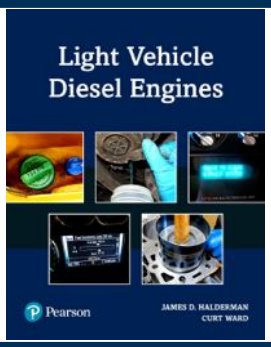
Light Vehicle Diesel Engines

First Edition



Chapter 4
Diesel Engine Lubrication Systems

LEARNING OBJECTIVES (1 of 2)

- **4.1** Prepare for the Light Vehicle Diesel Engine (A9) ASE certification test content area "D" (Lubrication and Cooling Systems Diagnosis and Repair).
- **4.2** Describe the operation of oil pumps.
- **4.3** Discuss the purpose and function of oil coolers.
- **4.4** Explain the purpose of engine oil and engine oil additives.

LEARNING OBJECTIVES (2 of 2)

- **4.4** Discuss the properties of engine oil.
- **4.5** Discuss SAE and API rating oil ratings.
- **4.6** Discuss the purpose and function of oil filters.
- **4.7** Describe the oil change procedure.

LUBRICATING PRINCIPLES (1 of 3)

- Lubrication between 2 moving surfaces results from an oil film that separates surfaces and supports load

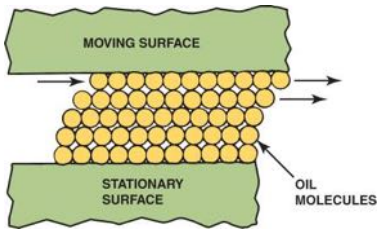


Figure 4–1

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Figure 4–1 Oil molecules cling to metal surfaces but easily slide against each other

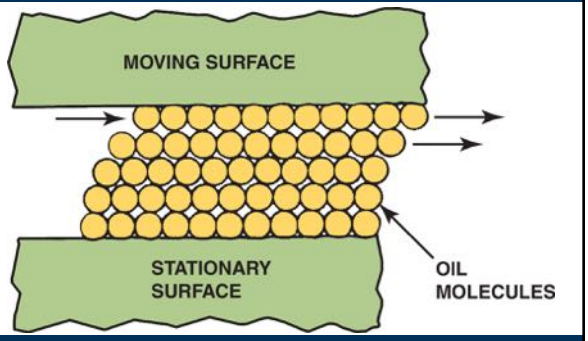

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Figure 4–2 Wedge-shaped oil film developed below a moving block.

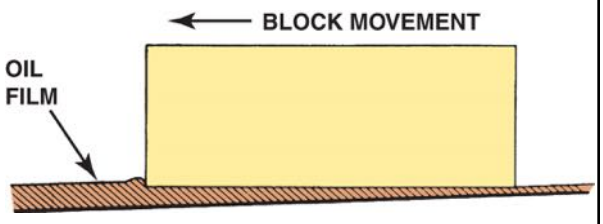

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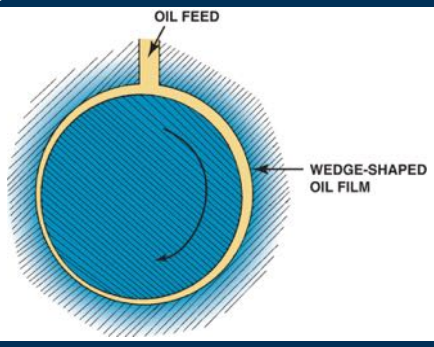
FIGURE 4–3 Wedge-shaped oil film curved around a bearing journal



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LUBRICATING PRINCIPLES (2 of 3)

- This wedging action is called hydrodynamic lubrication
- Depends on force applied to rate of speed between objects and thickness of oil

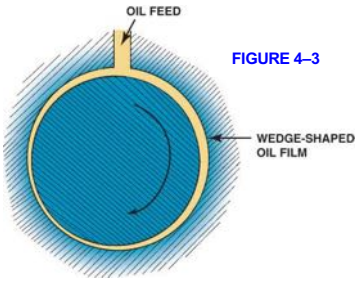

FIGURE 4–3

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QUESTION 1: ?

What is the Wedge-shaped oil film developed below a moving block called in an engine?

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ANSWER 1:

This wedging action is called hydrodynamic lubrication
Depends on force applied to rate of speed between objects and thickness of oil.

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FIGURE 14–4 The dash oil pressure gauge may be a good indicator of engine oil pressure. If there is any concern about the oil pressure, always use a mechanical gauge to be sure.

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LUBRICATING PRINCIPLES (3 of 3)

- Normal Oil Pressure
  - 0-60 PSI (200-400 kPa) or 10 PSI per 1,000 RPM
- Oil Temperature
  - Excessive temperatures, too low or too high, are harmful

FIGURE 14–4

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OIL PUMPS: INFO

- Purpose and Function
- Parts and Operation
- Types of Oil Pumps
  - External gear type
  - Internal/external gear type
  - Rotor type
  - Gerotor type

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FIGURE 4-5 In an external 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.

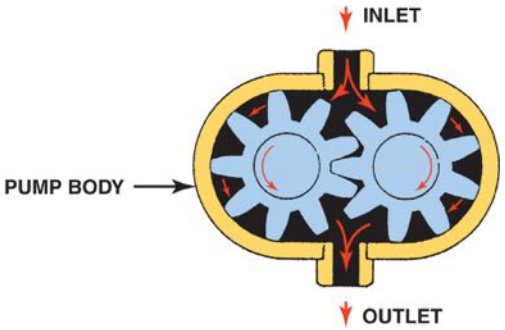

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FIGURE 4–6 typical internal/external oil pump mounted in the front cover of the engine that is driven by the crankshaft.

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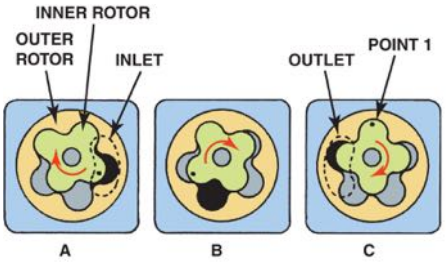
FIGURE 4–7 operation of a rotor-type oil pump.



A. OIL IS PICKED UP IN LOBE OF OUTER ROTOR.
B. OIL IS MOVED IN LOBE OF OUTER ROTOR TO OUTLET.
C. OIL IS FORCED OUT OF OUTLET BECAUSE THE INNER AND OUTER ROTORS MESH TOO TIGHTLY AT POINT 1 AND THE OIL CANNOT PASS THROUGH.

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FIGURE 4–8 Gerotor-type oil pump driven by the crankshaft.

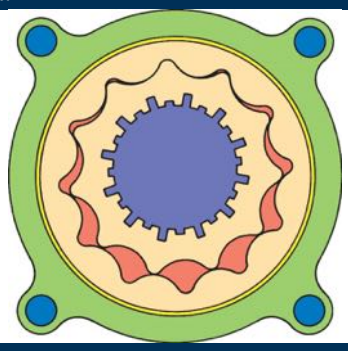

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FIGURE 4–9 Oil pressure relief valves are spring loaded. The stronger the spring tension, the higher the oil pressure.

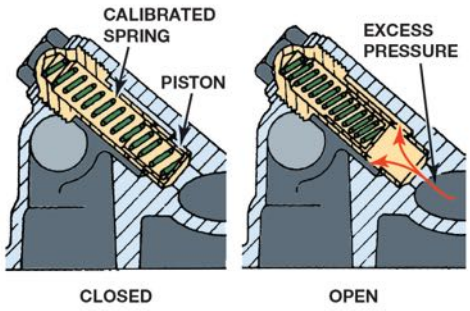

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FIGURE 4–10 typical engine design that uses both pressure and splash lubrication. Oil travels under pressure through galleries to reach top of engine. Other parts lubricated as oil flows back down into oil pan or is splashed onto parts.

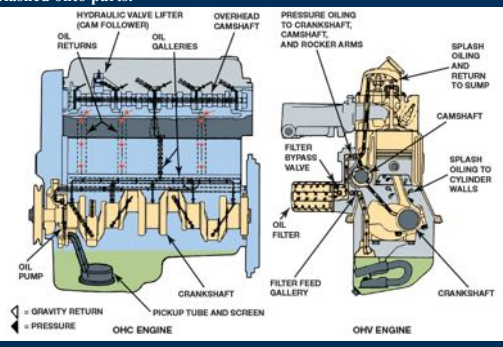

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FIGURE 4–11a visual inspection indicated that this pump cover was worn

(a)

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FIGURE 4–11B An embedded particle of something was found on one of the gears, making this pump worthless except for scrap metal.

(b)

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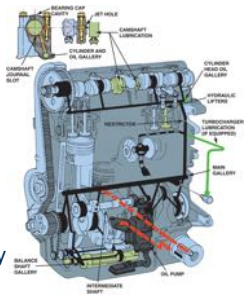
OIL PASSAGES (1 of 2)

- **Oil from pump first flows through oil filter**
  - Then through drilled hole that intersects
  - With drilled main oil gallery or longitudinal header
  - This is long hole drilled from front of block to back
  - Inline engines use one oil gallery
  - V-type engines may use 2 or 3 galleries



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OIL PASSAGES (2 of 2)

- **Passages drilled through block bulkheads**
  - **Oil goes from main oil gallery to main & cam bearings**
  - **Oil goes to cam bearings on some engines**
  - **Then to main bearings**
  - **Oil in diesel sent through oil cooler**
  - **To turbocharger,**
    - **FIGURE 4–12.**

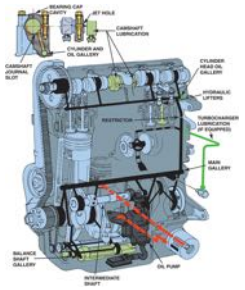

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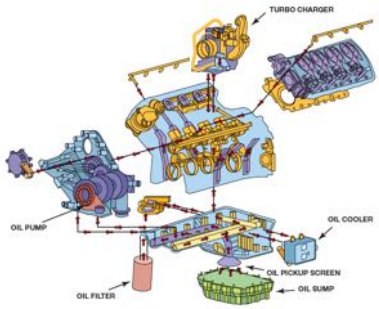
FIGURE 4–12 flow of oil in 6.7 liter Power Stroke diesel engine.



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QUESTION 2: ?

Oil from pump first flows through?

ANSWER 2:

The oil filter

Why Are There Holes on the Underside of Diesel Pistons?

FREQUENTLY ASKED QUESTION

Most diesel engines use piston squirt nozzles to force engine oil to the underside of the piston to help remove heat from the top of the piston. The nozzles are connected to the main oil gallery and oil is squirted through the nozzles whenever the engine is running. **SEE FIGURE 4–13a**.

FIGURE 4–13 (a) two holes in the underside of the piston lead to a passage where oil is squirted from nozzles to help cool the top of the piston.

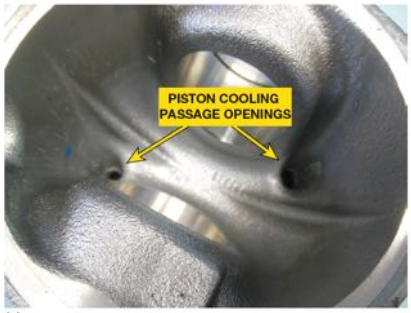

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FIGURE 4–13 (B) as the oil flows through the opening underneath the top of the

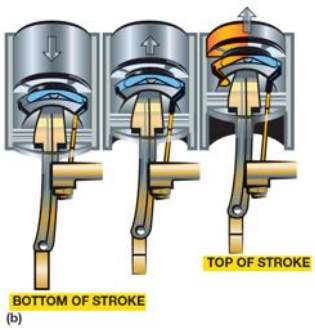

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FIGURE 4–14 Oil must be used to lubricate the gears used to drive the camshaft and high-pressure fuel pump on all engines, such as this 6.7 liter Cummins inline six-cylinder diesel engine.

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OIL PANS (1 of 2)

- **Oil Pan**
  - Engine oil stored for lubricating engine
  - Another name for the oil pan is sump
  - Pan baffles & oil pan shapes used to keep
  - Oil inlet under oil at all times

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FIGURE 4–15 (A) the pickup screen on a Duramax diesel engine is surrounded by

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FIGURE 4–15 (B) the oil pan has a built-in windage tray to help prevent the oil from being aerated during engine operation.

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OIL PANS (2 of 2)

- **Oil Pan**
  - Crankshaft rotates & acts like fan
  - Causes air within crankcase to rotate with it
  - Causing draft on oil, churning it so that air bubbles
  - Enter oil & causes foaming
  - Foaming causes bearing failure
  - Baffle or windage tray
  - Used to eliminate oil churning

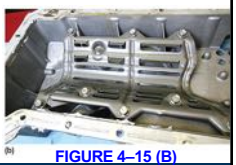

FIGURE 4–15 (B)

QUESTION 3: ?

What is a windage tray?

ANSWER 3:

The windage tray is used to keep oil from being churned up by the rotating crankshaft.

OIL COOLERS (1 of 1)

- **Coolant flows through oil cooler**
  - To help warm oil when engine is cold and cool oil when engine is hot
  - Oil temp should be:
    - Above 212°F (100°C) to boil off any accumulated moisture
    - Below 280°F to 300°F (138°C to 148°C)

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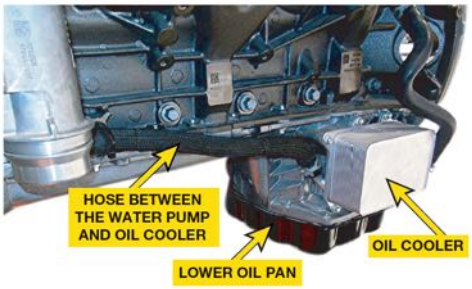
Figure 16–18 Oil is cooled by the flow of coolant through the oil filter adaptor



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ENGINE OIL (1 of 12)

- **Most important engine oil property**
  - Thickness or **viscosity**
  - As oil is cooled, it gets thicker
  - As oil is heated, it gets thinner

FIGURE 4–17

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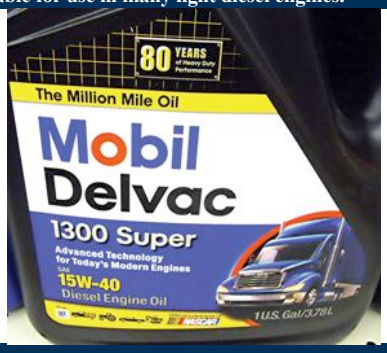
FIGURE 4–17 Container of SAE 15W-40 engine oil that may be suitable for use in many light diesel engines.



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ENGINE OIL (2 of 12)

- **Pour Point**
  - Lowest temperature at which oil will pour
  - **Viscosity Index (VI)**
    - Called Index of change in viscosity
    - Between cold & hot extremes
    - Oils with high VI thin less with heat than oils with low VI
    - Oils must be miscible, capable to mixing with other oils

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ENGINE OIL (3 of 12)

- **SAE # Indicates Viscosity Range**
  - Oils tested at 212°F (100°C)
    - Number with no letter following
  - Oils tested at 0°F (−18°C)
    - Rated with number & letter W, which means winter
  - Most OEMS Recommend following multi-viscosity
    - **Diesel Engine Oils:**
      - **SAE 15W-40**
      - **SAE 10W-30**
      - **SAE 5W-40**

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ENGINE OIL (4 of 12)

- **NOTE: Always use specified viscosity engine oil**

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ENGINE OIL (5 of 12)

- **API Rating**
  - American Petroleum Institute (API)
  - Established engine oil performance classification
  - Oils are tested and rated
  - In production automotive engines
  - SAE grade & API markings: only information
  - Available to help determine
  - Which oil is satisfactory for use in an engine.

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ENGINE OIL (6 of 12)

- **Diesel Oil Classifications**
  - Diesel classifications begin with letter C
  - Stands for commercial
  - Can indicate compression ignition
  - CJ-4–Required for use in all 2007 and newer
    - Using ultra-low-sulfur diesel (ULSD) fuel
  - CK-4–Replaced CJ-4 in 2018
  - FA-4–Designed for improved fuel economy
    - (for use in designated 2018 or newer diesel engines only)

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ENGINE OIL (7 of 12)

- **Engine Oil Additives**
  - Balance additives are called additive package
  - Additives to Improve Base Oil
  - Viscosity index (VI) improver allows
  - Lubricant to operate over wider temperature range
  - Pour point depressant keeps lubricant
  - Flowing at low temperatures
  - Antifoam agents reduce/stop foaming

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FIGURE 4–18 viscosity index (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.

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ENGINE OIL (8 of 12)

- **Additives to Protect Base Oil**
  - Antioxidants slow breakdown of base fluid
  - Caused by oxygen and heat
  - Oxidants prevent acid formation (corrosion)
  - In form of sludges, varnishes

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ENGINE OIL (9 of 12)

- **Additives to Protect Engine**
  - Total base number (TBN) neutralizes
  - Acids created during combustion
  - Rust inhibitor inhibits action of water
  - On ferrous metal, such as steel

ENGINE OIL (10 of 12)

- **Additives to Protect Engine**
  - Corrosion inhibitor protects nonferrous metals,
  - Such as copper
  - Antiwear additive forms protective layer
    - On metal surfaces to reduce friction and prevent wear
    - Extreme pressure additive functions
    - When heavy loads & temperatures occur

ENGINE OIL (11 of 12)

- **European Oil Rating System**
  - Starting in 2004
    - ACEA began using combined ratings such as A1/B1, A3/B3, A3/B4, and A5/B5
    - **Diesel** engine oils—ACEA **B1, B2, B3, or B4**
    - Higher number, more robust engine oil
    - ACEA oil requires low levels of sulfated ash, phosphorous, and sulfur (SAPS) and has high temperature/high shear rate viscosity (HTHS)

ENGINE OIL (12 of 12)

- **European Oil Rating System**
  - **C ratings** are catalytic converter compatible oils:
    - C1: basically A5/B5 oil with low SAPS, low HTHS
    - C2: A5/B5 with low HTHS and mid-level SAPS
    - C3: A5/B5 with high HTHS and mid-level SAPS
    - C4: low SAPS; high HTHS

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OIL FILTERS (1 of 3)

- **Construction**
  - Filter is made from closely packed cloth fibers or porous paper
- **Oil Filter Valves**
  - Many oil filters have an antidrainback valve
  - Valve keeps oil in filter, allows engine to receive immediate lubrication on startup

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Figure 4–19 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.

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Figure 4–20 A cutaway of typical spin-on oil filter. Engine oil enters filter through small holes around center of filter & flows through pleated paper filtering media & out large hole in center of filter. Center metal cylinder with holes is designed to keep paper filter from collapsing under pressure. Bypass valve can be built into center on oil filter or is part of oil filter housing and located in engine.

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OIL FILTERS (2 of 3)

- **Oil Filter Valves**
  - Engine or filter has bypass valve to allow oil to go around filter
  - Bypass allows engine to be lubricated with dirty oil rather than none
- **Oil Filter Disposal**
  - Crush or drain before discarding as metal scrap

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Figure 4–21 A typical filter crusher. The hydraulic ram forces out most of the oil from the filter. The oil is trapped underneath the crusher and is recycled

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QUESTION 4: ?

What does the rubber diaphragm in most spin-on oil filters used for?

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ANSWER 4:

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..

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OIL FILTERS (3 of 3)

- **Oil Life Monitors**
  - Vehicles since mid–1990s equipped with a warning light
  - Lets YOU know when engine oil should be changed.
  - 2 basic types of OLM
    - Service light on based on mileage
    - Algorithm. Computer programs contain algorithms that specify instructions a computer should perform before light comes on

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Figure 4–22 Many vehicle manufacturers can display the percentage of oil life remaining, whereas others simply turn on a warning lamp when it has been determined that an oil change is required.

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What is the Relationship Between Miles Driven and Engine Hours?

FREQUENTLY ASKED QUESTION

Most OEMs specify that each hour of engine run time is equal to 25 miles. Most pickup trucks have an hour meter that can be accessed using trip odometer button to scroll through miles & then hours. When servicing a truck, it is wise to check both mileage & hours of operation to see if service needs to be increased based on the number of hours spent idling compared to actual driving miles. **SEE FIGURE 4–23.**

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FIGURE 4–23 (a) number of miles shown on this two year old Ford F-250 with a Power stroke 6.7 liter diesel engine.

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FIGURE 4–23 (b) The number of hours with the engine running at idle (481 hours) is equal to about 12,000 miles, so the total is equal to about 26,000 miles instead of what the odometer reads (14,726).

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OIL CHANGE

- Oil Change Procedure
  - Step 1: Check oil level.
  - Step 2: Safely hoist vehicle.
  - Step 3: Position drain pan under drain plug; remove plug.
  - Step 4: Allow oil to drain freely.
  - Step 5: Examine oil plug gasket; replace if damaged.

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WARNING

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

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Summary (1 of 2)

- Viscosity is the oil thickness or resistance to flow.
- Normal engine oil pump pressure ranges from 10 to 60 PSI (200 to 400 kPa) or 10 PSI for every 1,000 engine RPM.
- Hydrodynamic oil pressure around engine bearings is usually over 1,000 PSI (6,900 kPa).
- The oil pump is driven directly by the crankshaft or by a gear or shaft from the camshaft.

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Summary (2 of 2)

- Viscosity is the oil thickness or resistance to flow.
- SAE rating measures the viscosity of the oil.
- API ratings reflect the quality of the oil.
- One hour of idling time is equal to about 25 miles of driving distance.

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