


Light Vehicle Diesel Engines
First Edition

Light Vehicle Diesel Engines



Chapter 3
Diesel Cylinder Heads & Valve Trains

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LEARNING OBJECTIVES (1 of 2)

3.1 Prepare for the Light Vehicle Diesel Engine (A9) ASE certification test content area “B” (Cylinder Head and Valve Train Diagnosis and Repair).

3.2 Explain the design and construction of cylinder heads.

3.3 Discuss camshaft design and valve train component operation.

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LEARNING OBJECTIVES (2 of 2)

3.4 Discuss the purpose and function of rocker arms and bridges.

3.5 Discuss the purpose, function, and operation of hydraulic valve lifters.

3.6 Describe how to disassemble a cylinder head.

3.7 Discuss valve-stem-to-guide clearance.

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CYLINDER HEADS (1 of 4)

• Cylinder Heads

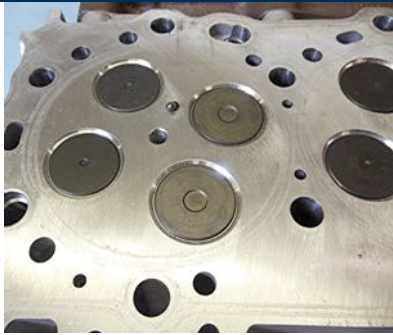
- Cast iron/aluminum alloy
- Support valves & valve train
- Passages: intake air, exhaust gases, coolant
 - Overhead camshaft design
 - Supports all valve train components



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FIGURE 3-1 (A) Aluminum GM Duramax v-8 diesel engine cylinder head.



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CYLINDER HEADS (2 of 4)

• Diesel Engines

- Two-valve configuration
 - 1 intake valve & 1 exhaust valve
 - 4-stroke engines
- Current designs are 4-VALVE type
 - 2 intake valves & 2 exhaust valves
 - Adding more than 2 valves per cylinder permits more air flow into and out of engine
- Valve Duration
 - Number of degrees by which crankshaft rotates when valve is off valve seat



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FIGURE 3-1(B) Cast iron Cummins 6.7 liter inline six cylinder diesel engine cylinder head.



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CYLINDER HEADS (3 of 4)

• Maximum Air Moving Through Valve Opening

- Depends on distance around valve & distance it lifts open
- Normal opening lift of 25%
 - 2" intake valve, normal amount of lift off seat is 25% of 2" or ½ inch
 - Amount of air that can enter a cylinder depends on total area around valve, calculated by equation:
 - $\pi \times \text{valve diameter}$



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FIGURE 3-2 Four valve cylinder head from a Fiat Chrysler 3.0 liter diesel engine.



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INTAKE AND EXHAUST VALVES (1 of 2)

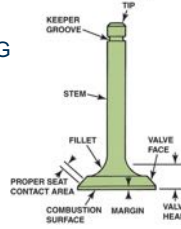
• Intake Valves

– Control Inlet Of Cool, Low-pressure Induction Charges.

• Exhaust Valves

– Handle Hot, High-pressure Exhaust G

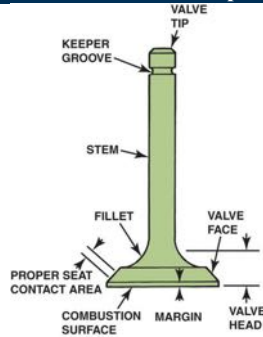
- Parts Involved
- Valve Size Relationships
- Valve Materials
- Two-material Valves
- Sodium-filled Valves



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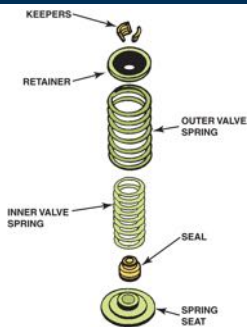
FIGURE 3–3 Identification of the parts of a valve.



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FIGURE 3-4 Typical valve spring and related components. Dual valve springs are used to reduce valve train vibrations and a spring seat is used to protect aluminum heads.



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FIGURE 3-5 Inertia welded valve stem and head before machining.

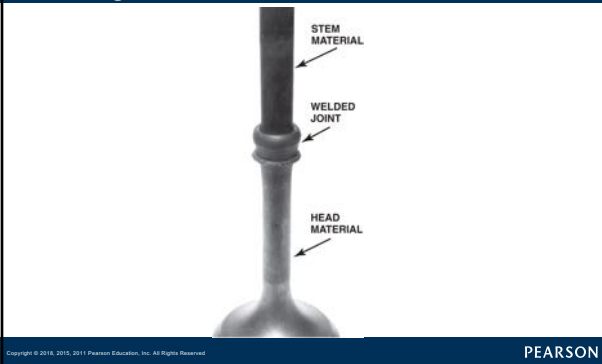
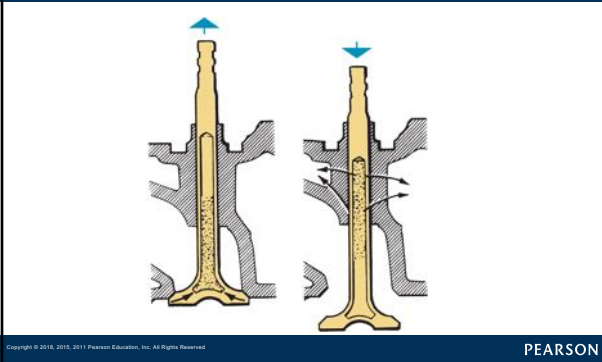


FIGURE 3-6 Sodium-filled valve uses a hollow stem, which is partially filled with metallic sodium (a liquid when hot) to conduct heat away from the head of the valve.



WARNING (1 OF 2)



WARNING

If a sodium-filled valve is damaged and the sodium leaks out, it can cause a fire if exposed to water. Sodium reacts violently when exposed to water and burns uncontrollably.

QUESTION 1: ?

Why are Sodium filled valves used?

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ANSWER 1:

Sodium-filled valve uses hollow stem, which is partially filled with metallic sodium (a liquid when hot) to conduct heat away from head of valve.

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VALVE SEATS (1 of 3)

- **Valve Face Closes Against Valve Seat**
 - Seal combustion chamber.
 - **Seat** generally formed as part of cast-iron head
 - Called *integral seat*
 - **Insert seat** fits into machined recess in
 - **Steel or aluminum cylinder head**
 - **Insert seats**
 - Used in all aluminum head engines
 - Applications for which corrosion & wear resistance are critical

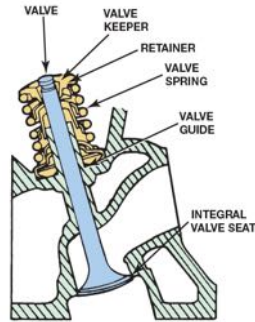


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FIGURE 3-7 Integral valve seats are machined directly into the cast-iron cylinder head and are induction hardened to prevent wear.

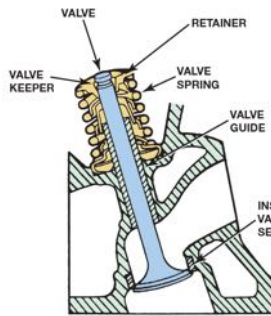
- Seats induction hardened to minimize
- Valve recession as engine operates. Wearing away of seat results in valve recession, causing valve to sit further
- Into cylinder head



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FIGURE 3-8 Insert valve seats are a separate part that is interference fitted to a



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VALVE SPRINGS (1 of 1)

• Valve Spring Holds

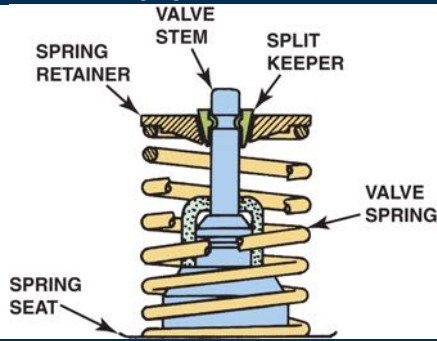
- Valve against seat when valve not being opened
- One end of valve spring seated against head
- Other end of spring attached under compression
- To valve stem through valve spring retainer
- & Valve spring keeper (lock)
 - Spring Materials & Design
 - Variable Rate Springs
 - Valve Spring Inspection



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FIGURE 3-9 A retainer and two split keepers hold the spring in place on the valve. A separate metal washer is used to prevent the valve spring from wearing into the aluminum cylinder head on aluminum heads. On cast iron heads, the spring seat is a machined area in the head.



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QUESTION 2: ?

Where do you position the close coil of a valve spring?

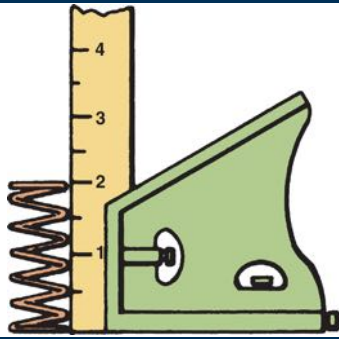
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ANSWER 2:

Toward the cylinder head.

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FIGURE 3–10 All valve springs should be checked for squareness by using a square on a flat surface and rotating the spring while checking.



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FIGURE 3–11 one popular type of valve spring tester used to measure compressed force of valve springs. Specifications usually include (1) free height (height without being compressed), (2) pressure at installed height with valve closed, and (3) pressure with valve open to height specified.



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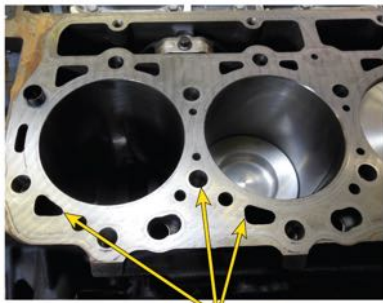
CYLINDER HEAD PASSAGES (1 of 3)

- **Coolant flows from coolest portion of engine**
 - To warmest portion
 - Water pump circulates coolant from radiator
 - Through block around cylinders
 - Flows upward through head gasket to head
 - Returned to radiator to be cooled

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FIGURE 3–12 Coolant passages on a Duramax diesel engine block.



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CYLINDER HEAD PASSAGES (2 of 3)

- **Lubricating oil delivered to OHV**
 - Through pushrods, or through drilled passages
 - Special openings in head gasket for oil
 - After the oil passes through valve mechanisms
 - returns to pan through oil return passages
 - **Called drainback holes**
 - Cast holes are large and not easily plugged

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CYLINDER HEAD PASSAGES (3 of 3)

• **NOTE: Many aluminum cylinder heads have smaller than-normal drain back holes. If an engine has excessive oil consumption, check the drain holes as a possible cause before removing engine.**

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CAMSHAFT (1 of 7)

• **Camshaft opens valves**

- Eccentric shapes called lobes
- Open valve against force of valve springs.
- Valve spring closes valve when
- Camshaft rotates off lobe
- Camshaft lobe changes rotary motion (camshaft)
 - To linear motion (valves).
- Cam shape or contour is major factor
 - Determining operating characteristics of engine



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CAMSHAFT (2 of 7)

• **Camshaft Driven By**

- Timing gears
- Timing chains
- Timing belts

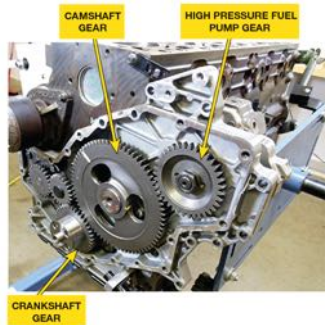


Duramax Cam Driven by Gears

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FIGURE 3-13 Cummins 6.7 liter inline six-cylinder diesel camshaft is driven by a gear



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CAMSHAFT (3 of 7)

• Camshaft Located

- In Engine Block
 - **Cam-in-block Design**
 - Camshaft supported in block by bearings.
 - Driven by crankshaft with gear/sprocket
 - Pushrod or overhead valve (OHV) engines



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CAMSHAFT (4 of 7)

• Overhead CAM

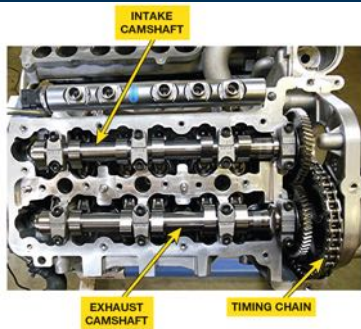
- Belt or chain driven from crankshaft
- Located in head(s)
- Called overhead camshaft (OHC) design
- Single overhead camshaft for each bank SOHC
- 2 overhead camshafts per bank
- **SEE FIGURE 3-14, NEXT SLIDE**



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FIGURE 3-14 Fiat-Chrysler 3.0 liter V-6 diesel engine that has double overhead



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CAMSHAFT (5 of 7)

• **Construction**

- Lobes
- Bearing journals
- Accessory drive gear

• **Other types of construction:**

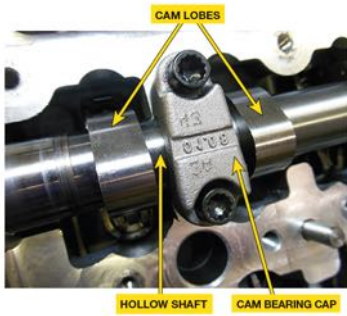
- Forged steel (often used in diesel engines)
- Steel machined from a solid billet
- Composite camshafts
 - Lightweight tubular shaft with hardened steel lobes, SEE Figure 3-15, NEXT SLIDE



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FIGURE 3–15 Hardened steel lobes are a press-fit onto the hollow steel tube to create



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CAMSHAFT (6 of 7)

• **NOTE:** Rockwell is a type of hardness test, and the represents the scale used. Higher the number is, harder surface. Abbreviation Rc60, indicates Rockwell hardness of 60 as measured on “c” scale

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QUESTION 3: ?

What are eccentric shapes on Camshafts called ?

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ANSWER 3:

Lobes

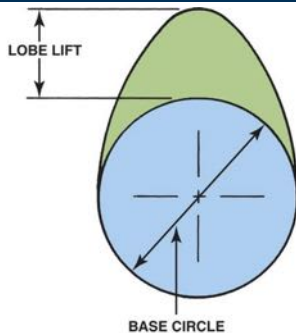
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FIGURE 3-16 Lobe lift is the amount the cam lobe lifts the lifter. The blue circle is called the base circle.

• Camshaft lobes

- in overhead valve (OHV) engines lubricated by splash oil
- thrown up by movement of the crankshaft
- At low engine speed, there is less splash lubrication than occurs at higher engine speeds.



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CAMSHAFT (7 of 7)

• Lobe Lift

- Higher lift of camshaft lobe
 - Greater amount of air can enter engine
 - More air in engine, **greater** power
- Lift Amount different for
 - Intake and exhaust valves
- **Asymmetrical** specifications vary
- **Symmetrical** if lift is same

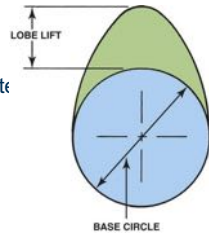


FIGURE 3-16

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ROCKER ARMS & BRIDGES (1 of 3)

• Rocker Arm

- Reverses upward movement of pushrod
- Produce downward movement on tip of valve
- Designed to reduce travel of cam follower
 - Or Lifter & pushrod while maintaining required lift
- Done by using rocker arm ratio usually of 1.5:1.



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ROCKER ARMS & BRIDGES (2 of 3)

• Rocker arms may be

- Cast
- Forged
- Stamped steel



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FIGURE 3-17 1.5:1 ratio rocker arm means that dimension A is 1.5 times length of dimension B. Therefore, if pushrod is moved up 0.4 inch by camshaft lobe, the valve will be pushed down (opened) 0.4 inch \times 1.5, or 0.6 inch.

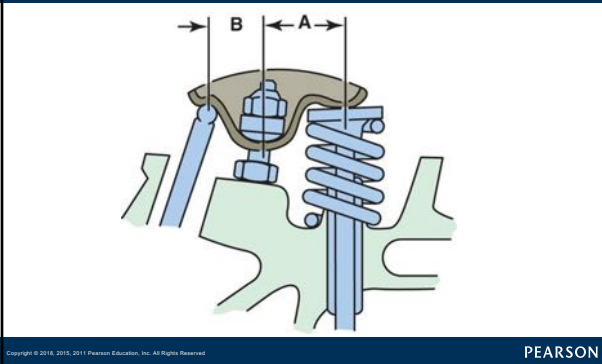
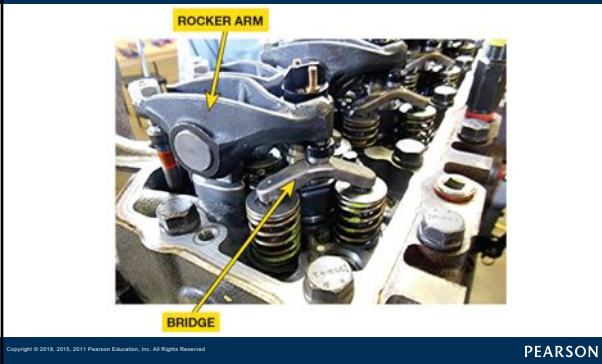


FIGURE 3-18 Bridges are used in many light diesel engines so that one rocker arm



ROCKER ARMS & BRIDGES (3 of 3)

• **Bridges**

- Also called **Crossheads**, LIKE rocker arms
- Used in diesel engines to span 2 valves
- From one pushrod
- Can be bent causing one of 2 valves to open less/more than other valve
- Valve clearance needs to be checked to make sure bridges are straight not warped or bent



FIGURE 3-18

PUSHRODS (1 of 3)

• Pushrods

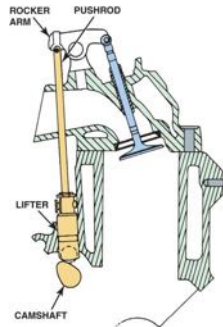
- Transfer lifting motion of valve train
- from cam lobe and lifters to rocker arms



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FIGURE 3–19 Overhead valve engines are also known as pushrod engines because of the long pushrod that extends from the lifter to the rocker arm.



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PUSHRODS (2 of 3)

• Pushrods

- Designed to be as light as possible
- Solid or hollow
- Used as passages for oil to lubricate rocker arms, they must be hollow
- Use convex ball on lower end that seats in lifter
- Rocker arm end is also a convex ball

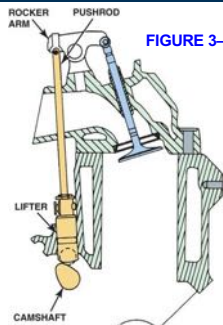


FIGURE 3–19

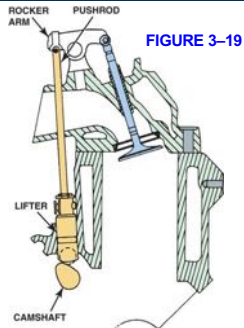
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PUSHRODS (3 of 3)

• Pushrods

- One of following changes made to engine, different pushrod length may be necessary:
 - Block deck height machined
 - Cylinder head deck height machined
 - Valve length increased (seats being ground)



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LIFTER OR TAPPETS (1 of 3)

• Valve Lifters or Tappets

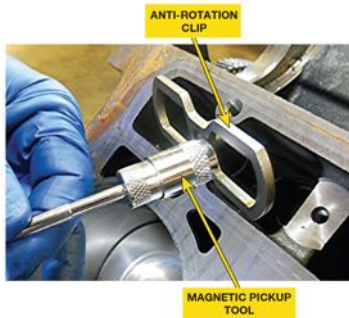
- Follow contour or shape of camshaft lobe
- Changes rotary cam motion to Reciprocating motion in valve train
- Diesel engines use roller lifters



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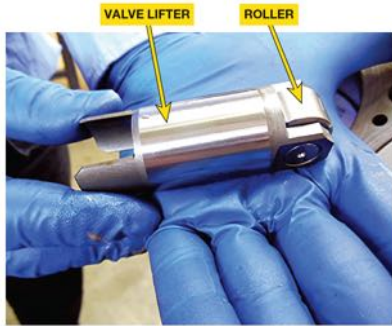
FIGURE 3-20 (A) Duramax diesel engine anti-rotation clip



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FIGURE 3–20 (B) lifter from a Duramax that shows the large size compared to a lifter



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LIFTER OR TAPPETS (2 of 3)

• Valve Adjustment

- Two methods used
 - One method involves solid valve lifter, adjusted mechanically at rocker arm, or by changing shims
 - Other method involves lifter with automatic hydraulic adjustment built into lifter body, hydraulic valve lifter

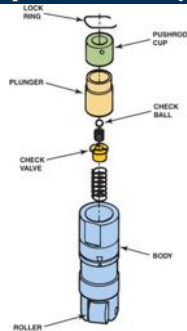


FIGURE 3–20 (B)

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FIGURE 3–21 exploded view of hydraulic roller lifter



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LIFTER OR TAPPETS (3 of 3)

• HYDRAULIC LIFTERS

- Take up all clearance in valve train
 - Hollow cylinder body enclosing hollow plunger, check valve, & pushrod cup.
- Lifters feed oil up through pushrod use metering disc under pushrod cup
- Engine oil under pressure fed through engine passage to exterior lifter body.
- Undercut portion allows oil under pressure to surround Lifter body
- Oil under pressure goes through holes in undercut section
 - Into center of plunger

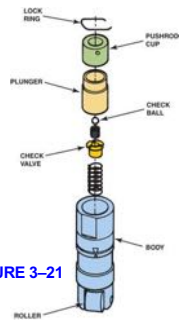


FIGURE 3-21

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CAMSHAFT REMOVAL (1 of 2)

• CAM-IN-BLOCK ENGINES

- Overhead valve (OHV) design
- Camshaft located in block above crankshaft
- Timing chain & gears should be removed
- After timing chain (gear) cover is removed
- Loosen rocker arms (or rocker arm shaft)
- Remove pushrods
- Remove valve lifters before removing camshaft

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CAMSHAFT REMOVAL (2 of 2)

NOTE: Be sure to keep each pushrod and rocker arm matched together if they are to be reused.

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CYLINDER HEAD DISASSEMBLY (1 of 4)

- Cylinder Head Servicing Sequence
- Disassembling Overhead Camshaft Head
- Valve Train Disassembly
- Cylinder Head Inspection

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CYLINDER HEAD DISASSEMBLY (2 of 4)

- **Cylinder Head Disassembly**
 - Valve train components to be reused
 - Must be kept together
 - Be sure to keep top part of pushrod at top.
 - Keep rocker arms with same pushrods
 - As they wear together.
 - Intake and exhaust valve springs can be different
 - Must be kept with correct valve

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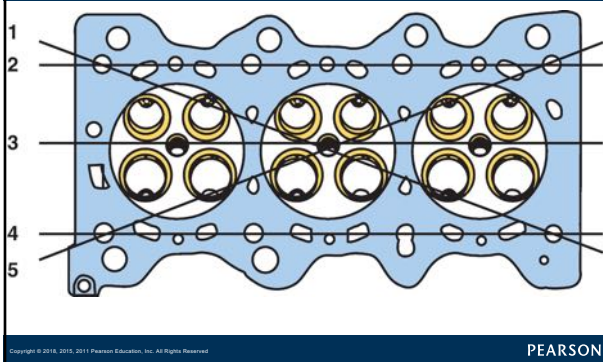
WARNING (2 OF 2)

Cast-iron Cummins inline six-cylinder head is very heavy, requiring an engine hoist to remove it from the block. Attempting to lift the head without help or a hoist could result in personal injury

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FIGURE 3–22 Cylinder heads should be checked in five planes for warpage, distortion, bend, and twist.

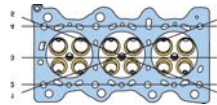


CYLINDER HEAD DISASSEMBLY (3 of 4)

• Cylinder Head Inspection

- STEP 1 After removing old gasket material, use file & draw it across surface of head to remove any small burrs.
- STEP 2 head should be checked in 5 planes. Checking cylinder head gasket surface in 5 planes checks head for warpage, distortion, bend, & twist.

FIGURE 3–22

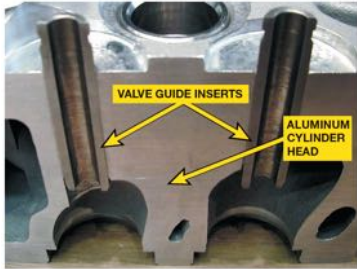


CYLINDER HEAD DISASSEMBLY (4 of 4)

• Injector Tips & Pre-chambers

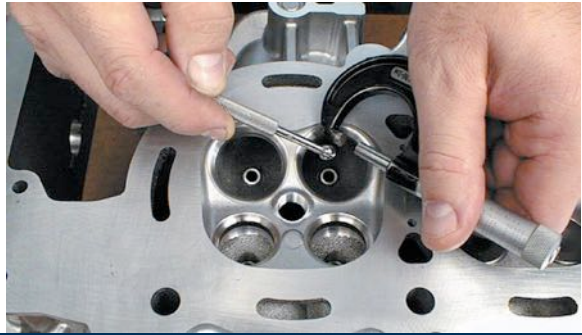
- **Protruded injector, or nozzle tip**
 - Must be measured & compared to specs
 - Protrusions, which could include a pre-chamber on older indirect light vehicle diesel engines, must be checked & corrected if necessary when cylinder head is machined.

FIGURE 3–23 All aluminum cylinder heads use valve guide inserts.



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FIGURE 3–24 A small-hole gauge and a micrometer are being used to measure the valve guide. The guide should be measured in three places: at the top, middle, and bottom.



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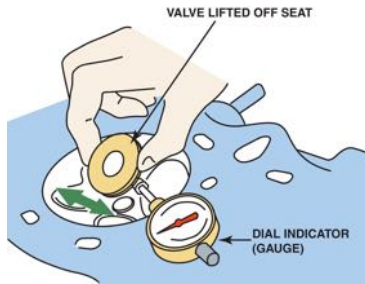
FIGURE 3–25 Diameter of the valve stem is being measured using a micrometer. The difference between the inside diameter of the valve guide and the diameter of the valve stem is the valve guide-to-stem clearance.



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FIGURE 3-26 Measuring valve guide clearance

Measuring valve guide-to-stem clearance with dial indicator while rocking stem in direction of normal thrust. Reading on dial indicator should be compared to specifications because it does not give guide-to-stem clearance directly. Valve is usually held open to its maximum operating lift. After checking in this direction, rotate dial indicator and measure movement 90 degrees from what is shown.



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Summary (1 of 4)

- Camshaft rotates at one-half crankshaft speed.
- On overhead valve engines, camshaft is usually placed in the block above the crankshaft.
- Overhead camshaft engines use 1 or 2 camshafts located in cylinder head above cylinders, and called single overhead camshaft (SOHC) engines or double overhead camshaft (DOHC) engines, depending on design.

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Summary (2 of 4)

- Lobes of camshaft are usually lubricated by splash lubrication.
- Valve lift is usually expressed in decimal inches and represents distance that valve is lifted off valve seat.
- In many engines, camshaft lobe lift is transferred to tip of valve stem to open valve by use of a rocker arm or follower.

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Summary (3 of 4)

- Valve train clearance is also called valve lash, which is needed to help compensate for thermal expansion and wear.
- Pushrods transfer camshaft lobe movement upward from camshaft to rocker arm.
- Camshaft duration is number of degrees of crankshaft rotation for which valve is lifted off seat.
- Coolant and lubricating openings and passages are located throughout most cylinder heads.

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Summary (4 of 4)

- Removing cylinder head is achieved by first loosening all of head bolts in reverse order of tightening sequence.
- Head should be checked in 5planes. Checking cylinder head gasket surface in 5planes checks head for warpage, distortion, bend, and twist.
- Valve guides should be checked for wear using a ball gauge or dial indicator. Typical valve stem-to-guide clearance is 0.001 to 0.003 inch for intake valves & 0.002 to 0.004 inch for exhaust valves.

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