for some repair work. While writing the repair order, the service advisor noted that the vehicle had 88,000 miles on the odometer and was, therefore, out of warranty for the repair. Because the owner approved the repair anyway, the service advisor asked how he had accumulated so many miles in such a short time. The owner said that he was a traveling salesperson with a territory of "east of the Mississippi River."

Because the vehicle looked to be in new condition, the technician asked the salesperson how often he had the oil changed. The salesperson smiled and said proudly, "Every Friday."

Many fleet vehicles put on over 2,000 miles per week. How about changing their oil every week instead of by mileage?

However, just as with any engine, the greatest amount of wear occurs during start-up, especially following an oil change when the oil has been drained from the engine. Some technicians fill the new oil filter with new oil prior to installation to help the engine receive oil as rapidly as possible after starting.

A number of vehicle manufacturers also suggest that turbo-equipped engines be "primed" before starting. This means that the engine should be rotated without ignition so that it does not start, to allow the oil pump to pump oil to the bearings of the turbocharger before the engine starts.

On older vehicles, it is a simple process to disconnect the ignition coil wire from the distributor cap and ground it to prevent coil damage. After the ignition has been disconnected in this manner, simply crank the engine for 15 seconds. Some manufacturers recommend repeating the 15 seconds of cranking after a 30-second period to allow the starter motor to cool.

There is one simple method that works on many fuel-injected vehicles. If the accelerator pedal is held down to the floor during cranking, then the engine computer senses the throttle position and reduces the amount of fuel injected into the engine. This mode of operation is often called the *clear-flood mode,* and during it, the computer limits the fuel delivery to such an extent that the engine should not start.

Therefore, to prime most late-model turbocharged engines, simply depress the accelerator to the floor and crank for 15 seconds. To start the engine, simply return the accelerator pedal to the idle position and crank the engine.

FREQUENTLY ASKED QUESTION

HOW DOES THE OIL LIFE MONITOR WORK?

Most vehicles built since 1990 have had some sort of oil change or maintenance reminder system. These systems vary greatly and can be grouped according to the following types:

1. **Mileage Only Method.** The maintenance reminder light comes on or flashes at a predetermined mileage interval, usually every 3,000 miles to 7,500 miles depending on the vehicle.
2. **Algorithm Method.** Used by General Motors, this method uses mathematical formulas that use engine coolant temperature, engine run time, speed, and load to calculate how harmful each is to the oil and deducts a percentage from 100 until the oil life monitor reaches 10%, and then it turns on a change oil light.
3. **Capacitance Method.** A capacitor consists of two metal plates with an insulator called a dielectric in the center. The oil is the dielectric and the physical qualities of the oil affect the ability of the capacitor to charge and discharge. Changes to the oil that change the dielectric include water, acids, coolant, and wear metals.

After an oil change, the oil life monitor should be reset. See service information for details.

OIL PUMPS

All production automobile engines have a full-pressure oil system. The pressure is maintained by an oil pump. The oil is forced into the lubrication system under pressure. In most engines that use a distributor, the distributor drive gear meshes with a gear on the camshaft, as shown in Figure 14-15.

The oil pump is driven from the end of the distributor shaft, often with a hexagon-shaped shaft. Some engines have a short shaft gear that meshes with the cam gear to drive both the distributor and oil pump. With these drive methods, the pump turns at one-half engine speed. In other engines, the oil pump is driven by the front of the crankshaft, in a setup similar to that of an automatic transmission pump, so that it turns at the same speed as the crankshaft. Examples of a crankshaft-driven oil pump are shown in Figures 14-16 and 14-17.

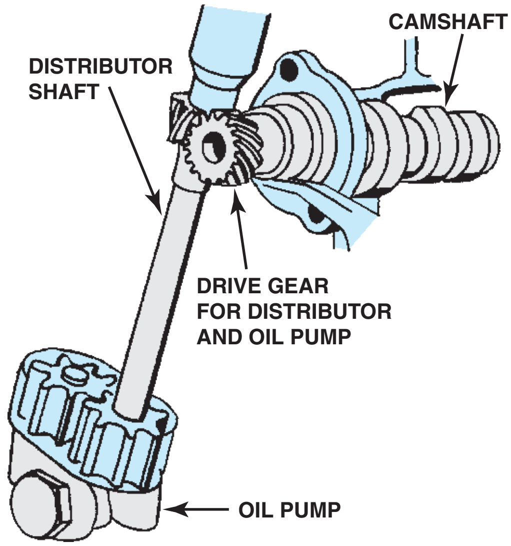


FIGURE 14-15 An oil pump driven by the camshaft.

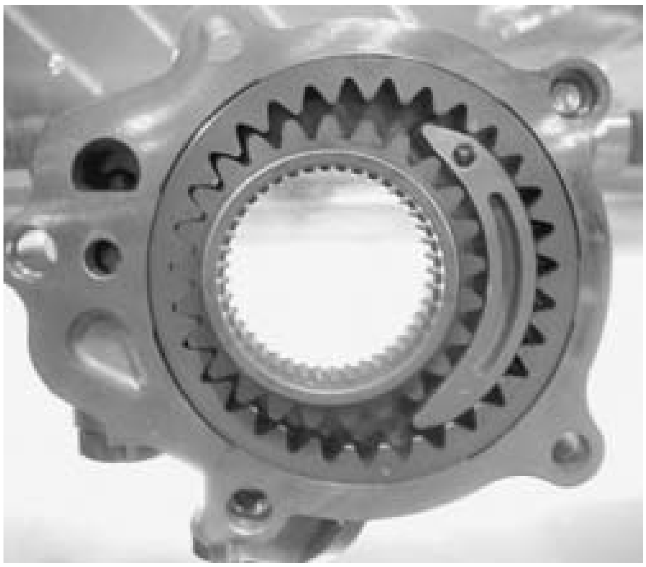


FIGURE 14-16 A typical oil pump mounted in the front cover of the engine that is driven by the crankshaft.

Most automotive engines use one of two types of oil pumps: **gear** or **rotor.** All oil pumps are called **positive displacement pumps,** and each rotation of the pump delivers the same volume of oil; thus, everything that enters must exit. The gear-type oil pump consists of two spur gears in a close-fitting housing—one gear is driven while the other idles. As the gear teeth come out of mesh, they tend to leave a space, which is filled by oil drawn through the pump inlet. When the pump is pumping, oil is carried around the *outside* of each gear in the space between the gear teeth and the housing, as shown in Figure 14-18.

As the teeth mesh in the center, oil is forced from the teeth into an oil passage, thus producing oil pressure. The rotor-type

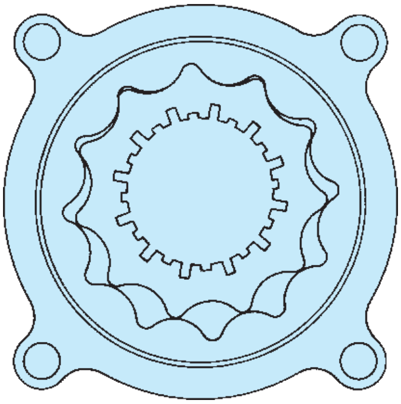


FIGURE 14-17 Geroter-type oil pump driven by the crankshaft.

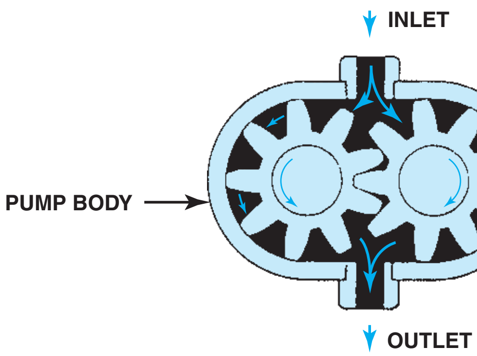


FIGURE 14-18 In a gear-type oil pump, the oil flows through the pump around the outside of each gear. This is an example of a positive displacement pump, wherein everything entering the pump must leave the pump.

oil pump consists essentially of a special lobe-shape gear meshing with the inside of a lobed rotor. The center lobed section is driven and the outer section idles. As the lobes separate, oil is drawn in just as it is drawn into gear-type pumps. As the pump rotates, it carries oil around and between the lobes. As the lobes mesh, they force the oil out from between them under pressure in the same manner as the gear-type pump. The pump is sized so that it will maintain a pressure of at least 10 PSI (70 kPa) in the oil gallery when the engine is hot and idling. Pressure will increase by about 10 PSI for each 1000 RPM as the engine speed increases, because the engine-driven pump also rotates faster.

OIL PRESSURE REGULATION

In engines with a full-pressure lubricating system, maximum pressure is limited with a pressure relief valve. The relief valve (sometimes called the **pressure regulating valve**) is located at the outlet of the pump. The relief valve controls maximum pressure by bleeding off oil to the inlet side of the pump. See Figure 14-19.

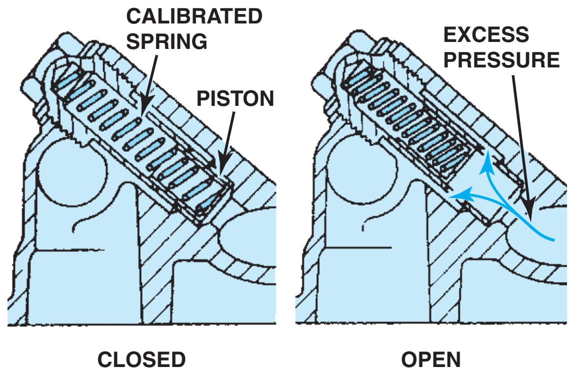


FIGURE 14-19 Oil pressure relief valves are spring loaded. The stronger the spring tension, the higher the oil pressure.

The relief valve spring tension determines the maximum oil pressure. If a pressure relief valve is not used, the engine oil pressure will continue to increase as the engine speed increases. Maximum pressure is usually limited to the lowest pressure that will deliver enough lubricating oil to all engine parts that need to be lubricated. *Between 3 to 6 gallons per minute are required to lubricate the engine.* See Figure 14-20.

The oil pump is made so that it is large enough to provide pressure at low engine speeds and small enough that it will not cavitate at high speed. **Cavitation** occurs when the pump tries to pull oil faster than it can flow from the pan to the pickup. When it cannot get enough oil, it will pull air. This puts air pockets or cavities in the oil stream. A pump is cavitating when it is pulling air or vapors.

NOTE: **The reason for sheet-metal covers over the pickup screen is to prevent cavitation. Oil is trapped under the cover, which helps prevent the oil pump from drawing in air, especially during sudden stops or during rapid acceleration.**

After the oil leaves the pump, it is delivered to the moving parts through drilled oil passages. See Figure 14-21 on page 221. It needs no pressure after it reaches the parts that are to be lubricated. The oil film between the parts is developed and maintained by hydrodynamic lubrication. Excessive oil pressure requires more horsepower and provides no better lubrication than the minimum effective pressure.

FACTORS AFFECTING OIL PRESSURE

Oil pressure can only be produced when the oil pump has a capacity larger than all the "leaks" in the engine. The leaks are the clearances at end points of the lubrication system. The end points are at the edges of bearings, the rocker arms, the connecting rod

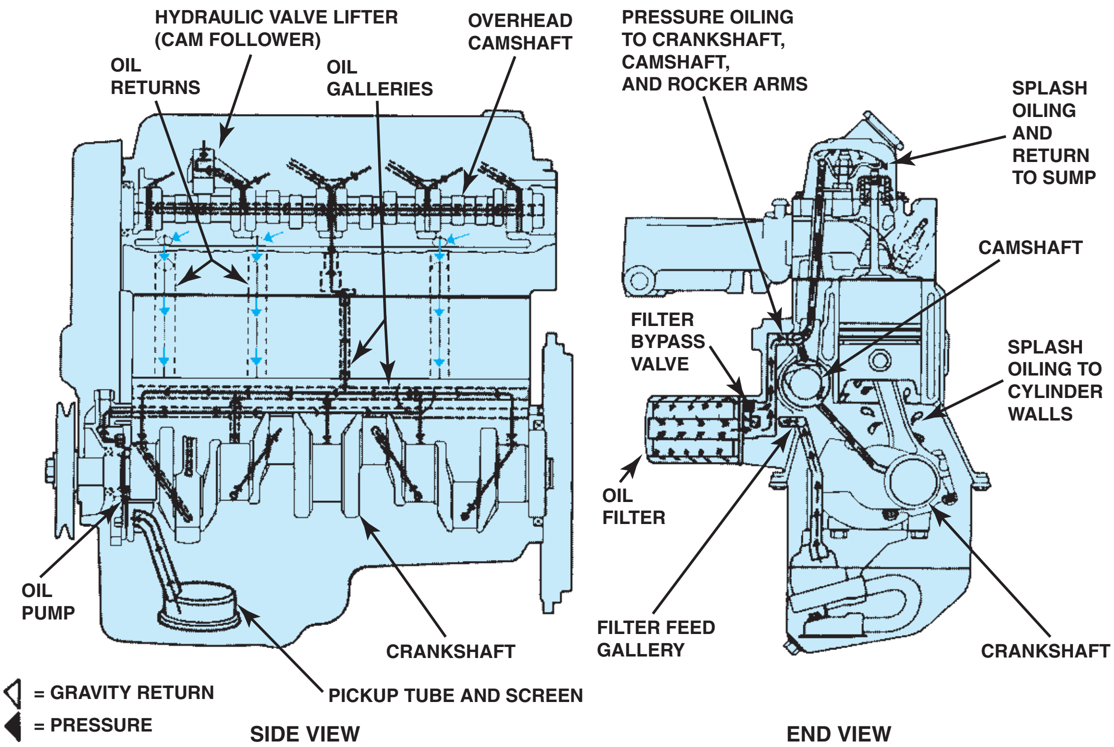


FIGURE 14-20 A typical engine design that uses both pressure and splash lubrication. Oil travels under pressure through the galleries (passages) to reach the top of the engine. Other parts are lubricated as the oil flows back down into the oil pan or is splashed onto parts.

spit holes, and so on. These clearances are designed into the engine and are necessary for its proper operation. As the engine parts wear and clearance becomes greater, more oil will leak out. The oil pump *capacity* must be great enough to supply extra oil for these leaks. The capacity of the oil pump results from its size, rotating speed, and physical condition. If the pump is rotating slowly as the engine is idling, oil pump capacity is low. *If the leaks are greater than the pump capacity, engine oil pressure is low.* As the engine speed increases, the pump capacity increases and the pump tries to force more oil out of the leaks. This causes the pressure to rise until it reaches the regulated maximum pressure.

The viscosity of the engine oil affects both the pump capacity and the oil leakage. Thin oil or oil of very low viscosity slips past the edges of the pump and flows freely from the leaks. Hot oil has a low viscosity, and therefore, a hot engine often has low oil pressure. Cold oil is more viscous (thicker) than hot oil. This results in higher pressures, even with the cold engine idling. High oil pressure occurs with a cold engine, because the oil relief valve must open further to release excess oil than is necessary with a hot engine. This larger opening increases the spring compression force, which in turn increases the oil pressure. Putting higher-viscosity oil in an engine will raise the engine oil pressure to the regulated setting of the relief valve at a lower engine speed.

OIL PUMP CHECKS

The cover is removed to check the condition of the oil pump. The gears and housing are examined for scoring. If the gears and housing are heavily scored, the entire pump should be replaced. If they are lightly scored, the clearances in the pump should be measured. These clearances include the space between the gears and housing, the space between the teeth of the two gears, and the space between the side of the gear and the pump cover. A feeler gauge is often used to make these measurements. Gauging plastic can be used to measure the space between the side of the gears and the cover. The oil pump should be replaced when excessive clearance or scoring is found. See Figure 14-22 on page 222.

On most engines, the oil pump should be replaced as part of any engine work, especially if the cause for the repair is lack of lubrication.

NOTE: The oil pump is the "garbage pit" of the entire engine. Any and all debris is often forced through the gears and housing of an oil pump. See Figure 14-23 on page 222.

See Figures 14-24 and 14-25 on page 223 for examples of oil pump clearance checks.

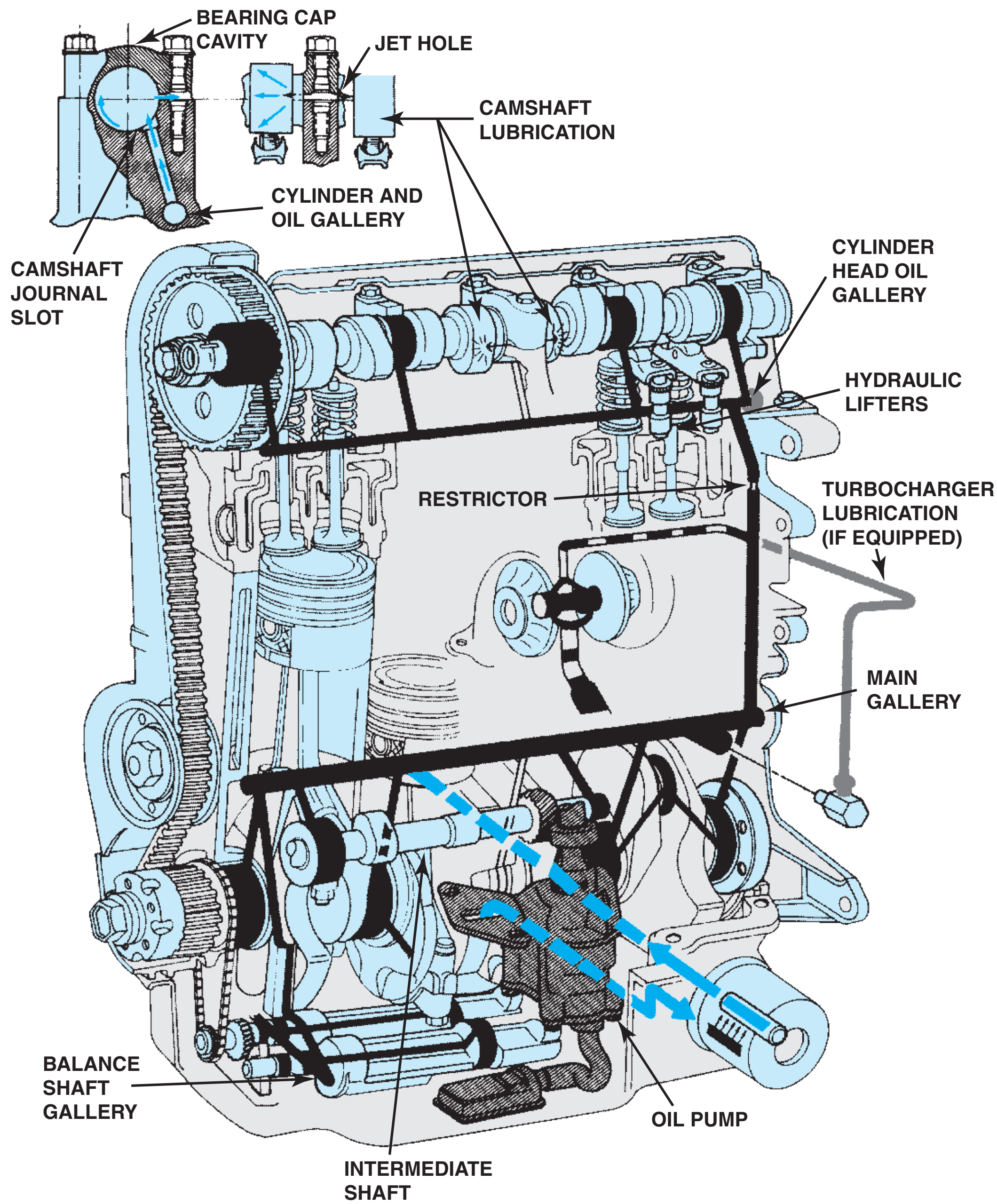


FIGURE 14-21 An intermediate shaft drives the oil pump on this overhead camshaft engine. Note the main gallery and other drilled passages in the block and cylinder head.

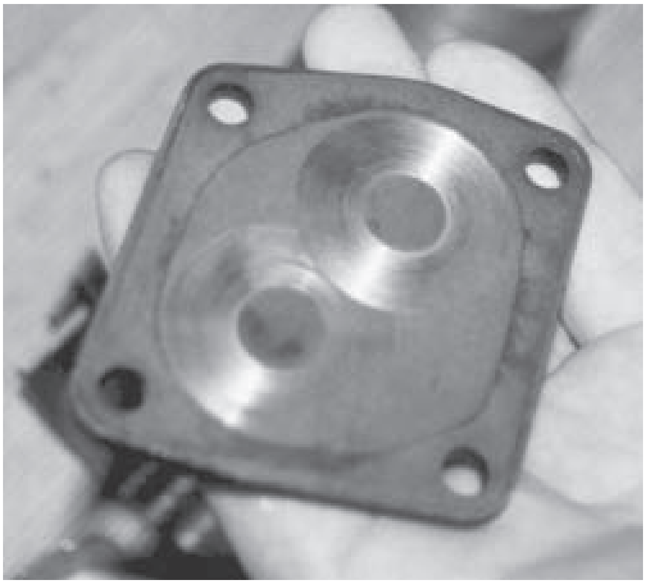
Always refer to the manufacturer's specifications when checking the oil pump for wear. Typical oil pump clearances include the following:

1. End plate clearance: 0.0015 inch (0.04 millimeter)
2. Side (rotor) clearance: 0.012 inch (0.30 millimeter)
3. Rotor tip clearance: 0.010 inch (0.25 millimeter)
4. Gear end play clearance: 0.004 inch (0.10 millimeter)

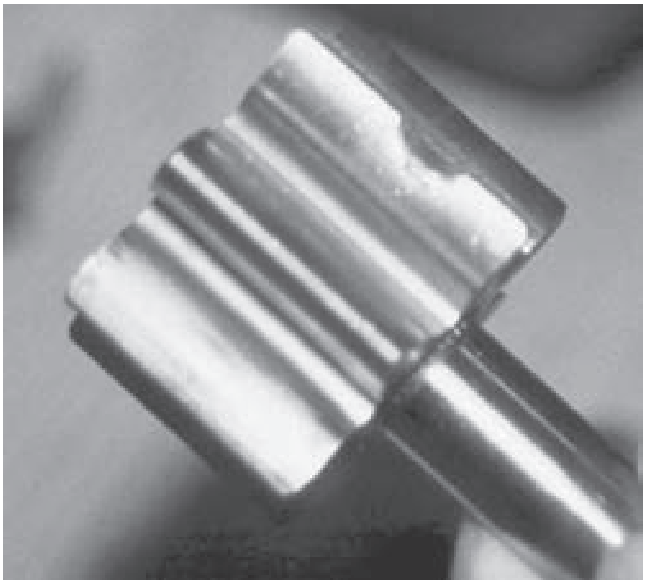
All parts should also be inspected closely for wear. Check the relief valve for scoring and check the condition of the spring. When installing the oil pump, coat the sealing surfaces with engine assembly lubricant. This lubricant helps draw oil from the oil pan on initial start-up.

OIL PASSAGES IN THE BLOCK

From the filter, oil goes through a drilled hole that intersects with a drilled main oil **gallery** or longitudinal header. This



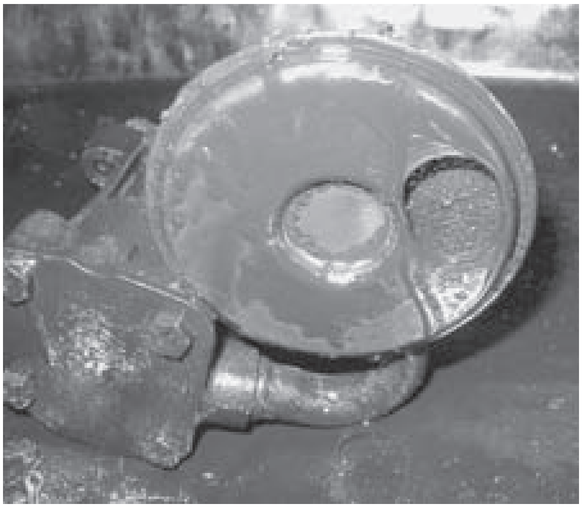
(a)



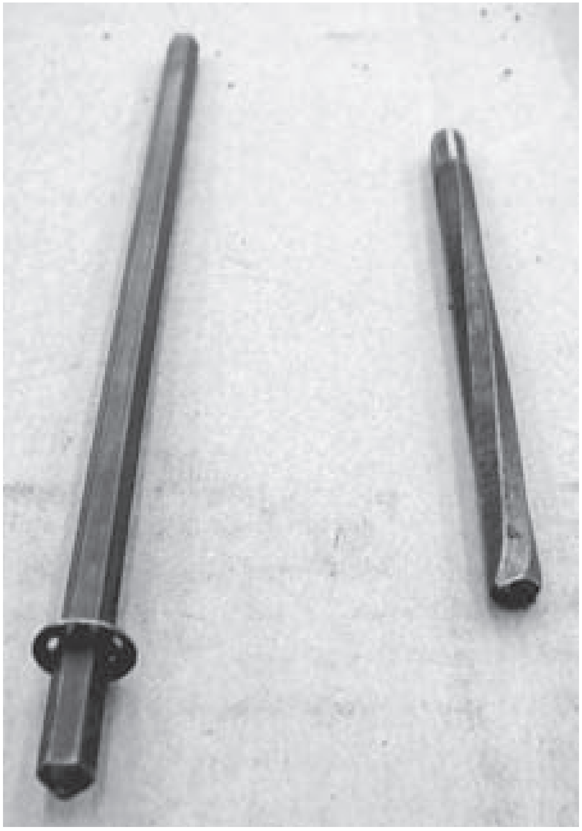
(b)

FIGURE 14-22 (a) A visual inspection indicated that this pump cover was worn. (b) An embedded particle of something was found on one of the gears, making this pump worthless except for scrap metal.

is a long hole drilled from the front of the block to the back. Inline engines use one oil gallery; V-type engines may use two or three galleries. Passages drilled through the block bulkheads allow the oil to go from the main oil gallery to the main and cam bearings. See Figure 14-26 on page 224. In some engines, oil goes to the cam bearings first, and then to the main bearings.



(a)



(b)

FIGURE 14-23 (a) The oil pump is the only part in an engine that gets unfiltered engine oil. The oil is drawn up from the bottom of the oil pan and is pressurized before flowing to the oil filter. (b) If debris gets into an oil pump, the drive or distributor shaft can twist and/or break. When this occurs the engine will lose all oil pressure.

FIGURE 14-24 Gear-type oil pump being checked for tooth clearance in the housing.

FIGURE 14-25 Measuring the gear-to-cover clearance of an oil pump.

It is important that the oil holes in the bearings match with the drilled passages in the bearing saddles so that the bearing can be properly lubricated. Over a long period of use, bearings will wear. This wear causes excess clearance. The excess clearance will allow too much oil to leak from the side of the bearing. When this happens, there will be little or no oil left for bearings located farther downstream in the lubricating system. This is a major cause of bearing failure. If a new bearing were installed in place of the oil-starved bearing, it, too, would fail unless the bearing having the excess clearance was also replaced.

VALVE TRAIN LUBRICATION

The oil gallery may intersect or have drilled passages to the valve lifter bores to lubricate the lifters. When hydraulic lifters are used, the oil pressure in the gallery keeps refilling them. On some engines, oil from the lifters goes up the center of a hollow pushrod to lubricate the pushrod ends, the rocker arm pivot, and the valve stem tip. In other engines, an oil passage is drilled from either the gallery or a cam bearing to the block deck, where it matches with a gasket hole and a hole drilled in the head to carry the oil to a rocker arm shaft. Some engines use an enlarged bolt hole to carry lubrication oil around the rocker shaft cap screw to the rocker arm shaft. This design is shown by a line drawing in Figure 14-27 on page 225.

Holes in the bottom of the rocker arm shaft allow lubrication of the rocker arm pivot. Mechanical loads on the valve train hold the rocker arm against the passage in the rocker arm shaft, as shown in Figure 14-28 on page 225. This prevents excessive oil leakage from the rocker arm shaft. Often, holes are drilled in cast rocker arms to carry oil to the pushrod end and to the valve tip. Rocker arm assemblies need only a surface coating of oil, so the oil flow to the rocker assembly is minimized using restrictions or metered openings. The restriction or metering disk is in the lifter when the rocker assembly is lubricated through the pushrod. Cam journal holes that line up with oil passages are often used to meter oil to the rocker shafts.

Oil that seeps from the rocker assemblies is returned to the oil pan through drain holes. These oil drain holes are often placed so that the oil drains on the camshaft or cam drive gears to lubricate them.

Some engines have means of directing a positive oil flow to the cam drive gears or chain. This may be a nozzle or a chamfer on a bearing parting surface that allows oil to spray on the loaded portion of the cam drive mechanism.

OIL PANS

As the vehicle accelerates, brakes, or turns rapidly, the oil tends to move around in the pan. Pan baffles and oil pan shapes are often used to keep the oil inlet under the oil at all times. As the crankshaft rotates, it acts like a fan and causes air within the crankcase to rotate with it. This can cause a strong draft on the oil, churning it so that air bubbles enter the oil, which then causes oil foaming. Oil with air will not lubricate like liquid oil, so oil foaming can cause bearings to fail. A baffle or **windage tray** is sometimes installed in engines to eliminate the oil churning problem. This may be an added part, as shown in Figure 14-29 on page 225, or it may be a part of the oil pan.

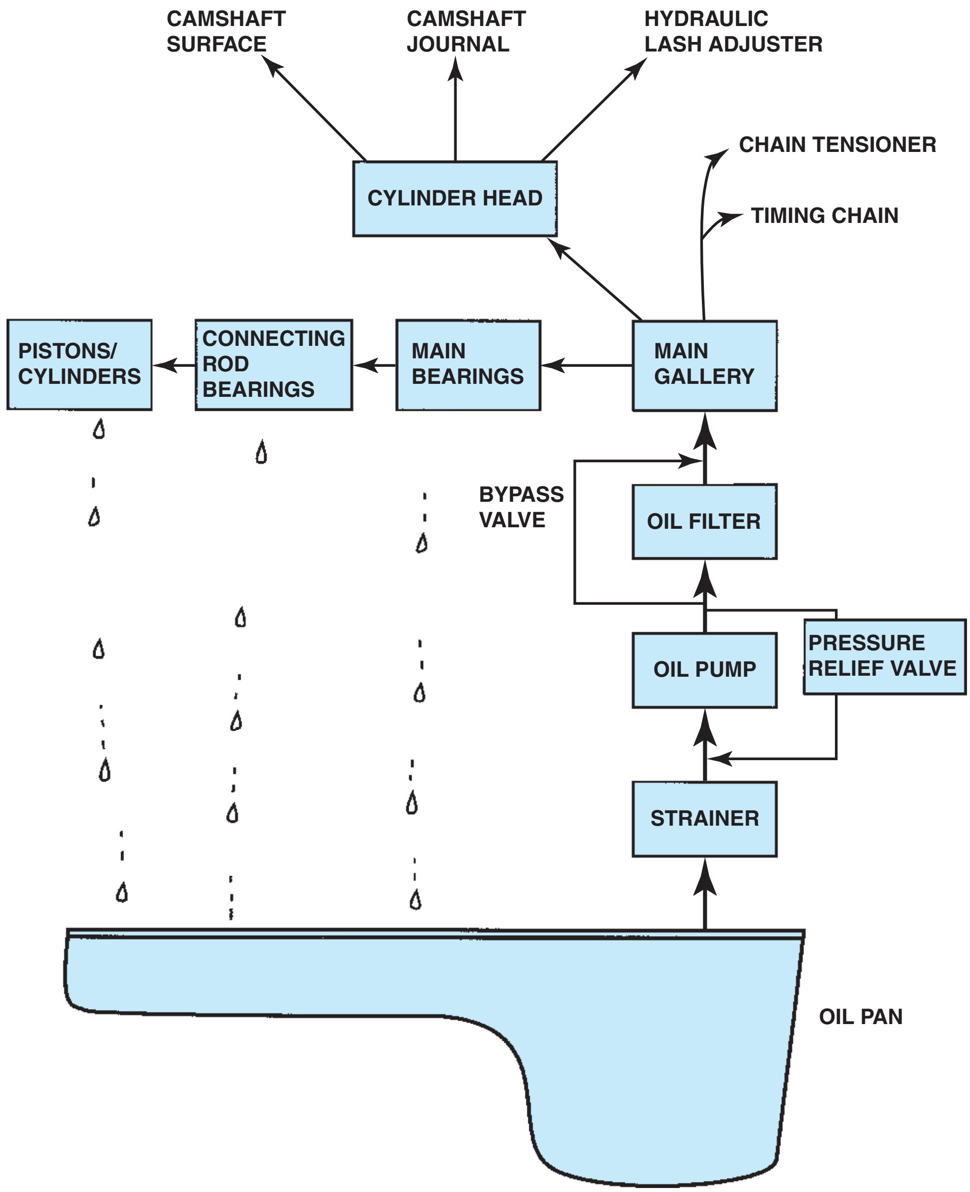


FIGURE 14-26 Oil flow through an engine starts at the oil pump pickup and eventually ends up with the oil dropping back into the oil pan.

Windage trays have the good side effect of reducing the amount of air disturbed by the crankshaft, so that less power is drained from the engine at high crankshaft speeds.

DRY SUMP SYSTEM

Construction and Operation

The term *sump* is used to describe a location where oil is stored or held. Another name for a sump is the oil pan. In most engines, oil is held in the oil pan and the oil pump drains the oil from the bottom. This type of system is called a **wet sump** oil system. In a **dry sump** system, the oil pan is shallow and the oil is pumped into a remote reservoir. In this reservoir, the oil is cooled and any trapped air is allowed to escape before being pumped back to the engine.

Advantages

The advantages of a dry sump system include:

1. A shallow oil pan, which allows the engine to be mounted lower in the vehicle to improve cornering.
2. The oil capacity can be greatly expanded because the size of the reservoir is not limited. A larger quantity of oil means that the oil temperature can be controlled.

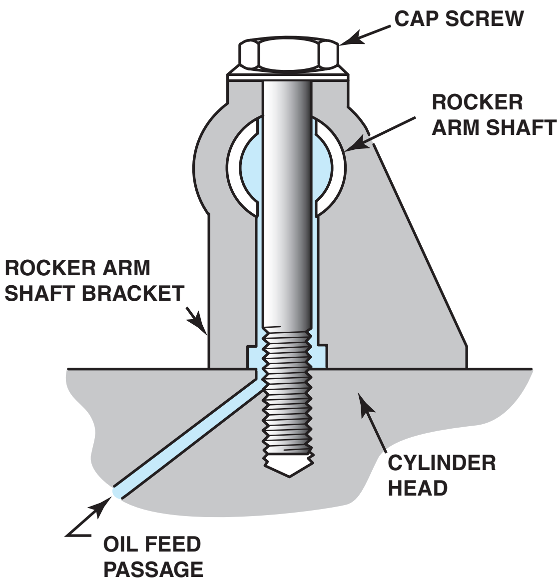


FIGURE 14-27 Clearance around the rocker shaft bracket cap screw makes a passage for oil to get into the rocker shaft. (*Courtesy of Dana Corporation*)

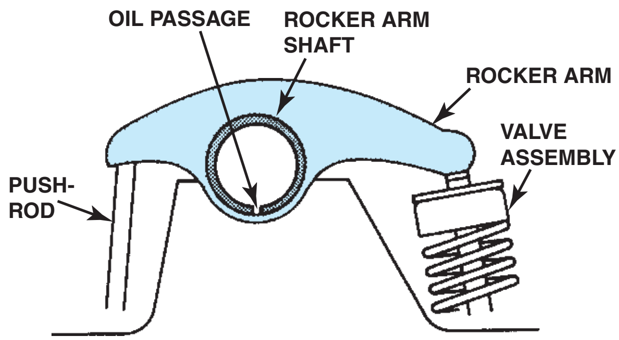


FIGURE 14-28 The rocker arm pivot is lubricated through the oil passage in the bottom of the rocker shaft. Other rocker arm styles are usually lubricated through a hollow pushrod.

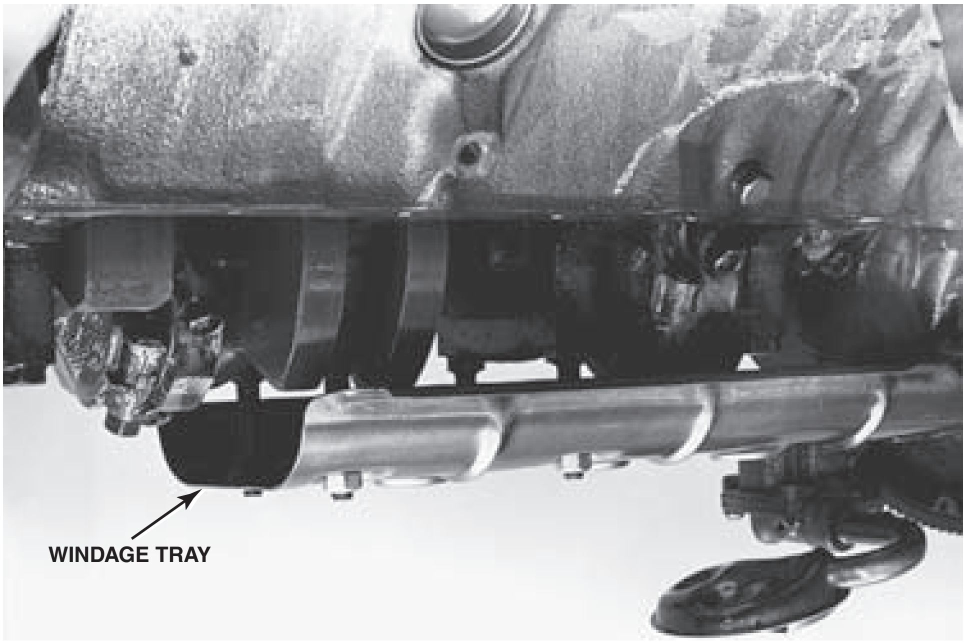


FIGURE 14-29 Windage tray attached between the crankshaft and the oil pan.

3. A dry sump system allows the vehicle to corner and brake for long periods, which is not able to be done with a wet sump system due to the oil being thrown to one side and away from the oil pickup.
4. A dry sump system also allows the engine to develop more power as the oil is kept away from the moving crankshaft.

Disadvantages

A dry sump system does have some disadvantages including:

1. A dry sump system is expensive as it requires components and plumbing not needed in a wet sump system.

2. A dry sump system is complex because the plumbing and connections, plus the extra components, result in more places where oil leaks can occur and change the way routine maintenance is handled.

A dry sump oil system is used in most motor sport vehicles and is standard on some high-performance production vehicles, such as some models of the Chevrolet Corvette, Porsche, and BMW. See Figure 14-30.

OIL COOLERS

Oil temperature must also be controlled on many high-performance or turbocharged engines. See Figure 14-31 for an example of an engine oil cooler used on a production high-performance engine.

A larger-capacity oil pan also helps to control oil temperature. Coolant flows through the oil cooler to help warm the oil when the engine is cold and cool the oil when the engine is hot. Oil temperature should be above 212°F (100°C) to boil off any accumulated moisture, but it should not exceed about 280° to 300°F (138° to 148°C).

FREQUENTLY ASKED QUESTION

WHY IS IT CALLED A WINDAGE TRAY?

A windage tray is a plate or baffle installed under the crankshaft and is used to help prevent aeration of the oil. Where does the wind come from? Pistons push air down into the crankcase as they move from top dead center to bottom dead center. The pistons also draw air and oil upward when moving from bottom dead center to top dead center. At high engine speeds, this causes a great deal of airflow, which can easily aerate the oil. Therefore, a windage tray is used to help prevent this movement of air (wind) from affecting the oil in the pan. Try this: take an oil pan and add a few quarts (liters) of oil. Then take an electric hair dryer and use it to blow air into the oil pan. Oil will be thrown everywhere, which really helps illustrate why windage trays are used in all newer engines.

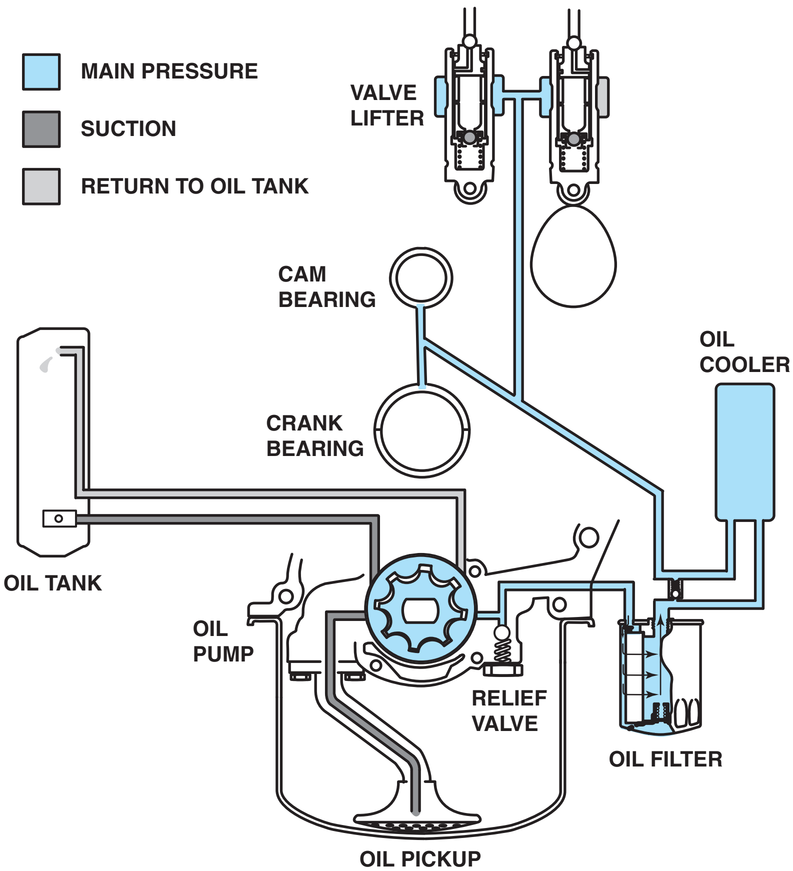


FIGURE 14-30 A dry sump system that is used on the Chevrolet Corvette.

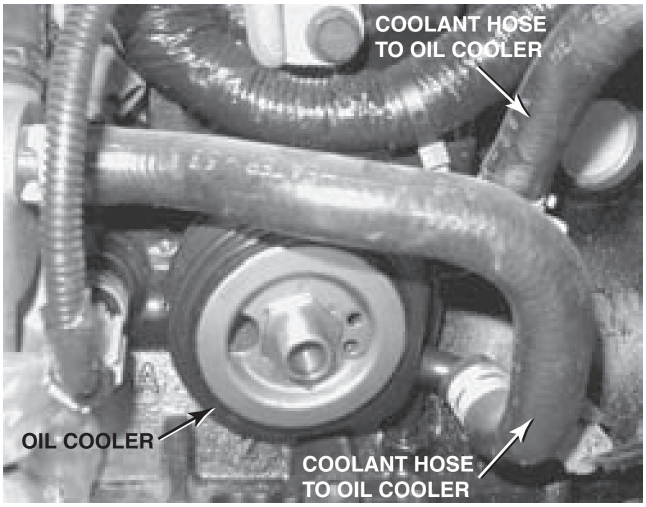


FIGURE 14-31 Typical engine oil cooler. Engine oil is cooled by passing coolant from the radiator through the auxiliary housing. The oil filter screws to the cooler.

FREQUENTLY ASKED QUESTION

WHAT IS ACCEPTABLE OIL CONSUMPTION?

There are a number of opinions regarding what is acceptable oil consumption. Most vehicle owners do not want their engine to use *any* oil between oil changes even if they do not change it more often than every 7,500 miles (12,000 kilometers)! Engineers have improved machining operations and piston ring designs to help eliminate oil consumption.

Many stationary or industrial engines are not driven on the road; therefore, they do not accumulate miles, yet they still may consume excessive oil.

A general rule for "acceptable" oil consumption is that it should be about 0.002 to 0.004 pounds per horsepower per hour. To figure, use the following:

$$\frac{1.82 \times \text{quarts used}}{\text{Operating hp} \times \text{total hours}} = \text{lb/hp/hr}$$

Therefore, oil consumption is based on the amount of work an engine performs. Although the formula may not be usable for vehicle engines used for daily transportation, it may be usable by the marine or industrial engine builder. Generally, oil consumption that is greater than 1 quart for every 600 miles (1,000 kilometers per liter) is considered to be excessive with a motor vehicle.

OIL PRESSURE WARNING LAMP

All vehicles are equipped with an oil pressure gauge or a warning lamp. The warning lamp comes on whenever the engine oil pressure has dropped to 3 to 7 PSI. Normal oil pressure is considered to be 10 PSI per 1000 RPM. An electrical switch is used to convert the ground circuit of the oil pressure warning lamp if the oil pressure is below the rating of the sending unit. See Figures 14-32 and 14-33.

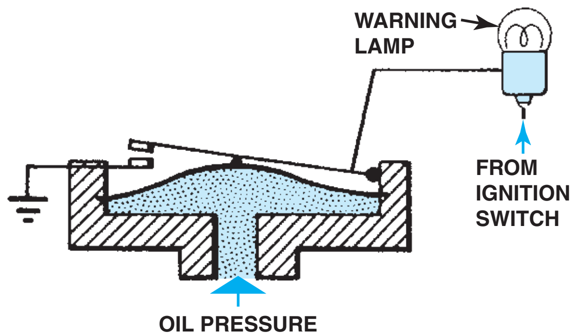


FIGURE 14-32 The oil pressure switch is connected to a warning lamp that alerts the driver of low oil pressure.

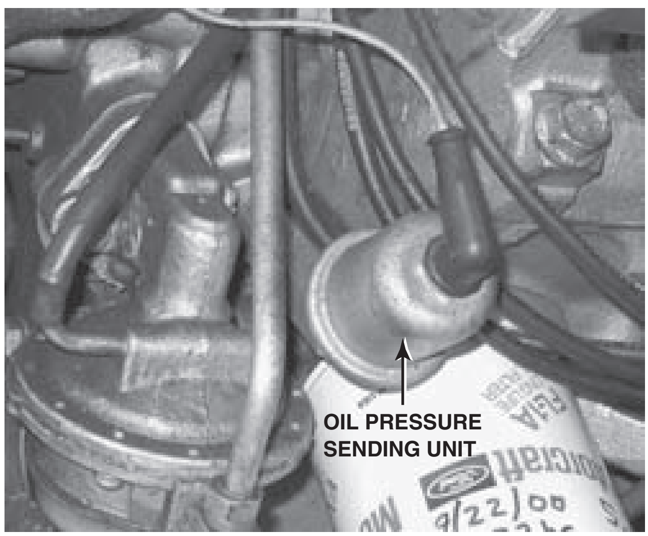


FIGURE 14-33 A typical oil pressure sending unit on a Ford V-8.

SUMMARY

1. Viscosity is the oil's thickness or resistance to flow.
2. Normal engine oil pump pressure ranges from 10 to 60 PSI (200 to 400 kPa) or 10 PSI for every 1000 engine RPM.
3. Hydrodynamic oil pressure around engine bearings is usually over 1,000 PSI (6,900 kPa).
4. Most vehicle manufacturers recommend use of SAE 5W-30 or SAE 10W-30 engine oil.
5. Most vehicle manufacturers recommend changing the engine oil every six months or every 7,500 miles (12,000 kilometers), whichever comes first. Most experts recommend changing the engine oil every 3,000 miles (5,000 kilometers), or every three months, to help ensure long engine life.
6. The oil pump is driven directly by the crankshaft or by a gear or shaft from the camshaft.

REVIEW QUESTIONS

1. What causes a wedge-shaped film to form in the oil?
2. What is hydrodynamic lubrication?
3. What is meant by the label "Energy Conserving"?
4. Explain why the oil filter is bypassed when the engine oil is cold and thick.
5. Explain why internal engine leakage affects oil pressure.
6. Explain the operation of the bypass valve located in the oil filter or oil filter adapter.
7. Describe how the oil flows from the oil pump, through the filter and main engine bearings, to the valve train.
8. What is the purpose of a windage tray?

CHAPTER QUIZ

1. Normal oil pump pressure in an engine is _____.
   a. 3 to 7 PSI
   b. 10 to 60 PSI
   c. 100 to 150 PSI
   d. 180 to 210 PSI
2. Oil change intervals as specified by the vehicle manufacturer _____.
   a. Are *maximum* time and mileage intervals
   b. Are *minimum* time and mileage intervals
   c. Only include miles driven between oil changes
   d. Generally only include time between oil changes
3. An SAE 10W-30 engine oil is _____.
   a. An SAE oil 10 with VI additives
   b. An SAE oil 20 with VI additives
   c. An SAE oil 30 with VI additives
   d. An SAE oil 30 with detergent additives
4. As engine oil is used in an engine _____.
   a. It becomes thinner as a result of chemical breakdown that occurs with age
   b. It becomes thicker because of oxidation, wear metals, and combustion by-products
   c. It becomes thicker because of temperature changes
   d. It becomes thinner because of oxidation, wear metals, and combustion by-products
5. Technician A says that the engine oil used should meet the vehicle manufacturer's standards. Technician B says that any engine oil of the correct API, SAE, and ILSAC ratings can be used. 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 some vehicle manufacturers recommend an ACEA grade be used in the engine. Technician B says that an oil with the specified API rating *and* SAE viscosity rating should be used in an 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

7. Two technicians are discussing oil filters. Technician A says that the oil will remain perfectly clean if just the oil filter is changed regularly. Technician B says that oil filters can filter particles smaller than the human eye can see. Which technician is correct?
   - a. Technician A only
   - b. Technician B only
   - c. Both Technicians A and B
   - d. Neither Technician A nor B

8. Turbocharged engines have special engine oil needs, such as _____.
   - a. Strict oil change intervals should be observed
   - b. Oil of the proper API and SAE ratings should be used
   - c. The turbocharger should be primed by cranking the engine before starting
   - d. All of the above

9. A typical oil pump can pump how many gallons per minute?
   - a. 3 to 6 gallons
   - b. 6 to 10 gallons
   - c. 10 to 60 gallons
   - d. 50 to 100 gallons

10. In typical engine lubrication systems, what components are the last to receive oil and the first to suffer from a lack of oil or oil pressure?
   - a. Main bearings
   - b. Rod bearings
   - c. Valve trains
   - d. Oil filters