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Service Information Bulletin

SUBJECT	DATE
Rocker Arm Housing and Camshafts	September 2018

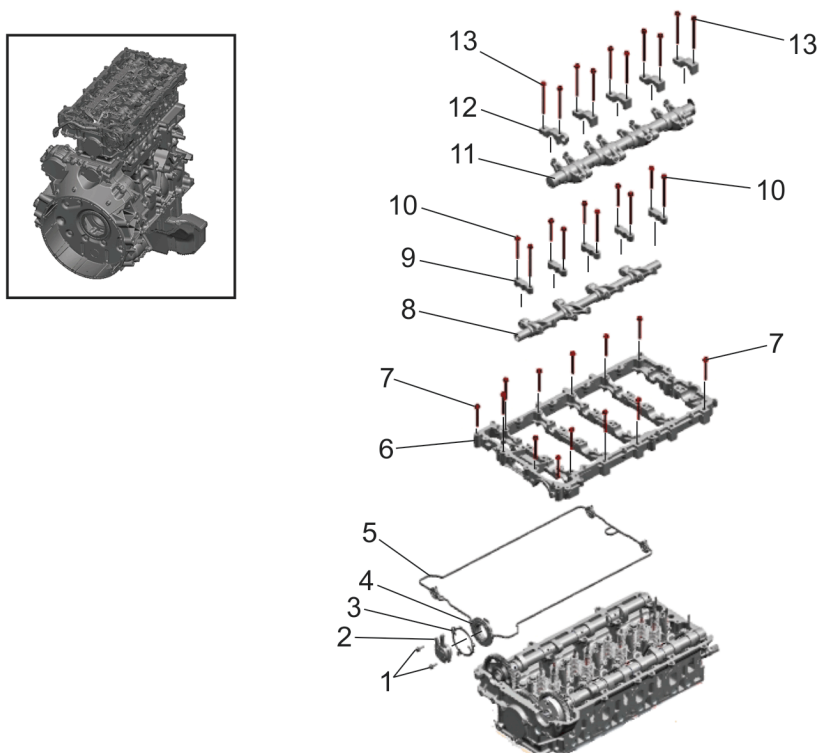
Additions, Revisions, or Updates

Publication Number / Title	Platform	Section Title	Change
DDC-SVC-MAN-0194	Medium Duty-DD5 934912(C)	Removal of the Rocker Arm Housing and Camshafts	Added notes and graphics regarding the camshaft phaser central valve.
		Inspection of the Rocker Arm Housing and Camshafts	Added graphics.
		Installation of the Rocker Arm Housing and Camshafts	Added notes and graphics regarding the camshaft phaser central valve.
DDC-SVC-MAN-0198	Medium Duty DD8	Removal of the Rocker Arm Housing and Camshafts	Added notes and graphics regarding the camshaft phaser central valve.
		Installation of the Rocker Arm Housing and Camshafts	



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2 Removal of the Rocker Arm Housing and Camshafts



d010201

- | | |
|--|---------------------------------------|
| 1. Variable Camshaft Phaser Solenoid Mounting Ring Bolts | 8. Intake Rocker Arm Shaft Assembly |
| 2. Variable Camshaft Phaser Solenoid | 9. Intake Rocker Shaft Caps |
| 3. Variable Camshaft Phaser Solenoid Mounting Ring | 10. Intake Rocker Shaft Cap Bolts |
| 4. Variable Camshaft Phaser Solenoid Mounting Seal | 11. Exhaust Rocker Arm Shaft Assembly |
| 5. Rocker Arm Housing Mounting Seal | 12. Exhaust Rocker Shaft Caps |
| 6. Rocker Arm Housing | 13. Exhaust Rocker Shaft Cap Bolts |
| 7. Rocker Arm Housing Mounting Bolts | |

Figure 1. Rocker Arm Housing and Rocker Arms

Remove as follows:



WARNING: PERSONAL INJURY

To avoid injury from hot surfaces, wear protective gloves, or allow engine to cool before removing any component.



WARNING: PERSONAL INJURY

To avoid injury before starting and running the engine, ensure the vehicle is parked on a level surface, parking brake is set, and the wheels are blocked.

1. Shut off the engine, apply the parking brake, chock the wheels, and perform any other applicable safety steps.



CAUTION: ELECTRICAL SHOCK

To avoid injury from electrical shock, use care when connecting battery cables. The magnetic switch studs are at battery voltage.

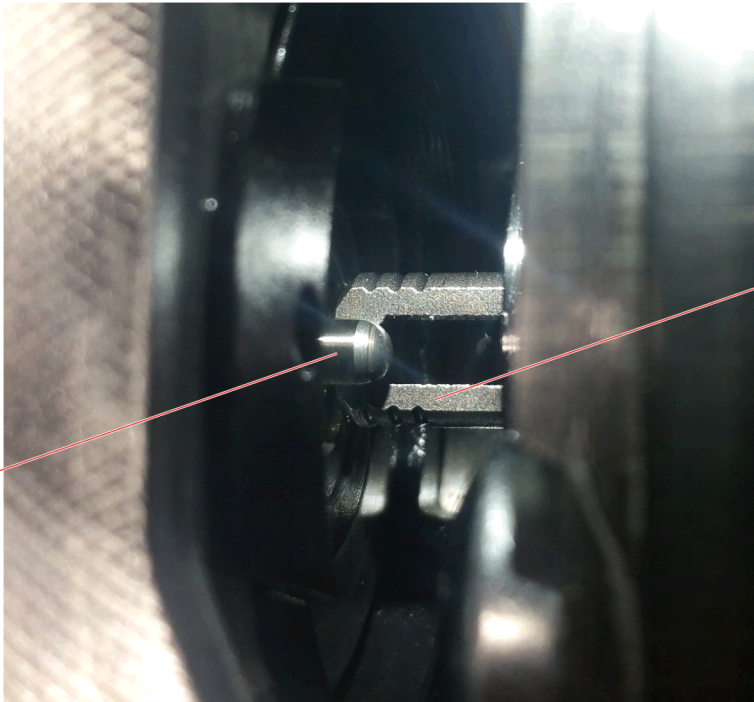
2. Disconnect the batteries.
3. Open the hood.
4. If necessary, remove the bumper end(s). Refer to the Original Equipment Manufacturer (OEM) procedures.

**WARNING: FIRE HAZARD**

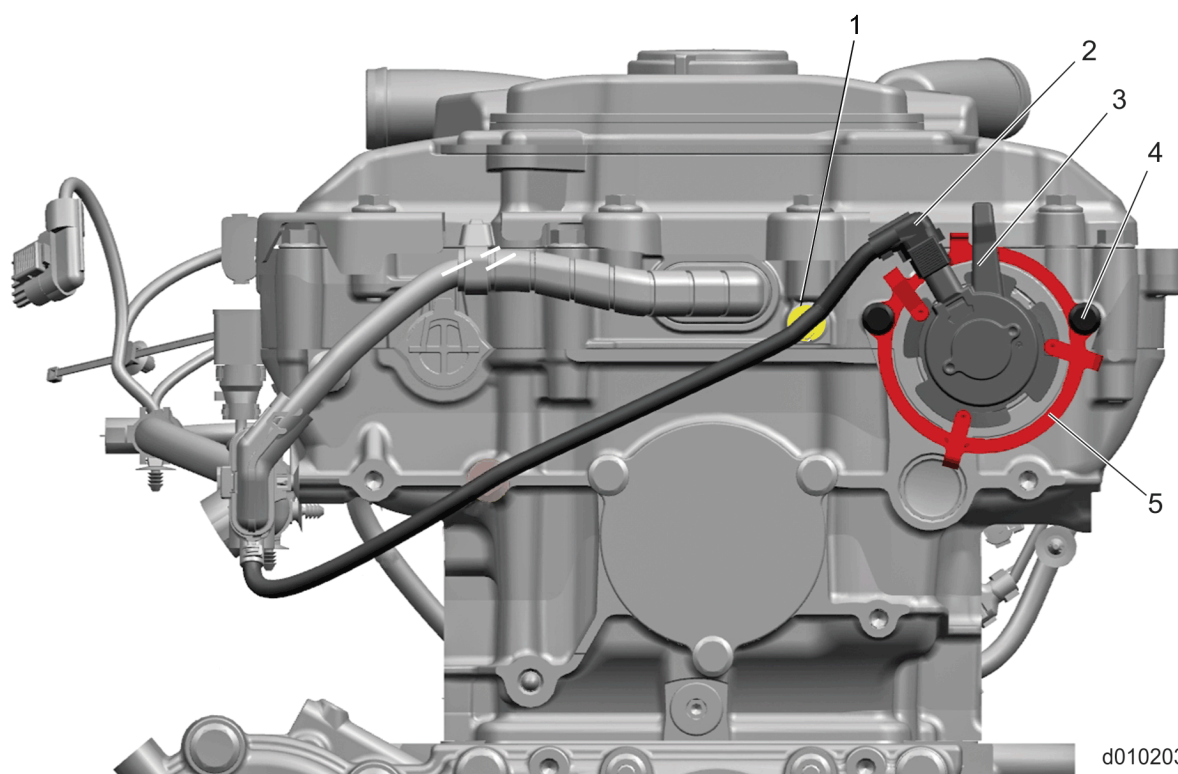
Do not power wash or steam clean the engine bay in the area of vehicle electrical components, unless specified by vehicle manuals or service literature. Power washing/steam cleaning can permanently damage these components, which could result in fire, personal injury, or property damage.

5. Steam clean the rocker cover and rocker cover mounting area.
6. Remove the rocker cover. Refer to section "Removal of the Rocker Cover".
7. Position the engine at No. 1 Top Dead Center (TDC) on the compression stroke. Refer to section "Camshaft Timing Verification".
8. Remove the fuel injector wiring harness. Refer to section "Removal of the Fuel Injector Wiring Harness".
9. Drain the cooling system. Refer to section "Cooling System Drain Procedure".
10. Remove the intake and exhaust rocker arm shaft assemblies.
Refer to section "Removal of the Intake Rocker Arm Shaft Assembly".
Refer to section "Removal of the Exhaust Rocker Arm Shaft Assembly".
11. Remove the air compressor resonator and air compressor resonator upper hose. Refer to section "Removal of the Air Compressor".
12. Remove the Exhaust Gas Recirculation (EGR) cooler mounting straps. Refer to section "Removal of the Exhaust Gas Recirculation Cooler".
13. Remove the EGR cooler upper mounting bracket from the rocker arm housing. Refer to section "Removal of the Exhaust Gas Recirculation Cooler Upper Bracket".
14. Remove the EGR hot pipe heat shield from the right-rear of rocker arm housing.

Table 1.

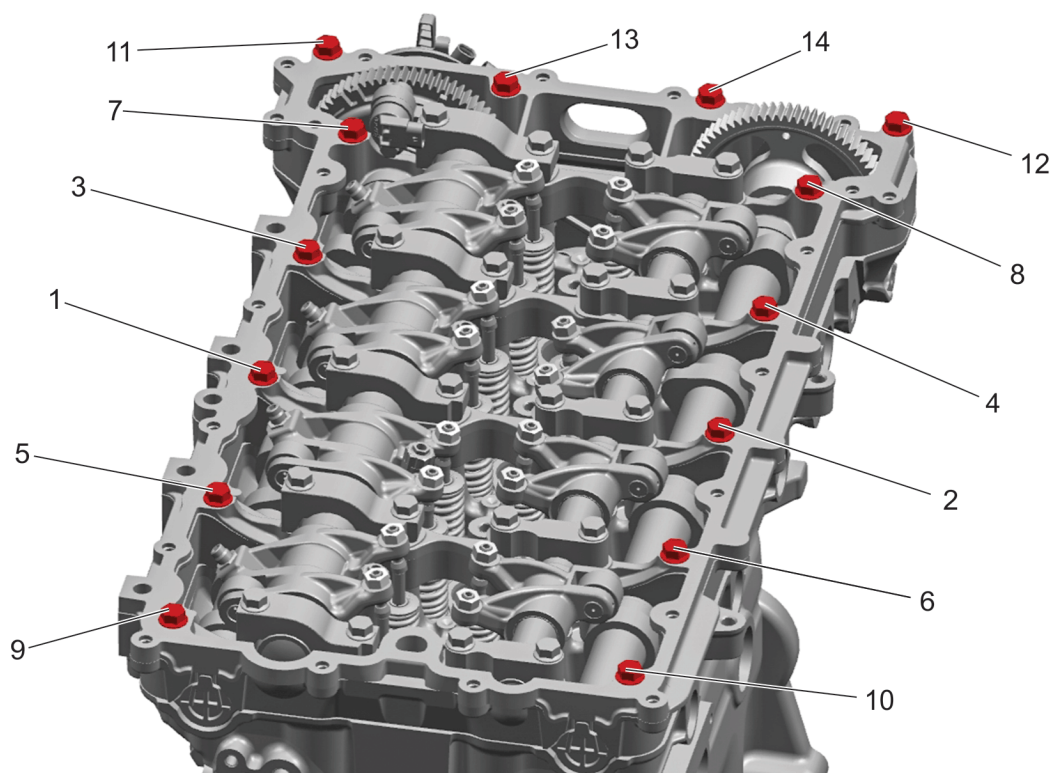
Rocker Arm Housing Removal	
NOTICE: The variable camshaft phaser solenoid must be removed prior to removal of the rocker arm housing. Damage to the central valve (2) on the exhaust camshaft can occur if the solenoid (1) is left in place. If the central valve is damaged the exhaust camshaft assembly will need to be replaced.	
 <p>d050084</p>	

15. Remove the variable camshaft phaser solenoid (3) from the rear of the rocker arm housing. Refer to section "Removal of the Variable Camshaft Phaser Solenoid".



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16. Disconnect the variable camshaft phaser solenoid harness (1) from the rear of the rocker arm housing.
17. Remove the camshaft timing tool from the rocker arm housing.
18. Remove the remaining fourteen rocker arm housing mounting bolts using the sequence shown below.

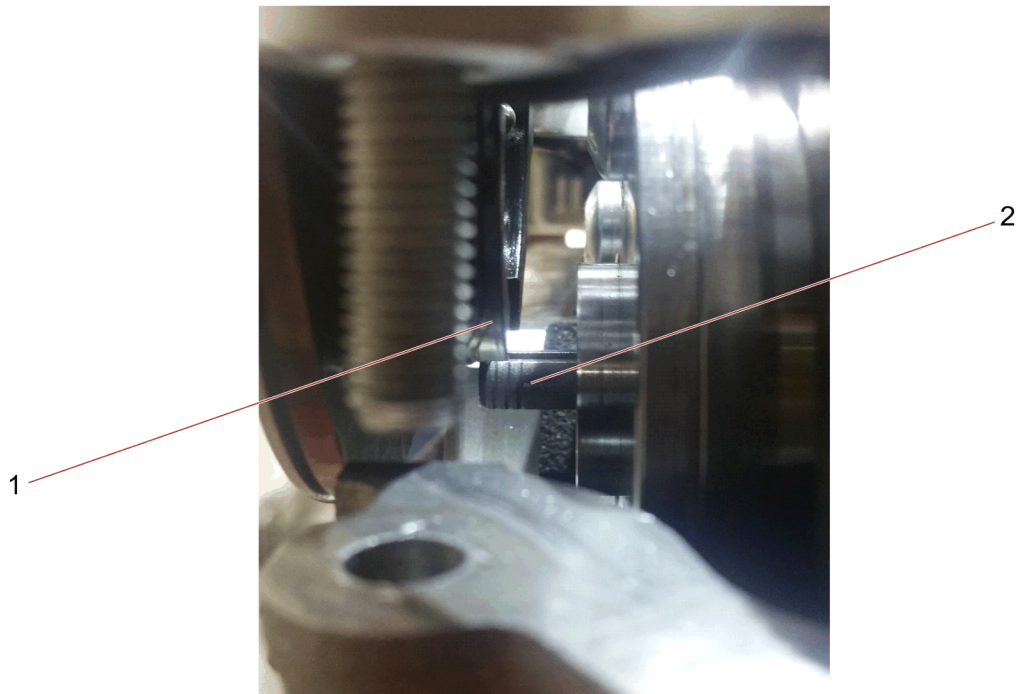


d010202

NOTICE: There are two rocker arm housing locating dowels in the cylinder head at the left-front and right-rear. Use care when removing the rocker arm housing to avoid damage.

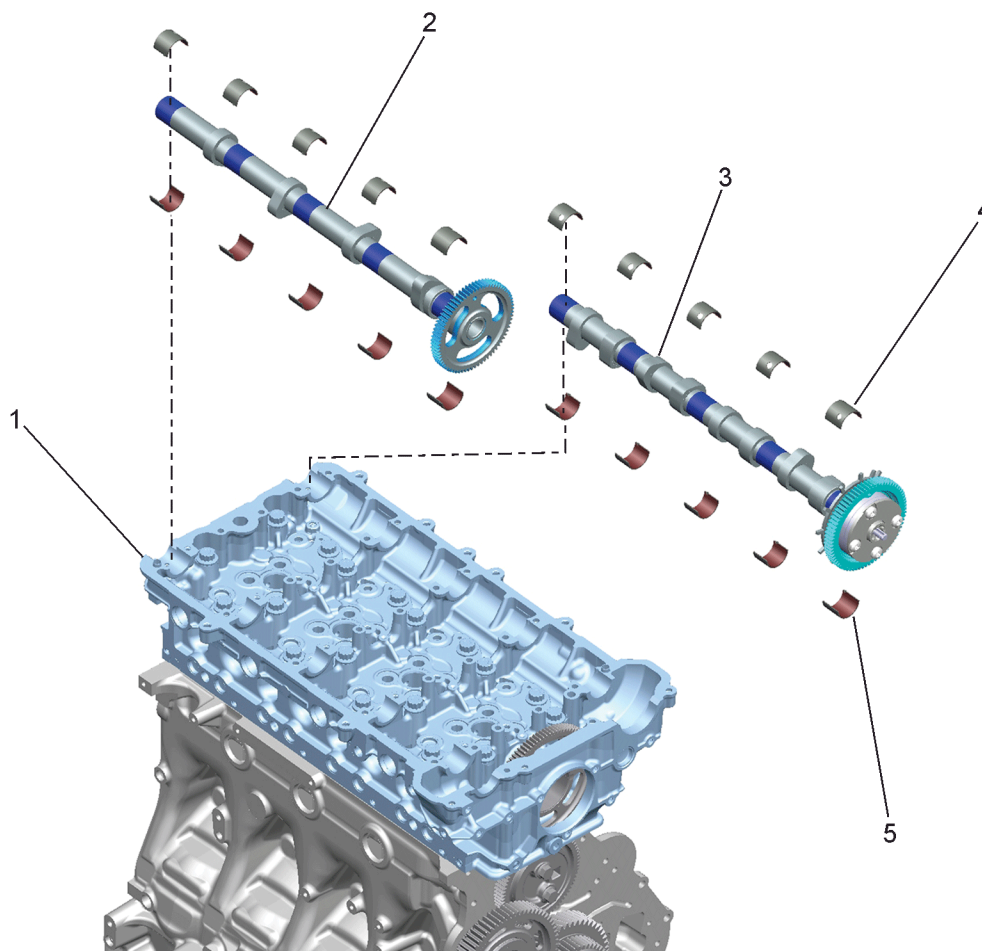
NOTICE: Failure to follow step 19 carefully can result in damage to the central valve on the exhaust camshaft. If the central valve is damaged the exhaust camshaft assembly will need to be replaced.

19. Lift the rocker arm housing from the cylinder head until the housing is loose from the locating dowels. Move the housing slightly toward the rear and lift up and out. This process is necessary to avoid contact between the rocker arm housing mounting seal (1) and the central valve (2) on rear of the exhaust camshaft. See illustration below.



d050083

20. Remove the two bolts securing the variable camshaft phaser solenoid mounting ring to the rocker arm housing.
21. Remove and discard the rocker arm housing mounting seal.
22. Place the rocker arm housing on a clean and flat surface to avoid damage.
23. Carefully lift straight up on the intake camshaft (2) to remove it from the cylinder head (1).



d050070

24. Place the intake camshaft on a clean and flat surface.

NOTE: Care must be used when handling the exhaust camshaft to avoid damage to the camshaft position sensor tone wheel and camshaft phaser.

25. Carefully lift straight up on the exhaust camshaft (3) to remove it from the cylinder head (1).

26. Place the exhaust camshaft on a clean and flat surface.

27. Remove the lower camshaft bearings from the cylinder head and discard.

28. Clean and inspect the rocker arm housing, camshaft bearings, camshafts and rocker arm assemblies. Refer to section "Inspection of the Rocker Arm Housing, Camshafts and Rocker Arm Assemblies".

3 Inspection of the Rocker Arm Housing, Camshafts and Rocker Arm Assemblies

Clean and inspect as follows:

1. Remove the upper camshaft bearings from the rocker arm housing and discard.



To avoid injury from flying debris when using compressed air, wear adequate eye protection (face shield or safety goggles) and do not exceed 40 psi (276 kPa) air pressure.

2. Clean the rocker arm housing and cylinder head sealing surface with a suitable cleaning agent and dry with compressed air.

NOTICE: The rocker arm housing must be removed from the engine for any type of thread repair, if not already removed. Debris from a thread repair can result in serious engine damage if debris ends up in the oil pan.

NOTE: The rocker arm housing is machined with the cylinder head and considered a matched set. If the rocker arm housing requires replacement, the cylinder head must also be replaced.

3. Inspect the rocker arm housing for cracks at the mounting seal surface and damage to the threads. Repair or replace the rocker arm housing as necessary.

NOTE: Light debris scratches and light scoring are normal wear conditions for the camshaft bearings, camshaft journals, camshaft lobes, rocker arm housing rocker shaft journals, rocker arm shafts, and rocker arm rollers.

4. Inspect the rocker arm housing rocker shaft journals and rocker shaft caps for excessive wear, deep scratches, and heavy scoring that can be caught with a fingernail. Replace the rocker arm housing and cylinder head if damage is extensive.
5. Ensure all of the oil passages in the rocker arm housing are clear and free of debris.
6. Inspect the rocker arm housing sealing surface on the cylinder head for damage that would affect sealing. Repair as necessary.
7. Inspect the rocker arm housing locating dowels in the cylinder head. Replace the dowels if damage is found.
8. Inspect the intake and exhaust camshaft journals and lobes for excessive wear, deep scratches, and heavy scoring that can be caught with a fingernail. See illustrations below. Replace the camshafts as necessary.

Table 2.

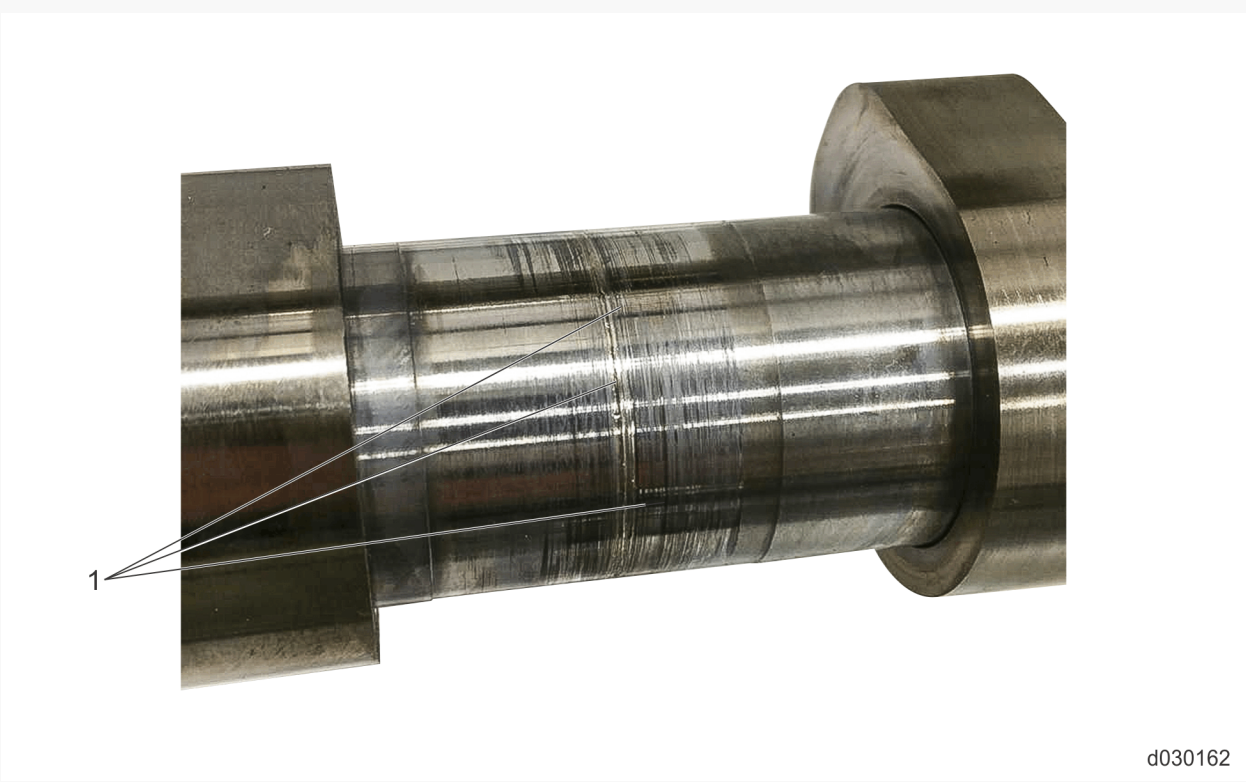
Camshaft Journal Abnormal Wear	
 <p>d030162</p>	
1. Abnormal Scoring	

Table 3.


Camshaft Journal Abnormal Wear	
	
d030163	
1. Abnormal Scoring	

Table 4.

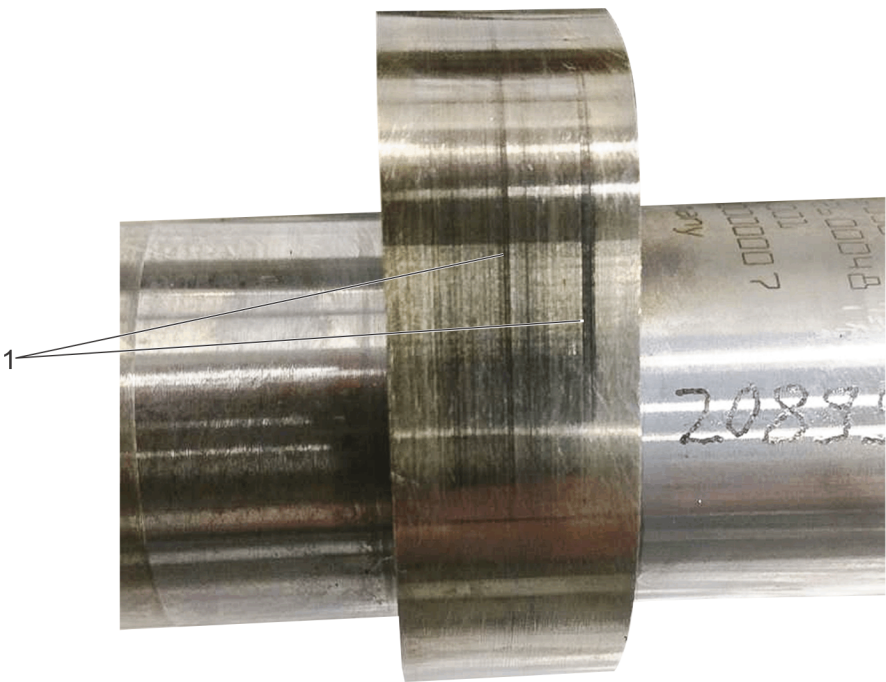
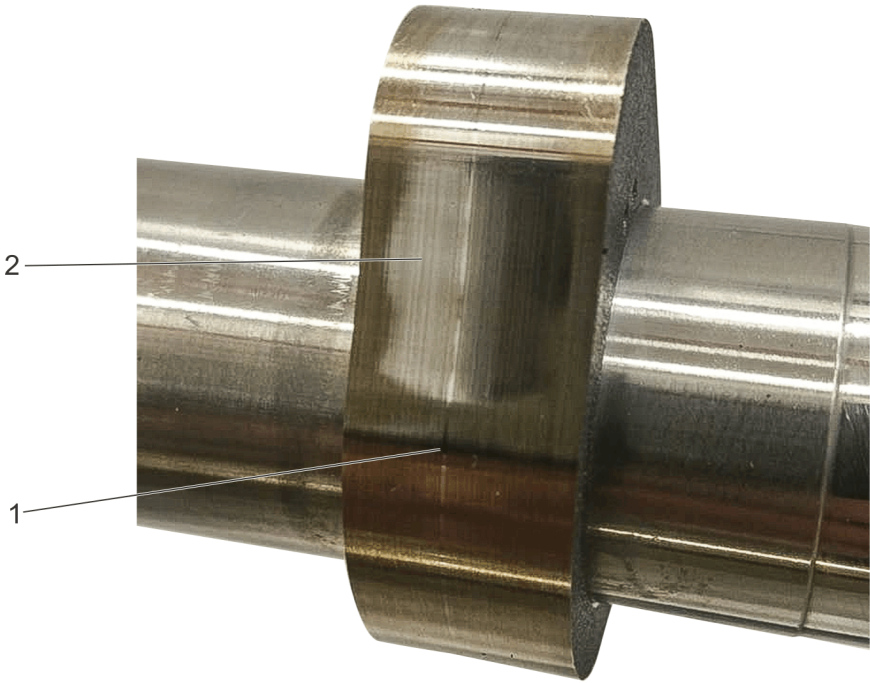
Camshaft Lobe Normal Wear	
	
d030160	
1. Normal Light Score Marks	

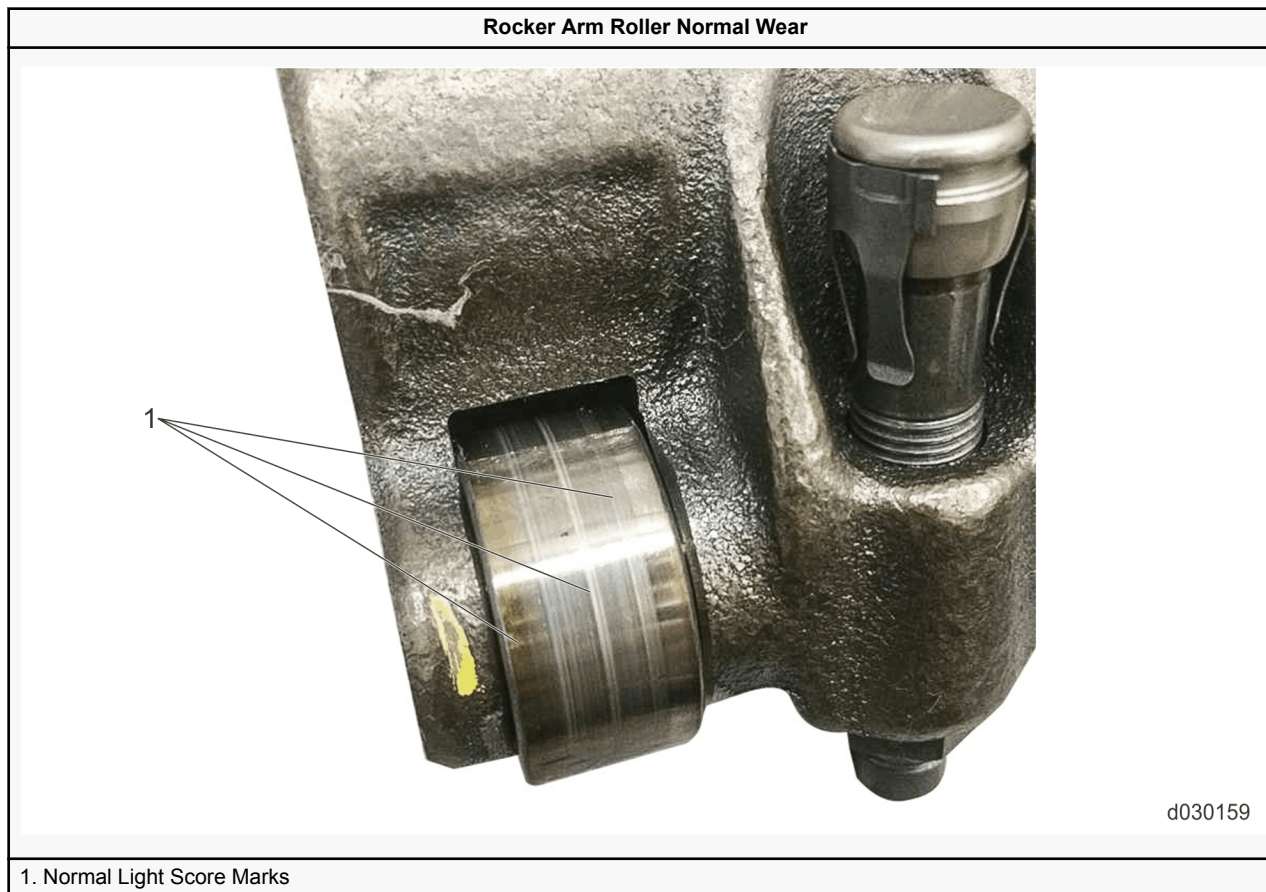
Table 5.

Camshaft Lobe Normal Wear	
	
1. Normal Light Score Mark	
2. Normal Wear Pattern	

d030161

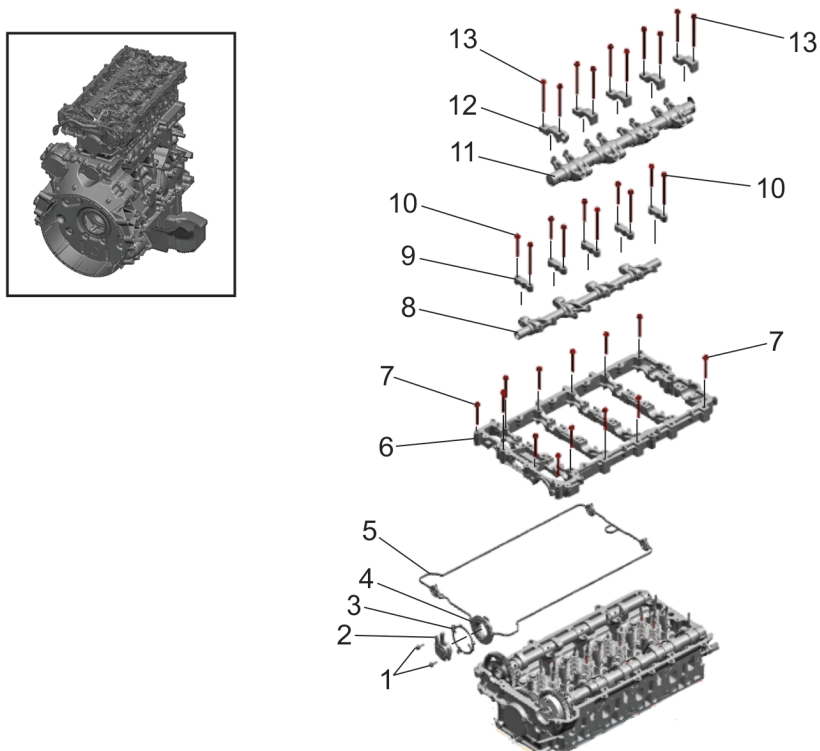
- 9. Inspect the upper and lower camshaft bearings for scoring or scratches that can be caught with a fingernail. Replace the bearings as necessary.
- 10. Inspect the intake and exhaust camshaft journals and lobes for excessive wear, deep scratches, and heavy scoring. Replace the camshafts as necessary.
- 11. Inspect the camshaft position sensor tone wheel on the exhaust camshaft for cracks or any other damage. If damaged, replace the exhaust camshaft.
- 12. Inspect the camshaft gears for damaged teeth. If found, replace the damaged camshaft and inspect the gear train.
- 13. Inspect the intake and exhaust rocker arm rollers for excessive wear, deep scratches, and heavy scoring that can be caught with a fingernail. See illustrations below. Replace the rocker arm shaft assemblies as necessary.

Table 6.



14. Inspect the rocker arm valve and engine brake adjusting screws and feet for damage. Replace parts as necessary.

4 Installation of the Rocker Arm Housing and Camshafts



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| 1. Variable Camshaft Phaser Solenoid Mounting Ring Bolts | 8. Intake Rocker Arm Shaft Assembly |
| 2. Variable Camshaft Phaser Solenoid | 9. Intake Rocker Shaft Caps |
| 3. Variable Camshaft Phaser Solenoid Mounting Ring | 10. Intake Rocker Shaft Cap Bolts |
| 4. Variable Camshaft Phaser Solenoid Mounting Seal | 11. Exhaust Rocker Arm Shaft Assembly |
| 5. Rocker Arm Housing Mounting Seal | 12. Exhaust Rocker Shaft Caps |
| 6. Rocker Arm Housing | 13. Exhaust Rocker Shaft Cap Bolts |
| 7. Rocker Arm Housing Mounting Bolts | |

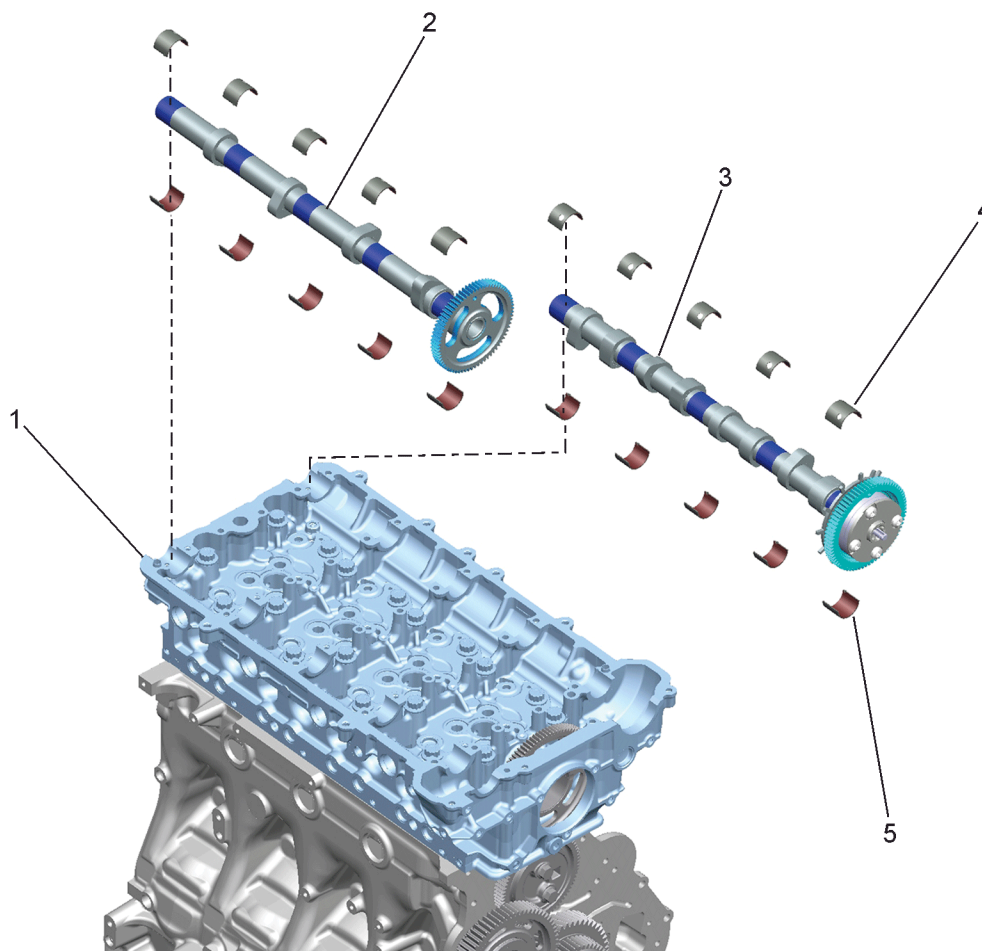
Figure 2. Rocker Arm Housing and Rocker Arms

Install as follows:

1. Clean and inspect the rocker arm housing, camshafts and rocker arm assemblies, if not already complete. Refer to section "Inspection of the Rocker Arm Housing, Camshafts and Rocker Arm Assemblies".
2. Position the engine at No. 1 Top Dead Center (TDC). Refer to section "Camshaft Timing Verification".

NOTE: Install the camshaft bearings to their original locations, if removed and reused.

3. Install new lower camshaft bearings (5) into the cylinder head (1), if removed. Make sure to align the bearings properly to the bearing journal.

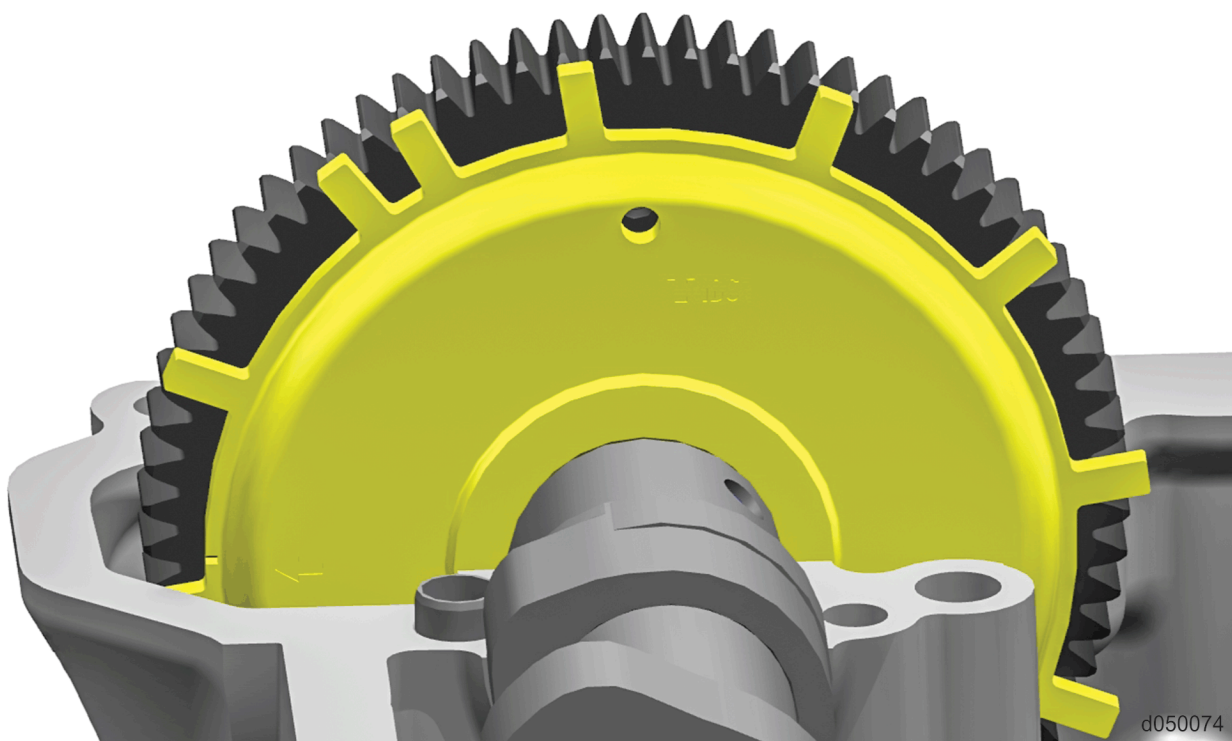


d050070

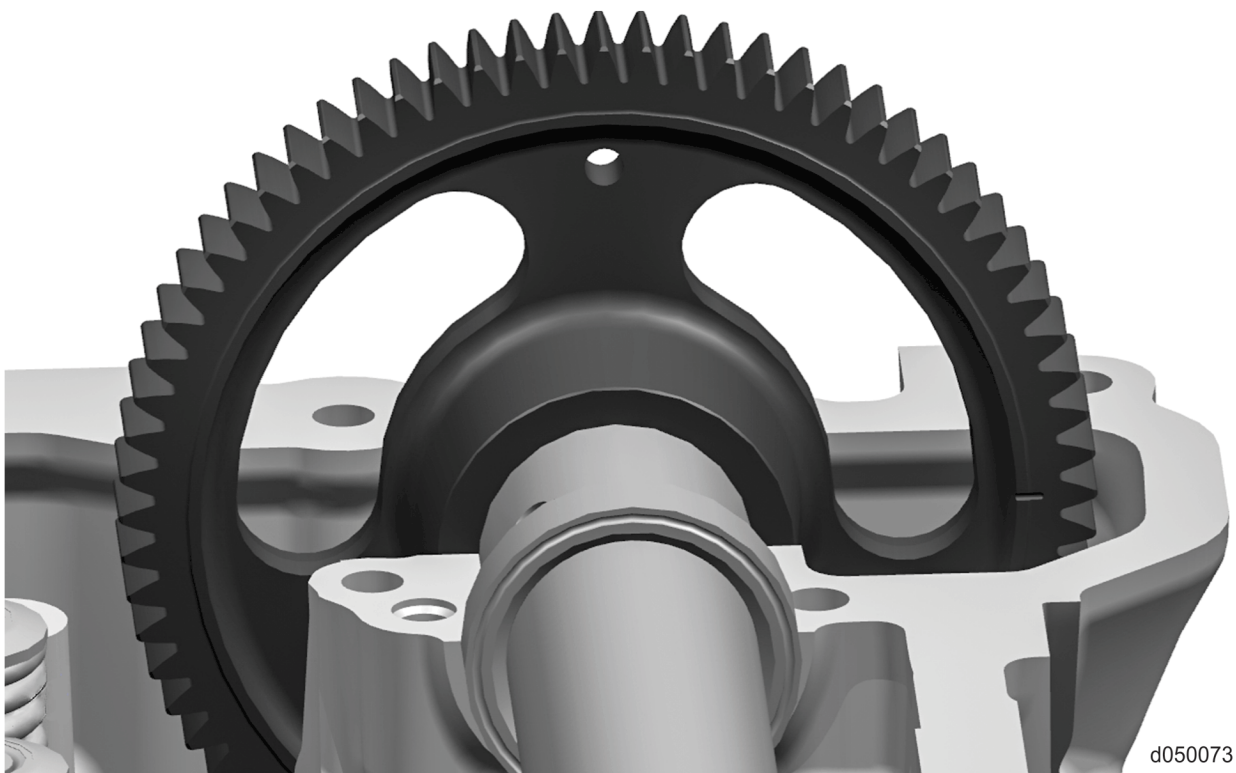
4. Lubricate the lower camshaft bearings and camshaft journals with clean engine lubricating oil.

NOTE: Care must be used when handling the exhaust camshaft to avoid damage to the camshaft position sensor tone wheel and camshaft phaser.

5. Carefully install the exhaust camshaft onto the cylinder head and mesh the camshaft gear with the idler gear. The indicator line on the exhaust camshaft tone wheel must line up with the top edge of the cylinder head casting. The Top Dead Center (TDC) hole in the tone wheel should also be at 12 o'clock.



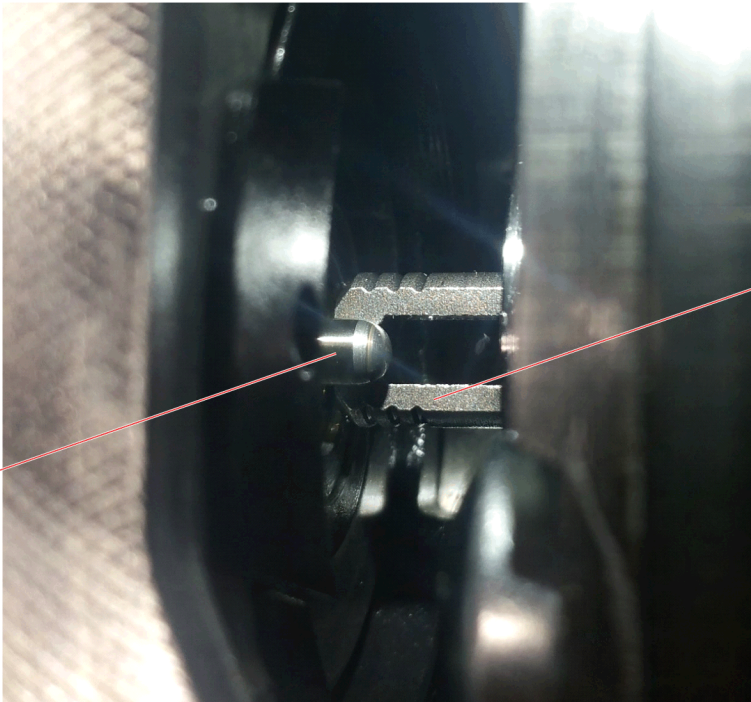
6. Carefully install the intake camshaft onto the cylinder head and mesh the camshaft gear with the idler gear. The indicator line on the intake camshaft gear must line up with the top edge of the cylinder head casting. The Top Dead Center (TDC) hole in the gear should also be at 12 o'clock.



7. Place Loctite 5970 sealant, or an equivalent, on the rocker arm housing in the position of the mounting seal end caps and the variable camshaft phaser solenoid seal. The sealant will help retain the seal during assembly.
8. Install a new rocker arm housing seal into the sealing groove on the rocker arm housing. Ensure the end caps of the seal are fully seated in the housing.

9. Loosely install the variable camshaft phaser solenoid mounting ring to the rocker arm housing with the two mounting bolts. This will help hold the seal in place. Do not install the variable camshaft phaser solenoid until instructed.
10. Install new upper camshaft bearings into the rocker arm housing, if removed. Make sure to align the bearings properly to the bearing journal and oil holes.
11. Lubricate the upper camshaft bearings with clean engine lubricating oil.

Table 7.

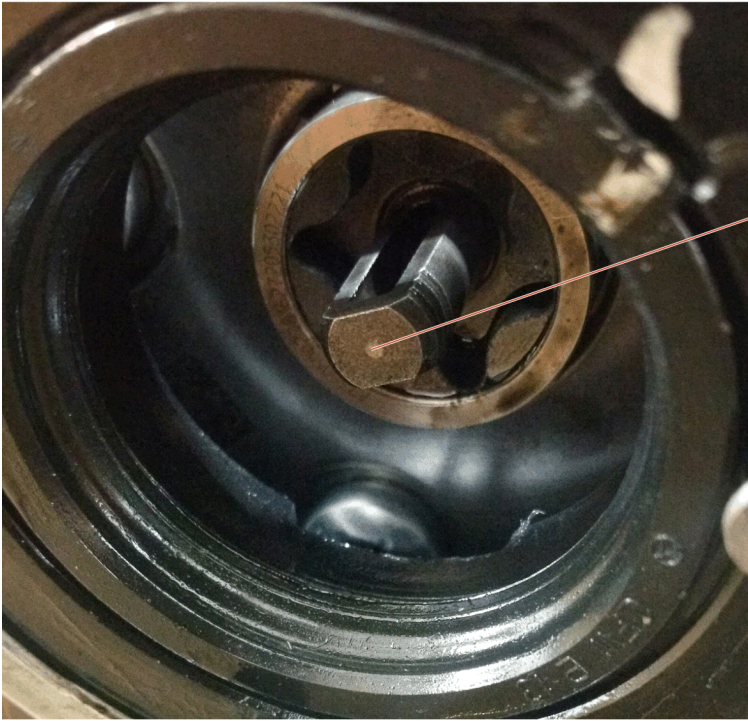
Broken Central Valve
<p>NOTICE: The variable camshaft phaser solenoid must not be installed prior to installation of the rocker arm housing. Damage to the central valve (2) on the exhaust camshaft can occur if the solenoid (1) is installed when the housing is lowered over the camshafts. If the central valve is damaged the exhaust camshaft assembly will need to be replaced. See illustrations below.</p>
 <p style="text-align: right;">d050084</p>

Broken Central Valve

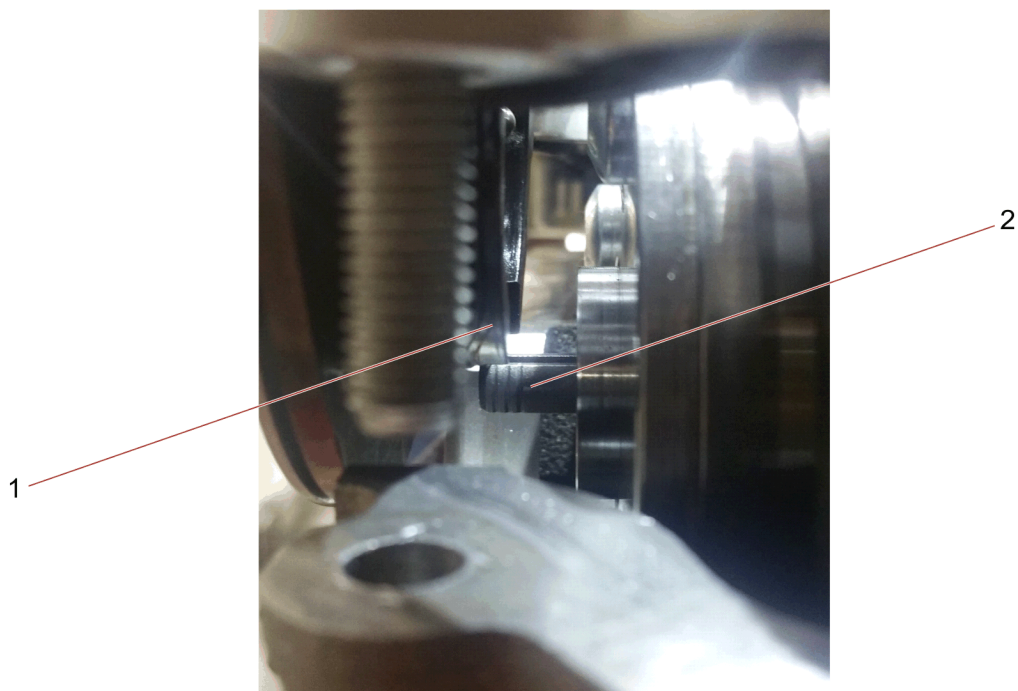
d050085

1. Broken Central Valve on Exhaust Camshaft

Table 8.

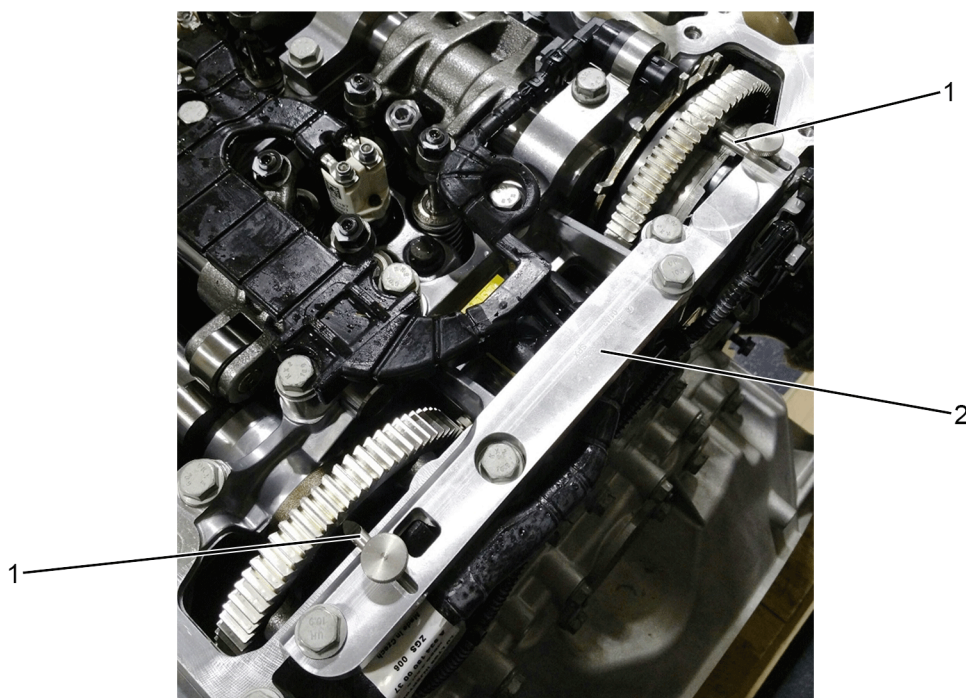
Central Valve
NOTICE: There are two rocker arm housing locating dowels in the cylinder head at the left-front and right-rear. Use care when installing the rocker arm housing to avoid damage.
NOTICE: Care must be taken to ensure the rocker arm housing mounting seal stays in place and is not damaged during rocker arm housing installation.
NOTICE: Failure to follow step 12 carefully can result in damage to the central valve (1) on the exhaust camshaft.
<div><p>d050082</p></div>

12. Position the rocker arm housing directly over the cylinder head. Move the housing slightly toward the rear while carefully lowering it into place onto the locating dowels. This process is necessary to avoid contact between the rocker arm housing mounting seal (1) and the central valve (2) on the rear of the exhaust camshaft. See illustration below.



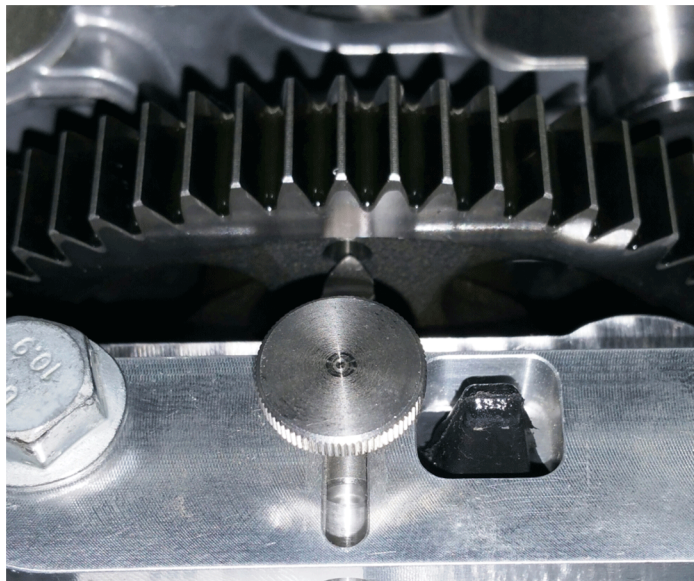
d050083

13. Ensure the mounting seal is still fully installed and seated properly in the rocker arm housing seal groove.
14. Install the camshaft timing tool (2) onto the rocker arm housing with two bolts as indicated below.

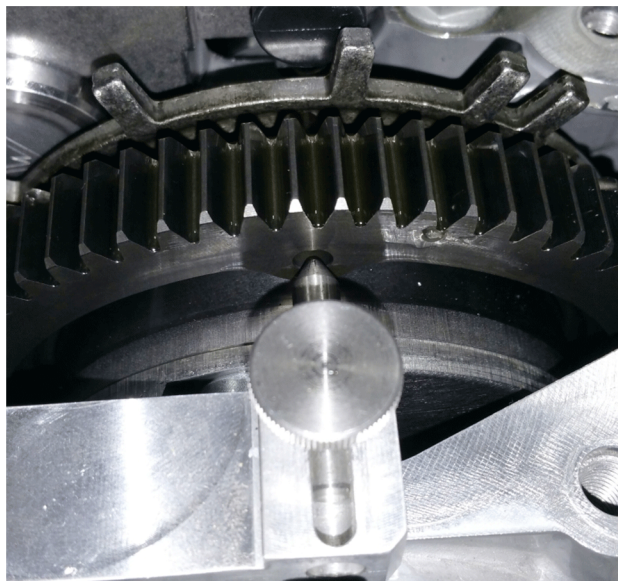


d050066

15. Check the positions of the intake and exhaust camshafts by confirming the holes in the camshaft gears are at 12 o'clock and line up with the pins in the camshaft timing tool. A mirror should be used for this step.



d050068



d050067

16. If the camshafts are not in time, and the engine is positioned at No. 1 TDC, the rocker arm housing must be lifted to correctly position the camshafts.
17. Once the camshafts are positioned correctly, remove the camshaft timing tool.
18. Install the fourteen rocker arm housing mounting bolts. Do not tighten the bolts at this time.
19. Lubricate the intake rocker arm shaft, rocker arm rollers and adjusting feet with clean engine lubricating oil.

NOTICE: The intake rocker arm shaft is equipped with a locating pin at the front of the shaft that engages the rocker arm housing. Use care when installing the intake rocker arm shaft assembly to avoid damage to the pin.

20. Line up the rocker shaft locating pin and install the intake rocker shaft assembly onto the rocker arm housing.

NOTE: The long intake rocker shaft cap mounting bolts are used toward the inside of the rocker arm housing and the short bolts are used toward the outside of the rocker arm housing.

NOTICE: Do not tighten the intake rocker shaft cap bolts at this time.

21. Using the paint marks added during the removal process, install the intake rocker shaft caps with mounting bolts to their respective locations from one to five.
22. Lubricate the exhaust rocker arm shaft, rocker arm rollers and adjusting feet with clean engine lubricating oil.

NOTICE: The exhaust rocker arm shaft is equipped with a locating pin at the front of the shaft that engages the rocker arm housing. Use care when installing the exhaust rocker arm shaft assembly to avoid damage to the pin.

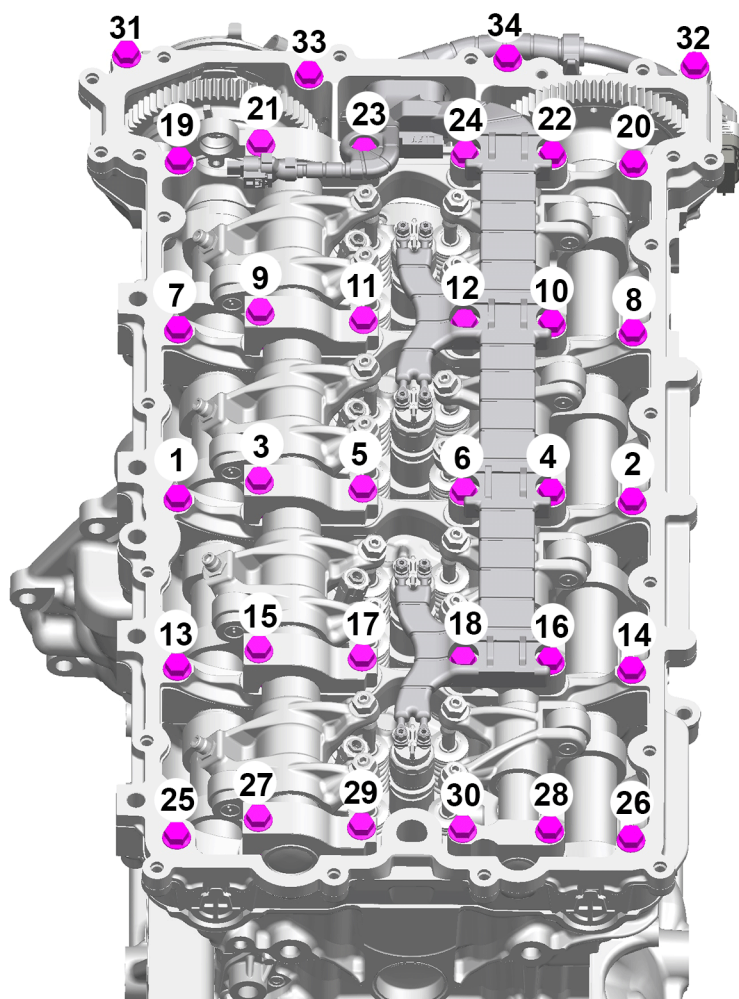
23. Line up the rocker shaft locating pin and install the exhaust rocker shaft assembly onto the rocker arm housing.

NOTICE: Do not tighten the exhaust rocker shaft cap bolts at this time.

24. Using the paint marks added during the disassembly process, install the exhaust rocker shaft caps with mounting bolts to their respective locations from one to five.

NOTICE: The tightening sequence must be followed in order to prevent damage to the rocker arm shafts.

25. Tighten the rocker arm housing and rocker shaft cap bolts (1 to 34) to 25 N·m (18 lb·ft) following the torque sequence shown below.



d050069

26. Adjust the valves and engine brakes. Refer to section "Setting the Valve and Engine Brake Lash".
27. Torque the variable camshaft phaser solenoid mounting ring bolts to 10 N·m (7 lb·ft).
28. Install the variable camshaft phaser solenoid into the rocker arm housing and connect the harness. Refer to section "Installation of the Variable Camshaft Phaser Solenoid".
29. Attach the variable camshaft phaser solenoid harness to the rear of the rocker arm housing.
30. Install the Exhaust Gas Recirculation (EGR) hot pipe heat shield onto the rocker arm housing. Torque the bolts to 25 N·m (18 lb·ft).
31. Install the EGR cooler upper mounting bracket onto the rocker arm housing. Refer to section "Installation of the Exhaust Gas Recirculation Cooler Upper Bracket".
32. Install the EGR cooler mounting straps. Refer to section "Installation of the Exhaust Gas Recirculation Cooler".
33. Install the air compressor resonator and air compressor resonator upper hose. Refer to section "Installation of the Air Compressor Resonator".
34. Remove the engine barring tool from the flywheel housing and reinstall the cover plate.
35. Remove the TDC locating tool from the flywheel housing and reinstall the crankshaft position sensor. Refer to section "Installation of the Camshaft Position Sensor".
36. Install the fuel injector wiring harness. Refer to section "Installation of the Fuel Injector Wiring Harness".
37. Install the rocker cover. Refer to section "Installation of the Rocker Cover".


CAUTION: ELECTRICAL SHOCK

To avoid injury from electrical shock, use care when connecting battery cables. The magnetic switch studs are at battery voltage.

38. Connect the batteries.
39. Fill the cooling system. Refer to section "Cooling System Fill Procedure".

**WARNING: ENGINE EXHAUST**

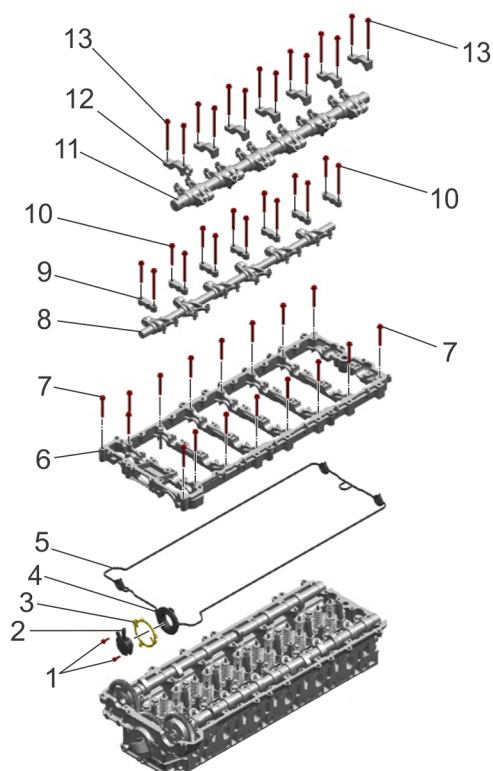
To avoid injury from inhaling engine exhaust, always operate the engine in a well-ventilated area. Engine exhaust is toxic.

**WARNING: PERSONAL INJURY**

To avoid injury before starting and running the engine, ensure the vehicle is parked on a level surface, parking brake is set, and the wheels are blocked.

40. Start the engine and inspect for leaks.
41. If removed, install the bumper end(s). Refer to the Original Equipment Manufacturer (OEM) procedures.
42. Close the hood.

5 Removal of the Rocker Arm Housing and Camshafts

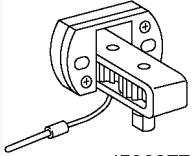
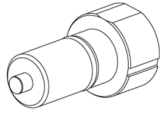
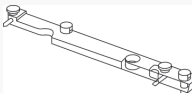


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| 1. Variable Camshaft Phaser Solenoid Mounting Ring Bolts | 8. Intake Rocker Arm Shaft Assembly |
| 2. Variable Camshaft Phaser Solenoid | 9. Intake Rocker Shaft Caps |
| 3. Variable Camshaft Phaser Solenoid Mounting Ring | 10. Intake Rocker Shaft Cap Bolts |
| 4. Variable Camshaft Phaser Solenoid Mounting Seal | 11. Exhaust Rocker Arm Shaft Assembly |
| 5. Rocker Arm Housing Mounting Seal | 12. Exhaust Rocker Shaft Caps |
| 6. Rocker Arm Housing | 13. Exhaust Rocker Shaft Cap Bolts |
| 7. Rocker Arm Housing Mounting Bolts | |

Figure 3. Rocker Arm Housing and Rocker Arms

Table 9.

Special Service Tools Used in the Procedure		
Tool Number	Tool Name	Tool Graphic
W904589046300	Engine Barring Tool	 d580077
W936589001500	TDC Locating Tool	 d580192
W936589002300	Camshaft Timing Tool	 d580191

Remove as follows:


WARNING: PERSONAL INJURY

To avoid injury from hot surfaces, wear protective gloves, or allow engine to cool before removing any component.


WARNING: PERSONAL INJURY

To avoid injury before starting and running the engine, ensure the vehicle is parked on a level surface, parking brake is set, and the wheels are blocked.

1. Shut off the engine, apply the parking brake, chock the wheels, and perform any other applicable safety steps.


CAUTION: ELECTRICAL SHOCK

To avoid injury from electrical shock, use care when connecting battery cables. The magnetic switch studs are at battery voltage.

2. Disconnect the batteries.
3. Open the hood.
4. If necessary, remove the bumper end(s). Refer to the Original Equipment Manufacturer (OEM) procedures.

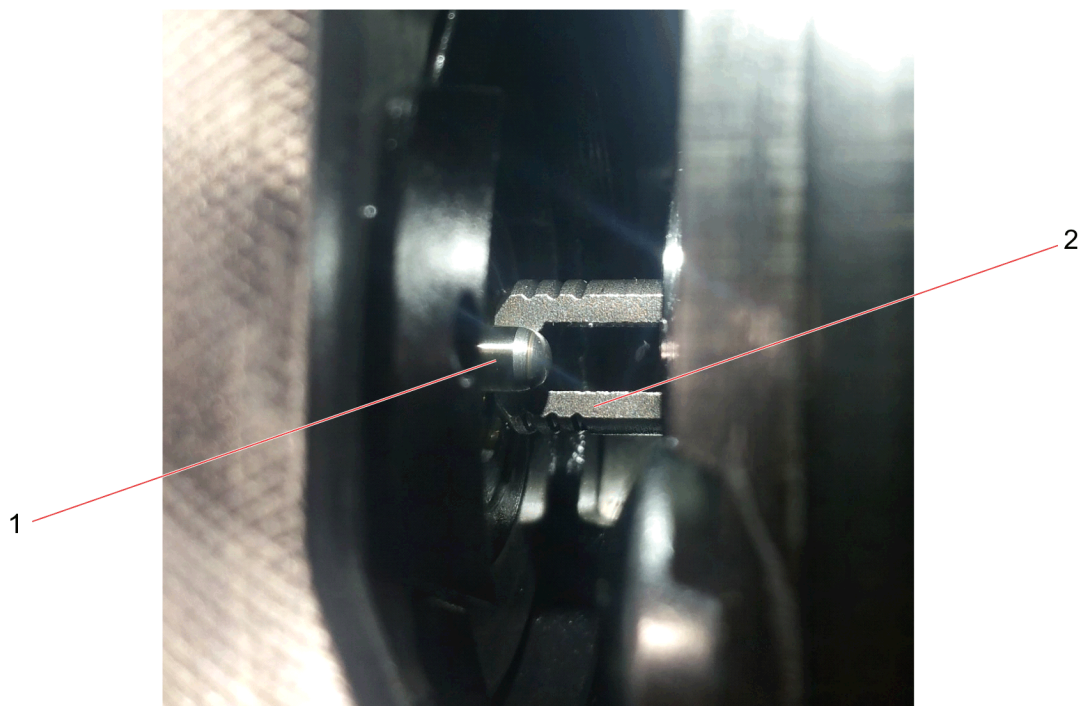
**WARNING: FIRE HAZARD**

Do not power wash or steam clean the engine bay in the area of vehicle electrical components, unless specified by vehicle manuals or service literature. Power washing/steam cleaning can permanently damage these components, which could result in fire, personal injury, or property damage.

5. Steam clean the rocker cover and rocker cover mounting area.
6. Remove the air compressor resonator and rocker cover. Refer to section "Removal of the Rocker Cover".
7. Position the engine at No. 1 Top Dead Center (TDC) on the compression stroke. Refer to section "Camshaft Timing Verification".
8. Remove the fuel injector wiring harness. Refer to section "Removal of the Fuel Injector Wiring Harness".
9. Drain the cooling system. Refer to section "Cooling System Drain Procedure".
10. Remove the intake and exhaust rocker arm shaft assemblies.
Refer to section "Removal of the Intake Rocker Arm Shaft Assembly"
Refer to section "Removal of the Exhaust Rocker Arm Shaft Assembly"
11. Remove the Exhaust Gas Recirculation (EGR) cooler mounting straps. Refer to section "Removal of the Exhaust Gas Recirculation Cooler".
12. Remove the EGR cooler upper mounting bracket from the rocker arm housing. Refer to section "Removal of the Exhaust Gas Recirculation Cooler Upper Bracket".
13. Remove the EGR hot pipe heat shield from the rocker arm housing.

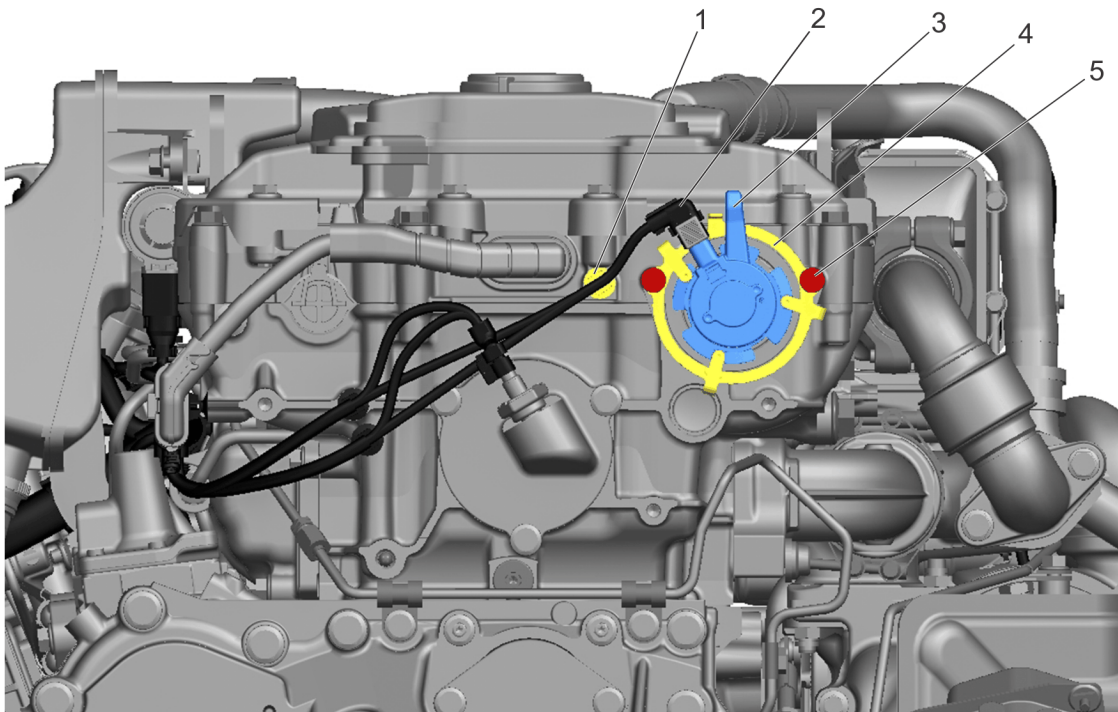
Table 10.

NOTICE: The variable camshaft phaser solenoid **must** be removed prior to removal of the rocker arm housing. Damage to the central valve (2) on the exhaust camshaft can occur if the solenoid (1) is left in place. If the central valve is damaged the exhaust camshaft assembly will need to be replaced.



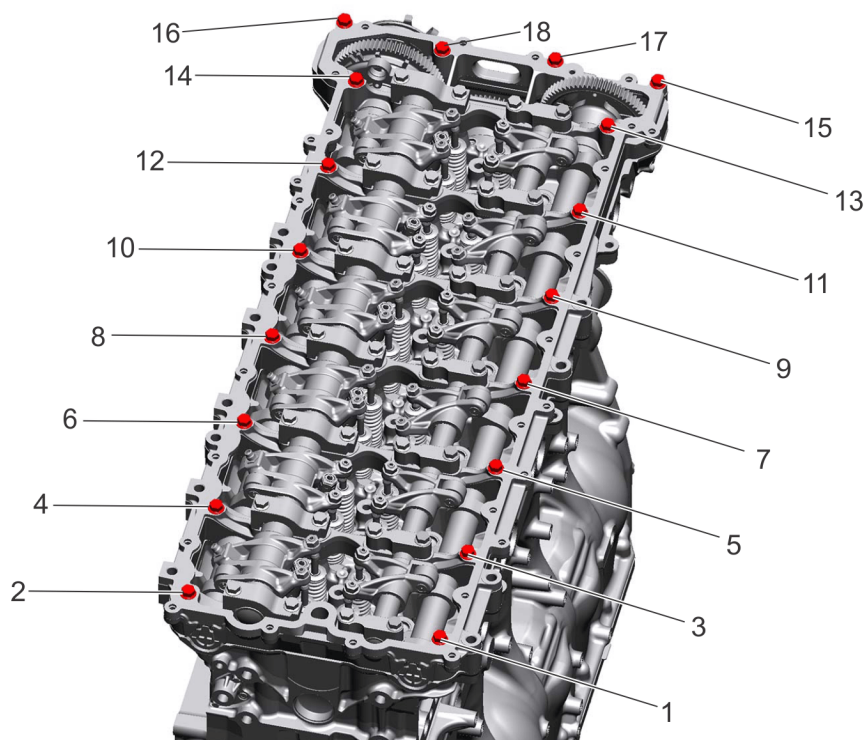
d050084

14. Remove the variable camshaft phaser solenoid (3) from the rear of the rocker arm housing. Refer to section "Removal of the Variable Camshaft Phaser Solenoid".



d010323

15. Remove the variable camshaft phaser solenoid harness attachment (1) from the rear of the rocker arm housing.
 16. Remove the camshaft timing tool from the rocker arm housing.
 17. Remove the remaining eighteen rocker arm housing mounting bolts using the loosening sequence shown below.



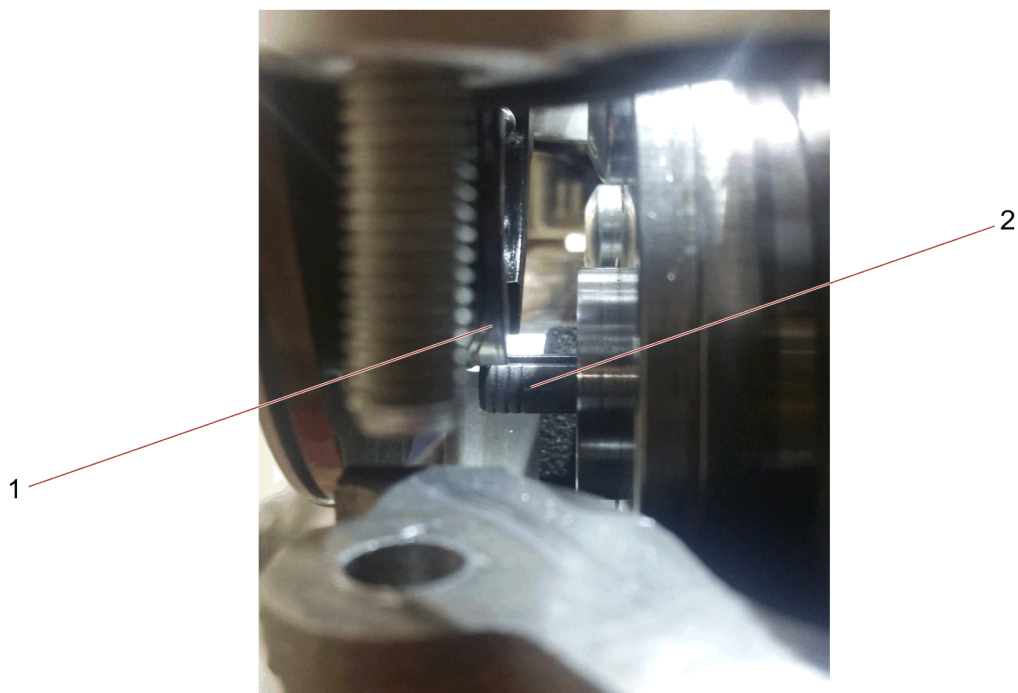
d010343

NOTICE: There are two rocker arm housing locating dowels in the cylinder head at the left-front and right-rear. Use care when removing the rocker arm housing to avoid damage.

NOTICE: On some applications, there is limited clearance between the rocker arm housing and the truck cab. Use caution during removal to prevent damage.

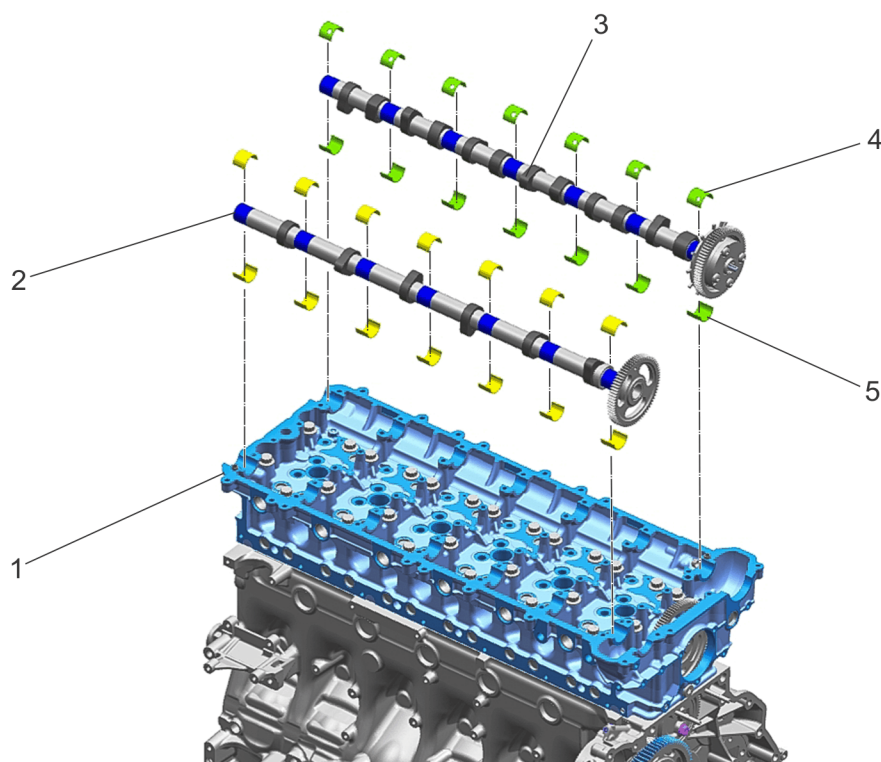
NOTICE: Failure to follow step 18 carefully can result in damage to the central valve on the exhaust camshaft. If the central valve is damaged the exhaust camshaft assembly will need to be replaced.

18. Lift the rocker arm housing from the cylinder head until the housing is loose from the locating dowels. Move the housing slightly toward the rear and lift up and out. This process is necessary to avoid contact between the rocker arm housing mounting seal (1) and the central valve (2) on rear of the exhaust camshaft. See illustration below.



d050083

19. Remove the two bolts securing the variable camshaft phaser solenoid mounting ring and seal to the rocker arm housing.
20. Remove and discard the rocker arm housing mounting seal.
21. Place the rocker arm housing on a clean and flat surface to avoid damage.
22. Carefully lift straight up on the intake camshaft (2) to remove it from the cylinder head (1).



d050079

23. Place the intake camshaft on a clean and flat surface.

NOTE: Care must be used when handling the exhaust camshaft to avoid damage to the camshaft position sensor tone wheel and camshaft phaser.

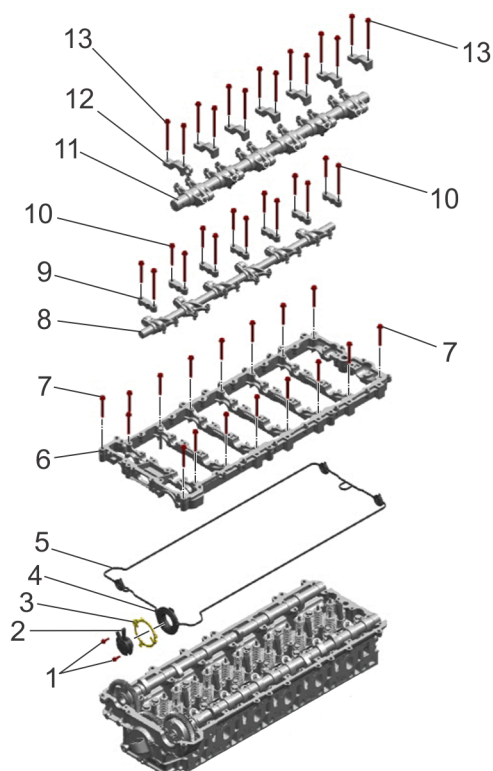
24. Carefully lift straight up on the exhaust camshaft (3) to remove it from the cylinder head (1).

25. Place the exhaust camshaft on a clean and flat surface.

26. Remove the lower camshaft bearings from the cylinder head and discard.

27. Clean and inspect the rocker arm housing, camshafts and rocker arm assemblies. Refer to section "Inspection of the Rocker Arm Housing, Camshafts and Rocker Arm Assemblies".

6 Installation of the Rocker Arm Housing and Camshafts

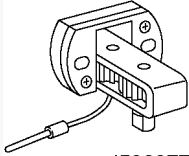
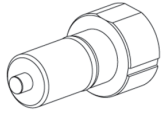
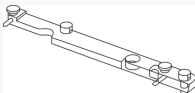


d010345

- | | |
|--|---------------------------------------|
| 1. Variable Camshaft Phaser Solenoid Mounting Ring Bolts | 8. Intake Rocker Arm Shaft Assembly |
| 2. Variable Camshaft Phaser Solenoid | 9. Intake Rocker Shaft Caps |
| 3. Variable Camshaft Phaser Solenoid Mounting Ring | 10. Intake Rocker Shaft Cap Bolts |
| 4. Variable Camshaft Phaser Solenoid Mounting Seal | 11. Exhaust Rocker Arm Shaft Assembly |
| 5. Rocker Arm Housing Mounting Seal | 12. Exhaust Rocker Shaft Caps |
| 6. Rocker Arm Housing | 13. Exhaust Rocker Shaft Cap Bolts |
| 7. Rocker Arm Housing Mounting Bolts | |

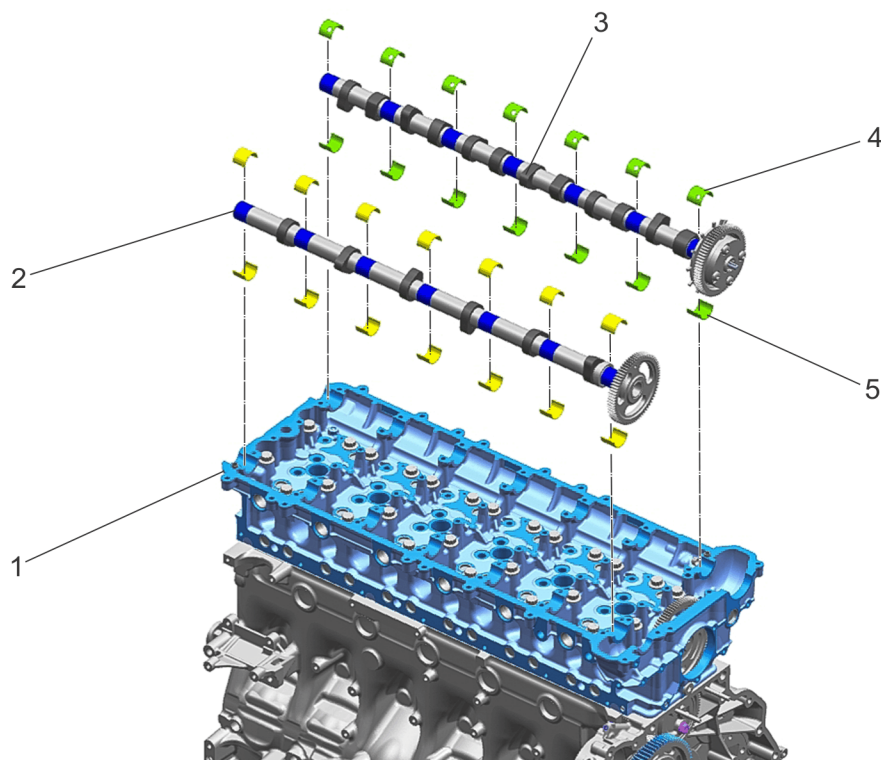
Figure 4. Rocker Arm Housing and Rocker Arms

Table 11.

Special Service Tools Used in the Procedure		
Tool Number	Tool Name	Tool Graphic
W904589046300	Engine Barring Tool	 d580077
W936589001500	TDC Locating Tool	 d580192
W936589002300	Camshaft Timing Tool	 d580191

Install as follows:

1. Clean and inspect the rocker arm housing, camshafts and rocker arm assemblies, if not already complete. Refer to section "Inspection of the Rocker Arm Housing, Camshafts and Rocker Arm Assemblies".
2. Position the engine at No. 1 Top Dead Center (TDC) on the compression stroke. Refer to section "Camshaft Timing Verification".
3. Install new lower camshaft bearings (5) into the cylinder head (1). Make sure to align the bearings properly to the bearing journals.

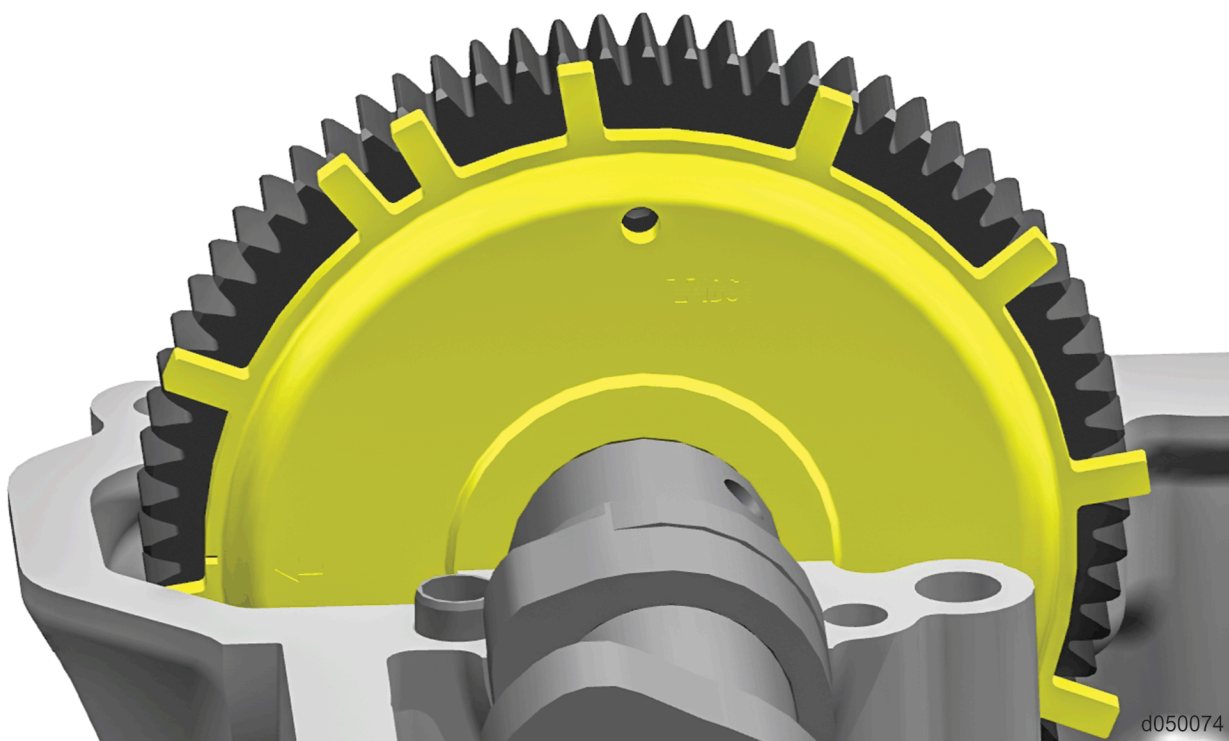


d050079

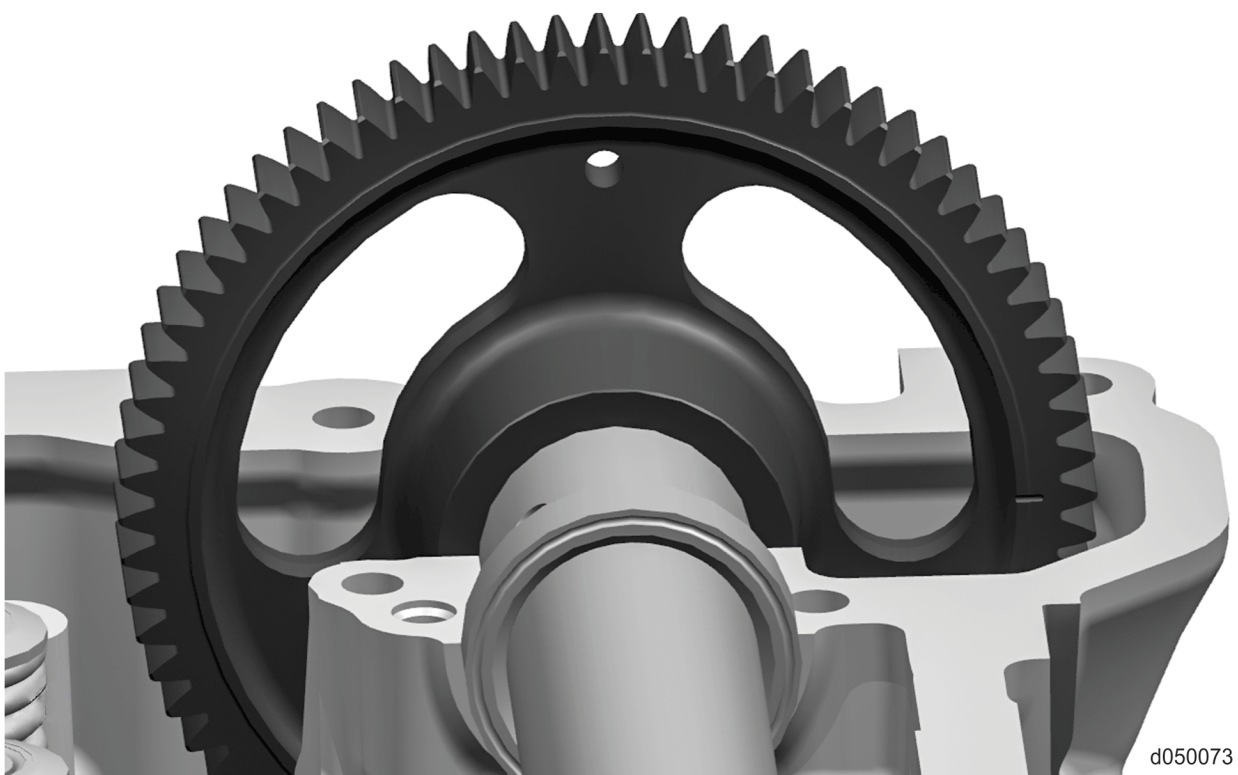
4. Lubricate the lower camshaft bearings and camshaft journals with clean engine lubricating oil.

NOTE: Care must be used when handling the exhaust camshaft to avoid damage to the camshaft position sensor tone wheel and camshaft phaser.

5. Carefully install the exhaust camshaft onto the cylinder head and mesh the camshaft gear with the idler gear. The indicator line on the exhaust camshaft tone wheel must line up with the top edge of the cylinder head casting. The Top Dead Center (TDC) hole in the tone wheel should also be at 12 o'clock.



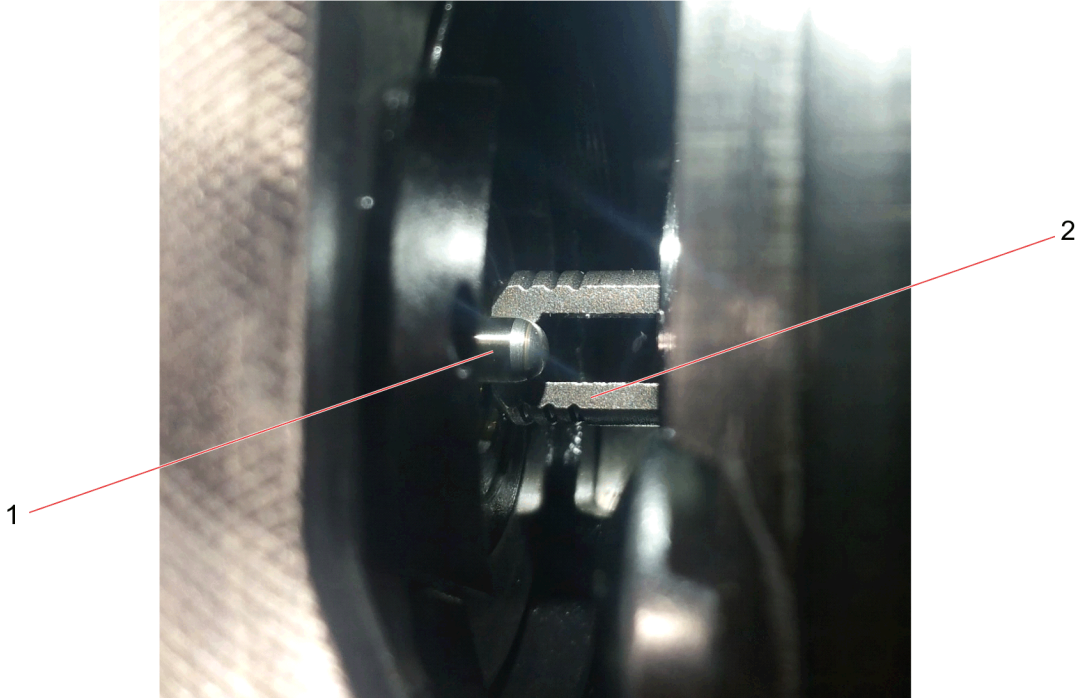
6. Carefully install the intake camshaft onto the cylinder head and mesh the camshaft gear with the idler gear. The indicator line on the intake camshaft gear must line up with the top edge of the cylinder head casting. The Top Dead Center (TDC) hole in the gear should also be at 12 o'clock.



7. Place Loctite 5970 sealant, or an equivalent, on the rocker arm housing in the position of the mounting seal end caps and the variable camshaft phaser solenoid seal. The sealant will help retain the seal during assembly.
8. Install a new rocker arm housing seal into the sealing groove on the rocker arm housing. Ensure the end caps of the seal are fully seated in the housing.

9. Install the variable camshaft phaser solenoid mounting ring to the rocker arm housing with the two mounting bolts. Hand-tighten the bolts. This will help hold the seal in place. Do not install the variable camshaft phaser solenoid until instructed.
10. Install new upper camshaft bearings into the rocker arm housing. Make sure to align the bearings properly to the bearing journals and oil holes.
11. Lubricate the upper camshaft bearings with clean engine lubricating oil.

Table 12.

Broken Central Valve	
<p>NOTICE: The variable camshaft phaser solenoid must not be installed prior to installation of the rocker arm housing. Damage to the central valve (2) on the exhaust camshaft can occur if the solenoid (1) is installed when the housing is lowered over the camshafts. If the central valve is damaged the exhaust camshaft assembly will need to be replaced. See illustrations below.</p>	
 <p>d050084</p>	

Broken Central Valve



d050085

2. Broken Central Valve on Exhaust Camshaft

Broken Central Valve

NOTICE: There are two rocker arm housing locating dowels in the cylinder head at the left-front and right-rear. Use care when installing the rocker arm housing to avoid damage.

NOTICE: Care must be taken to ensure the rocker arm housing mounting seal and end caps stay in place and are not damaged during rocker arm housing installation.

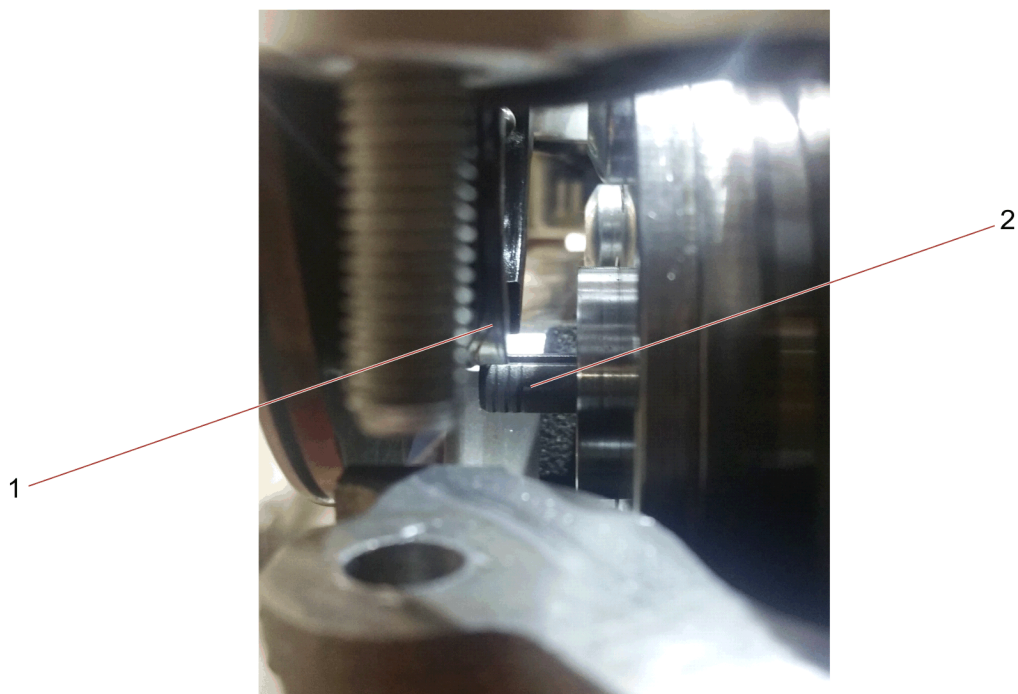
NOTICE: On some applications, there is limited clearance between the rocker arm housing and the truck cab. Use caution during installation to prevent damage.

NOTICE: Failure to follow step 12 carefully can result in damage to the central valve (1) on the exhaust camshaft.



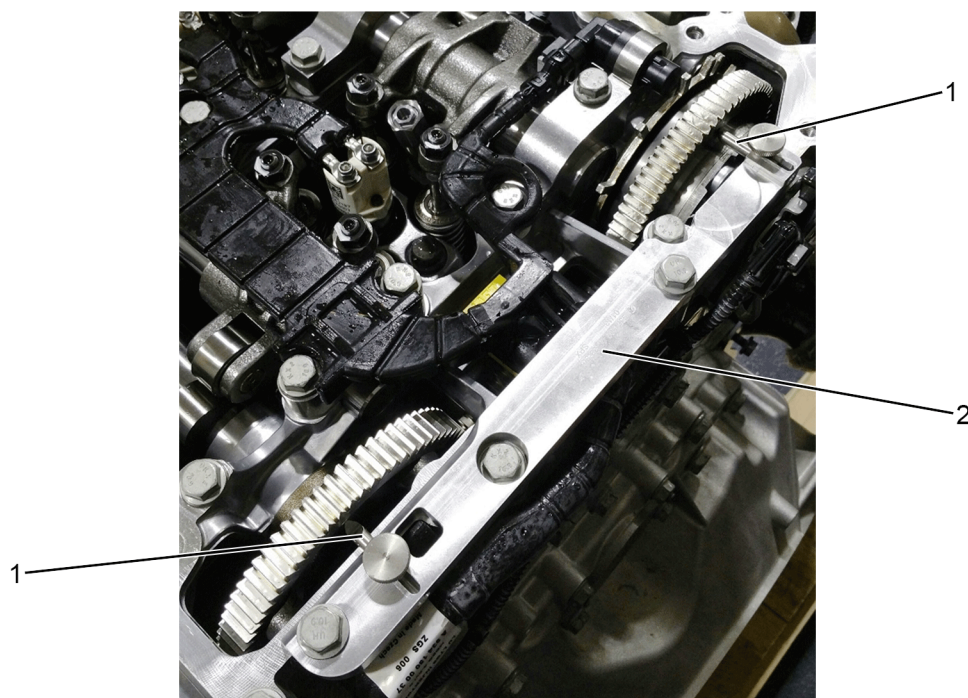
d050082

12. Position the rocker arm housing directly over the cylinder head. Move the housing slightly toward the rear while carefully lowering it into place onto the locating dowels. This process is necessary to avoid contact between the rocker arm housing mounting seal (1) and the central valve (2) on the rear of the exhaust camshaft. See illustration below.



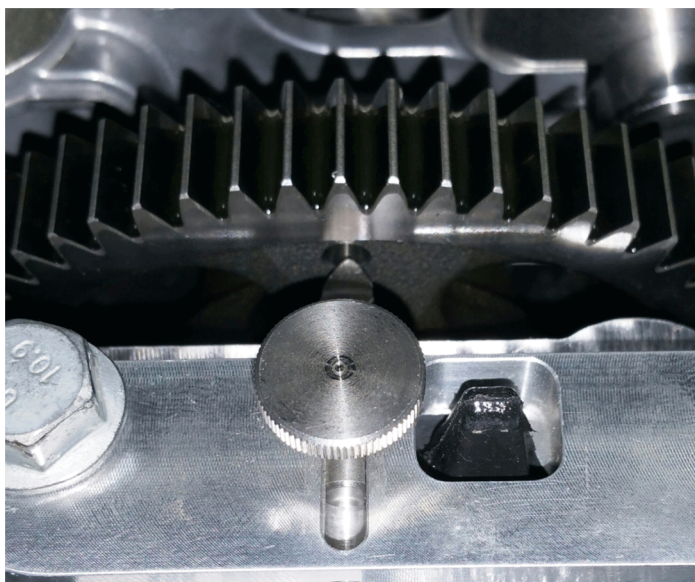
d050083

13. Ensure the mounting seal is still fully installed and seated properly in the rocker arm housing seal groove.
14. Install the camshaft timing tool (2) onto the rocker arm housing with two bolts as indicated below.



d050066

15. Check the positions of the intake and exhaust camshafts by confirming the holes in the camshaft gears are at 12 o'clock and line up with the pins (1) in the camshaft timing tool. A mirror should be used for this step.



d050068



d050067

16. If the camshafts are not in time, and the engine is positioned at No. 1 TDC on the compression stroke, the rocker arm housing must be lifted to correctly position the camshafts.
17. Once the camshafts are positioned correctly, remove the camshaft timing tool from the rocker arm housing.
18. Install the eighteen rocker arm housing mounting bolts. Do not tighten the bolts at this time.
19. Lubricate the intake rocker arm shaft, rocker arm rollers and adjusting feet with clean engine lubricating oil.

NOTICE: The intake rocker arm shaft is equipped with a locating pin at the front of the shaft that engages the rocker arm housing. Use care when installing the intake rocker arm shaft assembly to avoid damage to the pin.

20. Line up the rocker shaft locating pin and install the intake rocker shaft assembly onto the rocker arm housing.

NOTE: The long intake rocker shaft cap mounting bolts are used toward the inside of the rocker arm housing and the short bolts are used toward the outside of the rocker arm housing.

NOTICE: Do not tighten the intake rocker shaft cap bolts at this time.

21. Using the paint marks added during the removal process, install the intake rocker shaft caps with mounting bolts to their respective locations from one to seven.
22. Lubricate the exhaust rocker arm shaft, rocker arm rollers and adjusting feet with clean engine lubricating oil.

NOTICE: The exhaust rocker arm shaft is equipped with a locating pin at the front of the shaft that engages the rocker arm housing. Use care when installing the exhaust rocker arm shaft assembly to avoid damage to the pin.

23. Line up the rocker shaft locating pin and install the exhaust rocker shaft assembly onto the rocker arm housing.

NOTICE: Do not tighten the exhaust rocker shaft cap bolts at this time.

24. Using the paint marks added during the disassembly process, install the exhaust rocker shaft caps with mounting bolts to their respective locations from one to seven.

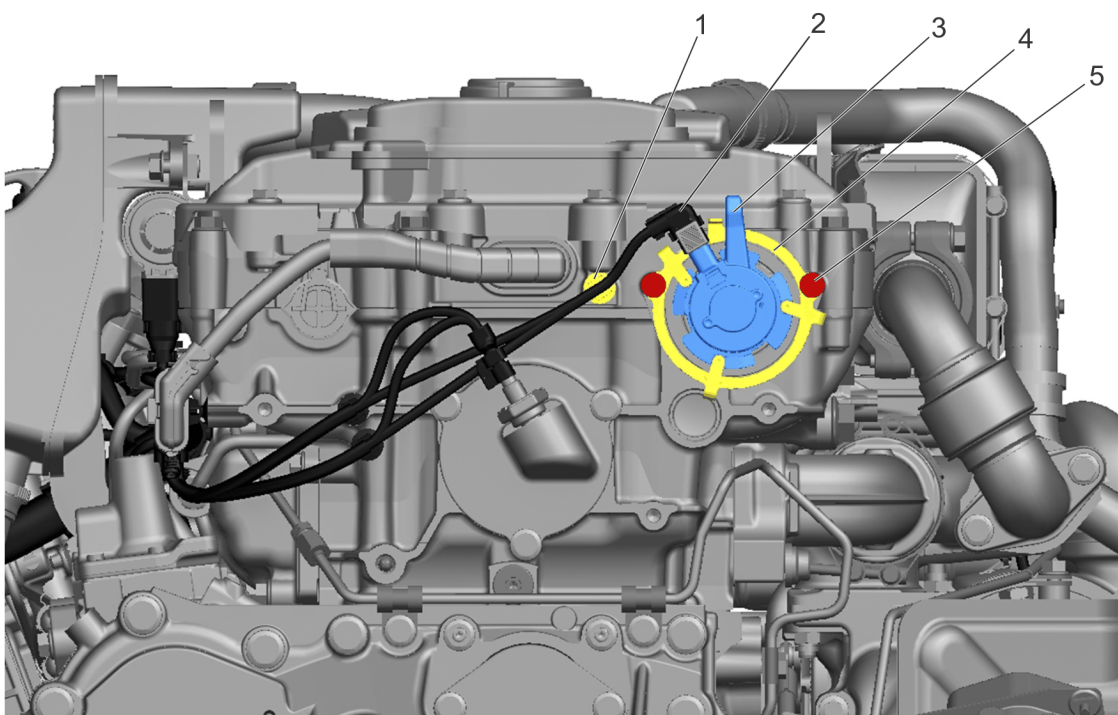
NOTICE: The tightening sequence must be followed in order to prevent damage to the rocker arm shafts.

25. Tighten the rocker arm housing and rocker shaft cap bolts (1 to 46) to 25 N·m (18 lb·ft) following the tightening sequence shown below.



d010344

26. Adjust the valves and engine brakes. Refer to section "Setting the Valve and Engine Brake Lash".
27. Torque the variable camshaft phaser solenoid mounting ring bolts to 10 N·m (7 lb·ft).
28. Install the variable camshaft phaser solenoid (3) into the rocker arm housing. Refer to section "Installation of the Variable Camshaft Phaser Solenoid".



d010323

29. Attach the variable camshaft phaser solenoid harness (1) to the rear of the rocker arm housing and to the solenoid (3).
30. Install the Exhaust Gas Recirculation (EGR) hot pipe heat shield onto the rocker arm housing. Torque the bolts to 25 N·m (18 lb·ft).
31. Install the EGR cooler upper mounting bracket onto the rocker arm housing. Refer to section "Installation of the Exhaust Gas Recirculation Cooler Upper Bracket".
32. Install the EGR cooler mounting straps. Refer to section "Installation of the Exhaust Gas Recirculation Cooler".
33. Install the air compressor resonator. Refer to section "Installation of the Air Compressor Resonator".
34. Remove the engine barring tool from the flywheel housing and reinstall the cover plate.
35. Remove the TDC locating tool from the flywheel housing and reinstall the crankshaft position sensor. Refer to section "Installation of the Camshaft Position Sensor".
36. Install the fuel injector wiring harness. Refer to section "Installation of the Fuel Injector Wiring Harness".
37. Install the rocker cover and air compressor resonator. Refer to section "Installation of the Rocker Cover".

**CAUTION: ELECTRICAL SHOCK**

To avoid injury from electrical shock, use care when connecting battery cables. The magnetic switch studs are at battery voltage.

38. Connect the batteries.
39. Fill the cooling system. Refer to section "Cooling System Fill Procedure".

**WARNING: PERSONAL INJURY**

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

- Always start and operate an engine in a well ventilated area.
- If operating an engine in an enclosed area, vent the exhaust to the outside.
- Do not modify or tamper with the exhaust system or emission control system.

**WARNING: PERSONAL INJURY**

To avoid injury before starting and running the engine, ensure the vehicle is parked on a level surface, parking brake is set, and the wheels are blocked.

**WARNING: ENGINE EXHAUST**

To avoid injury from inhaling engine exhaust, always operate the engine in a well-ventilated area. Engine exhaust is toxic.

40. Start the engine and inspect for leaks.
41. If removed, install the bumper end(s). Refer to the Original Equipment Manufacturer (OEM) procedures.
42. Close the hood.