

CYLINDER HEAD AND CYLINDER

SERVICE TOOLS

Description	Part Number	Page
BLIND HOLE BEARING PULLER SET.....	529 036 117	14
ENGINE LEAK DOWN TEST KIT	529 035 661	6
OIL SEAL INSTALLER	529 036 069	14
PISTON CIRCLIP INSTALLER 991	529 036 072	28
VALVE GUIDE INSTALLER (6 MM)	529 036 075	25
VALVE GUIDE REMOVER (6 MM)	529 036 074	25
VALVE SPRING COMPRESSOR CUP.....	529 036 073	20
VALVE SPRING COMPRESSOR	529 035 724	20

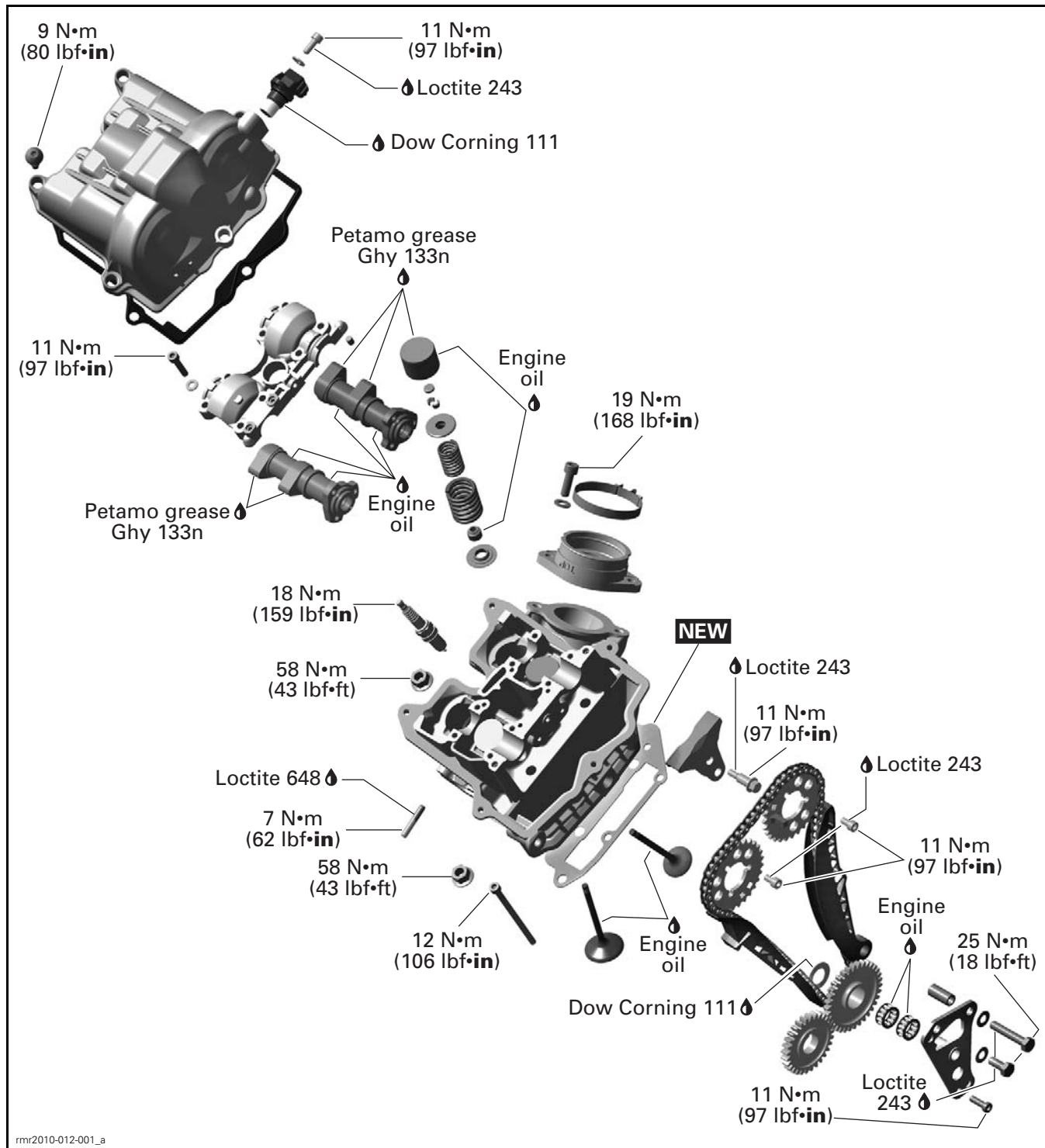
SERVICE TOOLS – OTHER SUPPLIER

Description	Part Number	Page
SNAP-ON PISTON RING COMPRESSOR TOOL	RC-980	19
SNAP-ON PLIERS.....	YA 8230	22

SERVICE PRODUCTS

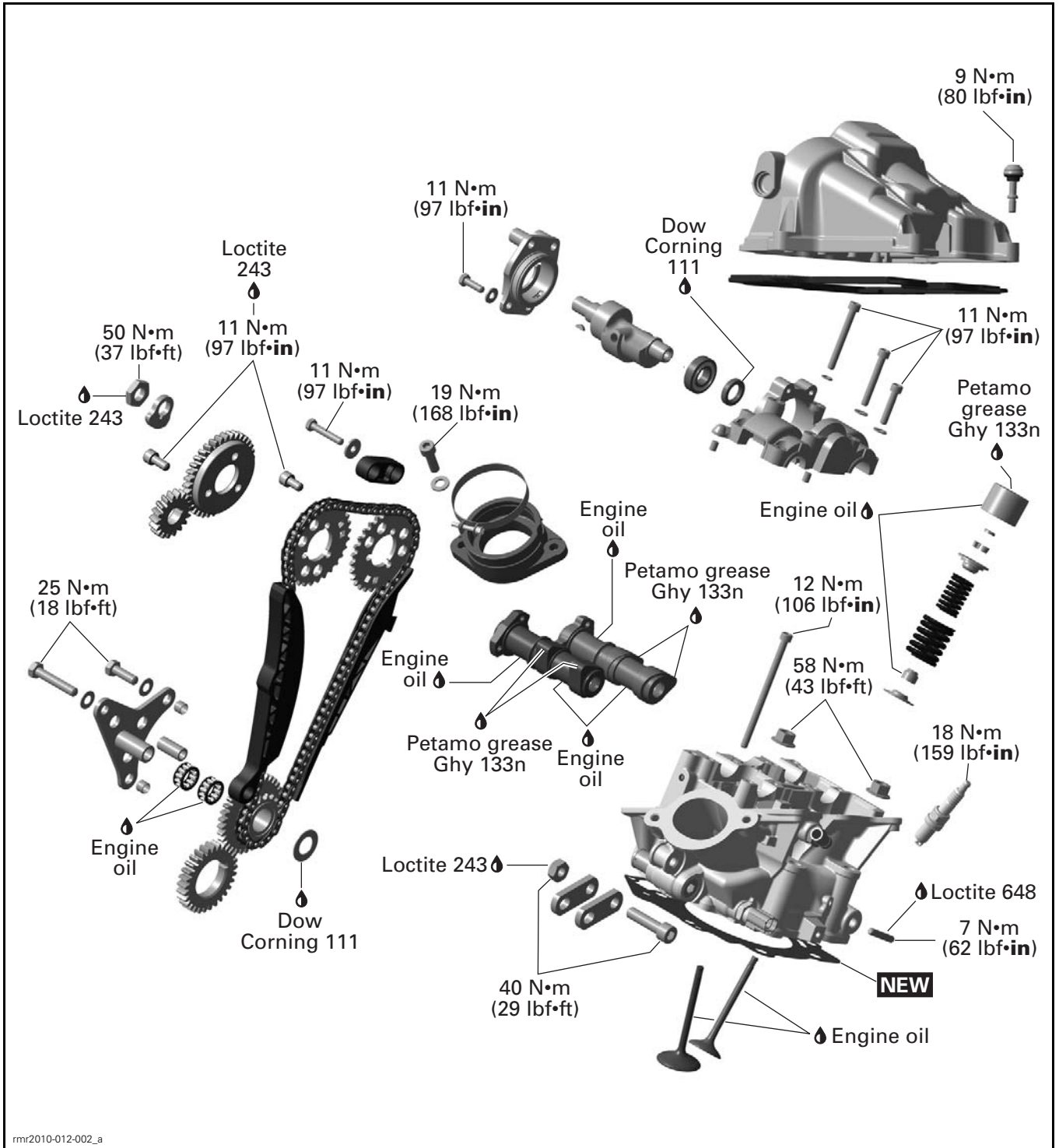
Description	Part Number	Page
LOCTITE 518.....	293 800 038	9
LOCTITE 5910.....	293 800 081	19
MOLYKOTE G-N.....	420 297 433	25

FRONT CYLINDER (NO. 1)

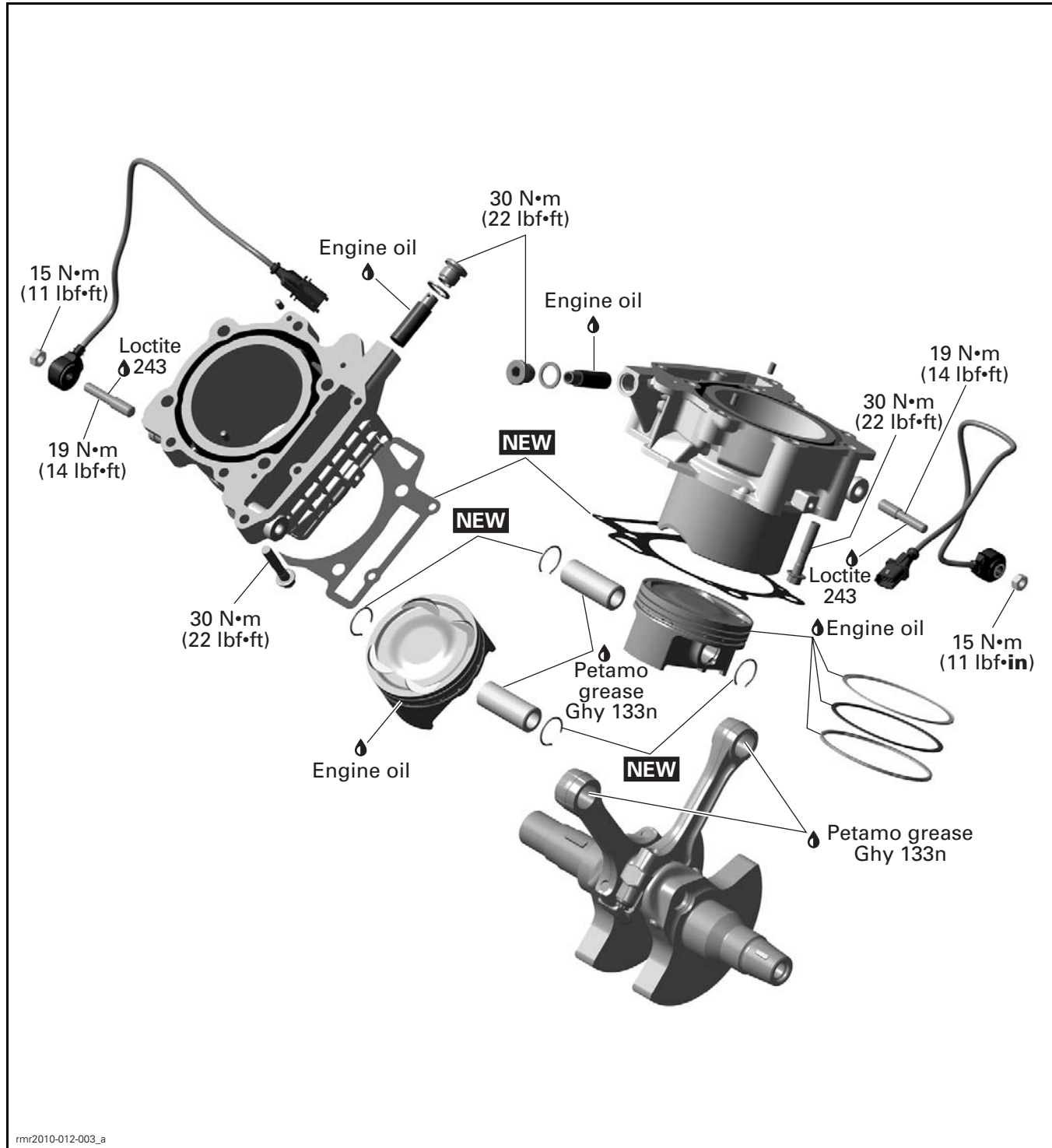


rnr2010-012-001_a

REAR CYLINDER (NO. 2)



CYLINDERS/PISTONS



GENERAL

NOTE: When diagnosing an engine problem, always perform the cylinder leak test. This will help pinpoint a problem. Refer to *LEAK TEST* in this subsection for procedures.

Always place the vehicle on a level surface.

NOTE: For a better understanding, some illustrations are taken with engine out of vehicle. To perform some instructions, it is not necessary to remove engine from vehicle.

Always disconnect BLACK (-) cable from the battery, then RED (+) cable before working on the engine.

⚠ WARNING

Always disconnect BLACK (-) cable first and reconnect last.

During assembly/installation, use the torque values and service products as in the exploded views.

Clean threads before applying a threadlocker. Refer to *SELF-LOCKING FASTENERS* and *LOCTITE APPLICATION* at the beginning of this manual for complete procedure.

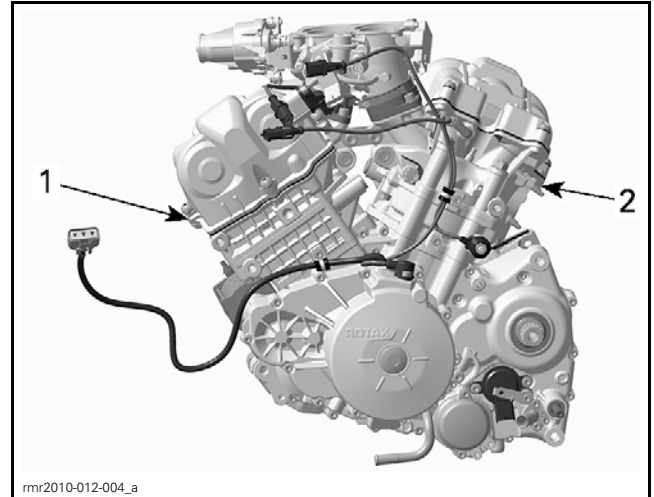
⚠ WARNING

Torque wrench tightening specifications must be strictly adhered to. Locking devices (e.g.: locking tabs, elastic stop nuts, cotter pin, etc.) must be replaced with new ones.

Even if the removal of many parts is not necessary to reach another part, it is recommended to remove these parts in order to check them.

When disassembling parts that are duplicated in the engine, (e.g.: valves, springs, etc.), it is strongly recommended to note their position and to keep the parts of the same assembly as a "group". If you find a defective component, it will be much easier to find the cause of the failure. Since parts were break-in together during the engine operation, they will keep their matched fit when parts are reassemble together within their "group".

NOTE: The cylinders are referenced as front (no. 1) and rear (no. 2).



1. Front cylinder (no. 1)
2. Rear cylinder (no. 2)

MAINTENANCE

VALVE CLEARANCE

NOTE: Check and adjust valve clearance only on a cold engine.

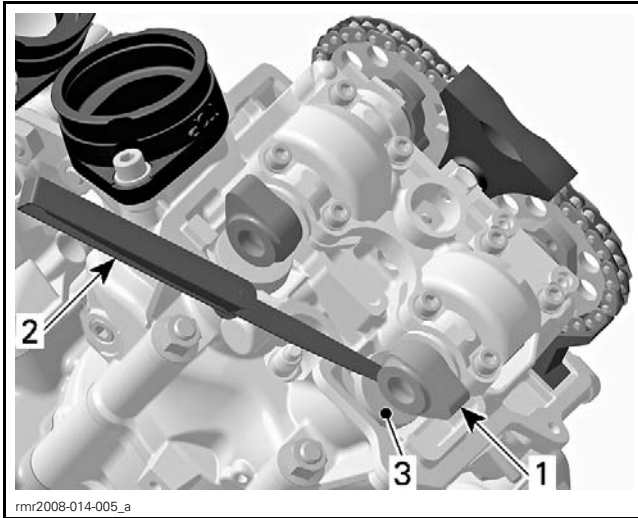
Valve Clearance Inspection

NOTE: Procedure is the same for both cylinders. Remove *VALVE COVER*. See procedure in this subsection.

Bring crankshaft to ignition TDC of the cylinder to be verified. Refer to *CRANKSHAFT LOCKING PROCEDURE* in the *CRANKCASE AND CRANKSHAFT* subsection.

Use a feeler gauge and check valve clearance.

NOTE: Intake and exhaust valves must be checked with cylinder at ignition TDC.



1. Camshaft
2. Feeler gauge
3. Valve lift bucket

VALVE CLEARANCE	
EXHAUST	0.22 mm to 0.29 mm (.0087 in to .0114 in)
INTAKE	0.11 mm to 0.18 mm (.0043 in to .0071 in)

Adjust valve clearance if out of specification.

NOTE: To ease valve adjustment procedure, note each valve clearance prior to proceed.

Valve Clearance Adjustment

Adjust valve clearance by replacing the adjustment shim of the required valve.

NOTE: When replacing the adjustment shims, crankshaft must be locked at ignition TDC.

Refer to appropriate procedures in this subsection to remove the following parts:

- Timing chain tensioner
- Balance shaft drive gears (rear cylinder)
- Camshaft timing gears
- Camshaft
- Valve lifter bucket.

Remove adjustment shim and check its thickness with a micrometer.

Choose the proper adjustment shim thickness to reach the specified valve clearance.

$$\text{New shim thickness} = \text{Recorded valve clearance} - \text{Adjustment specification} + \text{Old shim thickness}$$

After parts reassembly, check again valve clearance.

INSPECTION

CYLINDER LEAK TEST

General

Before performing the cylinder leak test, verify the following:

- Clamp(s) tightness
- Radiator and hoses condition.

NOTE: For best accuracy, the leak test should be done with the engine at normal operating temperature.

⚠ WARNING

Prevent burning yourself due to handling on the hot engine.

Preparation

Remove spark plugs. Refer to *IGNITION SYSTEM*.

Remove *VALVE COVER*. See procedure in this subsection.

Bring the piston of tested cylinder to ignition TDC. Refer to *CRANKSHAFT LOCKING PROCEDURE* in the *CRANKCASE AND CRANKSHAFT* subsection.

Leak Test

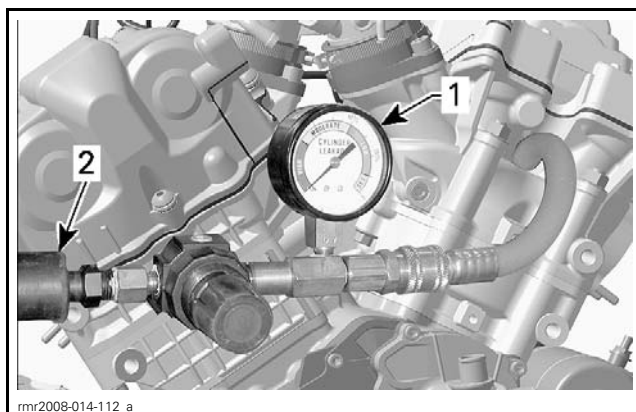
Install a gauge adaptor of the ENGINE LEAK DOWN TEST KIT (P/N 529 035 661) into previously cleaned spark plug hole.

Connect the tool to an adequate air supply.

Set needle of measuring gauge to zero.

NOTE: All testers have specific instructions on gauge operation and required pressure. Refer to manufacturer's instructions.

Supply combustion chamber with air pressure.



1. Leak tester
2. Air supply hose

Note the amount or percentage of leakage (depending on tester).

LEAKAGE PERCENTAGE	ENGINE CONDITION
0% to 15%	Excellent condition
16% to 25%	Good condition
26% to 40%	Fair condition; reduced engine performance
41% and higher	Poor condition, diagnose and repair engine

Diagnosis

Listen to for air leaks.

- Air escaping on intake port/throttle body means leaking intake valve(s).
- Air escaping on exhaust port means leaking exhaust valve(s).
- Air bubbles out of radiator means leaking cylinder head gasket.
- Air/coolant escaping from cylinder/head means damaged gasket(s) and/or loosened screws (refer to *CYLINDER HEAD* further in this subsection).
- Air escaping into crankcase area means excessively worn cylinder and/or broken piston rings (refer to *CYLINDER* and *PISTON RINGS* further in this subsection).

NOTE: For all the checkpoints mentioned above, see the appropriate engine subsection to diagnose and repair the engine.

Assembly

Reverse the preparation procedure. Ensure to respect torque values and use of appropriate products/lubricants. Refer to exploded views of this and other sections of this manual as required.

PROCEDURES

VALVE COVER

Valve Cover Removal (Engine in Vehicle)

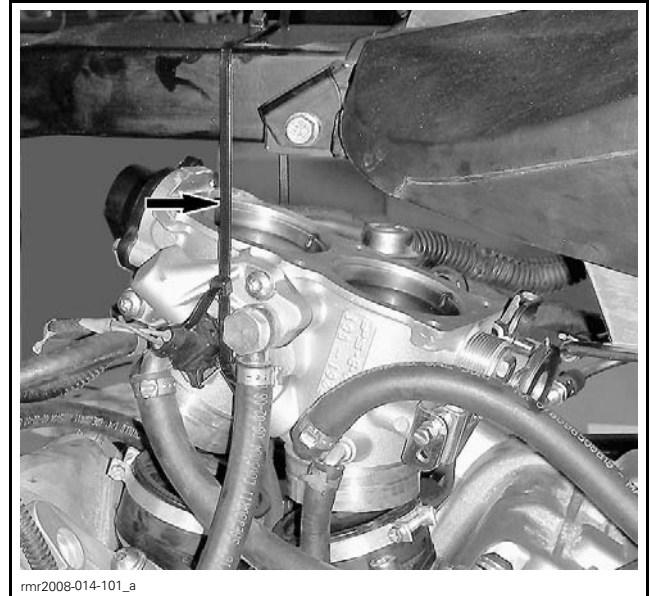
Remove RH lateral support, refer to the *FRAME* subsection.

Remove air filter housing and resonator. Refer to the *AIR INTAKE SYSTEM* subsection.

Remove fuel tank protectors. Refer to the *FUEL TANK AND FUEL PUMP* subsection.

Loosen throttle body clamps and lift throttle body in order to make room.

Support throttle body using locking ties.



TYPICAL

Rear Cylinder

Remove its retaining screws then pull EVAP canister away.



TYPICAL

Subsection XX (CYLINDER HEAD AND CYLINDER)

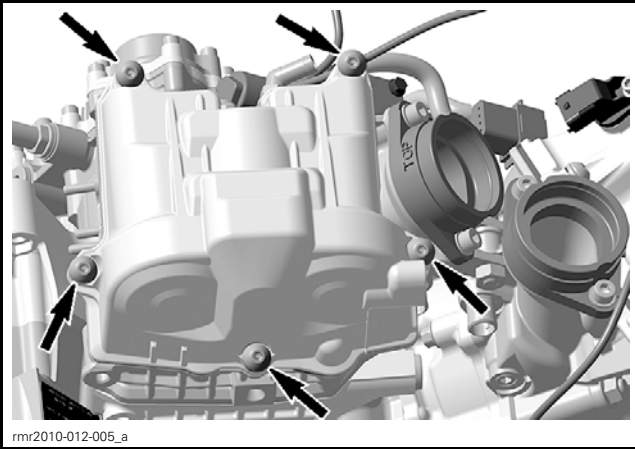


TYPICAL

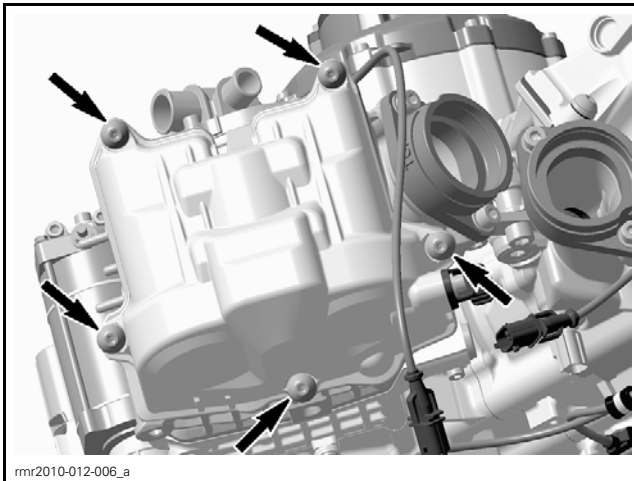
Completely remove valve cover screws.



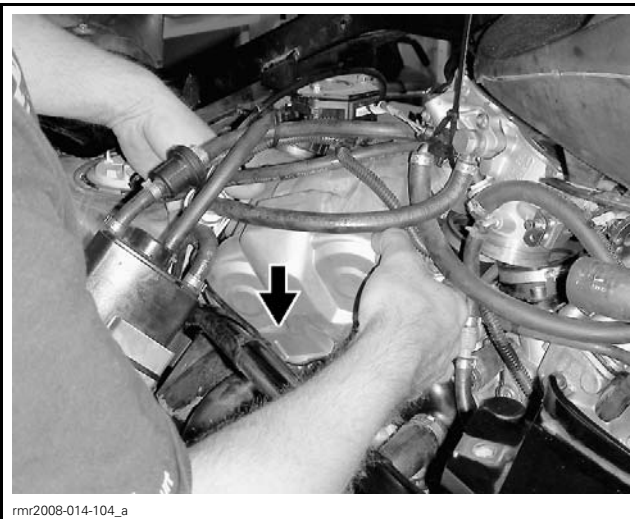
Completely remove valve cover screws.



Pull out valve cover towards RH side of vehicle. Be careful not to damage gasket.



Pull out valve cover. Be careful not to damage gasket.



Front Cylinder

Disconnect the camshaft position sensor (CAPS).

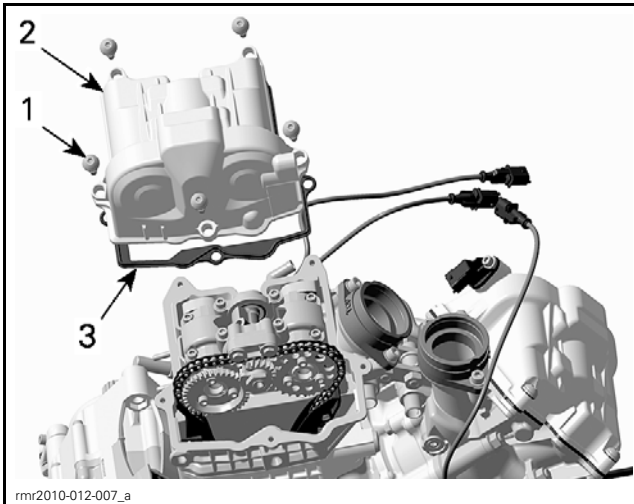


Valve Cover Removal (Engine Removed)

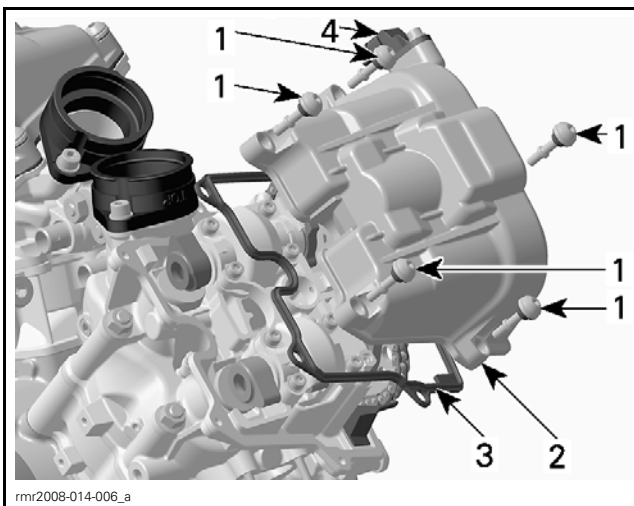
Disconnect camshaft position sensor (CAPS) (front cylinder).

Unscrew cover retaining screws.

Remove the cover with the gasket.



REAR CYLINDER
 1. Retaining screws
 2. Valve cover
 3. Valve cover gasket



FRONT CYLINDER
 1. Retaining screws
 2. Valve cover
 3. Valve cover gasket
 4. Camshaft position sensor (CAPS)

Valve Cover Inspection

Check the valve cover for cracks or other damages.

Check if the gasket is brittle, hard or otherwise damaged.

Replace all defective parts.

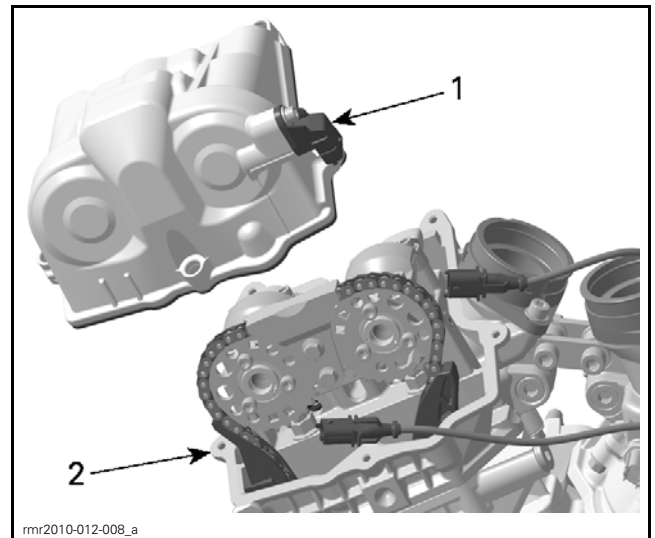
Valve Cover Installation

For installation reverse the removal procedure.

Take care that the gasket is located properly into the groove in the cover.

Position the valve cover with the camshaft position sensor on front cylinder.

NOTE: When installing valve cover while engine is on vehicle, it may be easier to first install gasket in cover using LOCTITE 518 (P/N 293 800 038).



1. Camshaft position sensor
 2. Front cylinder

BALANCE SHAFT DRIVE GEARS

The balance shaft drive gears are located in the rear cylinder head.

Balance Shaft Drive Gears Removal

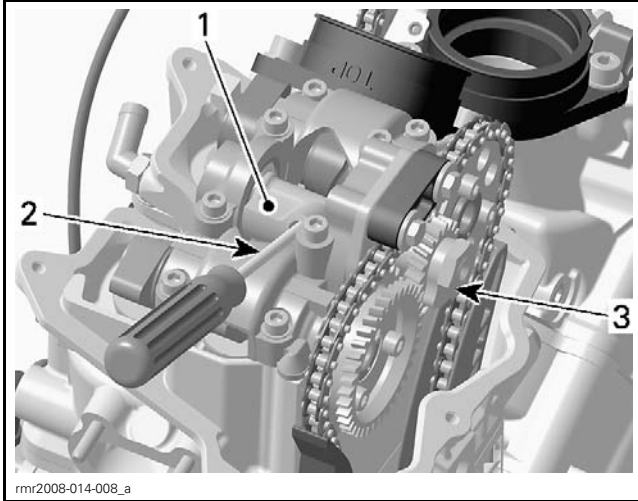
Remove valve cover, see procedure in this subsection.

Lock crankshaft at ignition TDC (rear cylinder). Refer to *CRANKSHAFT LOCKING PROCEDURE* in the *CRANKCASE AND CRANKSHAFT* subsection.

NOTE: Always place a rag into timing chain area to avoid parts falling inside the engine during removal.

NOTICE To avoid stretching the timing chain when loosening the nut, use a screwdriver to hold balance shaft.

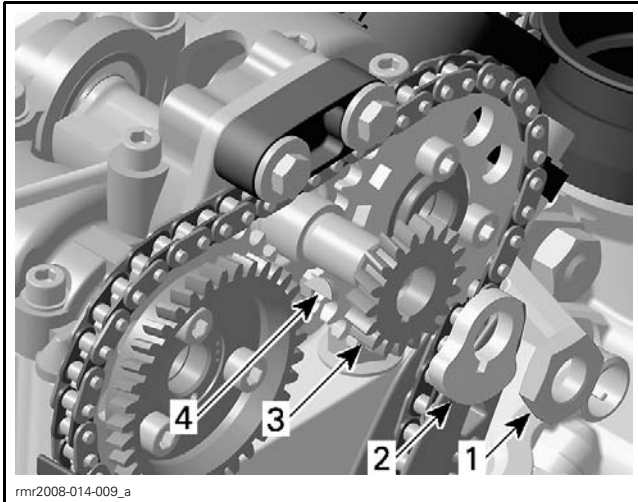
Subsection XX (CYLINDER HEAD AND CYLINDER)



1. Balance shaft
2. Screwdriver
3. Nut

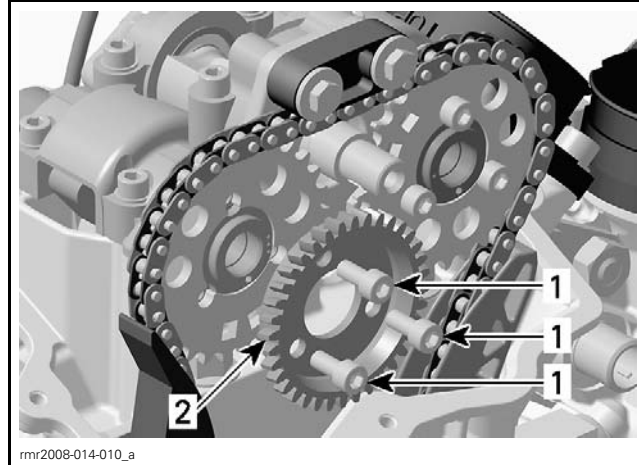
Remove nut, balance weight and balance shaft drive gears.

NOTE: Take care not to loose woodruff key when removing balance shaft gear.



1. Nut
2. Balance weight
3. Balance shaft gear
4. Woodruff key

Remove timing gear screws on exhaust side and remove balance shaft drive gear.



1. Timing gear screws
2. Balance shaft drive gear

Balance Shaft Drive Gears Inspection

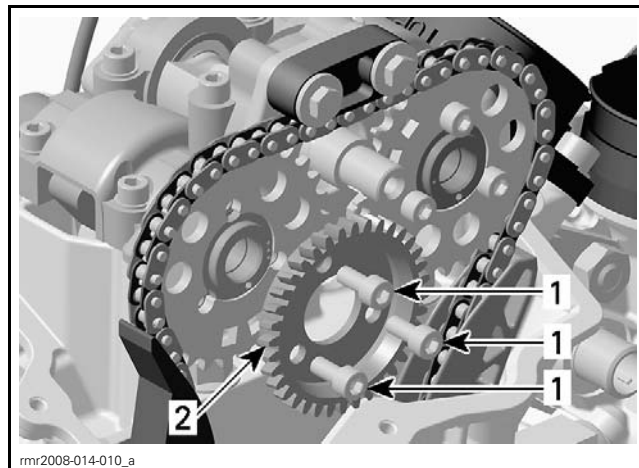
Inspect gear teeth for wear or other damage. If gears are pitted, scored, rounded, cracked or chipped, they should be replaced.

NOTE: Balance shaft drive gears are paired. Replace balance shaft drive gears as a set.

Balance Shaft Drive Gears Installation

For installation reverse the removal procedure. Pay attention to following details.

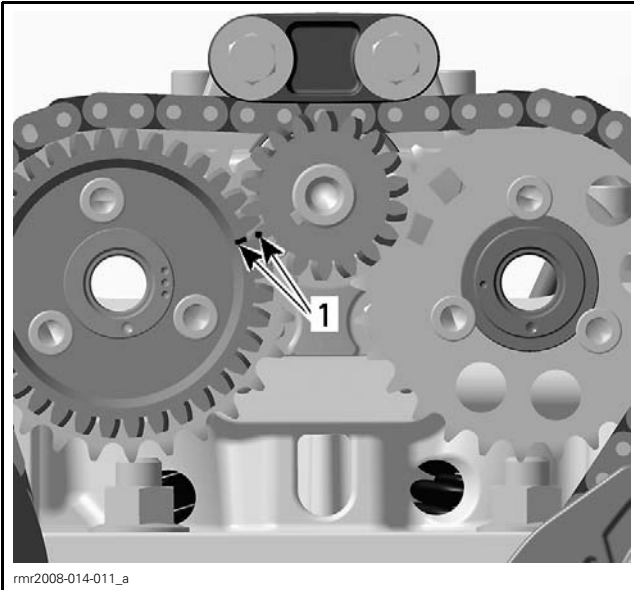
Install the longer screws (M6 x 14) on balance shaft drive gear.



1. Longer M6 x 14 screws here
2. Balance shaft drive gear

NOTICE Ensure to install longer screws M6 x 14 to balance shaft drive gear on exhaust camshaft (rear cylinder). If the longer screws were installed on the other gear, the camshaft would be blocked.

Align mark on balance shaft gear with mark on camshaft timing gear.



1. Marks

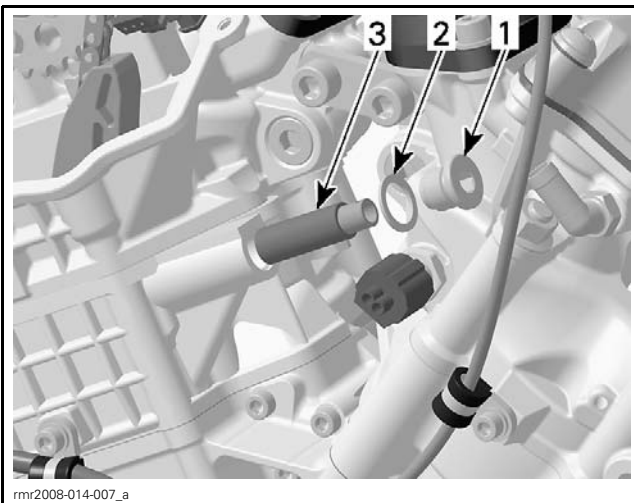
TIMING CHAIN TENSIONER

Timing Chain Tensioner Removal

NOTE: Make sure that the crankshaft is set to ignition TDC of the respective cylinder. Refer to *CRANKSHAFT LOCKING PROCEDURE* in the *CRANKCASE AND CRANKSHAFT* subsection.

Remove plug screw and gasket ring.

Pull out chain tensioner.



1. Plug screw
2. Gasket ring
3. Chain tensioner

Timing Chain Tensioner Inspection

Check chain tensioner for free movement in bore and/or for scoring.

Compress chain tensioner and check if it works properly.

Timing Chain Tensioner Installation

For installation reverse the removal procedure.

CAMSHAFT TIMING GEAR

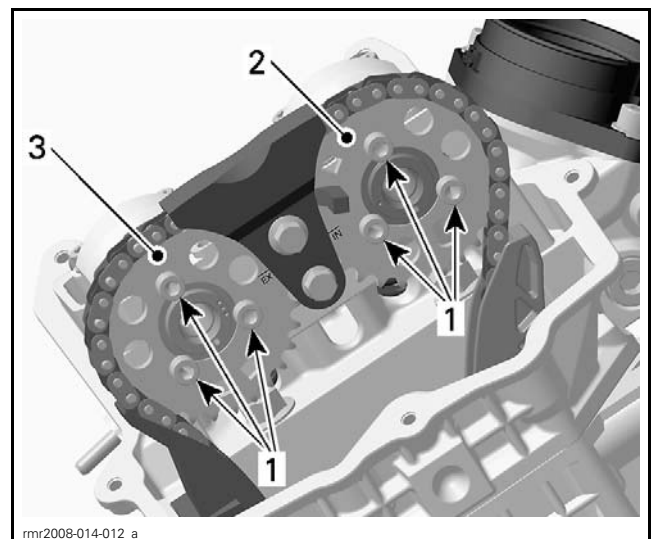
Camshaft Timing Gear Removal

Remove *VALVE COVER*. See procedure in this subsection.

Lock crankshaft at ignition TDC of the respective cylinder. Refer to *CRANKSHAFT LOCKING PROCEDURE* in the *CRANKCASE AND CRANKSHAFT* subsection.

Remove balance shaft drive gears (rear cylinder).

Loosen camshaft timing gear screws.

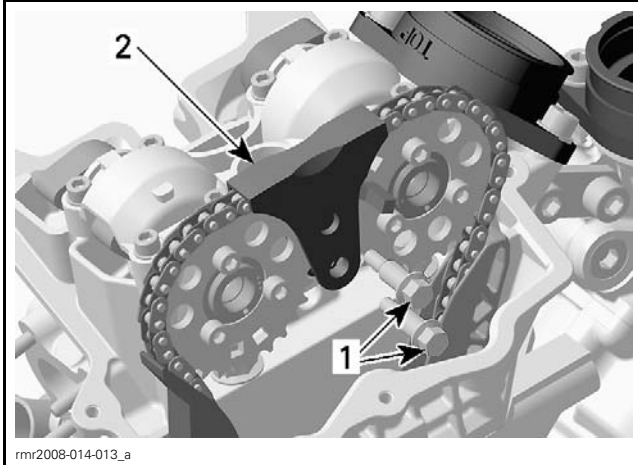


1. Timing gear screws
2. Timing gear (intake)
3. Timing gear (exhaust)

Remove *CHAIN TENSIONER*. See procedure in this subsection.

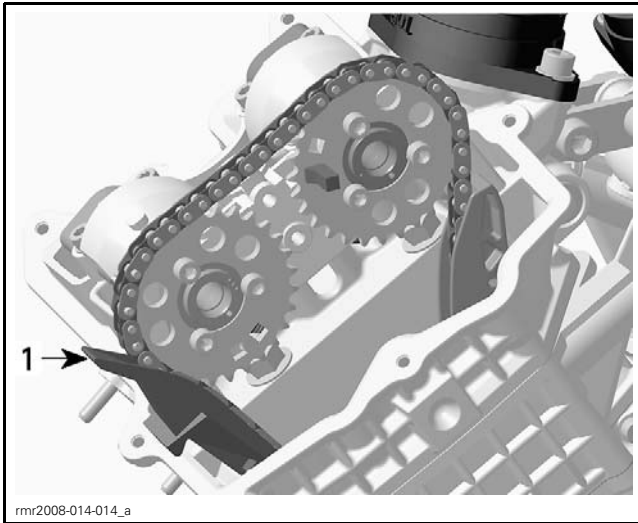
Remove upper chain guide (front cylinder).

Subsection XX (CYLINDER HEAD AND CYLINDER)



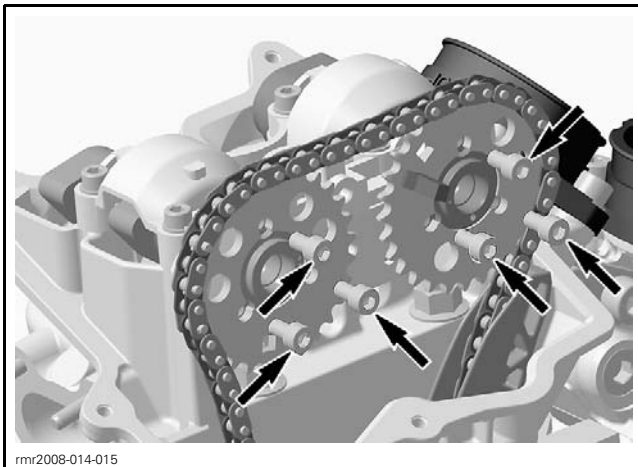
FRONT CYLINDER
1. Distance screws
2. Upper chain guide

Remove timing chain guide.



1. Timing chain guide

Remove camshaft timing gear screws.



Remove camshaft timing gears.

NOTE: Secure timing chain with a securing wire.

Camshaft Timing Gear Inspection

Check camshaft timing gears for wear or deterioration.

If a gear is worn or damaged, replace it as a set (both camshaft timing gears, intermediate gear and timing chain).

NOTE: For intermediate gear replacement refer to *CRANKCASE AND CRANKSHAFT* subsection.

Upper Chain Guide

Inspect upper chain guide for wear, replace if necessary.

Camshaft Timing Gear Installation

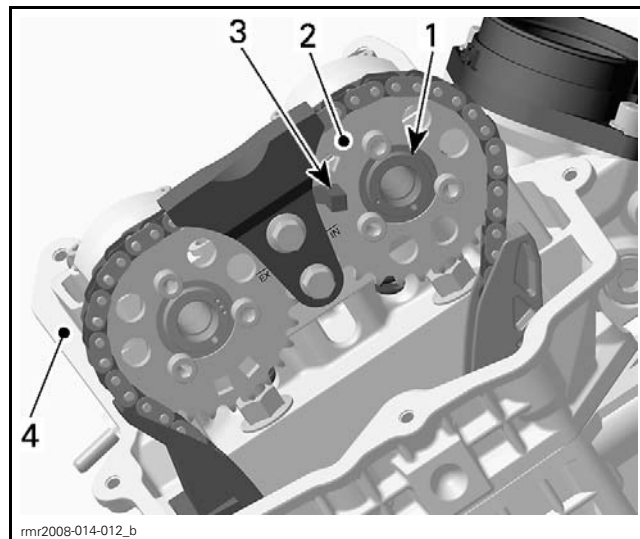
The installation is the reverse of the removal procedure. However, pay attention to the following.

NOTE: If timing gears of both cylinders have been removed, refer to *ENGINE REASSEMBLY SEQUENCE* in the *CRANKCASE AND CRANKSHAFT* subsection.

NOTICE Improper valve timing will damage engine components.

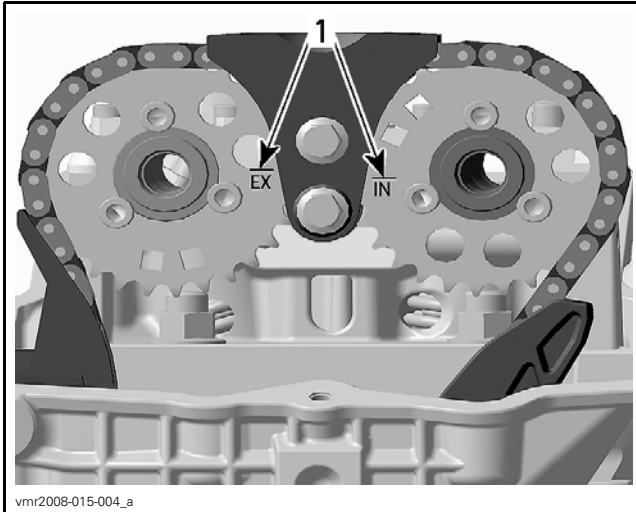
Make sure that crankshaft is locked at TDC of the respective cylinder.

Camshaft timing gear with trigger pin has to be installed at intake camshaft (front cylinder).



1. Intake camshaft
2. Timing gear
3. Trigger pin
4. Front cylinder head

Install timing gears on camshafts so that marks "IN" on intake and "EX" on exhaust camshaft are aligned.



TYPICAL
1. Marks on timing gears

Install the *BALANCE SHAFT DRIVE GEARS*. See procedure in this subsection.

Install the *TIMING CHAIN TENSIONER*. See procedure in this subsection.

BALANCE SHAFT

The balance shaft is located in cylinder head of rear cylinder.

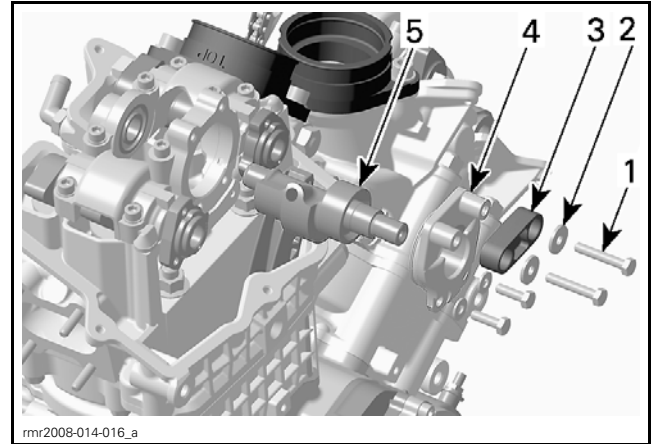
Balance Shaft Removal

Lock crankshaft at ignition TDC (rear cylinder). Refer to *CRANKSHAFT LOCKING PROCEDURE* in the *CRANKCASE AND CRANKSHAFT* subsection.

Remove:

- Valve cover
- Balance shaft drive gears
- Timing chain
- Camshaft timing gears.

Remove bearing flange retaining screws and withdraw bearing flange and balance shaft from cylinder head.



1. Retaining screw
2. Washer
3. Upper chain guide
4. Bearing flange
5. Balance shaft

Balance Shaft Inspection

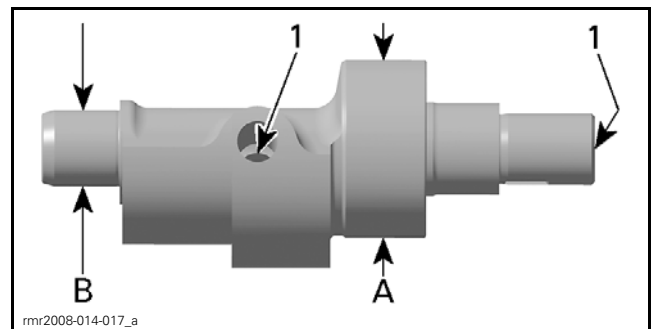
Check oil seal running surface of balance shaft for grooves.

Measure diameter of balance shaft bearing journals.

Replace if necessary.

Clean ventilation orifice in balance shaft using an air gun.

NOTICE Always wear eye protector.



1. Ventilation orifice
A. Plain bearing journal
B. Ball bearing journal

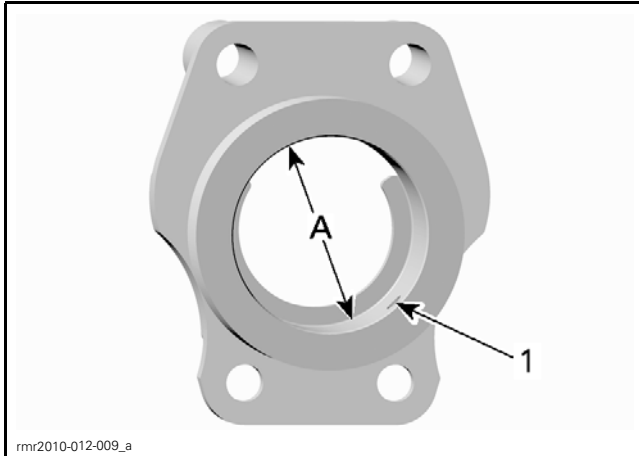
PLAIN BEARING JOURNAL "A"	
NEW	34.973 mm to 34.983 mm (1.3769 in to 1.3773 in)
SERVICE LIMIT	34.953 mm (1.376 in)

BALL BEARING JOURNAL "B"	
NEW	14.981 mm to 14.992 mm (.5898 in to .5902 in)
SERVICE LIMIT	14.970 mm (.5894 in)

Subsection XX (CYLINDER HEAD AND CYLINDER)

Bearing Flange

Check plain bearing for scoring or other damages. Measure plain bearing diameter and balance shaft journal to determine plain bearing radial clearance.



1. Oil orifice

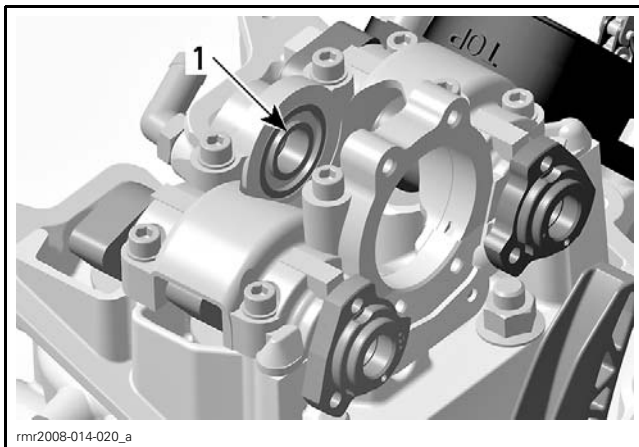
A. Measure plain bearing inside diameter

PLAIN BEARING RADIAL CLEARANCE

SERVICE LIMIT	0.07 mm (.0028 in)
---------------	--------------------

Ball Bearing and Oil Seal

Check ball bearing of balance shaft for excessive play and smooth operation.



1. Ball bearing

Check oil seal behind ball bearing if brittle hard or damaged.

Ball Bearing and Oil Seal Replacement

Ball Bearing Removal

Remove camshaft holder from cylinder head. Heat camshaft holder up to 100°C (212°F) before removing the ball bearing.

NOTICE Clean camshaft holder from oil before heating.

To remove ball bearing from camshaft holder use the BLIND HOLE BEARING PULLER SET (P/N 529 036 117).

NOTE: Take care not to damage cylinder head during removal.

Oil Seal Removal

Use a screwdriver to remove oil seal from camshaft holder.

NOTICE Take care not to damage oil seal area.

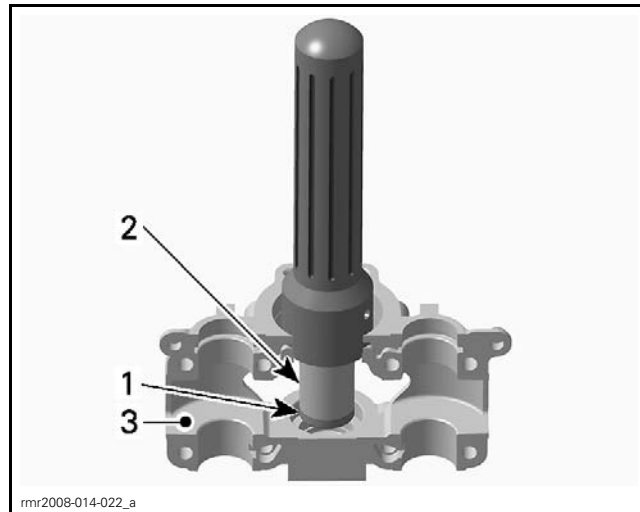
Oil Seal Installation

Install oil seal with sealing lip facing towards ball bearing.

To install oil seal use the OIL SEAL INSTALLER (P/N 529 036 069).



529036069



1. Oil seal
2. Oil seal installer
3. Camshaft holder

Ball Bearing Installation

Heat camshaft holder up to 100°C (212°F) before installing the ball bearing.

Use a suitable pusher to install ball bearing.

For installation of the camshaft holder refer to CAMSHAFT below.

Balance Shaft Installation

The installation is the reverse of the removal procedure.

Pay attention to following details.

For installation of camshaft timing gear refer to *CAMSHAFT TIMING GEAR*.

NOTICE Improper valve timing will damage engine components.

For installation of balance shaft drive gears, refer to *BALANCE SHAFT DRIVE GEARS* in this subsection.

CAMSHAFT

Camshaft Removal

Remove *VALVE COVER*. See procedure in this subsection.

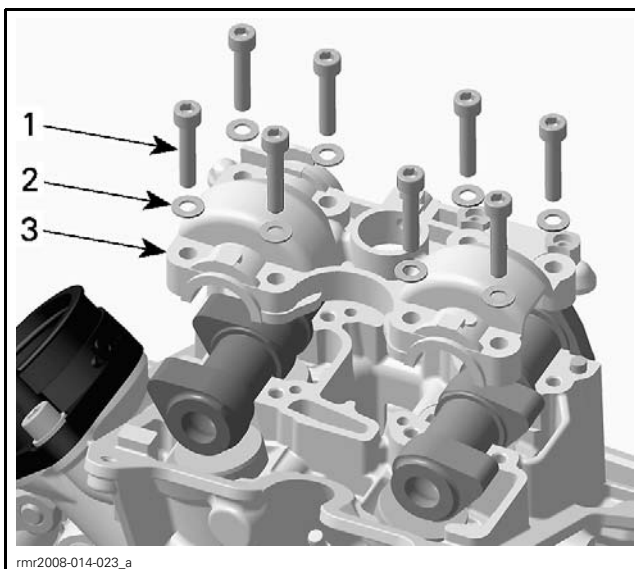
Lock crankshaft at ignition TDC of the respective cylinder, refer to *CRANKSHAFT LOCKING PROCEDURE* in the *CRANKCASE AND CRANKSHAFT* subsection.

Remove:

- Timing chain tensioner
- Balance shaft drive gears (rear cylinder)
- Timing chain guide
- Timing chain
- Upper chain guide (front cylinder)
- Camshaft timing gears.

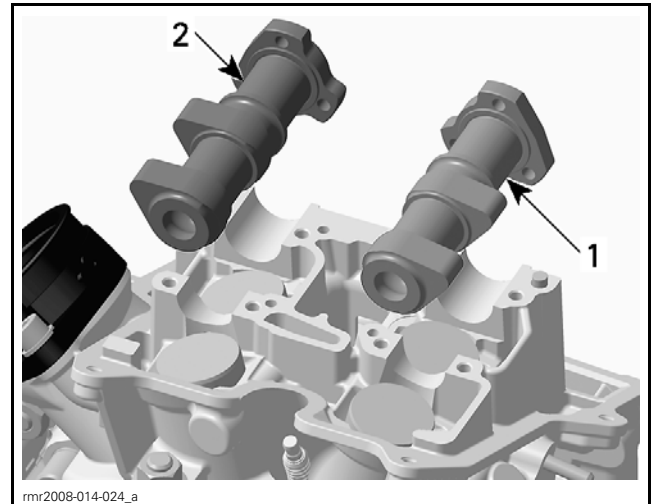
Secure timing chain with a retaining wire.

Remove camshaft holder.



1. Retaining screws
2. Washers
3. Camshaft holder

Remove exhaust and intake camshafts.

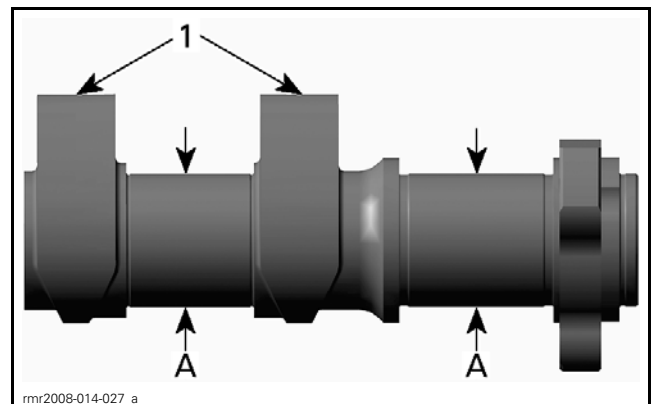


1. Exhaust camshaft
2. Intake camshaft

Camshaft Inspection

Check each lobe and bearing journal for scoring, scuffing, cracks, or other signs of wear.

Measure camshaft bearing journal diameter, using a micrometer.



1. Lobes
A. Camshaft journal

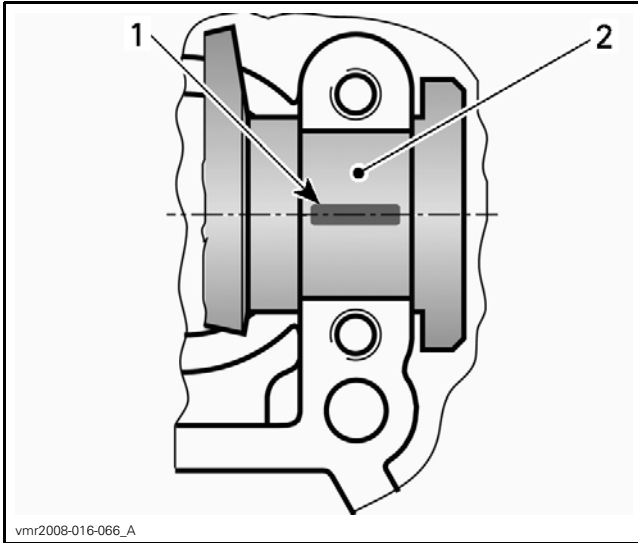
CAMSHAFT JOURNAL DIAMETER	
NEW	23.967 mm to 23.980 mm (.9436 in to .9441 in)
SERVICE LIMIT	23.950 mm (.9429 in)

Measure clearance between camshaft and camshaft holder, using a plastic feeler gauge.

NOTE: The plastic feeler gauge is available at automotive parts retailer.

Place the camshaft in the cylinder head and apply a plastic-gauge on the camshaft bearing journal.

Subsection XX (CYLINDER HEAD AND CYLINDER)

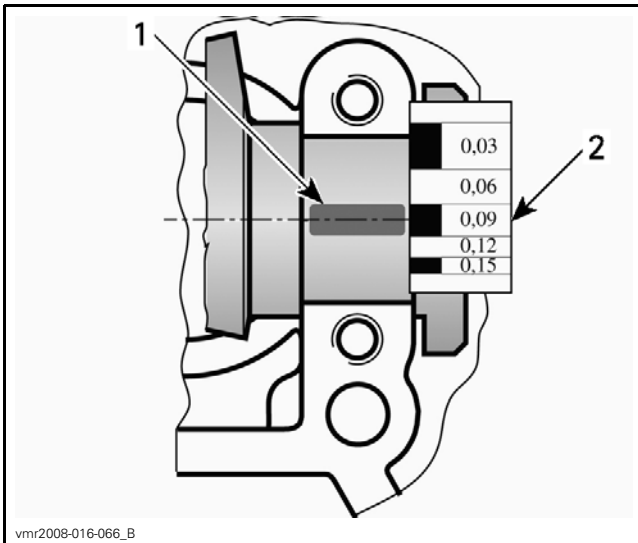


1. Plastic gauge
2. Camshaft bearing journal

Install camshaft holder in the proper position and tighten bearing cover screws to specified torque.

Unfasten camshaft holder.

Measure the maximum width of the pressed plastic gauge with the corresponding graduated scale.



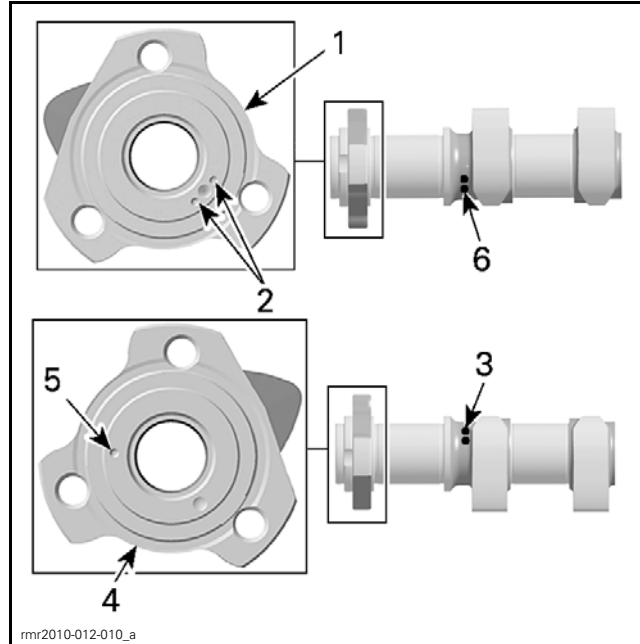
1. Pressed plastic gauge
2. Graduated scale

CLEARANCE BETWEEN CAMSHAFT AND CAMSHAFT HOLDER	
SERVICE LIMIT	0.06 mm (.0024 in)

Camshaft Installation

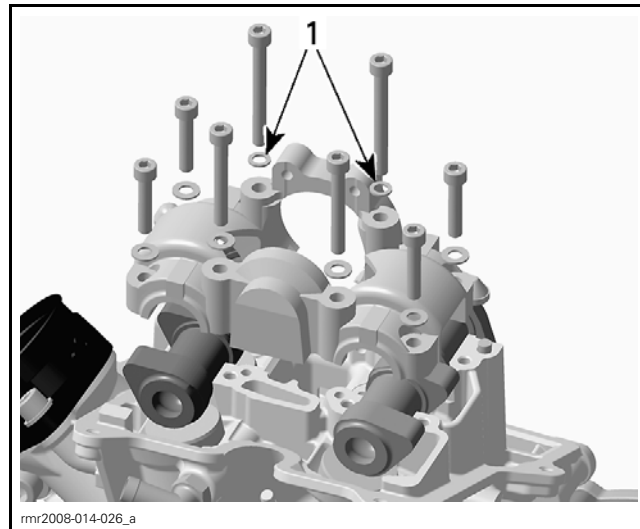
Installation is the reverse order of disassembly. Pay attention to the following details.

Take care not to interchange intake and exhaust camshafts.



1. Exhaust camshaft
2. 2 marks
3. Yellow + light blue paint mark
4. Intake camshaft
5. 1 mark
6. White + brown beige paint mark

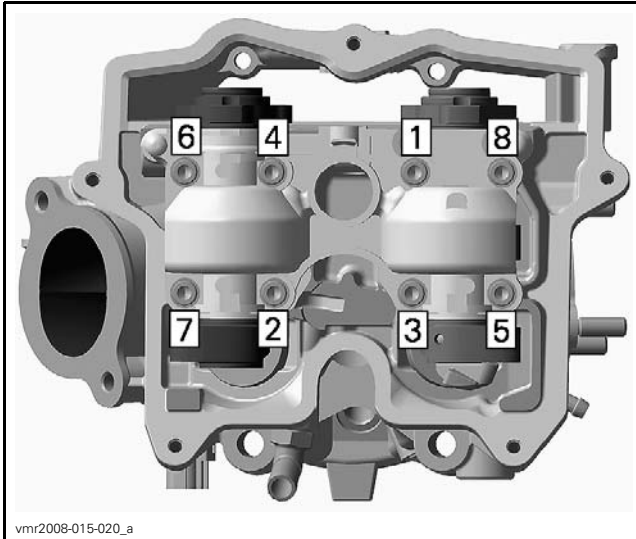
Install smaller washers where shown.



1. Smaller washers

Lubricate camshaft holders with engine oil before placing them into cylinder head.

Fit camshaft holder and tighten down as per following described sequence.



vmr2008-015-020_a
TIGHTENING SEQUENCE

NOTE: After bearing cover installation check if camshafts turn easily.

Check *VALVE CLEARANCE*. See procedure in this subsection.

VALVE LIFTER BUCKET

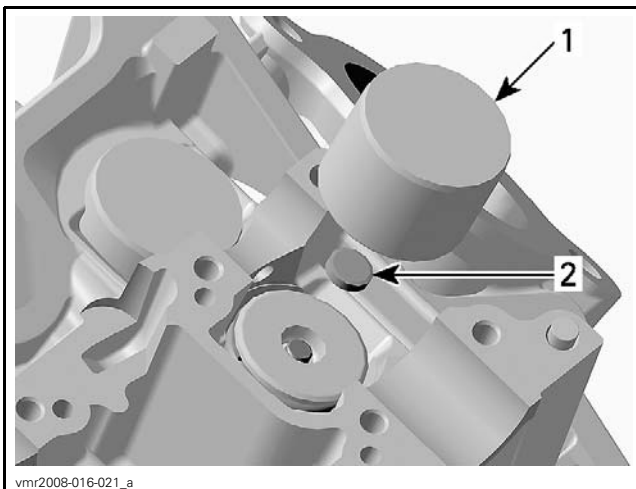
Valve Lifter Bucket Removal

Remove:

- Valve cover
- Balance shaft drive gears
- Chain tensioner
- Camshaft timing gears
- Camshafts.

Use a magnet and lift valve lifter bucket.

NOTICE Adjustment shim could be stuck in valve lifter bucket. Take care not to loose adjustment shim.



vmr2008-016-021_a
1. Valve lifter bucket
2. Adjustment shim

Valve Lifter Bucket Inspection

Check surface of valve lifter bucket for scoring or other damages.

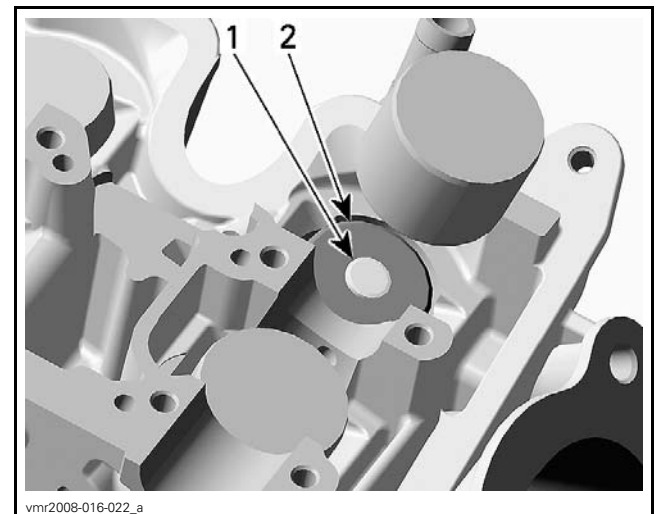
Measure diameter of valve lifter bucket. If diameter is out of specification replace it.

VALVE LIFTER BUCKET DIAMETER	
NEW	33.459 mm to 33.475 mm (1.3173 in to 1.3179 in)
SERVICE LIMIT	33.440 mm (1.3165 in)

VALVE LIFTER BUCKET RADIAL CLEARANCE	
SERVICE LIMIT	0.08 mm (.0031 in)

Valve Lifter Bucket Installation

NOTICE Place adjustment shim properly in place before installing valve lifter bucket.



vmr2008-016-022_a
1. Adjustment shim
2. Valve spring retainer

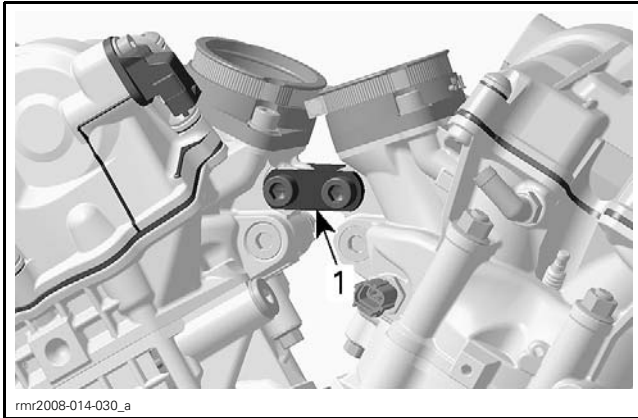
CYLINDER HEAD

Cylinder Head Removal

Remove engine from vehicle. Refer to *ENGINE REMOVAL AND INSTALLATION*.

Remove support between cylinder heads.

Subsection XX (CYLINDER HEAD AND CYLINDER)



1. Support

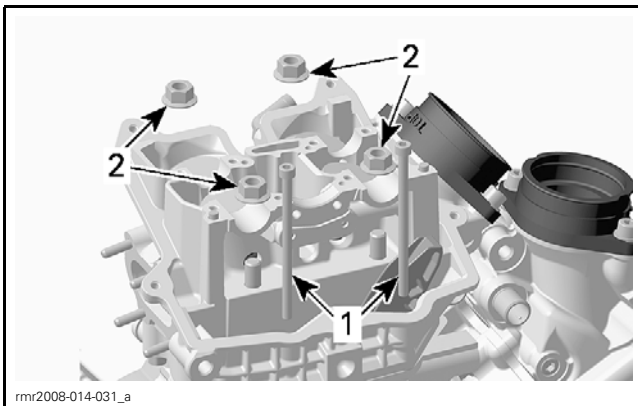
Unscrew spark plug.

Remove *VALVE COVER*. See the procedure in this subsection.

Remove *CAMSHAFT TIMING GEAR*. See procedure in this subsection.

First remove cylinder head screws.

Then remove cylinder head nuts.



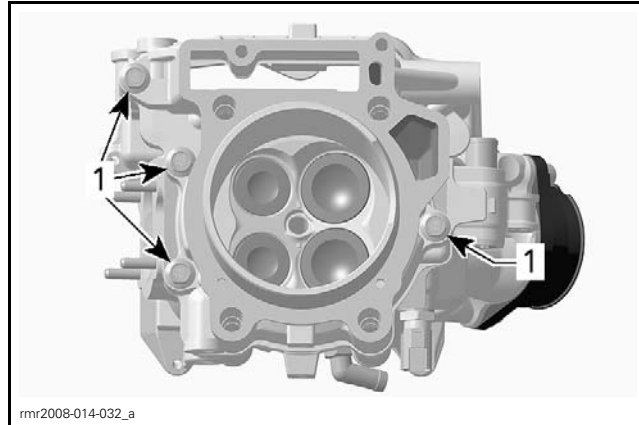
1. Cylinder head screws
2. Cylinder head nuts

Pull cylinder with cylinder head from bottom end.

NOTICE Take care not to damage piston and rings during cylinder removal.

Remove cylinder screws.

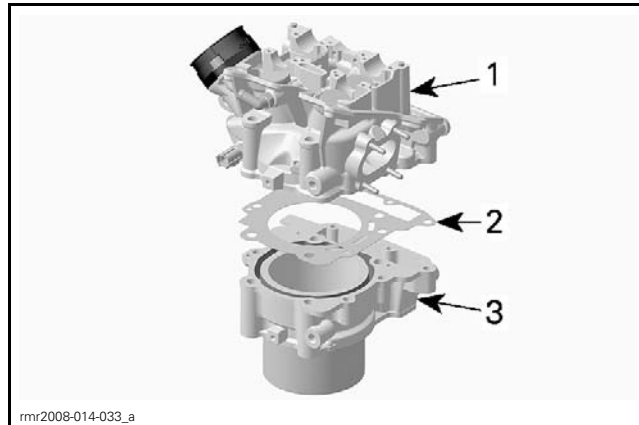
NOTE: If the cylinder head does not have to be disassembled, do not separate cylinder head from cylinder.



1. Cylinder screws

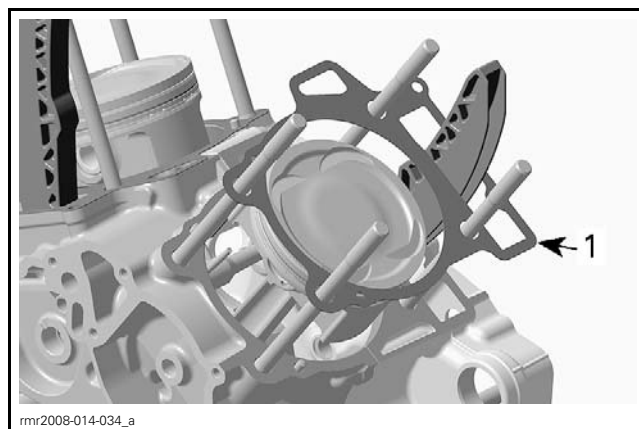
Separate cylinder head from cylinder.

Remove cylinder head gasket and discard it.



1. Cylinder head
2. Cylinder head gasket
3. Cylinder

Remove cylinder base gasket and scrap it.

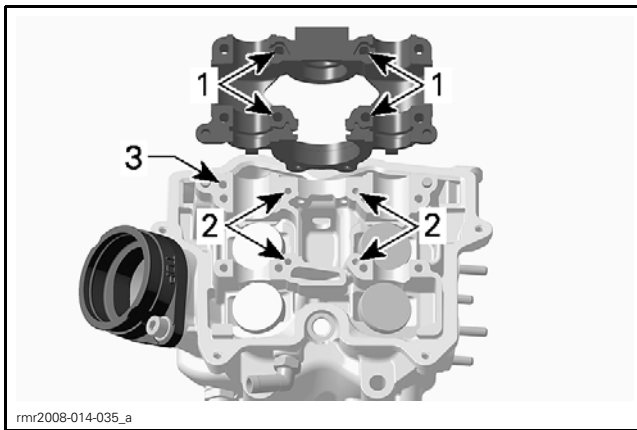


1. Cylinder base gasket

Cylinder Head Inspection

Check for cracks between valve seats or other damages, if so, replace cylinder head.

Blow out oil support through cylinder head to check if they are not clogged.



1. Oil orifices to lubricate camshaft bearings
2. Oil orifices
3. Oil orifice (front cylinder only)

Check valve lifter bucket bore for wear or scoring. Measure valve lifter bucket radial clearance, refer to *VALVE LIFTER BUCKET*. If clearance exceeds specified tolerance, replace valve lifter bucket and measure radial clearance again.

If radial clearance is still out of specification replace cylinder head.

Check camshaft bearing for wear or scoring.

To measure the camshaft bearing, install camshaft holder according to the specified torque in the exploded views and measure diameter with a bore gauge.

CAMSHAFT BEARING (CAMSHAFT HOLDER INSTALLED)	
NEW	24.007 mm to 24.020 mm (.9452 in to .9457 in)
SERVICE LIMIT	24.040 mm (.9465 in)

Measure camshaft radial clearance, refer to *CAMSHAFT*. If clearance exceeds specified tolerance, replace camshaft and measure radial clearance again.

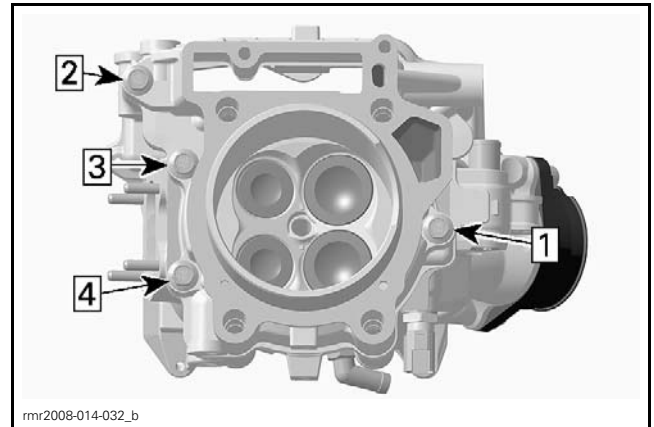
If radial clearance is still out of specification replace cylinder head.

Cylinder Head Installation

For installation, reverse the removal procedure. Pay attention to the following details.

Fit cylinder on cylinder head.

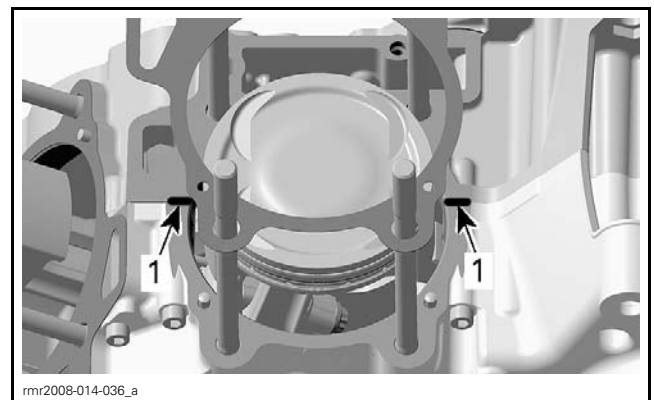
Install cylinder screws and pre-tighten them to 15 N•m (133 lbf•in) according to following tightening sequence.



TIGHTENING SEQUENCE

NOTICE Always replace cylinder base gasket by a NEW one before installing the cylinder with cylinder head.

Apply LOCTITE 5910 (P/N 293 800 081) on crankcase sealing surface where crankcase halves are jointed, as shown in the illustration below.

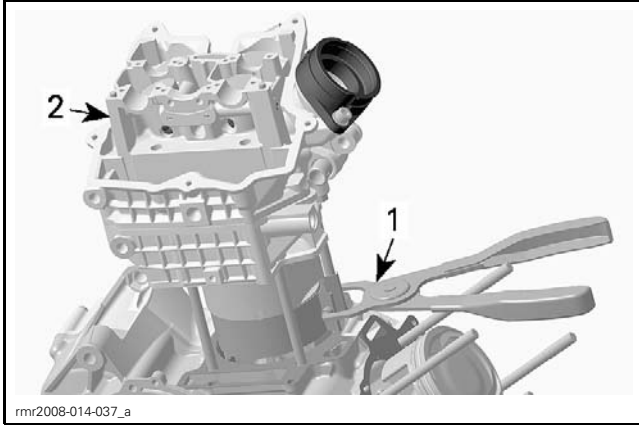


1. Apply Loctite 5910 here

Apply engine oil in the bottom area of the cylinder bore and on piston rings.

Compress piston rings using a piston ring compressor tool such as the SNAP-ON PISTON RING COMPRESSOR TOOL (P/N RC-980). Apply engine oil on the band of the tool.

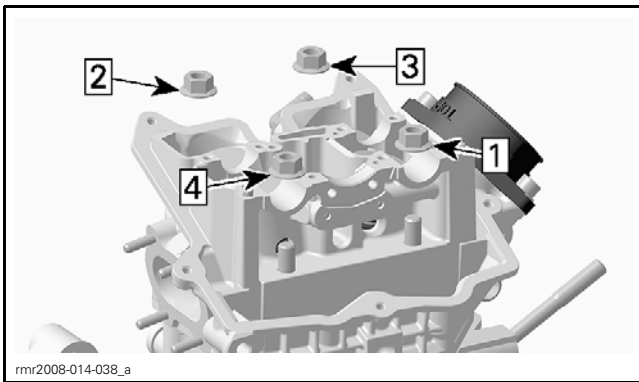
Subsection XX (CYLINDER HEAD AND CYLINDER)



1. Piston ring compressor tool
2. Cylinder with cylinder head assembly

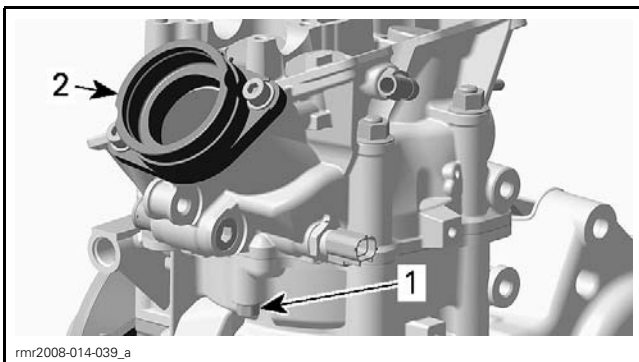
Slide timing chain through chain passage, then slide cylinder with cylinder head over piston.

First tighten M10 nuts by hand, then tighten them according to the following tightening sequence.



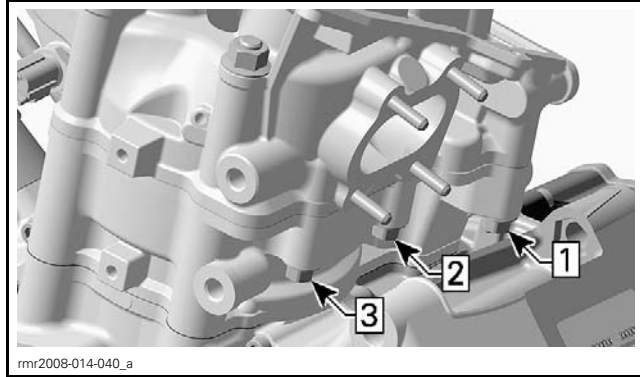
TIGHTENING SEQUENCE

Torque cylinder bolt underneath intake port.



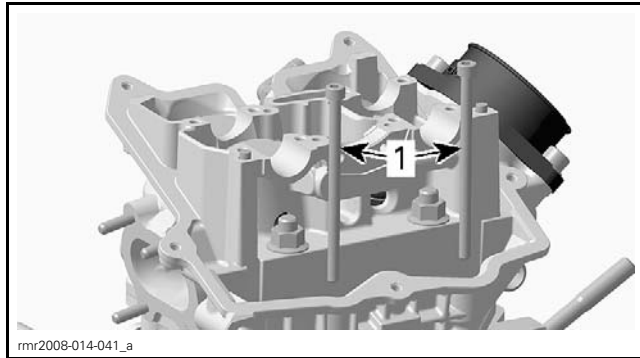
1. Cylinder bolt
2. Intake port

Then torque cylinder bolts underneath exhaust port according to the following tightening sequence.



TIGHTENING SEQUENCE

Finally tighten Allen socket screws in cylinder head.



1. Cylinder head screws

Install all other removed parts.

VALVE SPRING

Valve Spring Removal

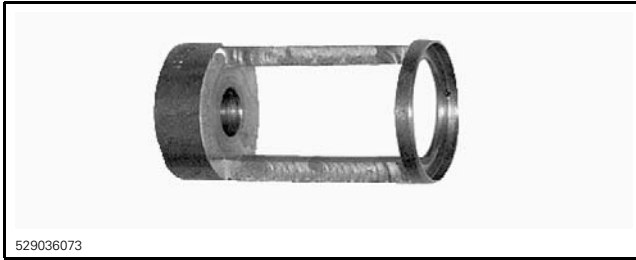
NOTE: Whenever valves are removed, it is recommended to replace valve stem seal at the same time.

Remove:

- Cylinder head, refer to *CYLINDER HEAD*
- Camshafts
- Valve lifter bucket and adjustment shim.

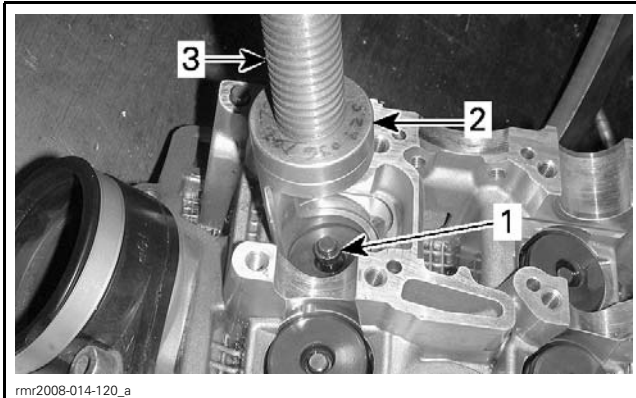
Compress valve spring, use the VALVE SPRING COMPRESSOR (P/N 529 035 724) and the VALVE SPRING COMPRESSOR CUP (P/N 529 036 073).





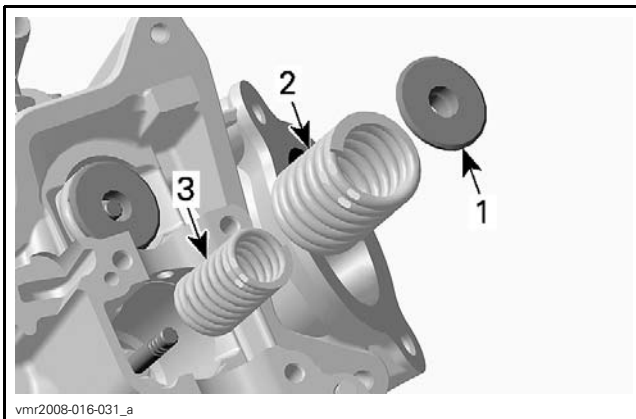
Remove valve coppers.

VALVE SPRING FREE LENGTH	
INNER VALVE SPRING	
NEW	39.24 mm (1.5449 in)
SERVICE LIMIT	38.00 mm (1.4961 in)
OUTER VALVE SPRING	
NEW	41.97 mm (1.6524 in)
SERVICE LIMIT	40.50 mm (1.5945 in)



1. Valve spring compressor clamp
2. Valve spring compressor cup
3. Valve coppers

Remove valve spring retainer, then outer and inner valve spring.



1. Spring retainer
2. Outer valve spring
3. Inner valve spring

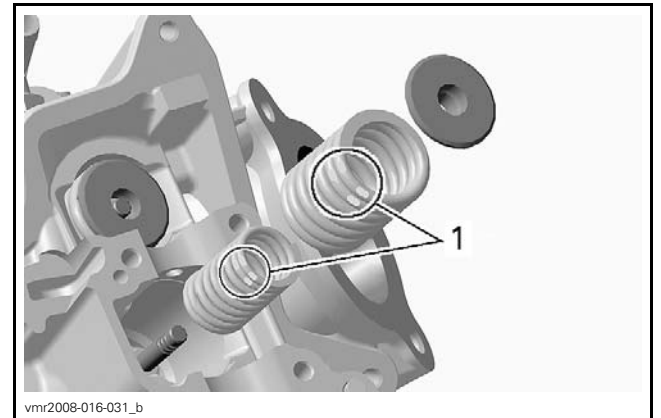
Valve Spring Inspection

Check valve spring for rust or corrosion and free length.

Valve Spring Installation

For installation reverse the removal procedure.

Colored area of the valve springs must be placed on top.

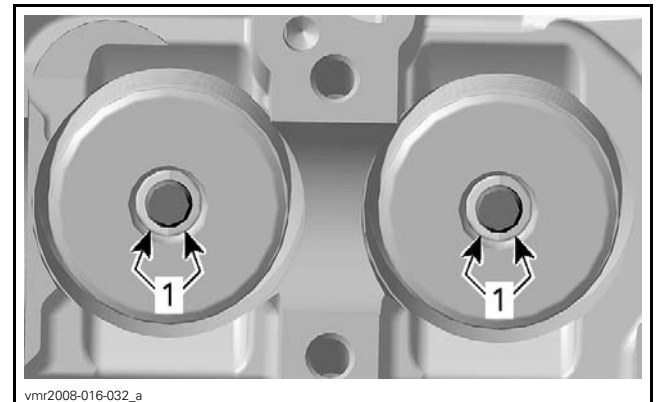


1. Colored area of the valve spring

To ease installation of coppers apply some oil or grease on them, so that they remain in place while releasing the spring.

NOTE: Valve coppers must be properly engaged in valve stem grooves.

NOTICE Improperly locked valve springs will cause engine damage.



1. Valve coppers

Subsection XX (CYLINDER HEAD AND CYLINDER)

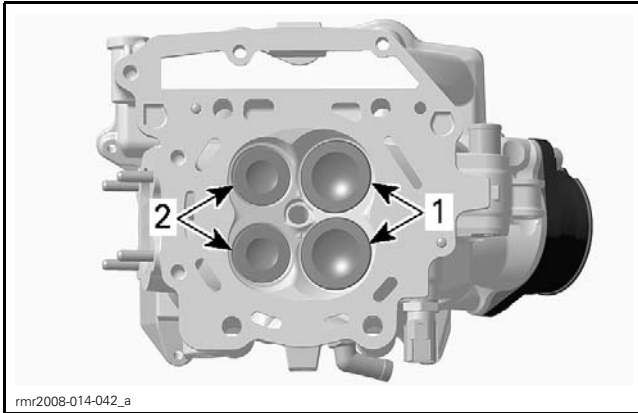
After springs are installed, ensure it is properly locked by tapping on valve stem end with a soft hammer so that valve opens and closes a few times.

VALVE

Valve Removal

Remove valve springs, see *VALVE SPRING*.

Push the valve stem, then pull intake and exhaust valves out of cylinder head.



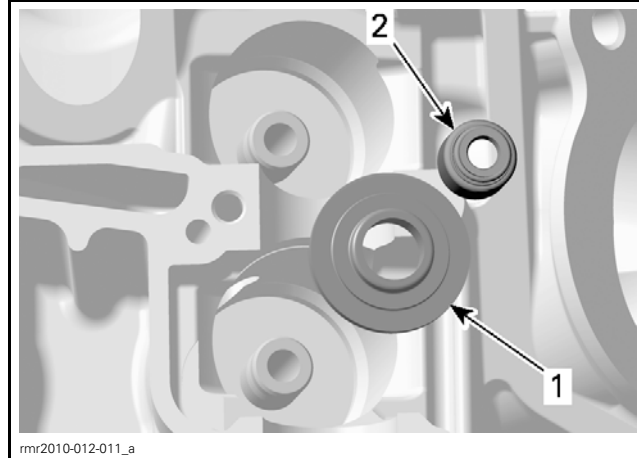
1. Intake valves 38 mm (1.5 in)
2. Exhaust valves 31 mm (1.2 in)

Valve Stem Seal Removal

Remove valve stem seal with SNAP-ON PLIERS (P/N YA 8230) and discard it.



Remove valve spring shim.



1. Valve spring shim
2. Valve stem seal

Valve Inspection

Valve Stem Seal

Always install **NEW** valve stem seals whenever valves are removed.

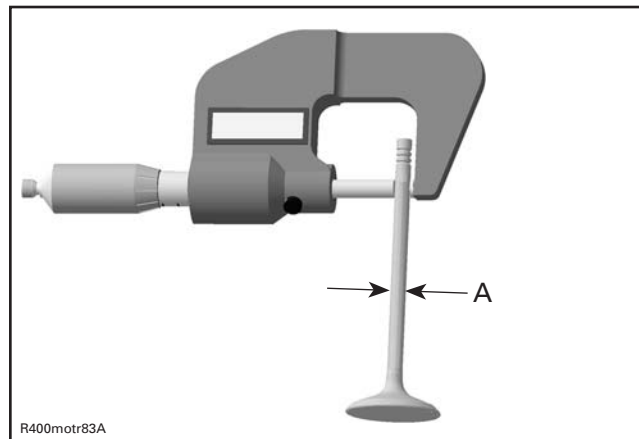
Valve

Inspect valve surface, check for abnormal stem wear and bending. If out of specification, replace by a new one.

VALVE STEM RUNOUT (INTAKE/EXHAUST)	
NOMINAL NEW	0.005 mm (.0002 in)
SERVICE LIMIT	0.05 mm (.002 in)

Valve Stem

Measure valve stem in three places using a micrometer.



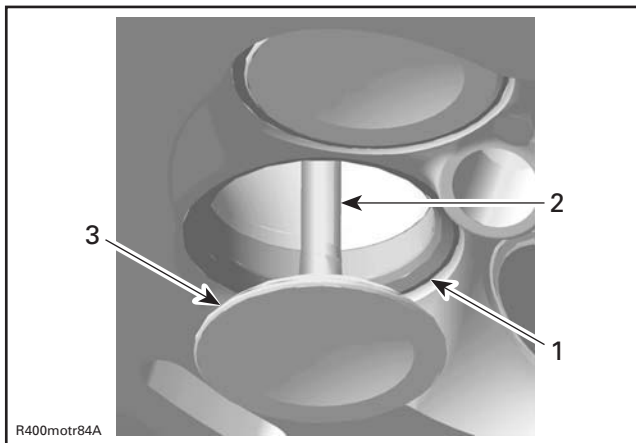
- A. Valves stem diameter

VALVE STEM DIAMETER	
INTAKE VALVE	
NEW	5.961 mm to 5.975 mm (.2347 in to .2352 in)
SERVICE LIMIT	5.950 mm (.2343 in)
EXHAUST VALVE	
NEW	5.946 mm to 5.960 mm (.2341 in to .2346 in)
SERVICE LIMIT	5.935 mm (.2337 in)

Change valve if valve stem is out of specification or has other damages such as wear or friction surface.

Measure valve guide. Refer to *VALVE GUIDE* in this subsection.

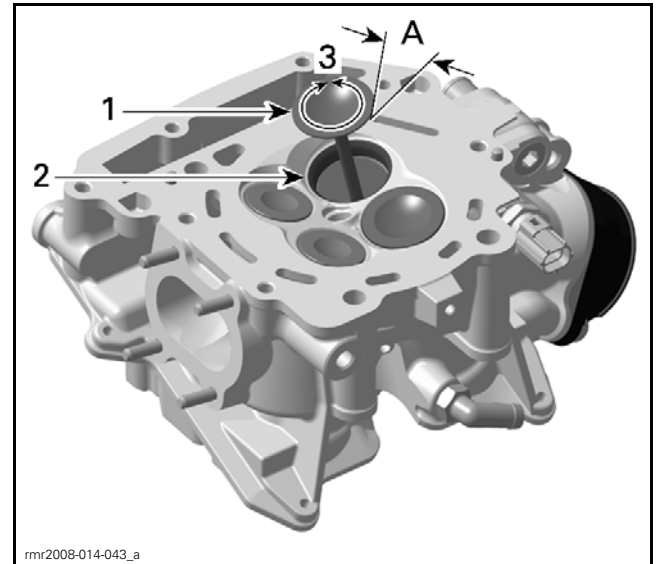
Valve Face and Seat



1. Valve seat
2. Exhaust valve contaminated area
3. Valve face (contact surface to valve seat)

Check valve face and seat for burning, pitting and other signs of damage. Replace valve or cylinder head if necessary.

Apply some lapping compound to valve face and work valve on its seat with a lapping tool.



1. Valve seat
2. Valve face (contact surface to valve seat)
3. Turn valve while pushing against cylinder head
- A. Valve seat angle 45°

NOTE: Ensure to seat valves properly. Apply marking paste to ease checking contact pattern.

Repeat procedure until valve seat/valve face fits together.

Measure valve face contact width.

NOTE: The location of contact area should be in center of valve face.

Measure valve seat width, using a caliper.

VALVE SEAT CONTACT WITH	
INTAKE VALVE	
NEW	1.00 mm to 1.40 mm (.0394 in to .0551 in)
SERVICE LIMIT	1.60 mm (.063 in)
EXHAUST VALVE	
NEW	1.25 mm to 1.55 mm (.0492 in to .061 in)
SERVICE LIMIT	1.80 mm (.0709 in)

If valve seat contact width is too wide, too narrow or has dark spots, replace the cylinder head.

Valve Installation

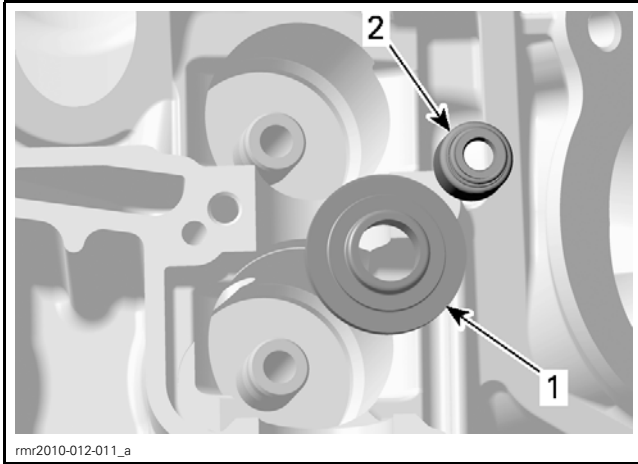
For installation reverse the removal procedure. Pay attention to the following details.

NOTE: Make sure the thrust washer and valve spring shim are installed before installing valve stem seal.

Apply engine oil on valve stem and install it.

Subsection XX (CYLINDER HEAD AND CYLINDER)

NOTICE Be careful when valve stem is passed through sealing lips of valve stem seal.



1. Valve spring shim
2. Sealing lips of valve stem seal

To ease installation of cotters, apply oil or grease on them so that they remain in place while releasing the spring.

After springs are installed, ensure it is properly locked by tapping on valve stem end with a soft hammer so that valve opens and closes a few times.

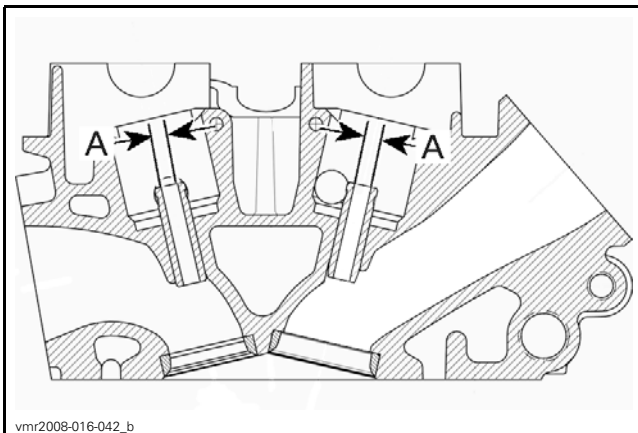
NOTICE Improperly locked valve springs will cause engine damage.

VALVE GUIDE

Valve Guide Inspection

NOTE: Clean valve guide to remove carbon deposits before measuring.

Measure valve guide in three places using a small bore gauge.



A. Valve guide diameter

VALVE GUIDE DIAMETER (INTAKE AND EXHAUST VALVES)	
NEW	6.006 mm to 6.018 mm (.2365 in to .2369 in)
SERVICE LIMIT	6.050 mm (.2382 in)

If valve guide is out of specification or has other damages such as wear or friction surface, replace it.

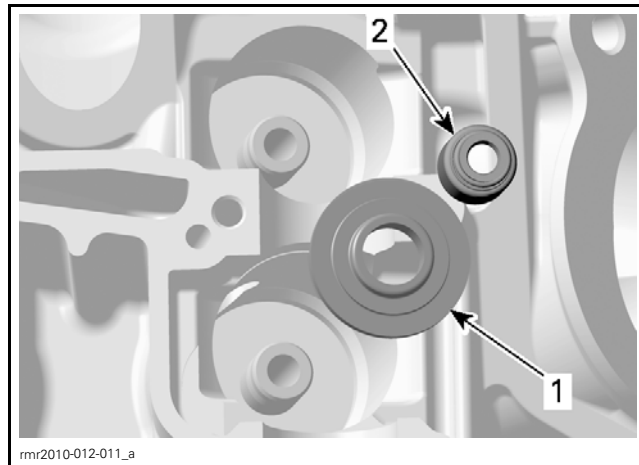
Valve Guide Replacement

NOTE: Do not heat up cylinder head for valve guide removal and installation.

Remove:

- Cylinder head (see *CYLINDER HEAD*)
- Valve springs (see *VALVE SPRING*)
- Valves (see *VALVE*).

Remove valve stem seal and valve spring shim.

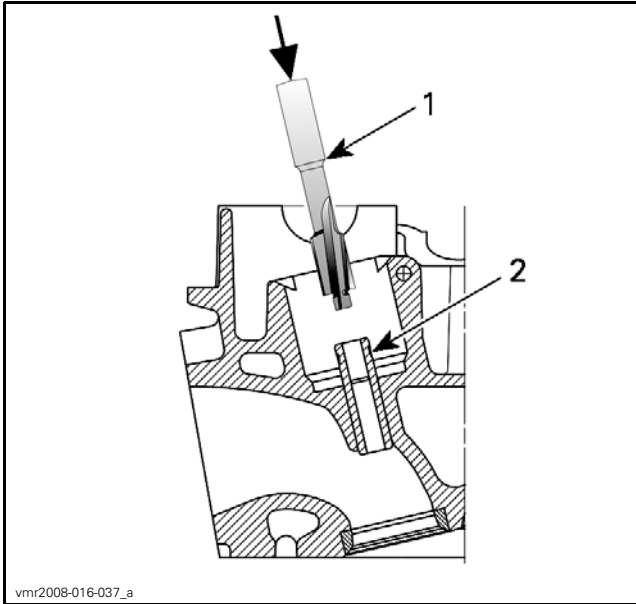


1. Valve spring shim
2. Sealing lips of valve stem seal

NOTE: Clean valve guide area from contamination before removal.

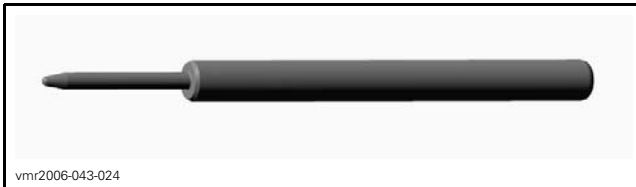
Use a special reamer and machine valve guide top until sharp edge is removed.

NOTICE The sharp edge near the top of the valve guide must be machined away. Otherwise it will foul the valve guide hole in the head and destroy the head when removing the valve guide.

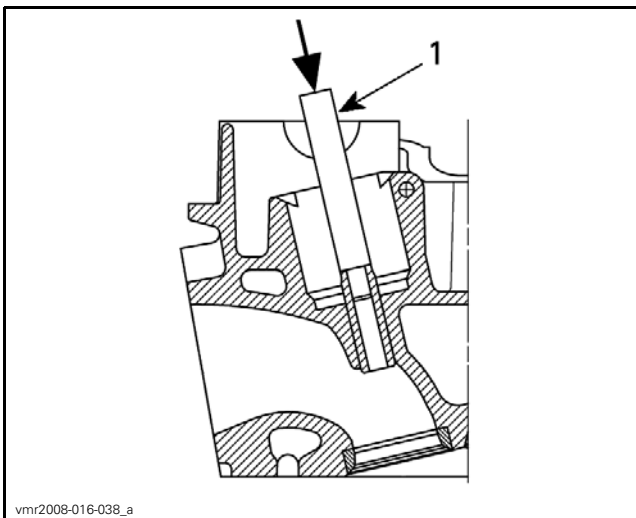


1. Reamer
2. Valve guide, sharp edge

Using the VALVE GUIDE REMOVER (6 MM) (P/N 529 036 074), remove valve guide with a hammer.



vmr2006-043-024



1. Valve guide remover

Check the valve guide bore in the head for scoring or other damage.

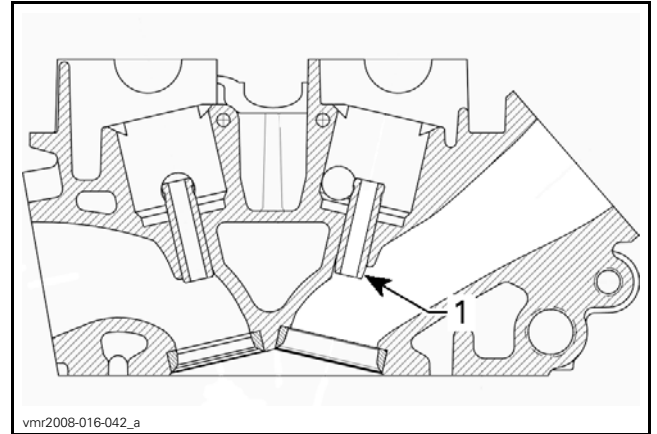
NOTICE If any signs of galling are visible in the bore, the cylinder head must be replaced.

Valve Guide Installation

For installation, reverse the removal procedure. Pay attention to the following details.

Clean the valve guide bore before reinstalling the valve guide into cylinder head.

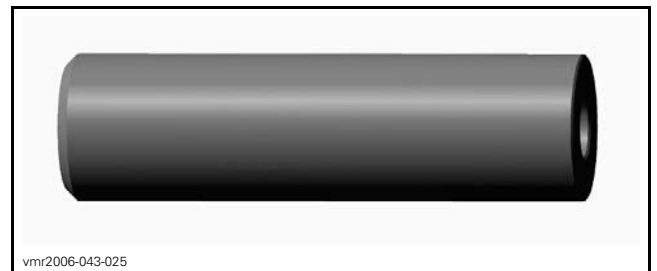
NOTE: Intake and exhaust valve guides are different. Intake valve guide has a longer chamfer.



1. Longer chamfer on intake valve guide

Apply MOLYKOTE G-N (P/N 420 297 433) on valve guide and in valve guide bore, prior to install it into the cylinder head.

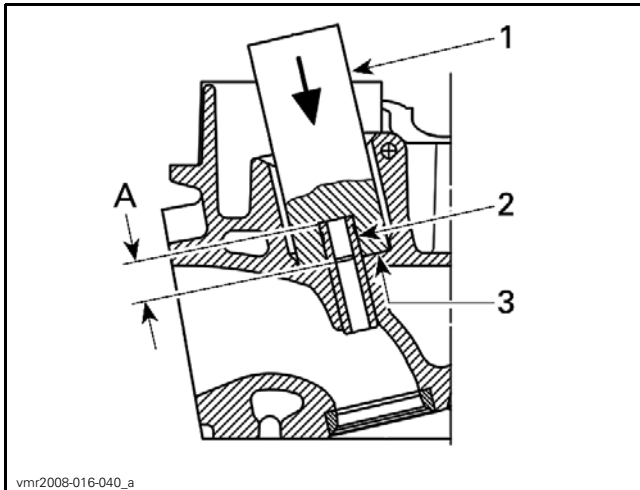
Use the VALVE GUIDE INSTALLER (6 MM) (P/N 529 036 075) to install valve guide.



vmr2006-043-025

Push valve guide in the cold cylinder head as per following illustration.

Subsection XX (CYLINDER HEAD AND CYLINDER)

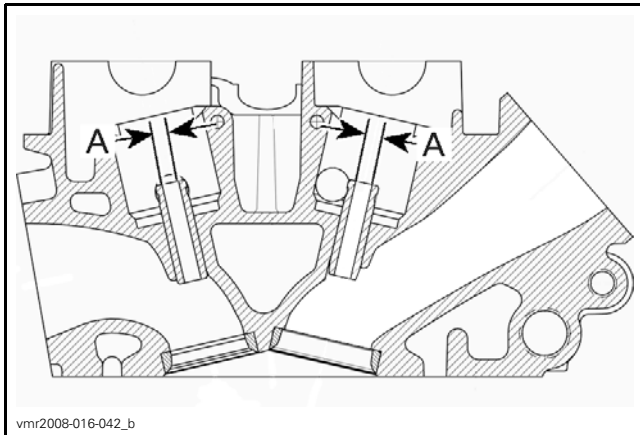


vmr2008-016-040_a

1. Valve guide installer
 2. Valve guide
 3. Thrust surface of cylinder head
- A. Measurement from thrust surface to valve guide top

VALVE GUIDE MEASUREMENT A	
MINIMUM NEW	13.10 mm (.5157 in)
MAXIMUM NEW	13.50 mm (.5315 in)

Valve has guide to be adjusted in diameter by using a reamer.



vmr2008-016-042_b

- A. Valve guide diameter

VALVE GUIDE DIAMETER (INTAKE/EXHAUST)	
NEW	6.006 mm to 6.018 mm (.2365 in to .2369 in)

NOTE: Ensure to turn reamer in the right direction. Use cutting oil and clean often reamer/valve guide from metal shavings.

CYLINDER

Cylinder Removal

For cylinder removal refer to *CYLINDER HEAD REMOVAL* in this subsection.

Cylinder Inspection

Cylinder

Check cylinder for cracks, scoring and wear ridges on the top and bottom of the cylinder.

Piston/Cylinder Clearance

Check piston/cylinder clearance, refer to *PISTON* below in this subsection.

Chain tensioner hole

Ensure that chain tensioner and hole in the cylinder are in perfect condition.

Cylinder Installation

For cylinder installation refer to *CYLINDER HEAD INSTALLATION* in this subsection.

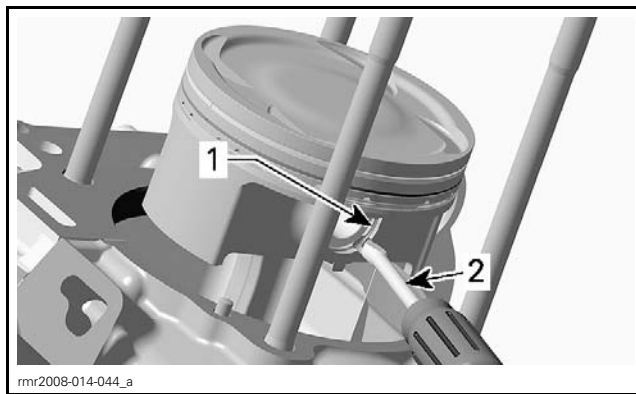
PISTON

Piston Removal

Remove cylinder head with cylinder, see *CYLINDER HEAD* in this subsection.

Place a rag under piston in the area of timing chain passage.

Remove one piston circlip and discard it.

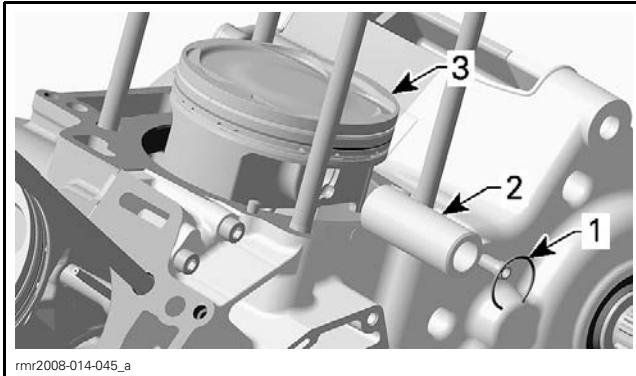


vmr2008-014-044_a

1. Piston circlip
2. Small screwdriver

NOTE: The removal of both piston circlips are not necessary to remove piston pin.

Push piston pin out of piston.



1. Piston circlip
2. Piston pin
3. Piston

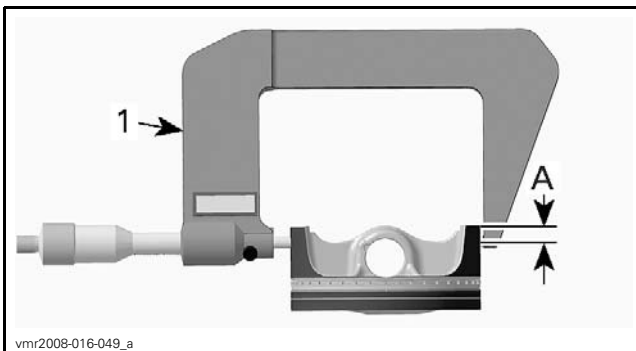
Detach piston from connecting rod.

Piston Inspection

Piston

Inspect piston for scoring, cracking or other damages. Replace piston and piston rings if necessary.

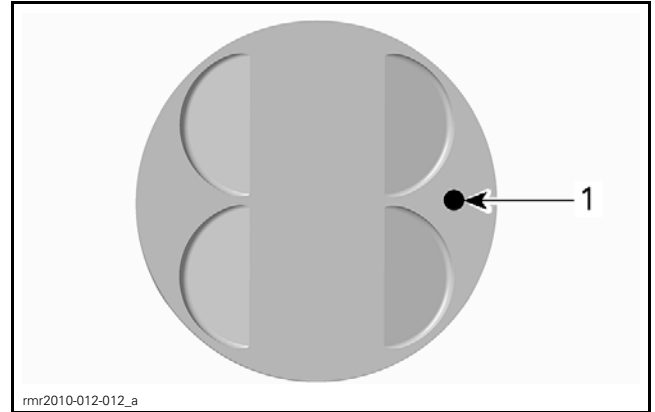
Using a micrometer, measure piston at 10 mm (.394 in) perpendicularly (90°) to piston pin.



1. Measuring perpendicularly (90°) to piston pin
A. 10 mm (.394 in)

The measured dimension should be as described in the following table. If not, replace piston.

PISTON MEASUREMENT	
SIZE A	
NEW	96.940 mm to 96.950 mm (3.8165 in to 3.8169 in)
SERVICE LIMIT	96.920 mm (3.8157 in)
SIZE B	
NEW	96.950 mm to 96.960 mm (3.8169 in to 3.8173 in)
SERVICE LIMIT	96.930 mm (3.8161 in)



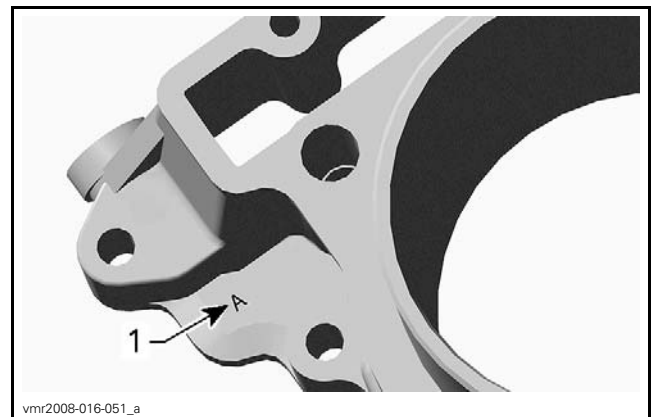
1. Red or green paint mark (size code) of piston

NOTE: If the wear limit is exceeded, a new piston must be used or the cylinder replaced, complete with piston. When replacing the piston always use new circlips securing the piston pin. Take special care when matching the piston with cylinder:

Piston with red paint mark = size "A" — Cylinder size "A"

Piston with green paint mark = size "B" — Cylinder size "B"

The cylinder size code "A" or "B" is stamped on the lower side of the cylinder.

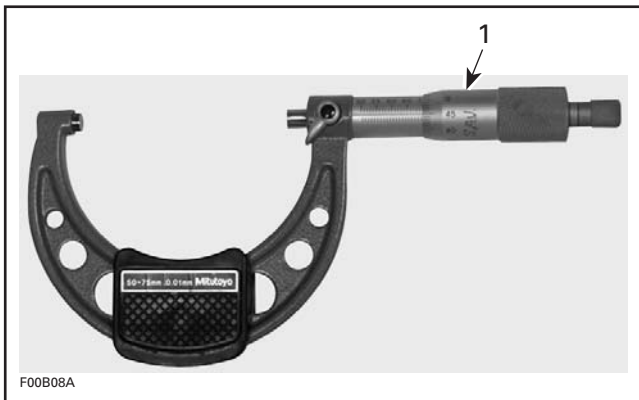


1. Size code "A" or "B" of cylinder

Piston/Cylinder Clearance

Adjust and lock a micrometer to the piston dimension.

Subsection XX (CYLINDER HEAD AND CYLINDER)

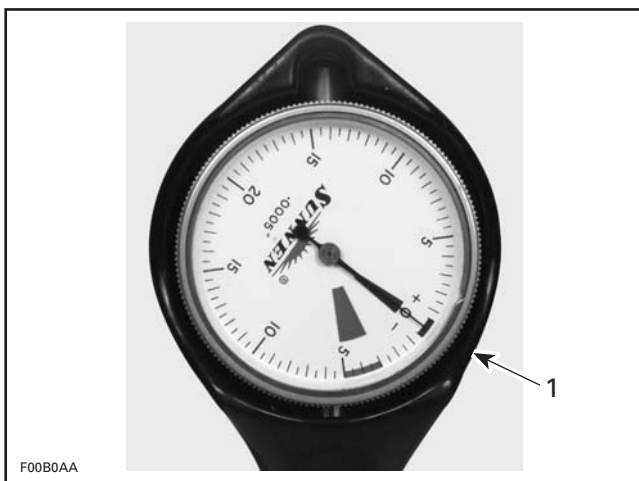


1. Micrometer set to the piston dimension

With the micrometer set to the dimension, adjust a cylinder bore gauge to the micrometer dimension and set the indicator to 0 (zero).



1. Use the micrometer to set the cylinder bore gauge
2. Dial bore gauge



TYPICAL
1. Indicator set to 0 (zero)

Position the dial bore gauge 20 mm (.787 in) above cylinder base, measuring perpendicularly (90°) to piston pin axis.

Read the measurement on the cylinder bore gauge. The result is the exact piston/cylinder wall clearance.

PISTON/CYLINDER CLEARANCE	
NEW	0.050 mm to 0.075 mm (.002 in to .003 in)
SERVICE LIMIT	0.090 mm (.0035 in)

NOTE: Make sure used piston is not worn. See *PISTON MEASUREMENT*.

If clearance exceeds specified tolerance, replace piston by a new one and measure piston/cylinder clearance again.

If piston/cylinder clearance is still out of specification replace cylinder also.

NOTE: Make sure the cylinder bore gauge indicator is set exactly at the same position as with the micrometer, otherwise the reading will be false.

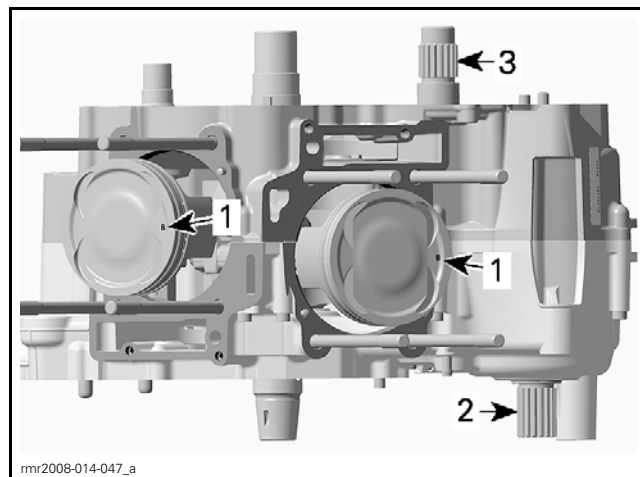
Piston Installation

For installation, reverse the removal procedure. Pay attention to the following details.

Apply engine oil on the piston pin.

Insert piston pin into piston and connecting rod.

NOTICE Take care that both pistons will be installed with the marks (size code of piston) showing to the rear of the engine.



1. Size code of piston
2. Main shaft
3. Clutch shaft

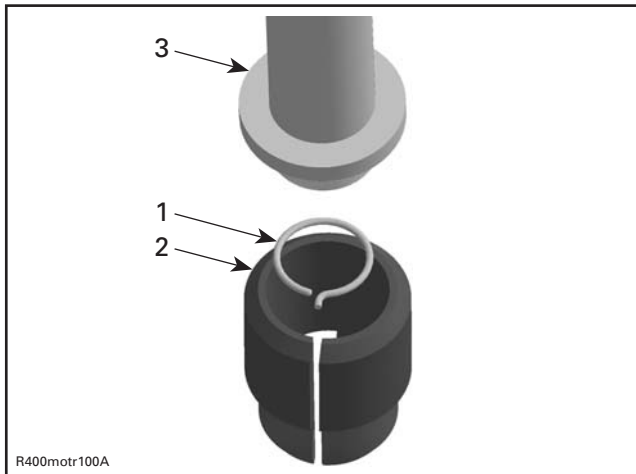
Use the PISTON CIRCLIP INSTALLER 991 (P/N 529 036 072) to assemble the **NEW** piston circlip as per following procedure:



529036072

NOTICE Always replace disassembled piston circlip(s) by NEW ones. Place a rag on cylinder base to avoid dropping the circlip inside the engine.

Place circlip in sleeve as per following illustration.



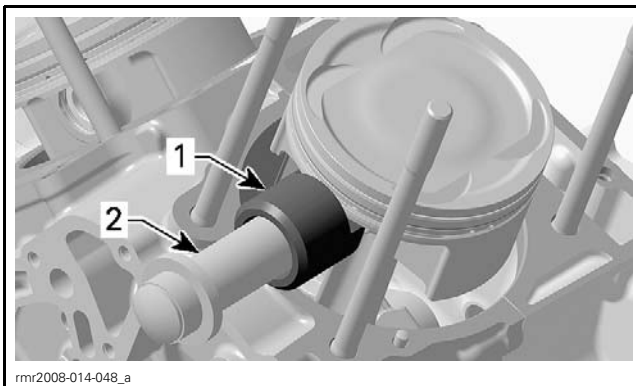
R400motr100A

1. Circlip
2. Sleeve
3. Piston circlip installer handle

Push piston circlip installer handle until circlip reaches middle of sleeve.

Insert the end of the handle into piston pin.

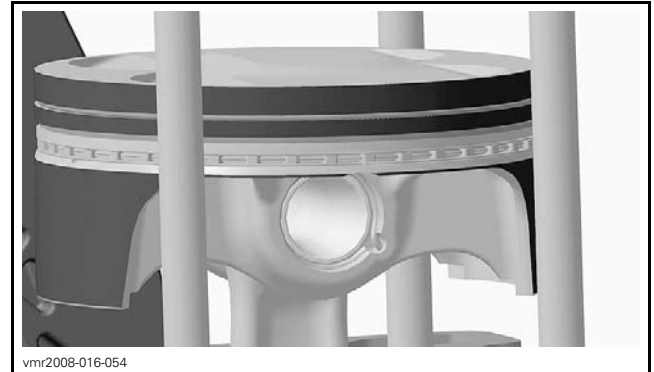
Hold piston and push handle to engage the circlip into piston groove.



rnr2008-014-048_a

1. Sleeve
2. Piston circlip installer handle

NOTE: Take care that the hook of the piston circlip is positioned properly.



vnr2008-016-054

CORRECT POSITION OF THE PISTON CIRCLIP

PISTON RINGS

Piston Rings Removal

Remove cylinder head with cylinder, refer to *CYLINDER HEAD*.

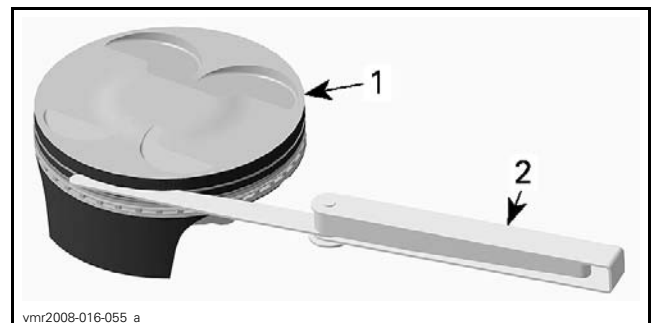
Remove *PISTON*. See preceding procedure.

Piston Rings Inspection

Ring/Piston Groove Clearance

Using a feeler gauge measure each ring/piston groove clearance. If the clearance is too large, the piston and the piston rings should be replaced.

RING/PISTON GROOVE CLEARANCE	
UPPER COMPRESSION RING	
NEW	0.025 mm to 0.070 mm (.001 in to .0028 in)
SERVICE LIMIT	0.120 mm (.0047 in)
LOWER COMPRESSION RING	
NEW	0.025 mm to 0.070 mm (.001 in to .0028 in)
SERVICE LIMIT	0.120 mm (.0047 in)
OIL SCRAPER RING	
NEW	0.015 mm to 0.060 mm (.0006 in to .0024 in)
SERVICE LIMIT	0.100 mm (.0039 in)



vnr2008-016-055_a

1. Piston
2. Feeler gauge

Subsection XX (CYLINDER HEAD AND CYLINDER)

Ring End Gap

To measure the ring end gap place the ring in the cylinder in the area of 8mm to 16mm (.315 in to .63 in) from top of cylinder.

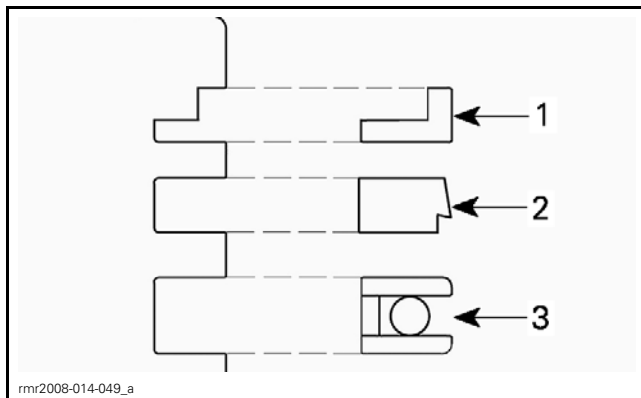
NOTE: In order to correctly position the ring in the cylinder, use piston as a pusher.

Using a feeler gauge, check ring end gap. Replace ring if gap exceeds above described specified tolerance.

RING END GAP	
ALL RINGS	
NEW	0.15 mm to 0.35 mm (.0059 in to .0138 in)
SERVICE LIMIT	0.100 mm (.0039 in)

Piston Rings Installation

Install the oil scraper ring first with marking "O" on top, then the lower compression ring with the stamping "E" and "TOP" facing up.



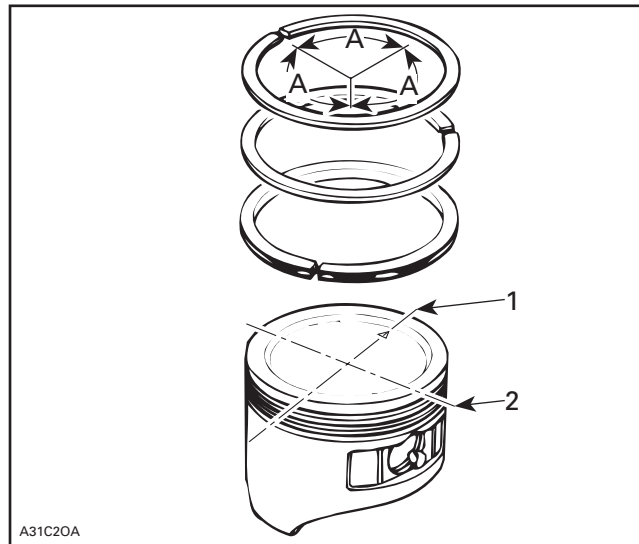
1. Upper compression ring
2. Lower compression ring
3. Oil scraper ring

NOTE: First install spring and then the ring of oil scraper ring. The oil scraper ring must be installed by hand.

Install other rings using a ring expander to prevent breakage.

Check that rings rotate smoothly after installation.

Space the piston ring end gaps 120° apart and do not align the gaps with the piston pin bore or the thrust side axis.



1. DO NOT align ring gap with piston thrust side axis
 2. DO NOT align ring gap with piston pin bore axis
- A. 120°

PISTON PIN

Piston Pin Removal

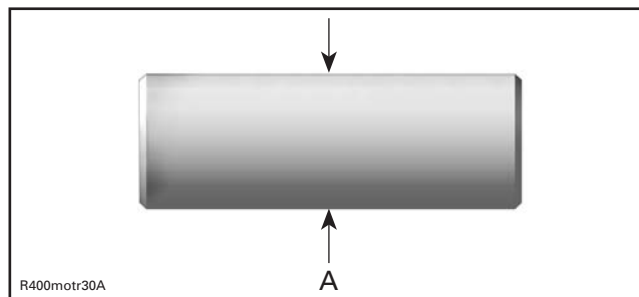
For piston pin removal see *PISTON*.

Piston Pin Inspection

Using synthetic abrasive woven, clean piston pin from deposits.

Inspect piston pin for scoring, cracking or other damages.

Measure piston pin. See the following illustration for the proper measurement positions.



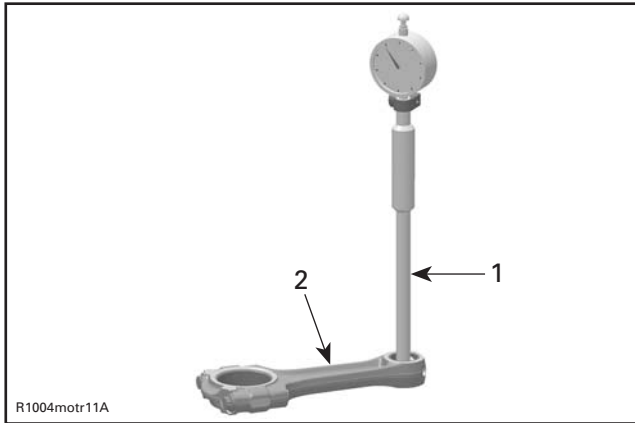
- A. Piston pin diameter

PISTON PIN DIAMETER	
NEW	21.997 mm to 22.000 mm (.866 in to .866 in)
SERVICE LIMIT	21.990 mm (.8657 in)

Replace piston pin if diameter is out of specifications.

Connecting Rod Small End Bushing

Measure inside diameter of connecting rod small end bushing.



1. Bore gauge
2. Connecting rod

CONNECTING ROD SMALL END DIAMETER	
NEW	22.010 mm to 22.020 mm (.8665 in to .8669 in)
SERVICE LIMIT	22.030 mm (.8673 in)

Compare measurements to obtain the connecting rod/piston pin clearance.

PISTON PIN RADIAL PLAY	
SERVICE LIMIT	0.040 mm (.0016 in)

Piston Pin Installation

Refer to *PISTON* in this subsection.