


Light Vehicle Diesel Engines
First Edition

Light Vehicle Diesel Engines



Chapter 2
Diesel Engine Blocks & Rotating Assemblies

PEARSON

ALWAYS LEARNING

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CURT WARD

Learning Objectives (1 of 2)

2.1 Prepare to take the ASE A9 certification test in area “C” (Engine Block Diagnosis and Repair).

2.2. Discuss the difference between gray cast iron and compacted graphite iron (CGI).

2.3. Explain the difference between a girdle and a bedplate engine design.

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Learning Objectives (2 of 2)

2.4. Explain the purpose of Nitriding and Tuftriding.

2.5. Describe how surface finish is measured.

2.6. Discuss engine bearing types and materials used in diesel engines.

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DIESEL ENGINE BLOCKS (1 of 9)

• Engine Block

- Supporting structure for entire engine
- Made from:
 - Gray cast iron
 - Cast aluminum
 - Die-cast aluminum alloy

- Block Deck

- Top surface of block
- Where cylinder head is fastened

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DIESEL ENGINE BLOCKS (2 of 9)

• Casting Numbers

- Whenever block is cast
- Number is put into mold to identify casting
- Casting numbers can be used to check dimensions,
 - Cubic inch displacement, & year of manufacture
- SEE FIGURE 2-2



FIGURE 2-2

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FIGURE 2-2 Casting number is shown literally cast with the block for



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QUESTION 1: ?

What are casting numbers?

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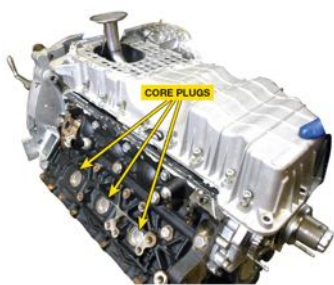
ANSWER 1:

Whenever an engine part, such as a block, is cast, a number is put into mold to identify casting. These casting numbers can be used to check dimensions & year of manufacture. FIGURE 2-2

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FIGURE 2-1 Core plugs on a Fiat Chrysler 3.0 liter V-6 diesel engine.



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QUESTION 2: ?

What is a freeze plug?

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ANSWER 2:

An expansion (core) plug is used to block the opening in the cylinder head or block the holes where the core sand was removed after the part was cast. The slang term is freeze plug.

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DIESEL ENGINE BLOCKS (3 of 9)

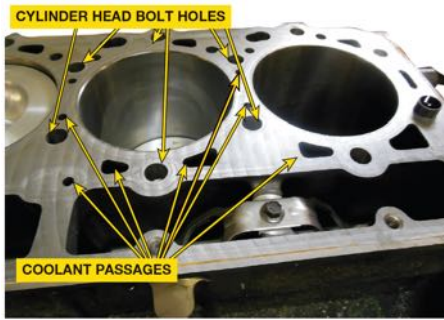
• Cooling Passages

- Cylinders surrounded by cooling passages
 - called the cooling jacket
 - Extend nearly to bottom of cylinder
 - Some built with **Siamese cylinder bores**
 - Cylinder walls are cast together without a water jacket
 - Between cylinders
 - Design improves block strength & stability
 - But reduces cooling capacity

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FIGURE 2-3 Deck of the block of a duramax diesel engine showing the location



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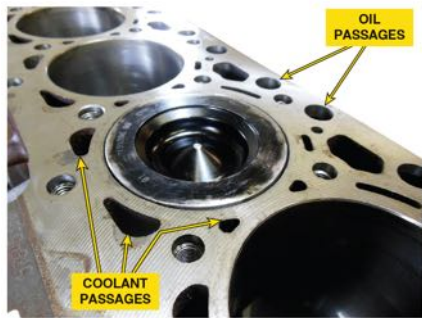
DIESEL ENGINE BLOCKS (4 of 9)

• Lubricating Passages

- Block has many oil holes that carry lubricating oil
- To required locations
- All oil holes (oil galleries) drilled from outside block
- When a curved passage is needed
 - Intersecting straight drilled holes are used
 - After oil holes are drilled, open ends capped
 - By pipe plugs, steel balls, or cup-type soft plugs
 - Called oil gallery plugs

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FIGURE 2-4 Cummins 6.7 liter inline six-cylinder diesel engine that shows the coolant



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Where Is the Block Heater Located?



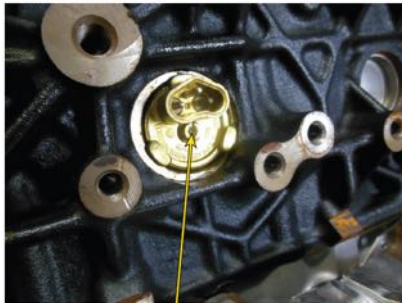
FREQUENTLY ASKED QUESTION

An engine block heater is used in many diesel engines operating in cold climates to electrically heat the coolant to make the engine start easier. A block heater is normally installed in one of the core (freeze) plugs where an electrical current from a 110-volt electrical outlet is used to heat the coolant in the block. SEE FIGURE 2-5.

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FIGURE 2-5 Block heater shown in one of the core plugs in a GM DURAMAX V-8



BLOCK HEATER

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DIESEL ENGINE BLOCKS (5 of 9)

• Main Bearing Caps

- Cast from sintered or billeted materials
- Separately from block
- Machined & then installed on block
- For a final bore-finishing operation



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DIESEL ENGINE BLOCKS (6 of 9)

• Main Bearing Caps

– Not interchangeable or reversible

- Because individually finished in place
- May have cast numbers indicating block position
- If not, steel stamps should be used to mark them
- With numbers and arrows pointing toward front



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DIESEL ENGINE BLOCKS (7 of 9)

• Main Bearing Caps

- Light diesel engines use
- Additional main bearing support bolts
- 4-bolt & 6-bolt main cap can be cross-bolted design
- Duramax Figure 2-7
- Uses cross-bolted design
- **SEE FIGURES 2-6 & 2-7**

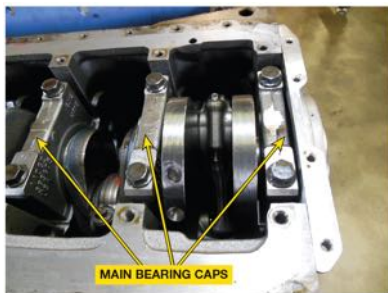


FIGURE 2-7

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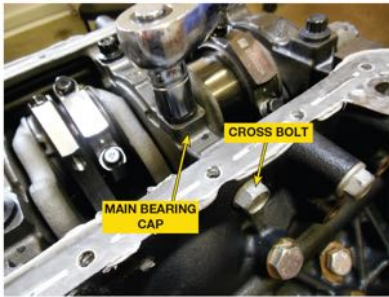
FIGURE 2-6 Main bearing caps used on Cummins



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FIGURE 2-7 GM DURAMAX V-8 Diesel engine uses two



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DIESEL ENGINE BLOCKS (8 of 9)

- **Expansion Force of Combustion**
 - Try to push head off top & crankshaft off bottom
 - Engine held together with head bolts & main caps
 - Extra bolts on main bearing cap help
 - Support crankshaft during high combustion pressures

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DIESEL ENGINE BLOCKS (9 of 9)

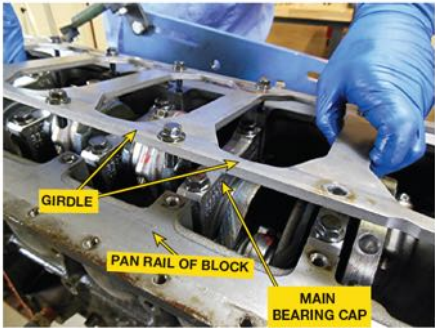
- **Girdle** Figure 2-8
 - Ties all of main bearing caps together
 - Add strength to lower part of block
- **Bedplate** Figure 2-9 (A)
 - Structural part of engine
 - Attached between block & oil pan, supports crankshaft



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FIGURE 2-8 typical girdle as found on a Cummins in line 6 cylinder diesel used to



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What Is the Difference between a Girdle and a Bedplate? See FIGURE 2-9A



FREQUENTLY ASKED QUESTION

Many engines use a girdle, which ties all of the main bearing caps together, to add strength to the lower part of the block. This type of design uses a solid steel support that attaches to the main bearing caps and ties the entire lower part of the block together.

● SEE FIGURE 2-8.

A bedplate, also called a frame-ladder design, is a structural member that attaches to the bottom of the block and supports the crankshaft. The oil pan is mounted under the bedplate, which in most cases is also part of the structure and support for the block assembly. ● SEE FIGURE 2-9.

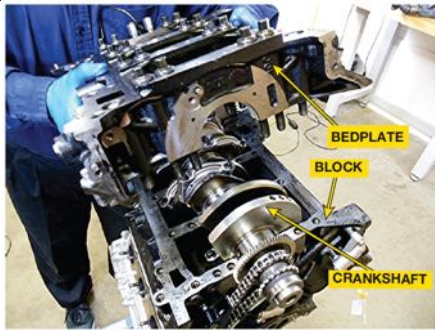
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FIGURE 2-9 (A) bedplate is a structural part of the engine which is attached between the block and the oil pan and supports crankshaft.



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FIGURE 2-9 (B) bedplate on a Fiat Chrysler 3.0 liter V-6 diesel engine. The Ford 6.0 and 6.4 liter power stroke V-8 diesel engines also use a frame-ladder block design.



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CRANKSHAFTS (1 of 5)

- Power from expanding gases
 - In combustion chamber
 - Delivered to crankshaft through
 - Piston, piston pin, and connecting rod

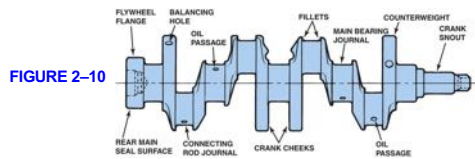


FIGURE 2-10

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CRANKSHAFTS (2 of 5)

- **Crankshaft includes following:**
 - Main bearing journals
 - Rod bearing journals
 - Crankshaft throws
 - Counterweights
 - Front snout
 - Flywheel flange
 - Keyways
 - Oil passages

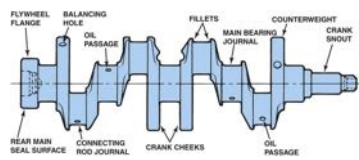


FIGURE 2-10

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FIGURE 2-10 Typical crankshaft with main journals that are supported by main bearings in the block. Rod journals are offset from the crankshaft centerline.

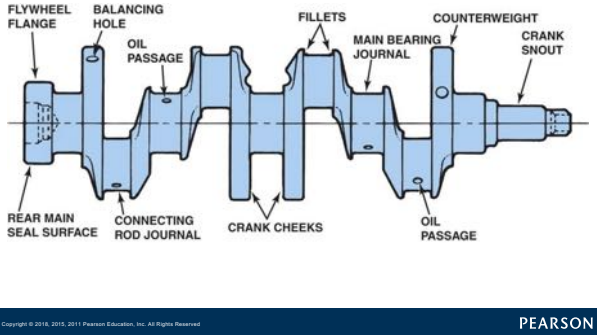
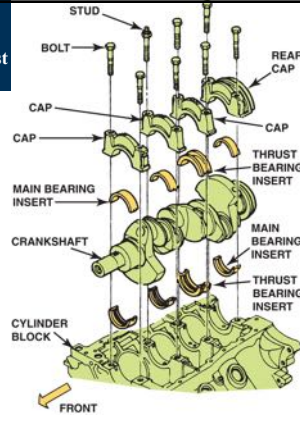


FIGURE 2-11 crankshaft rotates on main bearings. Longitudinal (end-to-end) movement is controlled by thrust bearing.

• Main Bearing Journals

- Crankshaft rotates in the cylinder block supported on main bearings

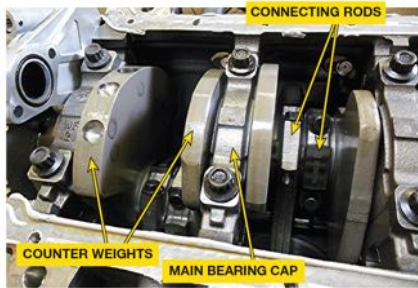


CRANKSHAFTS (3 of 5)

• Number of Cylinders

- Determines number of main bearings.
- 4-cylinder engines usually have main bearings.
 - (2.8 liter Duramax)
- Inline 6-cylinder engines have 7 main bearings.
 - (Cummins)
- V-8 engines have 5 main bearings.
 - (Power Stroke, Duramax, and Cummins V-8)
 - FIGURE 2-12

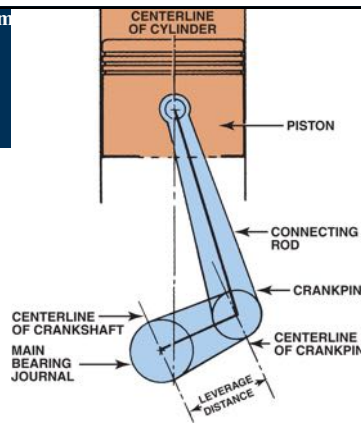
FIGURE 2-12 view of the crankshaft of a Duramax V-8 diesel engine with the oil pan



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FIGURE 2-13 Distance from crankpin centerline to centerline of crankshaft determines stroke, which is leverage available to turn crankshaft.



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QUESTION 3: ?

What determines engine stroke?

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ANSWER 3:

The distance from crankpin centerline to centerline of crankshaft determines the stroke, which is leverage available to turn the crankshaft .

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CRANKSHAFTS (4 of 5)

• Surface Finish

- Crankshaft journals are ground to smooth finish.
- Surface finish is measured in micro-inches
- Smaller number, smoother the surface
- Specification for main rod crankshaft journals
- Between 10 and 20 roughness average (Ra)

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CRANKSHAFTS (5 of 5)

• Journal Hardness

- **Improve wear-resistance**
 - Crankshaft journals hardened
- **Case Hardening**
 - heating crankshaft adding carbon to journals
- **Forged Crankshafts**
 - Used in most diesel engines are forged instead of cast
 - Stronger than cast but are more expensive
 - May have a wide separation line

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CRANKSHAFT CONSTRUCTION (1 of 1)

- **Forged**
 - Stronger than the cast crankshaft
- **Cast**
 - Casting improved, used on production engines
- **Billet Crankshafts**
 - Machined from solid piece of forged steel called a billet



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FIGURE 2–14 Wide separation lines of a forged crankshaft..



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QUESTION 4: ?

What are the three types of crankshafts?

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ANSWER 4:

Forged

Stronger than cast crankshaft

Cast

Casting improved, used on production engines

Billet Crankshafts

Machined from solid piece of forged steel called a billet

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FIGURE 2-15 billet crankshaft showing how it is machined from a solid chunk of steel, usually 4340 steel, at the right and the finished crankshaft on the left.



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CRANKSHAFT FEATURES (1 of 2)

- Crankshaft drilled to allow oil from main bearing oil groove to be directed to connecting rod bearings



FIGURE 2-16 Crankshaft sawed in half, showing drilled oil passages between the main and rod bearing journals
Larger in next slide

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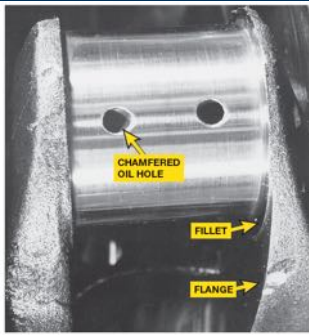
FIGURE 2-16 Crankshaft sawed in half, showing drilled oil passages between the main and rod bearing journals



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FIGURE 2-17 Typical chamfered hole in a crankshaft bearing journal



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FIGURE 2-18 fully counterweighted four-cylinder crankshaft with five main bearings.



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CRANKSHAFT FEATURES (2 of 2)

- Crankshafts are balanced by counterweights
 - Cast, forged, or machined as part of crankshaft
- A crankshaft that has counterweights on
 - Both sides of each connecting rod journal
 - Called fully counterweighted



FIGURE 2-18

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FIGURE 2-19 crankshaft broken as a result of a defective torsional vibration damper.

- **Crankshaft Deflections**
 - Back-and-forth deflections
 - Occur at same vibration frequency
 - As another engine part,
 - Parts vibrate together & resonate
 - Producing a thumping
 - Crankshaft may fail

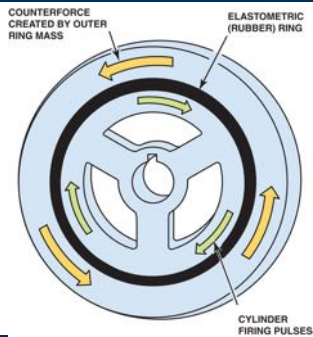


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FIGURE 2-20 hub of the harmonic balancer is attached to the front of the crankshaft. The elastomer (rubber) between the inertia ring and the center hub allows the absorption of crankshaft firing impulses.

- **Harmful crankshaft twisting vibrations**
 - Dampened with torsional vibration damper



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CRANKSHAFT SERVICE (1 of 2)

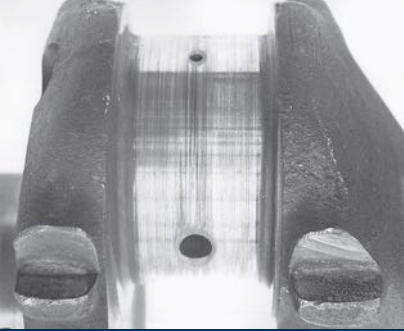
•Crankshaft Damage Includes:

- Worn journals
- Scored bearing journals
- Bends or warpage
- Cracks
- Thread damage (flywheel flange or front snout)
- Worn front or rear seal surfaces

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FIGURE 2-21 scored connecting rod bearing journal.



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CRANKSHAFT SERVICE (2 of 2)

•Crankshaft Service Includes:

- Measuring Crankshaft
- Crankshaft Grinding
- Crankshaft Polishing
- Welding a Crankshaft
- Stress Relieving Crankshaft
- Storing Crankshafts

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FIGURE 2-22 All crankshaft journals should be measured for diameter as well as taper and out-of-round.



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NOTE, PAGE 19

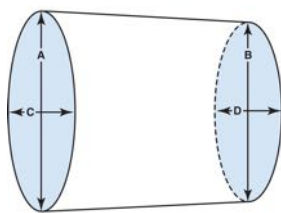
NOTE: If your fingernail catches on a groove when rubbed across a bearing journal, journal is too rough to reuse and must be reground. Another test is to rub a copper penny across journal. If any copper remains on crankshaft, it must be reground.

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FIGURE 2-23 Check each journal for taper and out-of-round.

CHECK FOR OUT-OF-ROUNDNESS
AT EACH END OF JOURNAL



A VS. B = VERTICAL TAPER
C VS. D = HORIZONTAL TAPER
A VS. C = OUT OF ROUND
B VS. D = OUT OF ROUND

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FIGURE 2-24 Crankshafts should be stored vertically to prevent possible damage or warpage. This clever bench-mounted tray for crankshafts not only provides a safe place to store crankshafts, but is also out of way & cannot be accidentally tipped.



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QUESTION 5: ?

What should be measured on a crankshaft?

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ANSWER 5:

All crankshaft journals should be measured for diameter as well as taper and out-of-round.

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ENGINE BEARINGS (1 of 1)

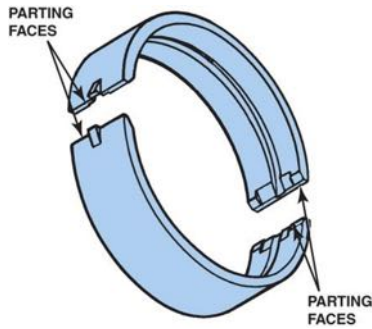
- Types of Bearings
- Bearing Materials
- Bearing Manufacturing
- Bearing Sizes
- Bearing Loads
- Bearing Fatigue
- Bearing Conformability
- Bearing Embedability



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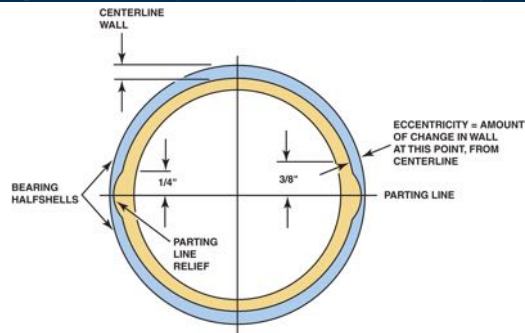
FIGURE 2–25 Two halves of a plain bearing meet at the parting faces.



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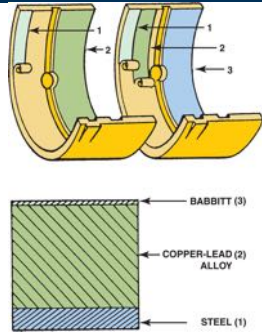
FIGURE 2–26 bearing wall thickness is not the same from the center to the parting line. This is called eccentricity and is used to help create an oil wedge between the journal and the bearing.



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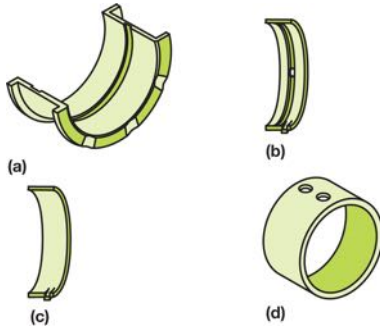
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FIGURE 2-27 Typical two- and three-layer engine bearing inserts showing the relative thickness of the various materials.



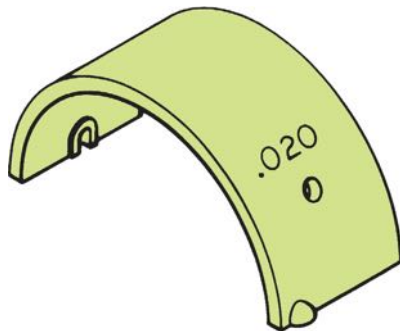
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FIGURE 2-28 Typical bearing shell types found in modern engines: (a) half-shell thrust bearing, (b) upper main bearing insert, (c) lower main bearing insert, (d) full round-type camshaft bearing.



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FIGURE 2-29 bearings are often marked with an undersized dimension. This bearing is used on a crankshaft with a ground journal that is 0.020 inch smaller in diameter than the stock size.



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BEARING CLEARANCE (1 of 2)

- Importance of Proper Clearance
- Checking Bearing Clearance
- Bearing Spread and Crush



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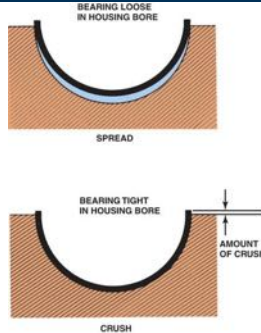
FIGURE 2-30 width of plastic gauging strip determines oil clearance of the main bearing. Alternate method of determining oil clearance includes careful measurement of crankshaft journal and bearings after they are installed, and the main housing bore caps are torqued to specifications.



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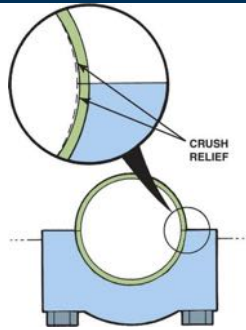
FIGURE 2-31 Bearing crush



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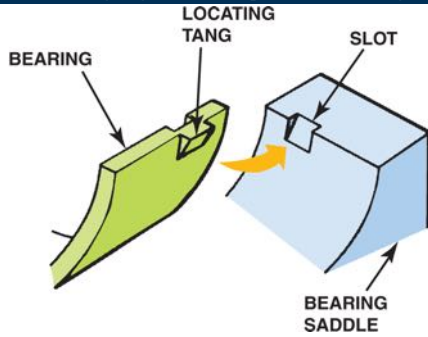
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FIGURE 2-32 bearings are thinner at the parting line faces to provide crush relief.



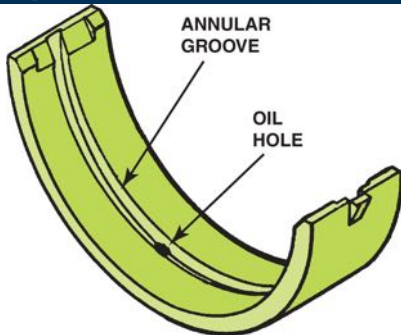
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FIGURE 2-33 tang (lug) and slot help index the bearing in the bore.



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FIGURE 2-34 Many bearings are manufactured with a groove down the middle to improve the oil flow around the main journal.



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BEARING CLEARANCE (2 of 2)

CAUTION: Some bearings may have oil holes in the top shell only. If these are installed incorrectly, no oil will flow to the connecting or main rods, resulting in instant engine failure. To help the oil spread across the entire bearing, some bearings use an oil groove.

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CAMSHAFT BEARINGS (1 of 1)

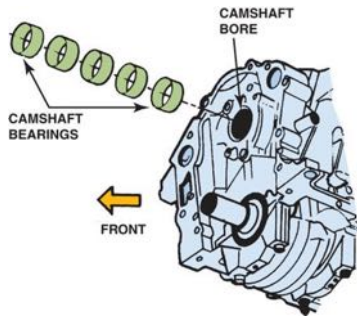
- Types of Camshaft Bearings
- Camshaft Bearing Installation



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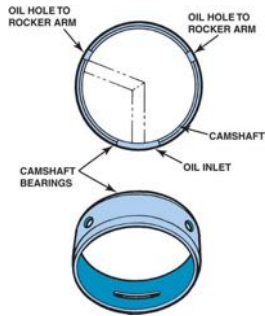
FIGURE 2-35 Cam-in-block engines support the camshaft with sleeve-type bearings.



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FIGURE 2-36 Camshaft bearings must be installed correctly so that oil passages are not blocked.



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Summary (1 of 4)

- During block casting process, cores are used inside a mold to form water jackets and cylinder bores. After cast iron has cooled, block is shaken, which breaks up cores so that they fall out of openings in the side of block. **Core plugs** are used to fill the holes.
- **Block deck** is surface to which cylinder head attaches. It must be flat, true, and parallel with centerline of main bearing journals for proper engine operation.

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Summary (2 of 4)

- Many diesel engines use a **girdle** or a **bedplate** to provide lower engine stability.
- Cast crankshafts have a narrow mold parting line, and forged crankshafts have a wide parting line.
- Oil for the rod bearings comes from holes in crankshaft drilled between main journal and rod journal.

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Summary (3 of 4)

- A **vibration damper**, also known as a harmonic balancer, is used to dampen harmful twisting vibrations of the crankshaft.
- Most engines are internally balanced. This means the crankshaft and vibration damper are both balanced.
- Most crankshafts can be reground to be 0.010, 0.020, or 0.030 inch undersize.

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Summary (4 of 4)

- Most engine bearings are constructed with a steel shell for strength and are covered with a lead alloy. Many bearings also have a thin overlay of babbitt.
- Bearings should have spread and crush to keep them from spinning when the crankshaft.

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