2022
Shop Manual

1630 Engines

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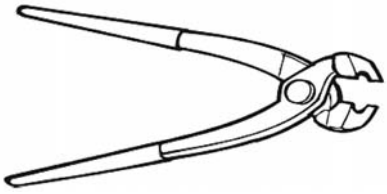

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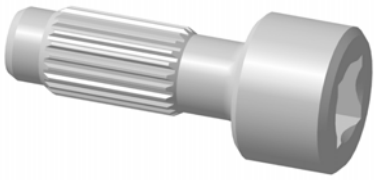

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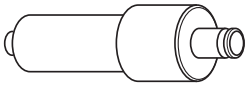

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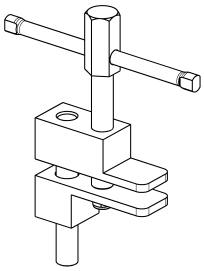

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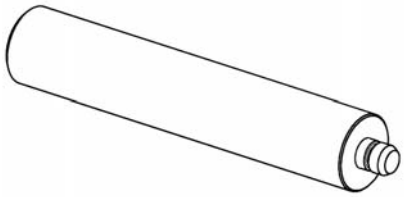

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INTAKE MANIFOLD

SERVICE PRODUCTS

Description	Part Number	Page
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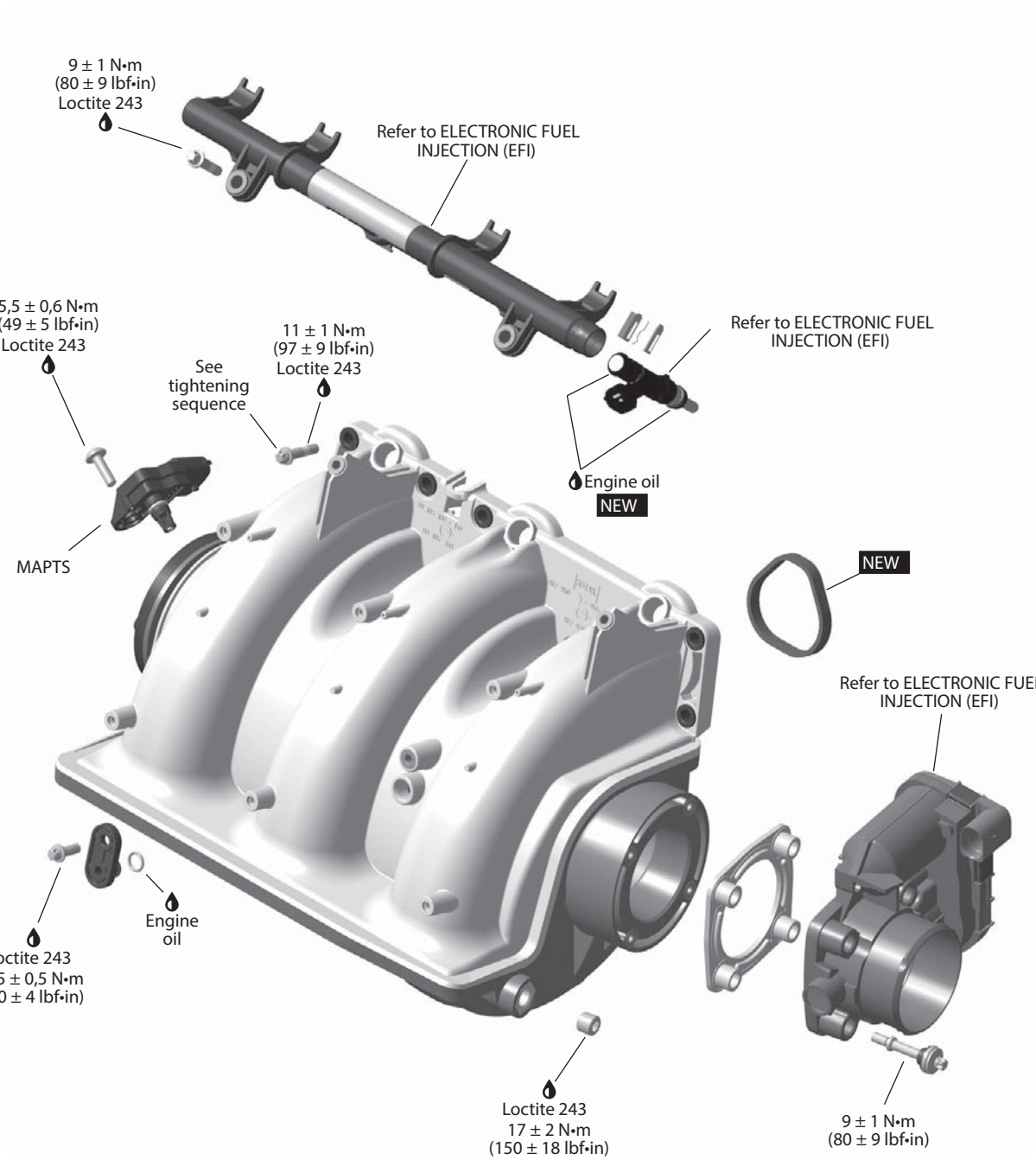
With Throttle Body Frontward



NEW = Component must be replaced when removed.

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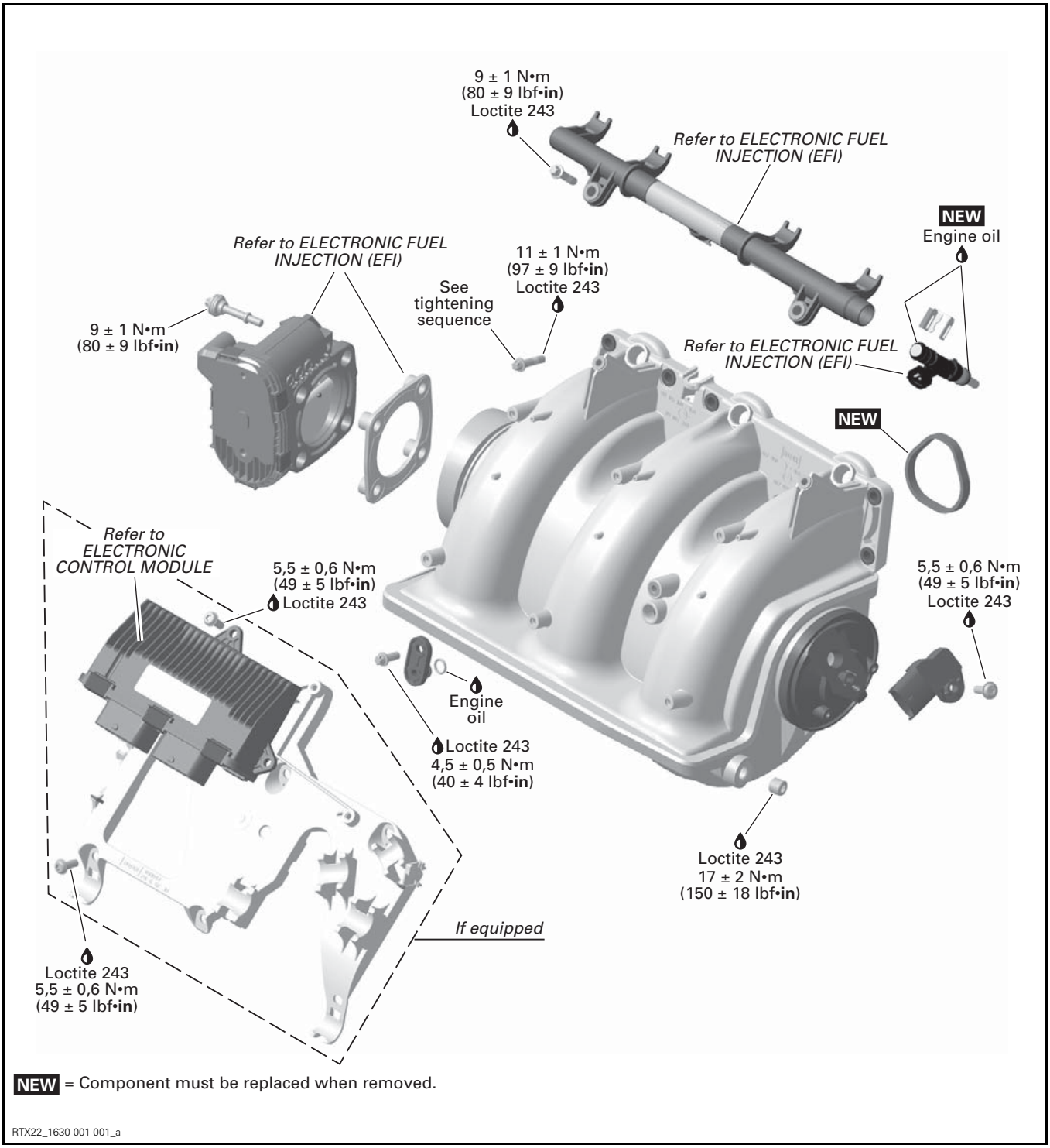
With Throttle Body Rearward



NEW = Component must be replaced when removed.

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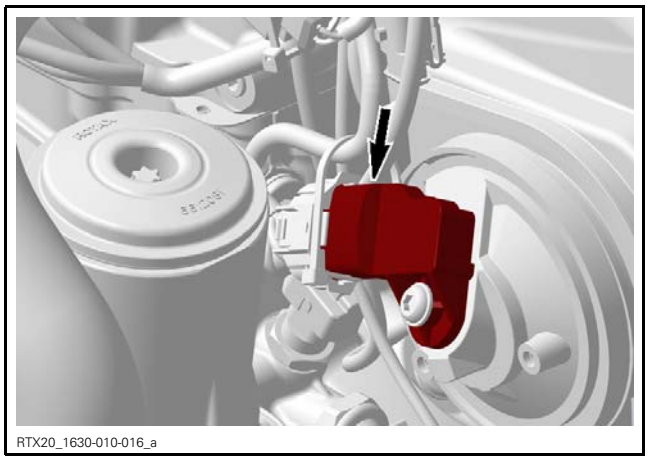
PROCEDURES

MANIFOLD ABSOLUTE PRESSURE AND TEMPERATURE SENSOR (MAPTS)

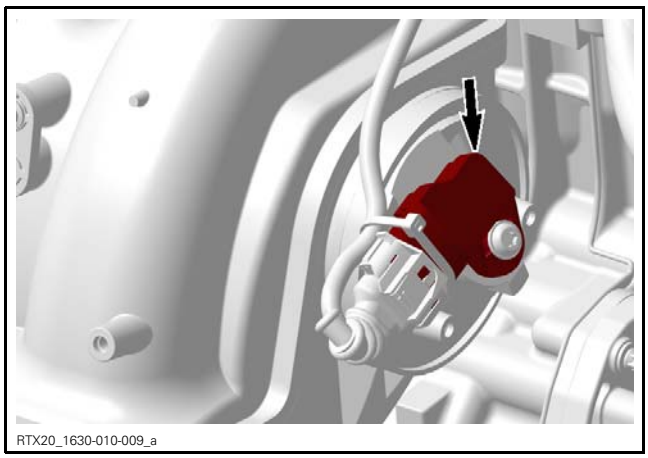
This sensor is a multifunction device. It measures manifold absolute pressure and intake air temperature for air flow calculations.

With Throttle Body Frontward



MAPTS - REAR SIDE OF ENGINE

With Throttle Body Rearward



MAPTS - FRONT SIDE OF ENGINE

MAPTS Pressure Function

This sensor is a dual function device. Before the engine is started, when power is applied to the system, the sensor measures the ambient atmospheric pressure and stores it in the ECM. Thereafter, once the engine is started, it measures the air pressure in the intake manifold at operating RPMs.

Ensure sensor is correctly installed on intake manifold. Otherwise, the MAPTS could generate a fault code for an unexpected sensor range at idle when it reads an erroneous intake manifold pressure. Remove sensor and check for oil or dirt on its end and if problem persists, check throttle plate condition/position and the wiring harness. Perform the following tests.

MAPTS Pressure Function Quick Test

1. Connect the vehicle to the BRP diagnostic software (BUDS2).
2. Press the START button to wake up the ECM.
3. Install the tether cord on the engine cut-off switch.
4. In BUDS2, go to:
   - Measurements page
   - ECM button
   - ECM - Basic tab
   - Intake Air Pressure (hPa)
5. Look for and take note of the MAPTS pressure reading while the engine is stopped.

Values have to be within ± 3.4 kPa (.5 PSI).

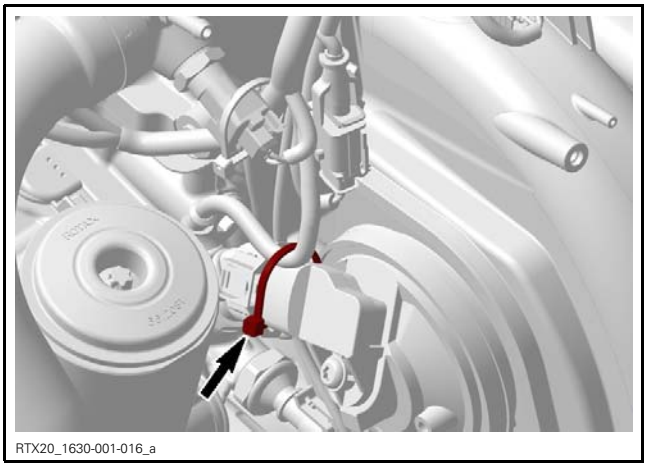
MAPTS PRESSURE FUNCTION QUICK TEST			
RESULT (1 KPA = 10 HPA)	SERVICE ACTION		
NO READING	Circuit Continuity Test of MAPTS Pressure Function	MAPTS Input Voltage Test	Repair or replace wiring
VALUE IS OUT OF RANGE	Replace MAPTS		

6. Perform the same test with a new MAPTS and compare both readings.

Testing the MAPTS Input Voltage (Pressure Function)

1. Remove the parts required to access the MAPTS.
2. Cut locking tie and disconnect connector from MAPTS.

With Throttle Body Frontward



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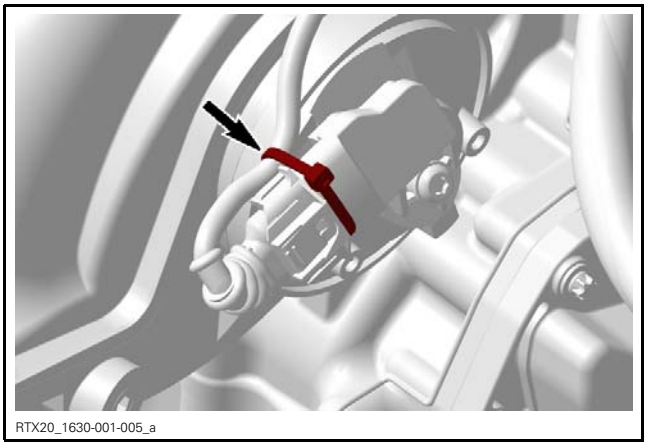
With Throttle Body Rearward



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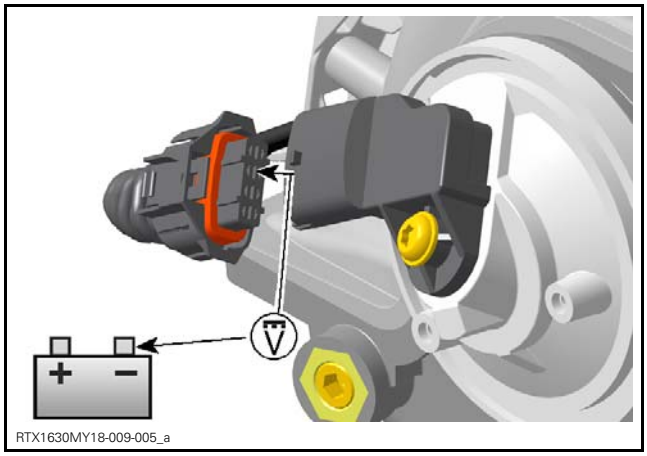
3. Press the START button to wake up the ECM.
4. Install the tether cord on the engine cut-off switch.
5. Set the multimeter to Vdc.
6. Read voltage as per following table.

MAPTS INPUT VOLTAGE TEST		
MAPTS CONNECTOR PIN	BATTERY	SPECIFICATION
3	Negative (-) post	5V
4		0V
1		0V



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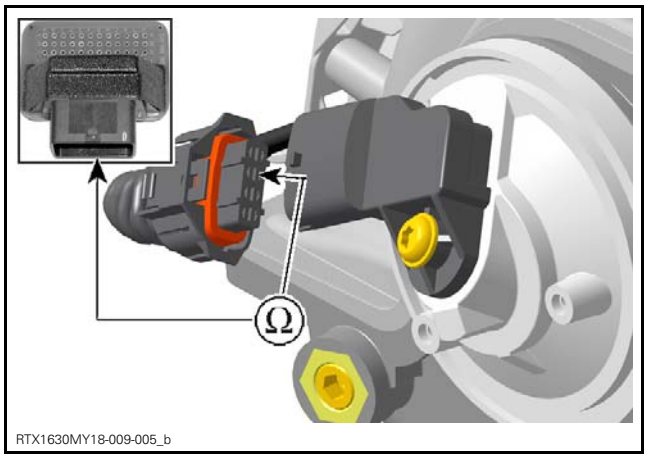
7. If voltage measured is as specified, replace the MAPTS.
8. If voltage measured is not as specified, refer to *TESTING THE CONTINUITY OF MAPTS WIRING HARNESS (PRESSURE FUNCTION)*.

Testing the Continuity of MAPTS Wiring Harness (Pressure Function)

1. Disconnect ECM-A connector from the ECM and install it on the ECM adapter tool.
2. Set the multimeter to Ω.
3. Test for circuit continuity as per following table.

MAPTS CIRCUIT CONTINUITY TEST		
MAPTS CONNECTOR PIN	ECM ADAPTER PIN	SPECIFICATION
3	A-B4	Close to 0 Ω
4	A-G4	
1	A-H2	



RTX1630MY18-009-005_b

4. If resistance is not within specification, repair or replace the wiring harness between ECM connector and the MAPTS. Refer to *WIRING DIAGRAM*.

MAPTS Temperature Function

The sensor monitors the air temperature inside the intake manifold.

MAPTS Quick Test (Temperature Function)

1. Connect the vehicle to the BRP diagnostic software (BUDS2).
2. Press the START button to wake up the ECM.
3. Install the tether cord on the engine cut-off switch.
4. In BUDS2, go to:
   – Measurements page
   – ECM button
   – ECM - Basic tab
   – Intake Temperature
5. Look for the temperature reading while the engine is stopped.

NOTE: If the complete vehicle is at room temperature, BUDS2 should display the ambient air temperature at the intake manifold.

6. Perform the same test with a new MAPTS and compare both readings.
7. If the engine's MAPTS temperature reading is significantly different than the new MAPTS, replace it.

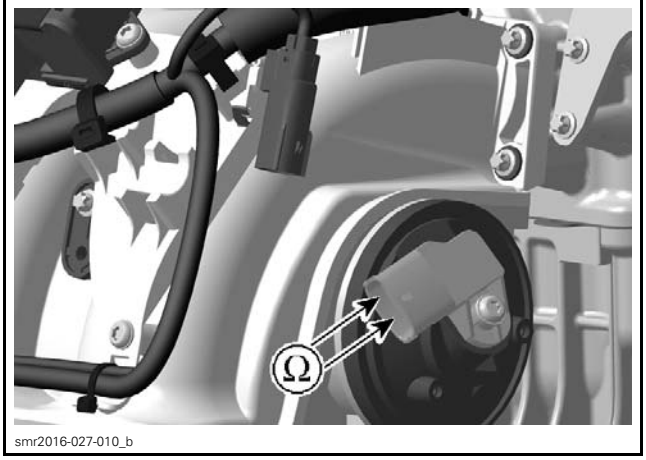
NOTE: Both sensors must measure the same ambient air temperature.

8. If there is no reading, carry out *TESTING THE MAPTS RESISTANCE (TEMPERATURE FUNCTION)*.

Testing the MAPTS Resistance (Temperature Function)

1. Cut locking tie and disconnect the connector from the MAPTS.
2. Set the multimeter to Ω.
3. Check the resistance of the sensor itself as shown.

MAPTS RESISTANCE TEST (TEMPERATURE FUNCTION)		
MAPTS CONNECTOR PIN		SPECIFICATION
1	2	Refer to *MAPTS TEMPERATURE SENSOR TABLE*



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MAPTS TEMPERATURE SENSOR TABLE			
TEMPERATURE		RESISTANCE (OHMS)	
°C	°F	LOW	HIGH
- 40	- 40	40528	56935
- 10	14	8103	10919
20	68	2193	2863
80	176	294	368
120	248	98	122

4. If resistance is not within specification, replace the MAPTS.
5. If resistance tests good, reconnect the MAPTS.
6. Disconnect ECM-A connector from the ECM and install it on the ECM adapter tool.
7. Recheck resistance value as per following table.

MAPTS RESISTANCE TEST (TEMPERATURE FUNCTION)		
ECM ADAPTOR PIN		SPECIFICATION
A-H2	A-H3	Refer to *MAPTS TEMPERATURE SENSOR TABLE*

MAPTS TEMPERATURE SENSOR TEST RESULTS			
RESULT	SERVICE ACTION		
NO READING	Circuit Continuity Test of MAPTS Temperature Function	MAPTS Input Voltage Test	Repair or replace wiring
INCORRECT RESISTANCE VALUE	Replace MAPTS		
CORRECT RESISTANCE VALUE	Try a new ECM		

Testing the MAPTS Circuit Continuity (Temperature Function)

MAPTS CIRCUIT CONTINUITY TEST (TEMPERATURE FUNCTION)		
MAPTS CONNECTOR PIN	ECM ADAPTOR PIN	SPECIFICATION
1	A-H2	Close to 0 Ω
2	A-H3	

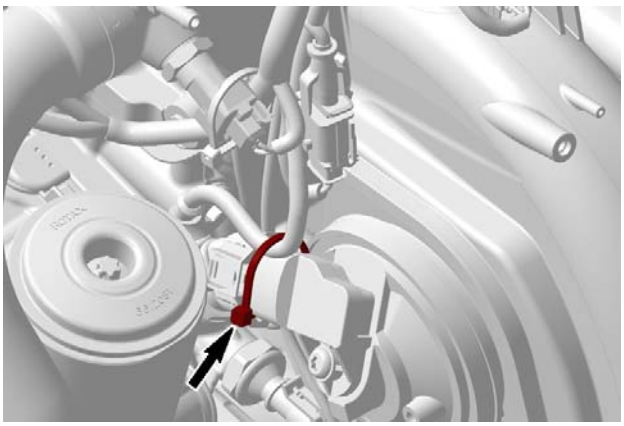
Replacing the MAPTS

1. Disconnect MAPTS connector and remove the MAPTS.
2. Install the new MAPTS.
3. Tighten retaining screw to specification.

TIGHTENING TORQUE	
MAPTS retaining screw	5.5 N•m ± 0.6 N•m (49 lbf•**in** ± 5 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)

4. Connect MAPTS connector.
5. Secure MAPTS wire to the sensor.

With Throttle Body Frontward



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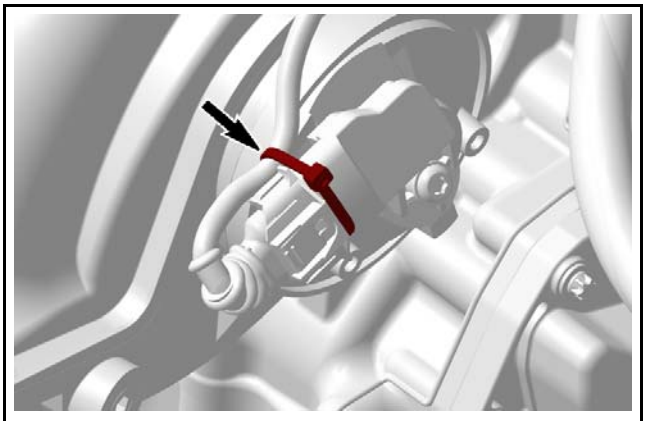
With Throttle Body Rearward



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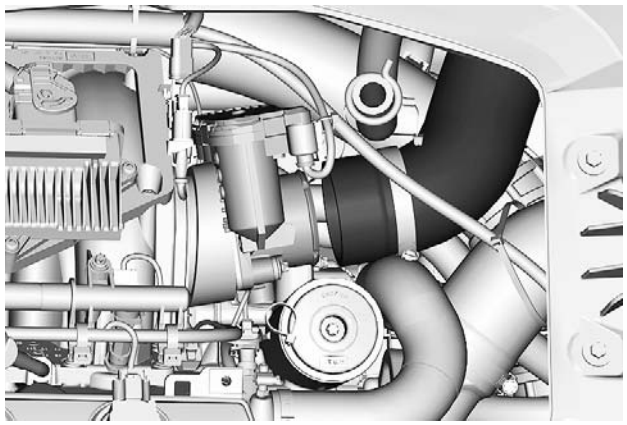
6. Reinstall remaining parts removed, refer to applicable subsections.

INTAKE MANIFOLD

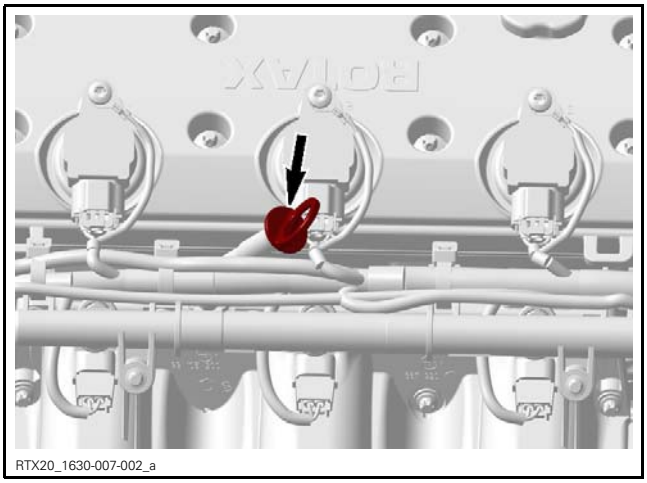
Removing the Intake Manifold

1. Disconnect the intake hose from the throttle body.



TYPICAL

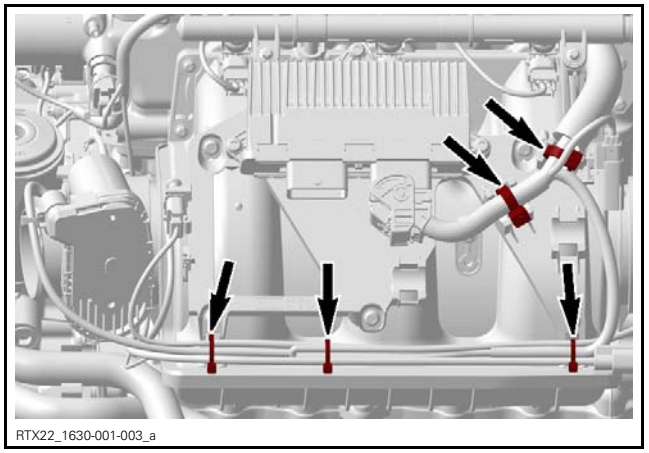
2. Remove the oil dipstick.



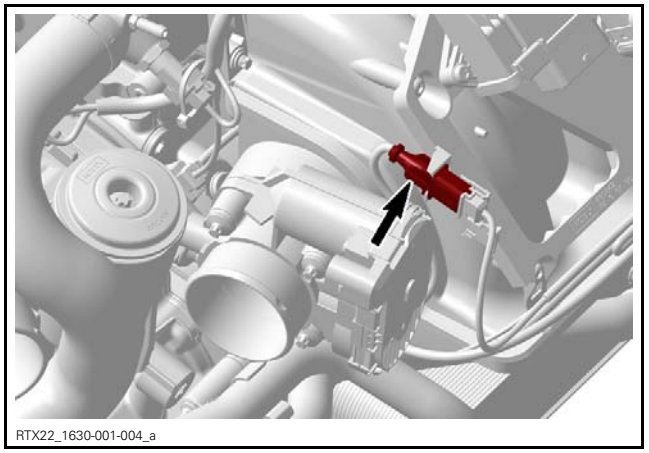
3. Cut locking ties and disconnect:
   – MAPTS, see procedure in this subsection
   – Throttle body connector, refer to *ELECTRONIC FUEL INJECTION (EFI)* subsection.

Engines with ECM Mounted on the Intake Manifold

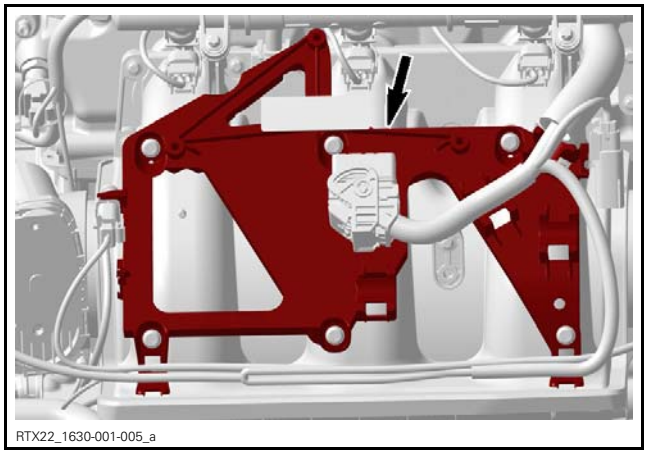
4. Cut locking ties securing the wiring harness to the ECM support.



5. Disconnect ECM connectors and remove ECM, refer to *ELECTRONIC CONTROL MODULE* subsection.
6. Disconnect KS connector and remove it from ECM support.

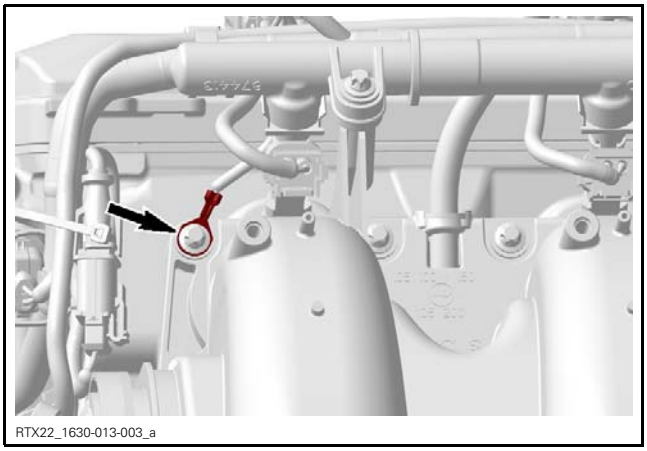


7. If necessary remove ECM support from intake manifold.



All Engines

8. If applicable, remove ground connector from intake manifold.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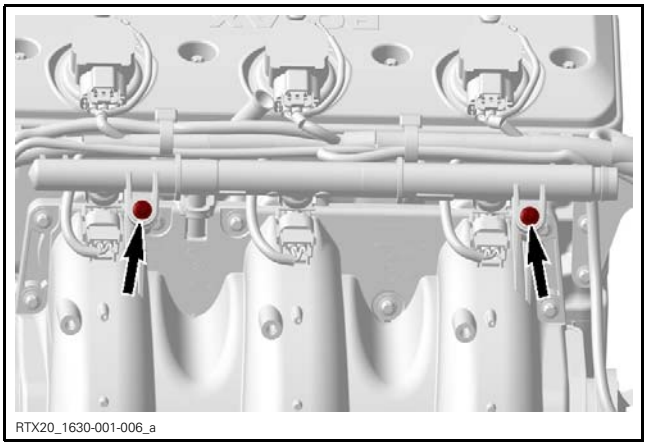
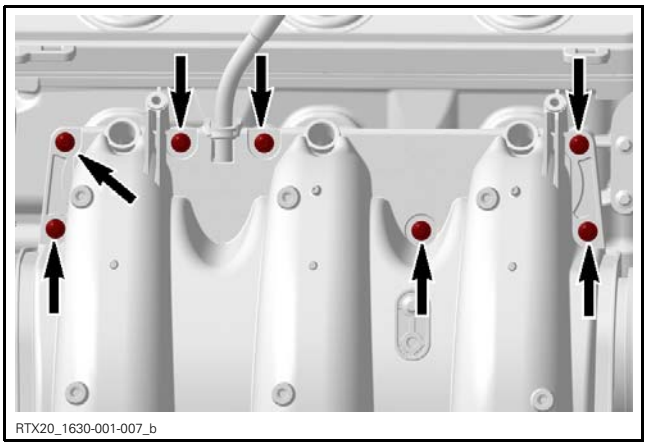
9. Remove fuel rail retaining screws.


RTX20_1630-001-006_a

10. If necessary disconnect ignition coils.
11. Carefully pull fuel rail with injectors out of the intake manifold.
12. Remove manifold retaining screws.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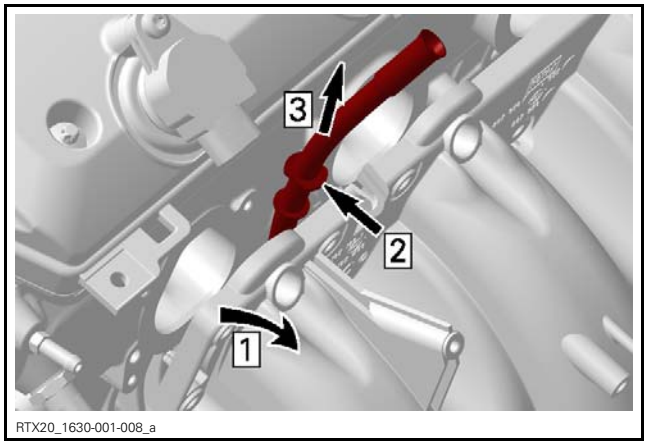
13. Carefully tilt intake manifold.
14. Then push the oil dipstick tube out of the manifold slot and pull it out of its bore in the cylinder block.



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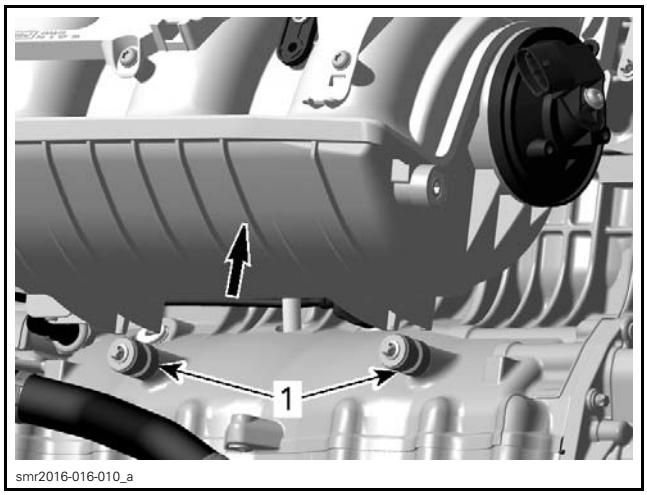
Step 1: Tilt intake manifold
Step 2: Push back oil dipstick tube
Step 3: Pull out oil dipstick tube

15. Lift intake manifold up to pull it out of the mounting brackets.



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1. Mounting brackets

16. Pull intake manifold out.
17. Remove and discard intake manifold gaskets.

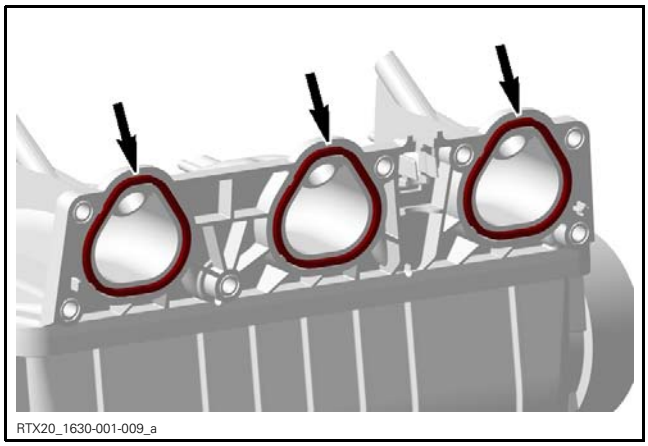
Inspecting the Intake Manifold

1. Check intake manifold for cracks, warping at flanges or any other visible damage.
2. Check if intake manifold gaskets are cracked, brittle or otherwise damaged.
3. Replace damaged parts as necessary.

Installing the Intake Manifold

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

1. Properly install NEW gaskets.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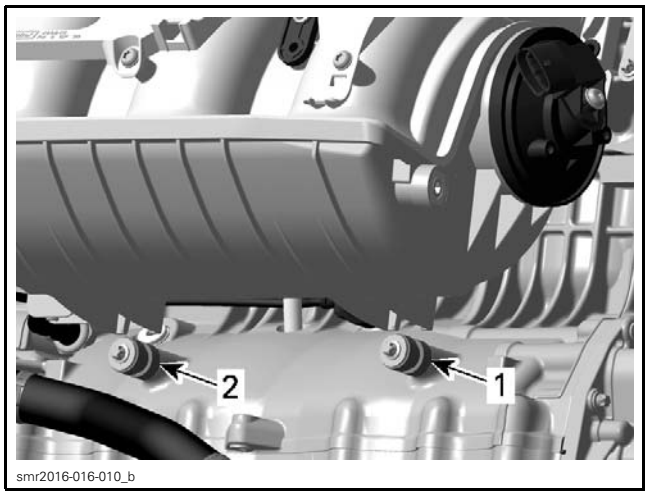
2. First, position intake manifold on front mounting bracket then push manifold toward engine, then proceed with rear mounting bracket.



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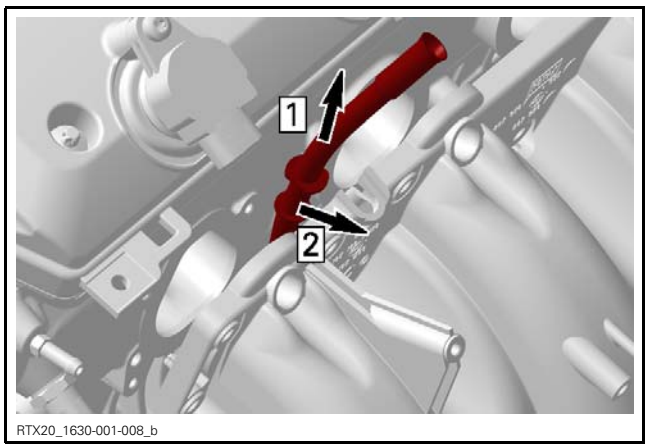
1. Front mounting bracket
2. Rear mounting bracket

3. When installing the intake manifold, lift up the oil dipstick tube a little bit to fit in the slot of the manifold.



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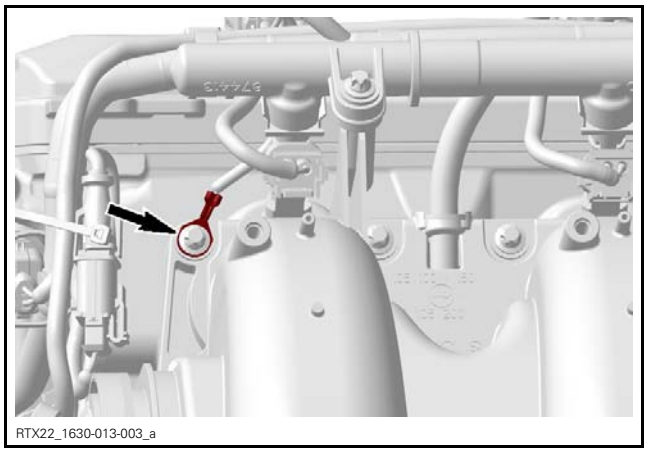
Step 1: Lift up oil dipstick tube
Step 2: Fit into manifold

4. Tighten intake manifold to specification using the following sequence.

TIGHTENING TORQUE	
Intake manifold screws	11 N•m ± 1 N•m (97 lbf•**in** ± 9 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)

5. If applicable, reinstall ground connector to the intake manifold.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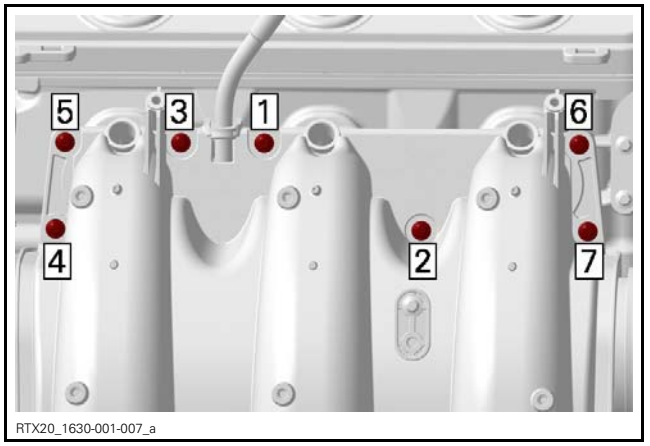

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TIGHTENING SEQUENCE

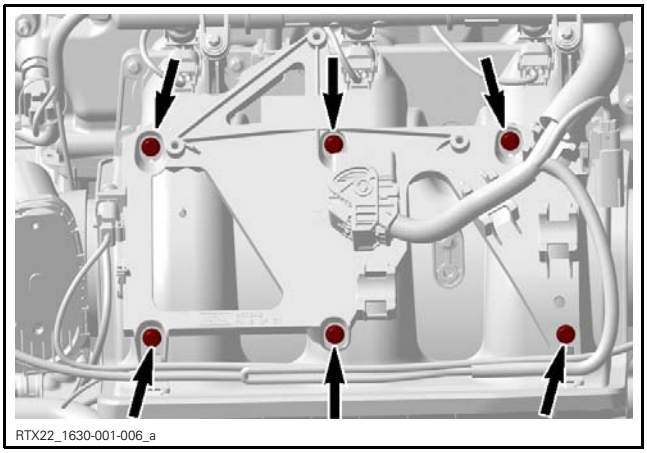
6. Tighten fuel rail retaining screws to specification.

TIGHTENING TORQUE	
Fuel rail retaining screws	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)

Engines with ECM Mounted on the Intake Manifold

7. If removed, install ECM support on intake manifold.

TIGHTENING TORQUE	
ECM support retaining screws	5.5 N•m ± 0.6 N•m (49 lbf•**in** ± 5 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)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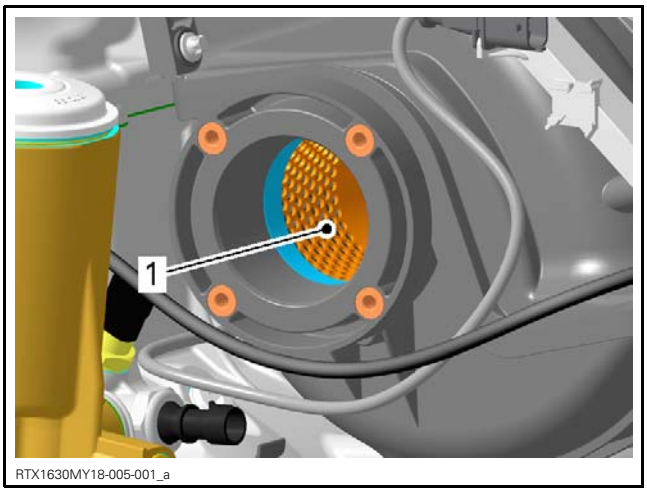
All Engines

8. Ensure to properly route and secure wiring harness with locking ties.
9. Install all other removed parts.

FLAME ARRESTER

Flame Arrester Location

The flame arrester is integrated in the intake manifold.



RTX1630MY18-005-001_a

1. Flame arrester inside intake manifold

Inspecting the Flame Arrester

The flame arrester in the intake manifold is maintenance free.

Flame Arrester Replacement

NOTE: The flame arrester can not be removed from the intake manifold.

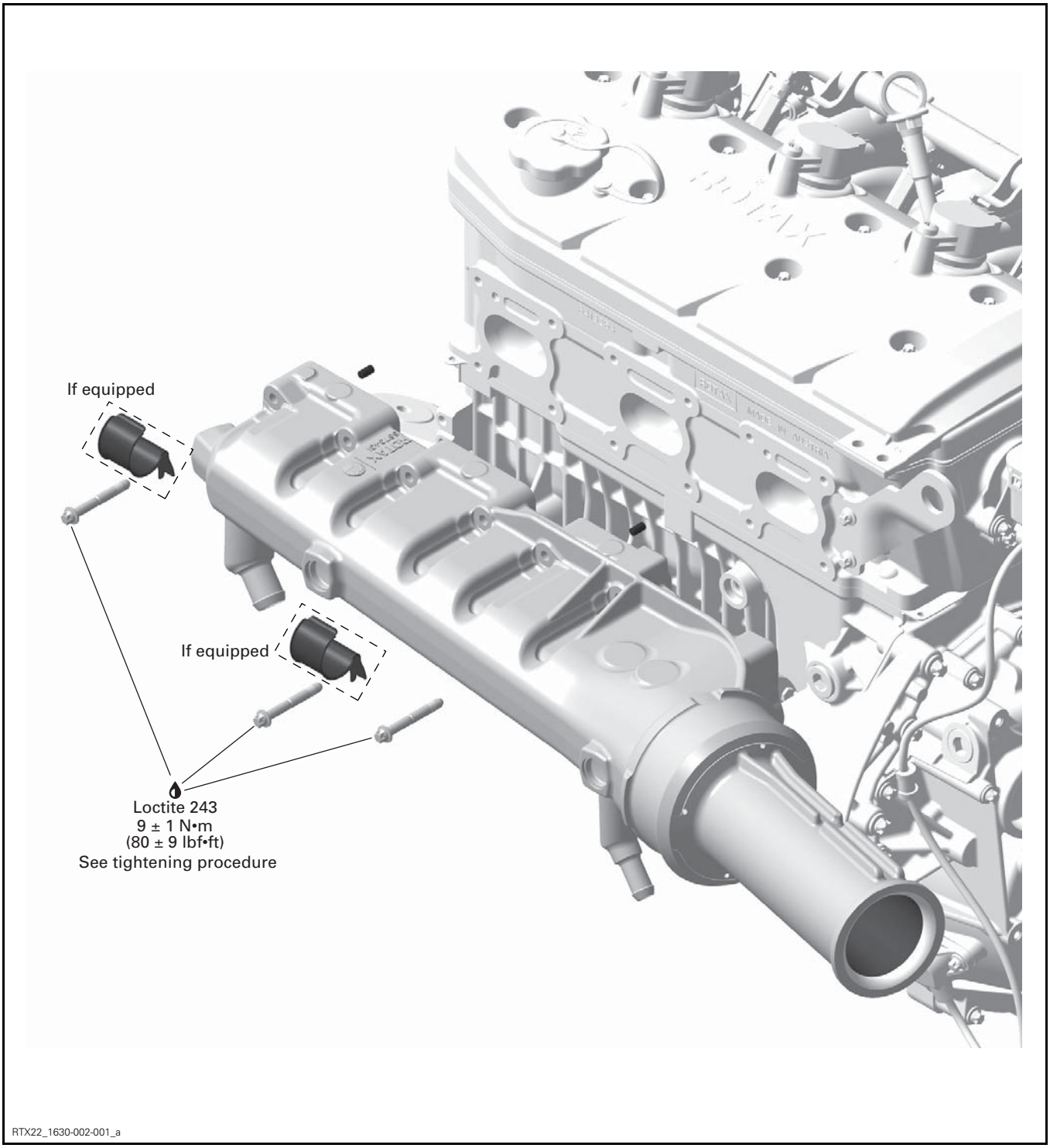
Replace intake manifold if necessary. Refer to *INTAKE MANIFOLD* in this subsection.

EXHAUST MANIFOLD

SERVICE PRODUCTS

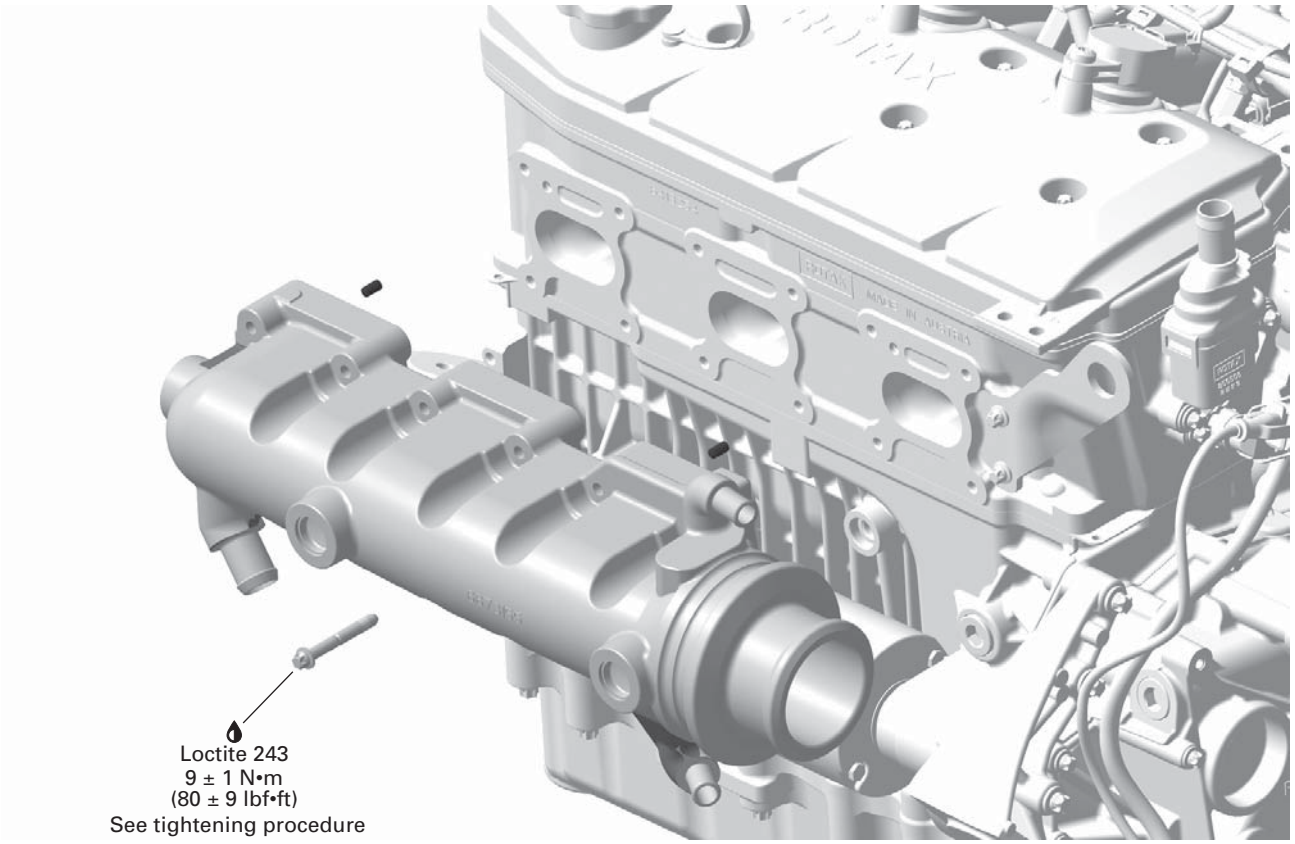
Description	Part Number	Page
LOCTITE 243 (BLUE)	293 800 060	17

Exhaust System without Catalyst



RTX22_1630-002-001_a

Exhaust System with Catalyst



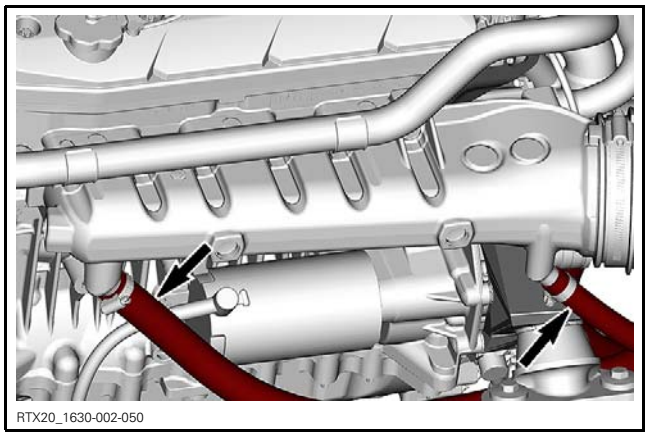
RTX22_1630-002-002_a

PROCEDURES

EXHAUST MANIFOLD

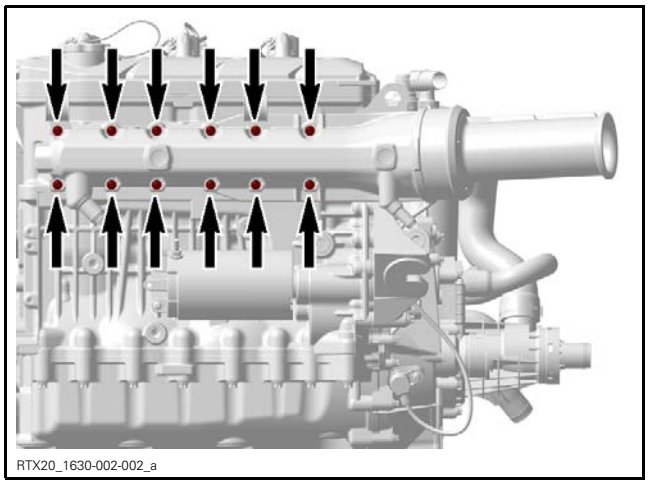
Removing the Exhaust Manifold

1. Move muffler rearwards to make room.
2. Unplug inlet and outlet hoses.



RTX20_1630-002-050

3. Remove the exhaust manifold screws.



RTX20_1630-002-002_a

TYPICAL

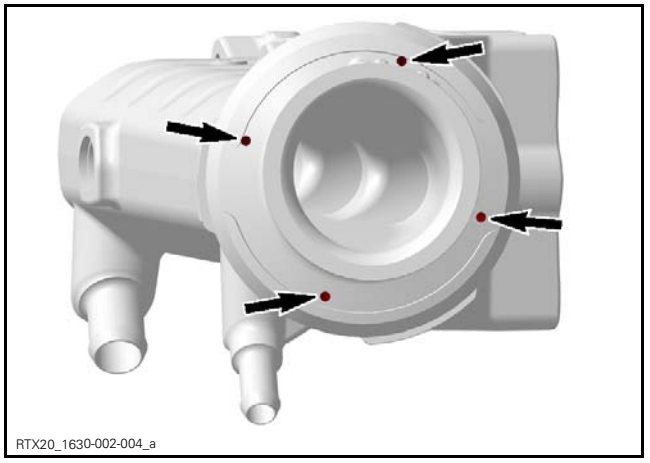
4. Remove the exhaust manifold from vehicle.

Inspecting the Exhaust Manifold

1. Inspect exhaust manifold condition paying attention for cracks or other damage. Check contact surfaces and hose. Replace any defective part.
2. Inspect plane surfaces for warpage. Small deformation can be corrected by grinding surface with a fine sand paper. Install sand paper on a surface plate and rub part against oiled sand paper.
3. Clean all metal components in a solvent.

Exhaust System without Catalyst

4. Check if water injection holes are not clogged.



RTX20_1630-002-004_a

Installing the Exhaust Manifold

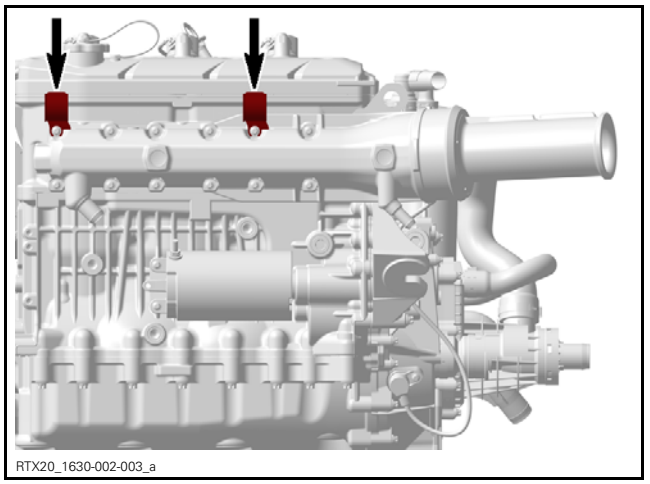
The installation is the reverse of the removal procedure. However, pay attention to the following.

NOTE: There is no gasket between cylinder block and exhaust manifold.

1. Apply threadlocker on threads of screws.

SERVICE PRODUCT
LOCTITE 243 (BLUE) (P/N 293 800 060)

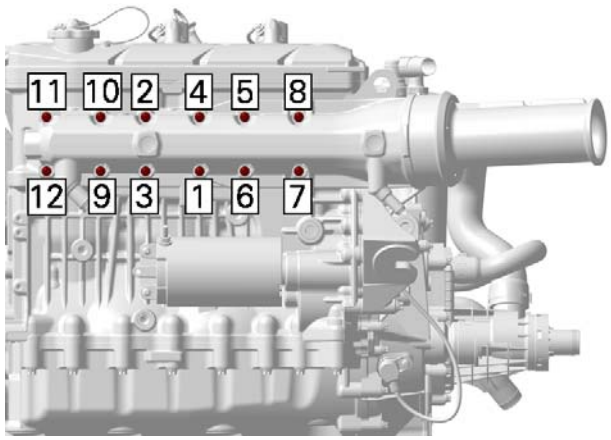
2. If equipped, install holding clamps.



RTX20_1630-002-003_a

3. Tighten screws to specification as per following illustrated sequence.

TIGHTENING TORQUE	
Repeat the procedure twice.	
Exhaust manifold screw	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**)



RTX20_1630-002-002_b

4. After installation, ensure there is no water or exhaust gas leak when the engine is running. Test run the engine while supplying water to the flushing connector.

NOTICE **Never run engine without supplying water to the exhaust system when watercraft is out of water.**

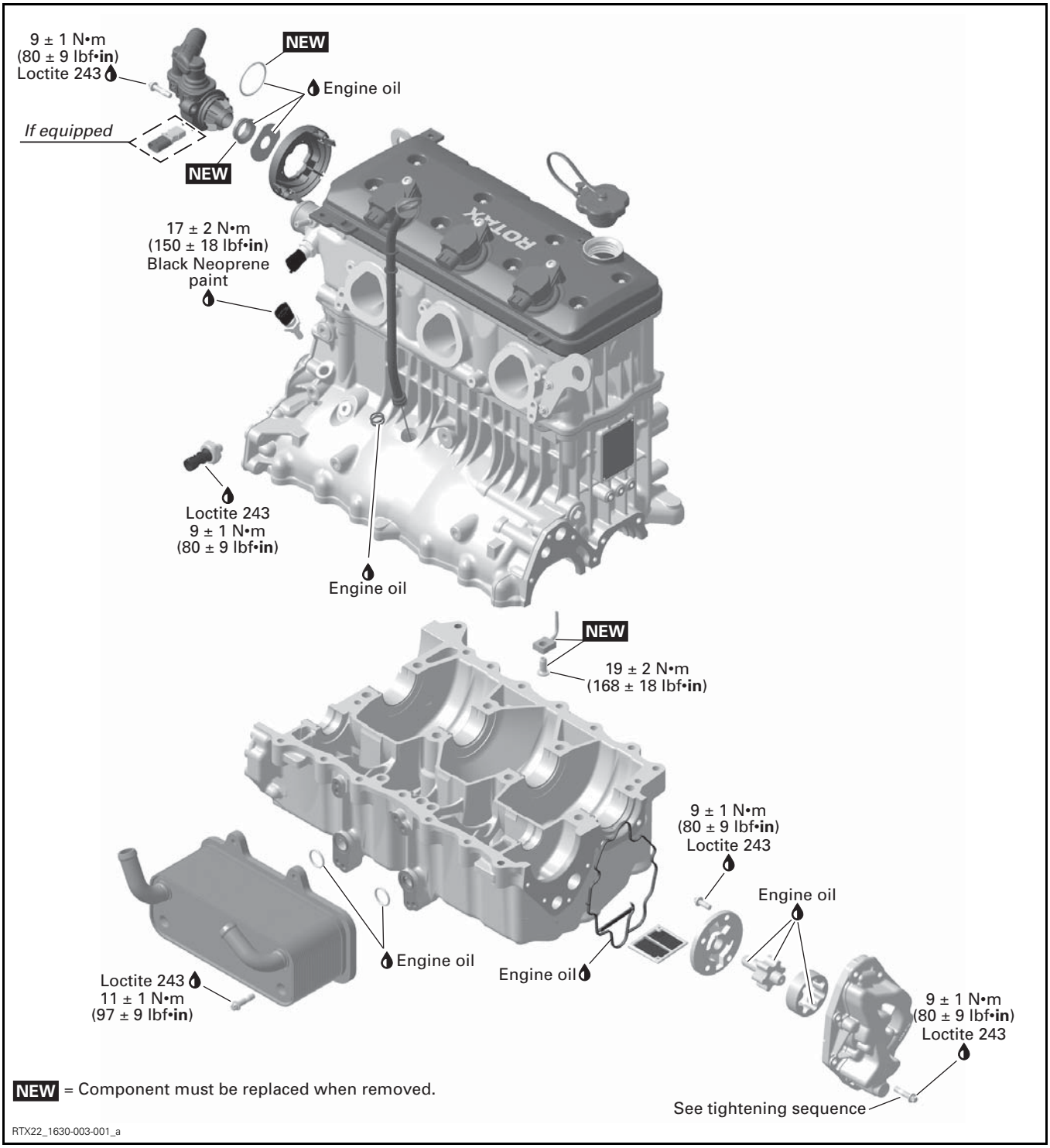
LUBRICATION SYSTEM

SERVICE TOOLS

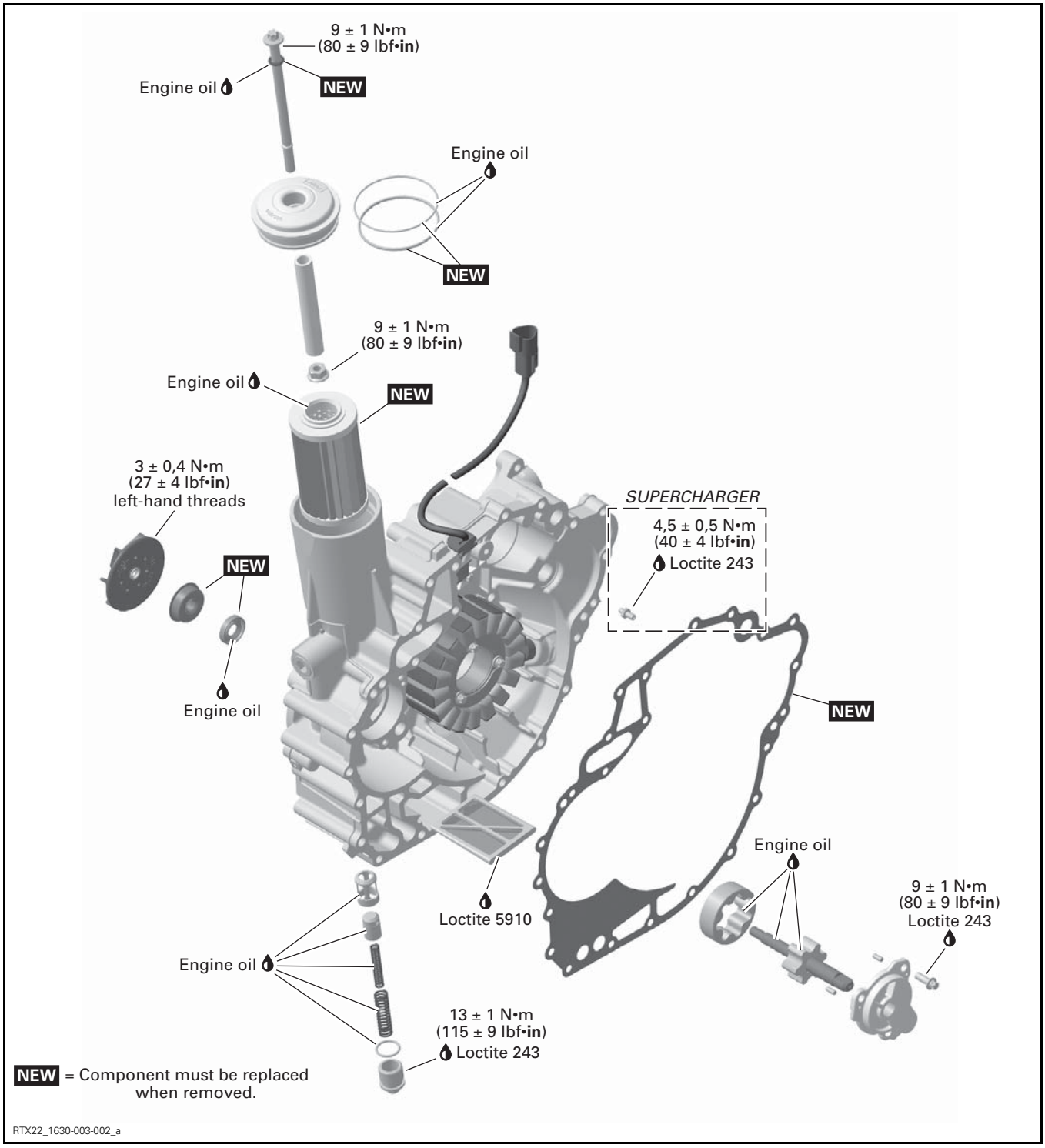
Description	Part Number	Page
BACK PROBE TEST WIRES	529 036 063	24
CERAMIC SEAL PULLER	529 036 365	37
ECM ADAPTER TOOL	529 036 166	24
FLUKE 115 MULTIMETER	529 035 868	24
HANDLE	420 877 650	37
OIL PRESSURE HOSE	529 036 394	28
OIL SEAL GUIDE	529 035 822	36
OIL SEAL PUSHER	529 035 757	37
PRESSURE GAUGE	529 036 395	28
SUCTION PUMP	529 035 880	27
WATER PUMP SEAL PUSHER	529 035 823	36, 38

SERVICE PRODUCTS

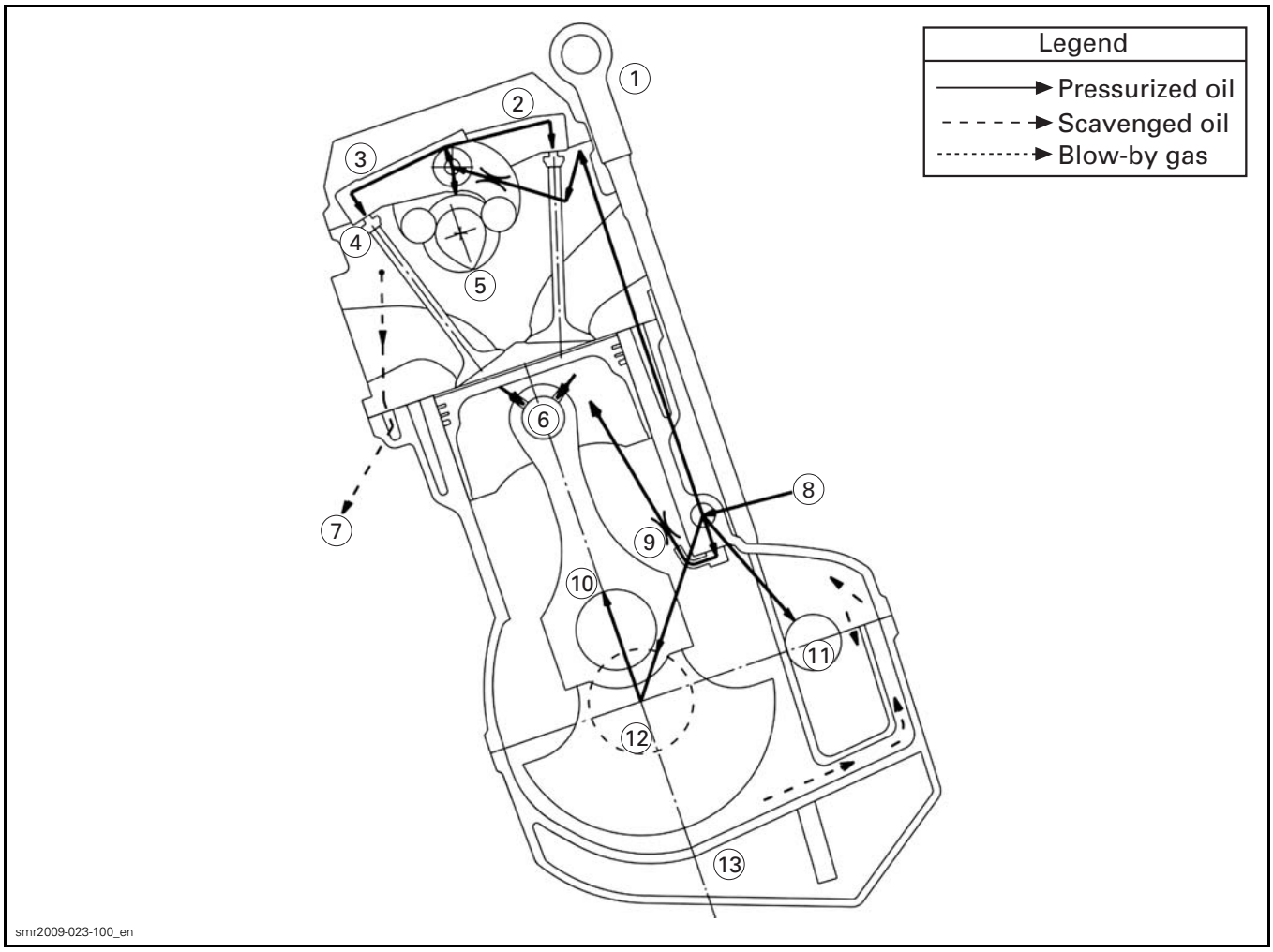
Description	Part Number	Page
4T 5W40 SYNTHETIC BLEND OIL (EUR)	779290	24
4T 5W40 SYNTHETIC BLEND OIL	779133	24
BLACK NEOPRENE PAINT	909570	32
BRAKE AND PARTS CLEANER PRO S2	779245	27, 38
LOCTITE 243 (BLUE)	293 800 060	31, 34, 36, 40–42, 46, 49
SUPER LUBE GREASE	293 550 030	28



RTX22_1630-003-001_a

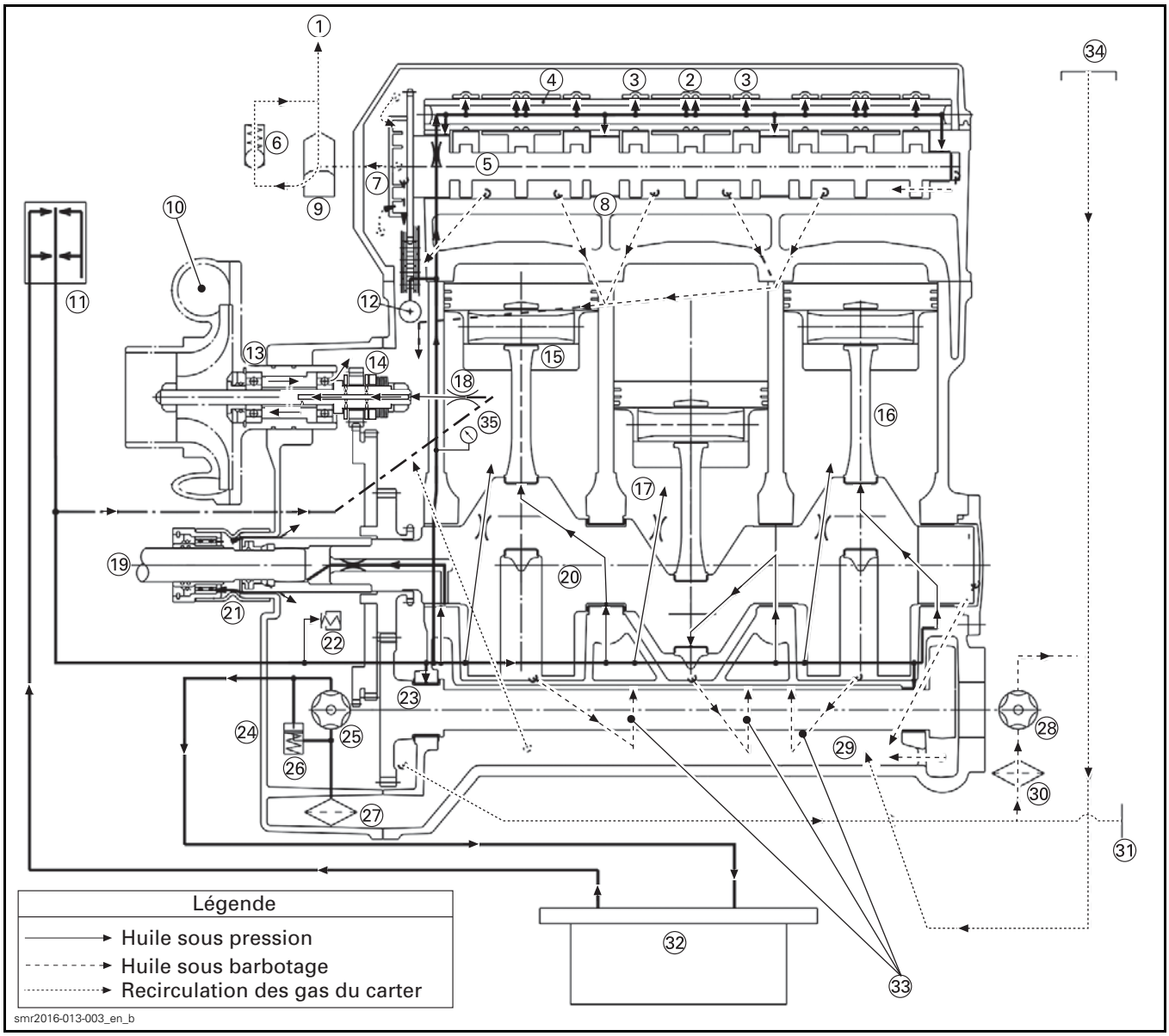

9 ± 1 N•m
(80 ± 9 lbf•in)
Engine oil
NEW
Engine oil
NEW
9 ± 1 N•m
(80 ± 9 lbf•in)
Engine oil
NEW
3 ± 0,4 N•m
(27 ± 4 lbf•in)
left-hand threads
NEW
Engine oil
SUPERCHARGER
4,5 ± 0,5 N•m
(40 ± 4 lbf•in)
Loctite 243
NEW
Engine oil
9 ± 1 N•m
(80 ± 9 lbf•in)
Loctite 243
Loctite 5910
Engine oil
13 ± 1 N•m
(115 ± 9 lbf•in)
Loctite 243
NEW = Component must be replaced when removed.
RTX22_1630-003-002_a

ENGINE LUBRICATION CIRCUIT



1. *Oil dipstick*
2. *Rocker arm (intake)*
3. *Rocker arm (exhaust)*
4. *Hydraulic valve lifter*
5. *Camshaft*
6. *Piston pin*
7. *Into PTO housing*
8. *From oil filter*
9. *Piston cooling*
10. *Connecting rod*
11. *Balance shaft*
12. *Crankshaft*
13. *Oil tank*

ENGINE LUBRICATION CIRCUIT (CONT'D)



1. *To air intake silencer*
2. *Rocker arm (intake)*
3. *Rocker arm (exhaust)*
4. *Rocker arm axle*
5. *Camshaft*
6. *Pressure relief valve*
7. *Oil separator*
8. *Cylinder head*
9. *Blow-by valve*
10. *Supercharger*
11. *Oil filter*
12. *Hydraulic chain tensioner*
13. *Supercharger bearing*
14. *Friction clutch*
15. *Piston pin*
16. *Connecting rod*
17. *Piston cooling*
18. *Oil spray nozzle*
19. *Drive shaft*
20. *Crankshaft*
21. *PTO seal*
22. *Oil pressure switch*
23. *Balance shaft*
24. *PTO housing*
25. *Pressure pump*
26. *Pressure relief valve*
27. *Oil strainer (pressure pump)*
28. *Suction pump*
29. *Oil tank*
30. *Oil strainer (scavenge pump)*
31. *Oil drainage (PTO housing)*
32. *Oil cooler*
33. *Scavenge of oil and blow-by gas*
34. *Oil filler cap*
35. *Oil temperature sensor*

GENERAL

MAINTENANCE

The following tools are required to test most of the electrical parts.

REQUIRED TOOLS	
ECM ADAPTER TOOL (P/N 529 036 166)	
FLUKE 115 MULTIMETER (P/N 529 035 868)	
BACK PROBE TEST WIRES (P/N 529 036 063)	

ENGINE OIL

Recommended Oil

Rotax® engines were developed and validated using the XPS™ oil. BRP recommends the use of its XPS engine oil or an equivalent at all time. Do not add any oil additives to the recommended engine oil. Damages caused by the use of an oil not suitable for the engine or by adding of an oil additives may not be covered by the BRP Limited Warranty.

XPS RECOMMENDED ENGINE OIL	
Scandinavia	4T 5W40 SYNTHETIC BLEND OIL (EUR) (P/N 779290)
Other Countries	4T 5W40 SYNTHETIC BLEND OIL (P/N 779133)

XPS RECOMMENDED ENGINE OIL	
IF THE RECOMMENDED XPS ENGINE OIL IS NOT AVAILABLE	
Engine **without** supercharger	Use a 5W40 4-stroke SAE synthetic engine oil meeting or exceeding the following lubricant industry specifications. Always check the API service label certification on the oil container, it must contain at least one of the indicated standards. – JASO-MA2 – API service classification SN
Engine **with** supercharger	Use a 5W40 4-stroke SAE **motorcycle engine oil compatible with wet clutches** meeting or exceeding <u>both</u> following lubricant industry specifications. Always check the API service label certification on the oil container, it must contain at least one of the indicated standards. – JASO-MA2 – API service classification SN

Verifying the Oil Level

NOTICE **Check level frequently and refill if necessary. Do not overfill — it would make the engine smoke and reduce its power. Operating the engine with an improper level may severely damage engine. Wipe off any spillage.**

Check the oil level as follows:

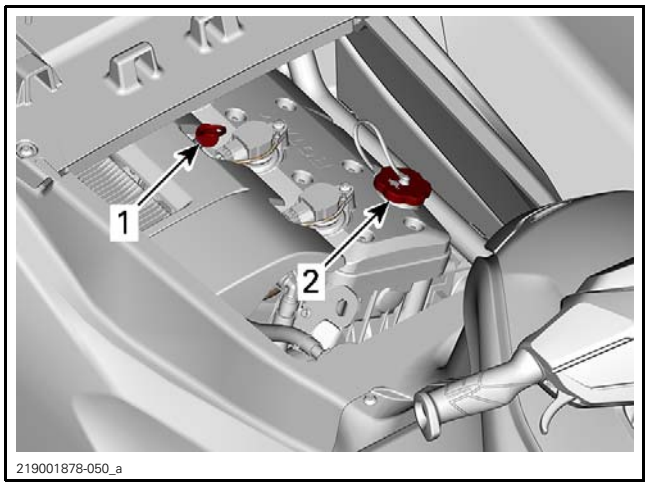
NOTE: It is of the utmost importance to follow this procedure in order to obtain an accurate reading of the engine oil level.

If Watercraft is IN Water

1. Bring the engine to its normal operating temperature.

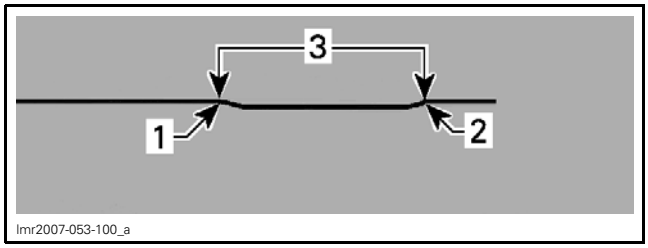
Usually after 15 minutes of riding time, not idling.

2. Remove the seats.
3. Let engine **idle for 30 seconds** then stop engine.
4. Wait at least 30 seconds for the oil to settle in the engine.
5. Pull dipstick out and wipe clean



TYPICAL
1. *Oil dipstick*
2. *Oil filler cap*

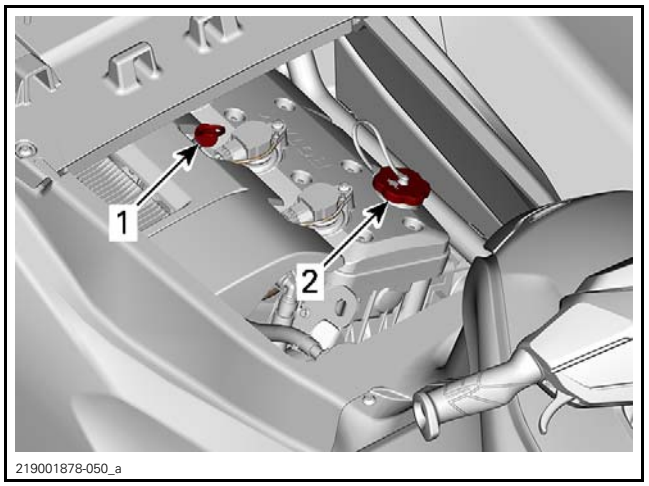
6. Reinstall dipstick, push in completely.
7. Remove dipstick again and read oil level. It should be between the dipstick marks.



TYPICAL
1. *Full*
2. *Add*
3. *Operating range*

RESULT	ACTION
Oil level between marks	Oil level is good, do nothing
Oil level below MIN	Add small amounts of engine oil to ensure the level is between dipstick marks

8. Add engine oil if required.
   8.1 Remove the oil cap.



1. *Oil dipstick*
2. *Oil filler cap*

   8.2 Place a funnel in valve cover opening.
   8.3 Add a small amount of the recommended oil to reach the proper level.

NOTICE Be careful not overfill. There is 1 L (1.06 qt (U.S. liq.)) between dipstick marks.

   8.4 Check oil level again by restarting the whole procedure from the STEP 3.

NOTICE Every time oil is added in the engine, carry out the engine oil level verification procedure again starting to step 3. Otherwise, you will obtain a false oil level reading.

   8.5 Properly reinstall oil cap and dipstick.

If Watercraft is OUT of the Water

This procedure must be performed when engine is cool, non started yet.

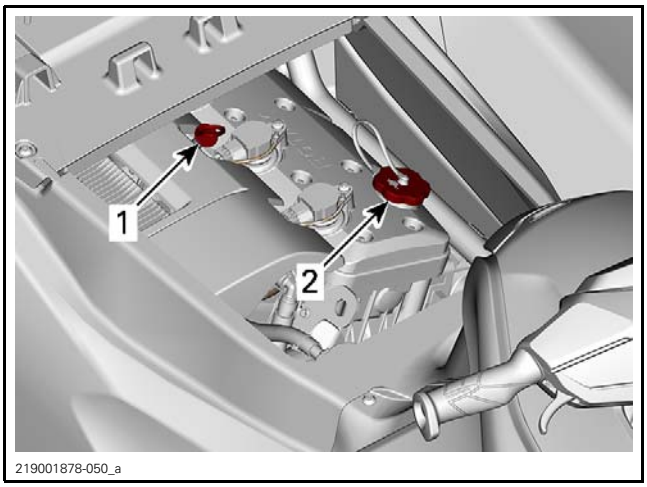
NOTICE Watercraft must be level.

⚠ CAUTION When operating the engine while the watercraft is out of water, the heat exchanger in the ride plate may become very hot. Avoid any contact with the ride plate as burns may occur.

1. Ensure the vehicle is level.
2. Install a garden hose on the exhaust system flushing connector.DO NOT open water tap now.

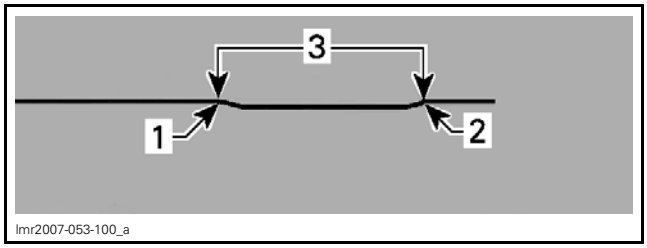
NOTICE Unless otherwise specified:
- Never run engine without supplying water to the exhaust system. Severe exhaust system damages could occur.
- To avoid damaging the drive shaft seal, never run engine longer than 2 minutes when the PWC is out of the water.

3. Remove the seats.
4. Start the engine.
5. Open the water tap.
6. Run the COLD engine at **idle for 30 seconds**.
7. Close water tap.
8. Bring engine RPM to 4000-4500 RPM for 15 seconds.
9. Stop the engine abruptly by pressing the start/stop button or removing the tether cord.
10. Wait at least 30 seconds for the oil to settle in the engine.
11. Remove the dipstick and clean it.



TYPICAL
1. Oil dipstick
2. Oil filler cap

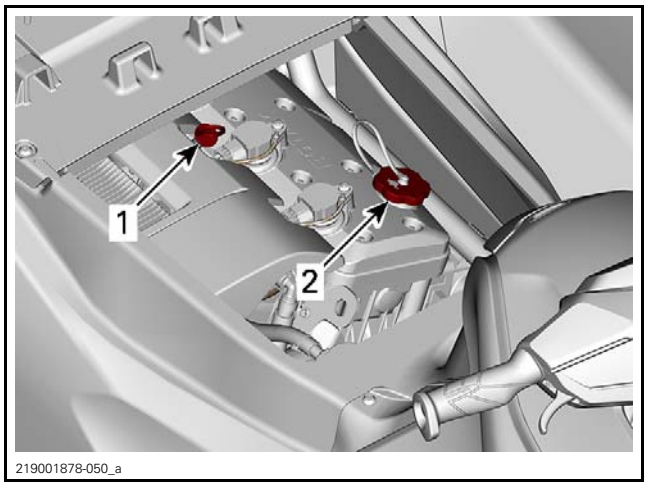
12. Reinstall the dipstick, ensure to push it in completely.
13. Remove dipstick again and read oil level. It should be between the dipstick marks.



TYPICAL
1. Full
2. Add
3. Operating range

RESULT	ACTION
Oil level between marks	Oil level is good, do nothing
Oil level below MIN	Add small amounts of engine oil to ensure the level is between dipstick marks

14. Add engine oil if required.
    14.1 Remove the oil cap.



1. Oil dipstick
2. Oil filler cap

    14.2 Place a funnel in valve cover opening.
    14.3 Add a small amount of the recommended oil to reach the proper level.

NOTICE Be careful not overfill. There is 1 L (1.06 qt (U.S. liq.)) between dipstick marks.

    14.4 Check oil level again by restarting the whole procedure from the STEP 4.

NOTICE Every time oil is added in the engine, carry out the engine oil level verification procedure again starting to step 4. Otherwise, you will obtain a false oil level reading.

14.5 Properly reinstall oil cap and dipstick.

Engine Oil Change

NOTE: Oil and oil filter must be replaced at the same time. Oil change and oil filter replacement should be done with a warm engine.

1. Bring engine to its normal operating temperature.

NOTICE When watercraft is out of water:
- Never run engine without supplying water to the exhaust system.
- Never run engine longer than 2 minutes. Drive line seal has no cooling when watercraft is out of water.

2. Run engine for 10 seconds at 4000 RPM and shut it off at this RPM. This will move oil from PTO housing to oil tank to allow maximum oil draining.
3. Remove oil filler cap and dipstick.

⚠ CAUTION Engine oil may be hot. Certain components in the engine compartment may be very hot. Direct contact may result in skin burn.

4. Siphon oil through the dipstick tube.
5. To siphon the maximum amount of oil from the crank chamber do the following:
   - Put some electrical tape on hose at 475 mm (18-11/16 in) from its end
   - Then insert the hose until the tape flushes with the edge of the dipstick tube.

REQUIRED TOOL	
SUCTION PUMP (P/N 529 035 880)	

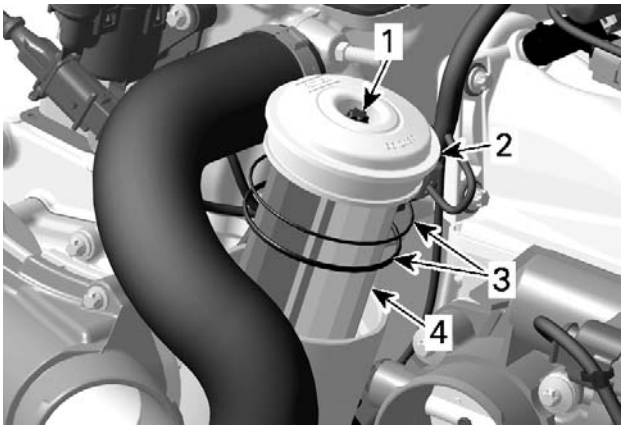
NOTICE Never crank or start engine when suction pump hose is in the dipstick tube. Never start engine when there is no oil in engine.

6. Pull suction pump hose out of dipstick tube.
7. Fully depress the throttle lever and HOLD it while cranking engine for 10 seconds. Siphon oil again. Repeat the crank-siphon cycle 2 - 3 times.
8. Refill engine with the recommended oil. Refer to *RECOMMENDED OIL* in this subsection.
9. Reinstall oil filler cap and dipstick.
10. Replace *OIL FILTER*. Refer to procedure in this subsection.

OIL FILTER

Removing the Oil Filter

1. Remove the oil filter cover and the oil filter.



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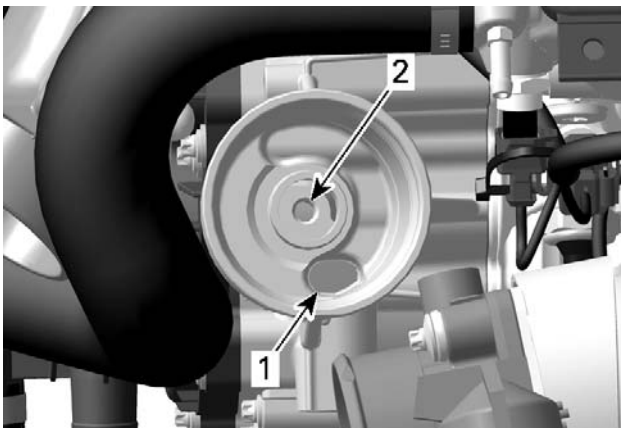
1. Oil filter screw
2. Oil filter cover
3. O-rings
4. Oil filter

2. Place rags in filler area to prevent spillage. If spillage occurs, clean immediately to prevent stains.

SERVICE PRODUCT
BRAKE AND PARTS CLEANER PRO S2 (P/N 779245)

Inspecting the Oil Filter

1. Check oil filter screw O-ring, change if necessary.
2. Check and clean the oil filter inlet and outlet area for dirt and other contaminations.



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1. Inlet bore from the oil pump to the oil filter
2. Outlet bore to the engine oil providing system

Installing the Oil Filter

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

1. Install a **NEW** oil filter.
2. Install **NEW** O-rings on oil filter cover.
3. Apply engine oil on:
   – Oil filter ring
   – Filter cover O-rings
   – Oil filter screw O-ring.

NOTE: In salt water area, it is recommended to coat mating surface of cover with grease.

SERVICE PRODUCT
SUPER LUBE GREASE (P/N 293 550 030)

4. Torque oil filter screw to specification.

TIGHTENING TORQUE	
Oil filter screw	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**)

INSPECTION

ENGINE OIL PRESSURE

Oil Pressure Test Requirement

Bring engine to its normal operating temperature.

⚠ CAUTION Certain components in the engine compartment may be very hot. Direct contact may result in skin burn.

NOTICE When watercraft is out of water:
– Never run engine without supplying water to the exhaust system.
– Never run engine longer than 2 minutes. Drive line seal has no cooling when watercraft is out of water.

Required Tools for Oil Pressure Test

REQUIRED TOOLS	
PRESSURE GAUGE (P/N 529 036 395)	
OIL PRESSURE HOSE (P/N 529 036 394)	

NOTE: A 1/8 NPT pipe extension may ease the installation.

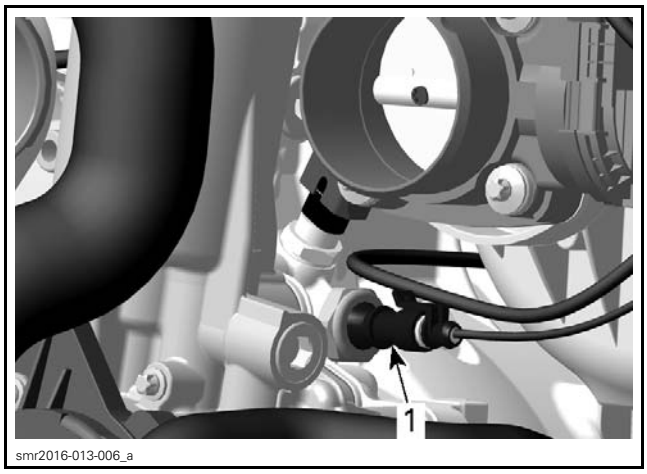
Oil Pressure Specifications

Use the following table to compare the oil pressure at different RPM.

OIL PRESSURE	
Idle (cold)	400 kPa - 600 kPa (58 PSI - 87 PSI)
Idle (at 80°C (176°F))	Min. 150 kPa (22 PSI)
4000 - 8000 (at 100°C (212°F))	350 kPa - 500 kPa (51 PSI - 73 PSI)

Test at the Oil Pressure Switch Location

1. Remove the oil pressure switch and install the gauge.



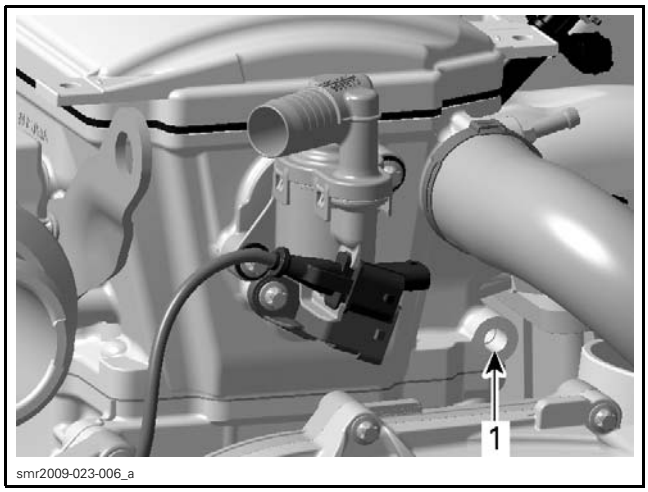
INSTALLATION AT PRESSURE SWITCH LOCATION
1. Oil pressure switch

2. To prevent the EMS to go in limp home mode (at 2500 RPM) or to generate a fault code, do the following:
   2.1 Ground the OPS to the engine.
   2.2 Connect the OPS to the harness.
   2.3 Start engine.
   2.4 While the engine is running, disconnect the OPS from the harness.
3. Read the oil pressure at different RPM as per table above.
4. Reinstall the oil pressure switch.

Test at the Cylinder Head Location

The oil pressure may be measured from the cylinder head if desired.

1. Remove the plug located on the cylinder head and install the gauge.



INSTALLATION AT CYLINDER HEAD
1. Remove plug and install gauge here

2. Start engine and read pressure at different RPM as per table above.
3. Reinstall the plug.

TROUBLESHOOTING

The following is provided to help in diagnosing the probable source of troubles. It is a guideline and it should not be assumed to list all possible problems.

Always check for fault codes. If a fault code is detected, service the fault code first. Refer to *ENGINE MANAGEMENT* section.

LOW OR NO ENGINE OIL PRESSURE

1. Oil level too low.
   - *Refill engine oil.*
   - *Check for high oil consumption. See below.*
   - *Check for oil leaks (oil leaking out of leak indicator hole, gaskets, oil seal or O-rings). Repair or replace.*
2. Oil pressure switch defective.
   - *Check and replace if necessary.*
3. Oil filter clogged.
   - *Replace engine oil and oil filter at the same time.*
4. Oil pressure regulator valve sticks open, or spring load is too small.
   - *Clean oil regulator piston and its bore. Replace if necessary.*
   - *Measure spring free length. Replace if too small.*
5. Oil pump(s) worn or damaged.
   - *Check oil pump rotors and its bore for wear limits. Replace if out of specification.*
6. Engine oil strainers are clogged.
   - *Remove and clean engine oil strainers.*
7. Heavy wear on plain bearings.
   - *Check radial clearance of plain bearings. Replace if out of specification.*

HIGH OIL CONSUMPTION

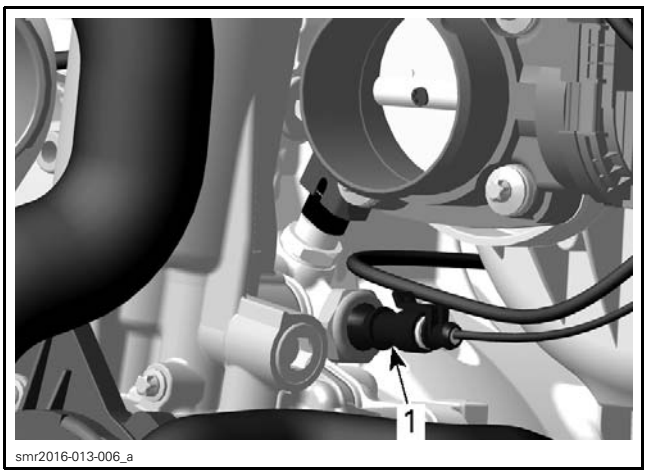
1. Oil in breathing system.
   - *Check if breather V-ring is brittle, hard or damaged. Replace V-ring.*
2. Valve stem seals worn or damaged.
   - *Replace valve stem seals.*
3. Piston rings worn out (blue colored exhaust smoke).
   - *Replace piston rings.*

OIL CONTAMINATION (WHITE APPEARANCE)

1. Water ingestion through drive shaft and floating ring
   - *Check if water is leaking between drive shaft and floating ring. Repair or replace defective parts. Refer to PTO HOUSING, MAGNETO AND STARTER subsection.*
   - *Change engine oil and filter.*
2. Oil seal and rotary seal on water pump shaft leaking.
   - *Replace oil seal and water pump shaft assembly.*
   - *Change engine oil and oil filter.*
3. Cylinder head gasket leaking.
   - *Replace cylinder head gasket and tighten cylinder head with recommended torque.*
   - *Change engine oil and oil filter.*
4. Cylinder head screws not properly tightened.
   - *Retighten screws with recommended torque.*
   - *Change engine oil.*
5. Oil cooler O-rings are leaking.
   - *Replace O-rings.*
   - *Change engine oil and oil filter.*
6. Cylinder block or cylinder head casting is leaking.
   - *Check for internal cracks in casting. Replace damaged components.*
   - *Change engine oil and oil filter.*

PROCEDURES

OIL PRESSURE SWITCH (OPS)



1. OPS

Oil Pressure Switch Access

Remove the throttle body. Refer to *ELECTRONIC FUEL INJECTION (EFI)* subsection.

Oil Pressure Switch Operation

The oil pressure switch activates when the engine oil pressure is lower than following specified pressure range.

OIL PRESSURE SWITCH ACTIVATION RANGE
180 kPa to 220 kPa (26.11 PSI to 31.91 PSI)

Inspecting the Oil Pressure Switch

1. Check the condition of the connector terminals.
   1.1 Remove dirt and corrosion that could affect proper operation of the OPS.
2. IMPORTANT: Do not apply dielectric grease on terminal.
3. Perform an oil pressure test to be sure the oil pressure is not in fault. Refer to *INSPECTION* in this subsection.

When the engine oil pressure tests good but the OIL message in the information center is present and the beeper sounds:

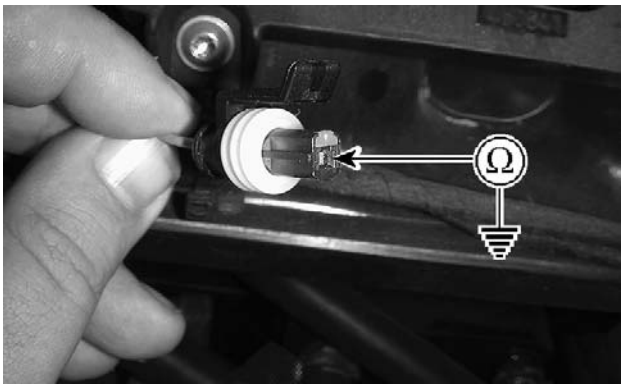
4. Ensure the OPS is connected to the harness.
5. Check the resistance of the OPS while engine is off and while engine is running.

Testing the Oil Pressure Switch Resistance

1. Disconnect the connector from the OPS.
2. Use a multimeter to check the resistance as shown.

OIL PRESSURE SWITCH RESISTANCE TEST		
OPS CONNECTOR PIN	ENGINE	SPECIFICATION ENGINE NOT RUNNING
1	Ground	Close to 0 Ω

OIL PRESSURE SWITCH RESISTANCE TEST		
OPS CONNECTOR PIN	ENGINE	SPECIFICATION ENGINE RUNNING
1	Ground	Open Loop (OL) when pressure reaches 180 kPa (26.11 PSI) and 220 kPa (32 PSI)

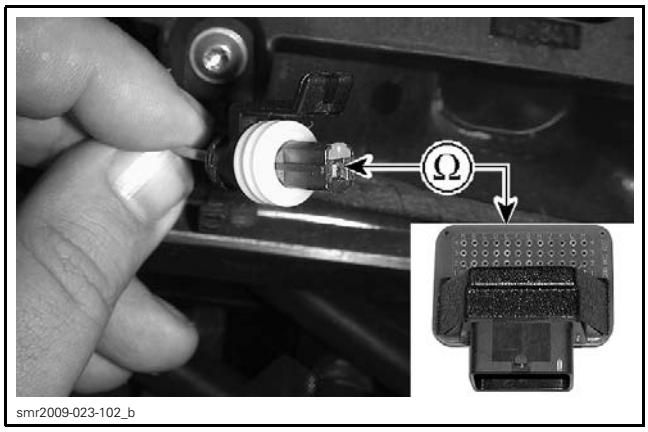


3. If resistance values are incorrect, replace the OPS.
4. If the values are correct, check the continuity of the wiring harness.

Testing the Oil Pressure Switch Circuit Continuity

1. Disconnect the ECM-A connector from the ECM.
2. Connect the ECM-A connector on the ECM adaptor tool.
3. Check continuity of the OPS circuit as per the following table.

OIL PRESSURE SWITCH RESISTANCE TEST		
OPS CONNECTOR PIN	ECM ADAPTER	SPECIFICATION
1	A-E3	Close to 0 Ω



smr2009-023-102_b

4. If continuity test failed, repair or replace the connector and wiring between ECM connector and OPS.
5. If continuity test succeeded, check the ECM. Refer to *ELECTRONIC CONTROL MODULE* subsection.

Removing the Oil Pressure Switch

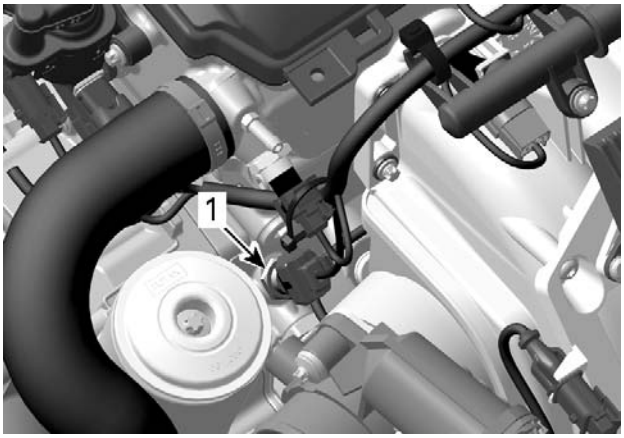
1. Unplug the OPS connector.
2. Unscrew and remove the oil pressure switch.

Installing the Oil Pressure Switch

1. Apply threadlocker on the OPS thread.
2. Tighten the OPS to specification.

TIGHTENING TORQUE	
OPS	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)

OIL TEMPERATURE SENSOR (OTS)



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1. Oil temperature sensor (OTS)

NOTE: Engine will be set to limp home mode and an overheat indication will come on in the information center when the oil temperature reaches:

OVERHEAT TEMPERATURE	
100 130 170	115°C (239°F)
230	120°C (248°F)
300 (Boat)	95°C (203°F)
300 (Watercraft)	97°C (207°F)

Check for debris or blockage in lubrication system.

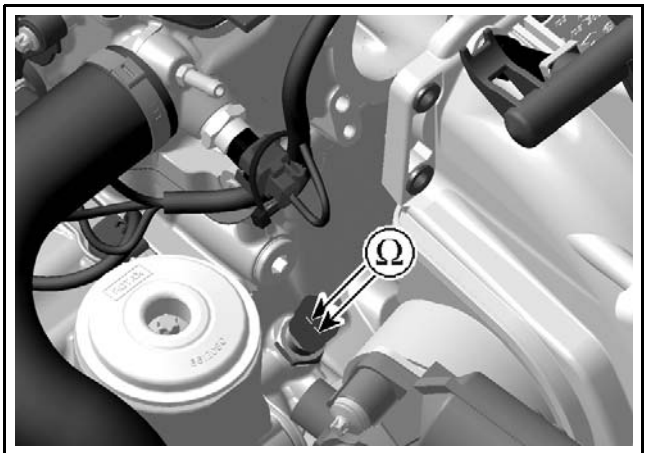
OTS Access

Engines with Throttle Body Rearward

Remove the throttle body. Refer to *ELECTRONIC FUEL INJECTION (EFI)* subsection.

Testing the OTS Resistance

1. Disconnect the connector from the OTS and test the resistance of the sensor. Refer to the *OTS RESISTANCE CHART* in this subsection.



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2. If resistance measured is not as specified, replace the OTS.
3. If the resistance measured is as specified, proceed with the following steps.
4. Reconnect the OTS connector and disconnect ECM connector "A" from the ECM.
5. Check the OTS circuit resistance as per table.

OTS RESISTANCE TEST		
ECM ADAPTER PIN		SPECIFICATION
A-H4	A-J4	See *OTS RESISTANCE CHART*

OTS RESISTANCE CHART				
TEMPERATURE		RESISTANCE (OHMS)		
°C	°F	NOMINAL	LOW	HIGH
- 30	- 22	12600	11800	13400
- 20	- 4	11400	11000	11800
- 10	14	9500	8000	11,000
0	32	5900	4900	6900
10	50	3800	3100	4500
20	68	2500	2200	2800
30	86	1700	1500	1900
40	104	1200	1080	1320
50	122	840	750	930
60	140	630	510	750
70	158	440	370	510
80	176	325	280	370
90	194	245	210	280
100	212	195	160	210
110	230	145	125	160
120	248	115	100	125

6. If the resistance value measured is as specified, check ECM. Refer to *ELECTRONIC CONTROL MODULE* subsection.
7. If the resistance value is not within specification, repair or replace wiring and connectors between ECM connector and the OTS.

Replacing the OTS

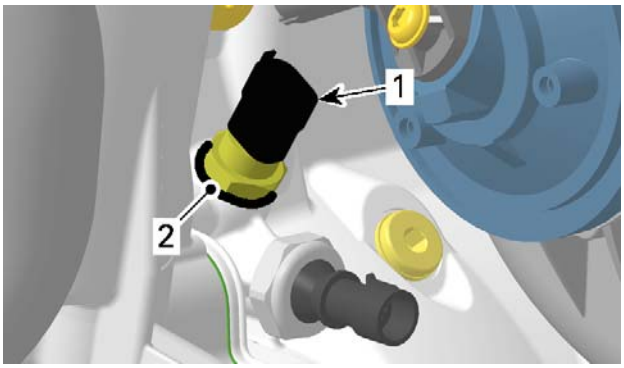
1. Disconnect OTS connector and remove OTS.
2. Install the new OTS.

TIGHTENING TORQUE	
Oil temperature switch	17 N•m ± 2 N•m (150 lbf•**in** ± 18 lbf•**in**)

3. Apply sealant around OTS as defined in the illustration.

NOTE: Gasket ring of OTS must be coated completely.

SERVICE PRODUCT
BLACK NEOPRENE PAINT (P/N 909570)



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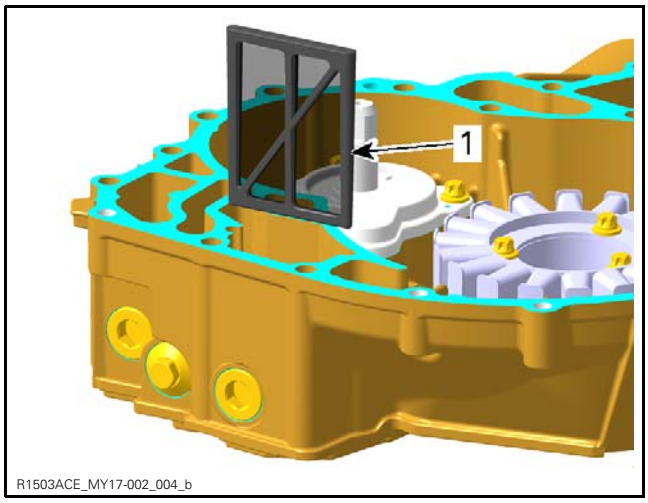
1. OTS
2. Apply black neoprene paint here

4. Reinstall remaining removed parts.

PTO OIL STRAINER

Removing the PTO Oil Strainer

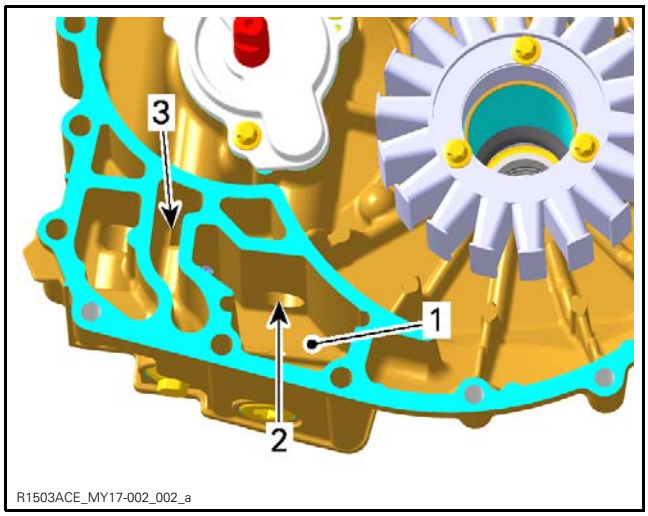
1. Remove the PTO housing. Refer to *PTO HOUSING, MAGNETO AND STARTER* subsection.
2. Remove the oil strainer.



1. PTO oil strainer

Cleaning and Inspecting the PTO Oil Strainer

1. Clean oil strainer with a part cleaner then use compressed air to dry it.
2. Check oil strainer for damage, replace if necessary.
3. Check and clean the oil strainer compartment and oil bores for dirt and other contaminations.

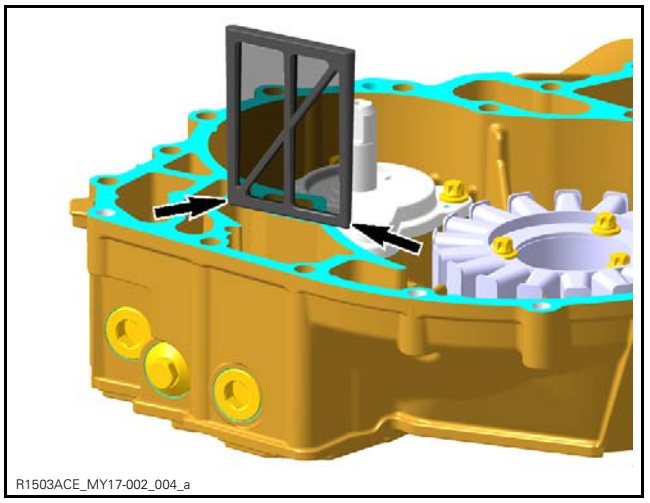


1. Oil strainer compartment
2. Oil bore to the oil pump
3. Oil bore from the oil pump

Installing the PTO Oil Strainer

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

1. Apply a small amount of grease on the frame of the oil strainer to keep it in place while installing the PTO cover.

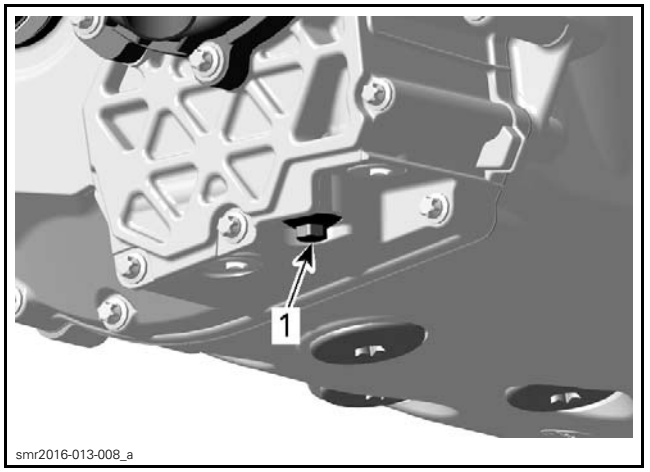


SERVICE PRODUCT
Multi Purpose Grease

2. Install the oil strainer in the PTO housing.
3. Install the PTO housing, Refer to *PTO HOUSING, MAGNETO AND STARTER* subsection.
4. Refill engine at the proper level with the recommended oil. Refer to *ENGINE OIL* for the procedure.

ENGINE OIL PRESSURE REGULATOR

The oil pressure regulator is located on the bottom of the PTO housing.

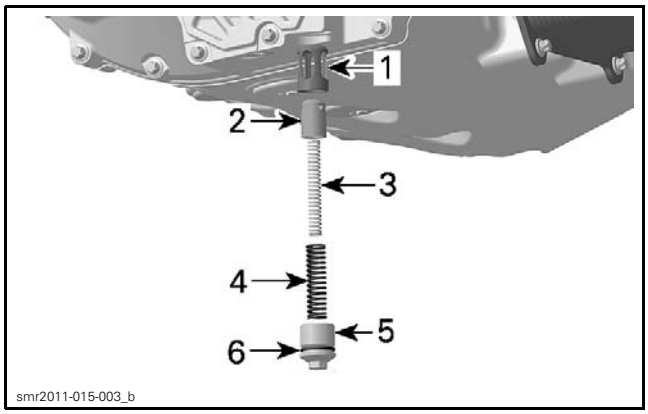


1. Oil pressure regulator

NOTE: The oil pressure regulator system opens when the oil pressure exceeds 400 kPa (58 PSI).

Removing the Oil Pressure Regulator

1. Remove the engine oil. Refer to *ENGINE OIL CHANGE* in this subsection.
2. Remove the oil pressure regulator.



1. Valve piston guide
2. Valve piston
3. Inner compression spring
4. Outer compression spring
5. Oil pressure regulator plug
6. O-ring

NOTE: Oil pressure regulator plug on oil pump housing is spring loaded.

Inspecting the Oil Pressure Regulator

1. Inspect the valve piston and valve piston guide for scoring or other damages.
2. Check outer compression spring for free length.

OUTER COMPRESSION SPRING FREE LENGTH	
New	60 mm (2.362 in)
Service limit	57 mm (2.244 in)

3. Replace the inner and outer compression spring as an assembly.
4. Replace parts if important wear or damage are present.
5. Clean bore and threads in the PTO housing from metal shavings and other contaminations.

Installing the Oil Pressure Regulator

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

1. Make sure that the O-ring is on the plug screw.
2. Apply threadlocker on the plug thread.
3. Tighten the plug screw to specification.

NOTICE **Make sure not over tighten the plug. Damages to springs may cause oil pressure regulator malfunction.**

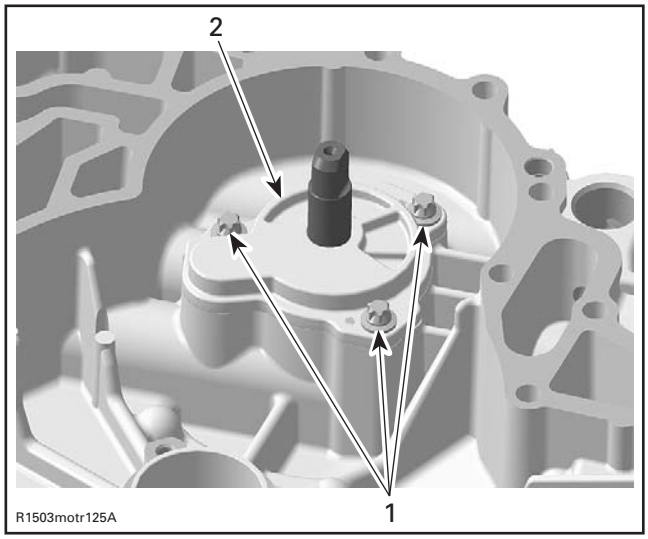
TIGHTENING TORQUE	
Oil pressure regulator plug	13 N•m ± 1 N•m (115 lbf•**in** ± 9 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)

OIL PRESSURE PUMP

The oil pressure pump is located in the PTO housing and is driven by the balance shaft.

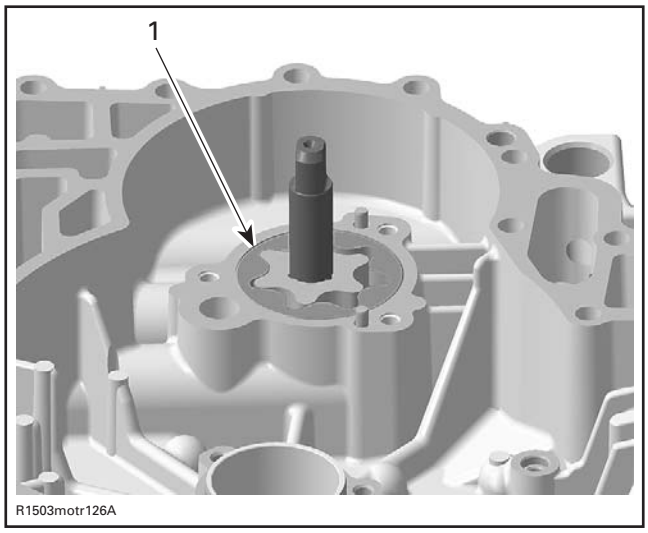
Removing the Oil Pressure Pump

1. Remove the PTO housing. Refer to *PTO HOUSING, MAGNETO AND STARTER* subsection.
2. Remove the water pump impeller. Refer to *COOLING SYSTEM - ENGINE COMPONENTS* subsection.
3. Remove the screws securing the oil pump cover.



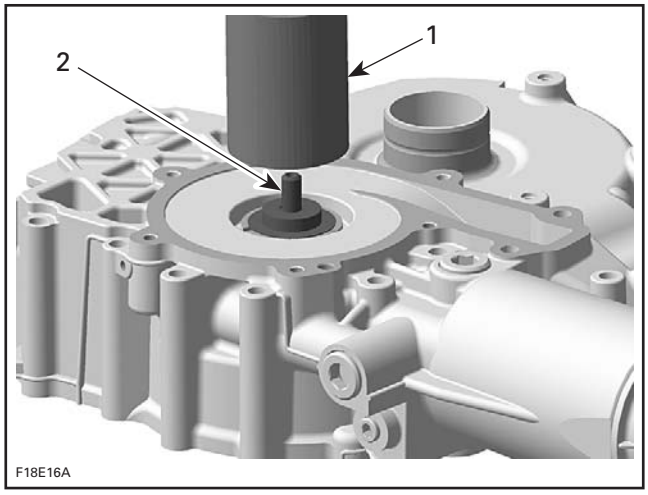
1. Screws
2. Oil pump cover

4. Pull and remove the outer oil pump rotor.



1. Outer oil pump rotor

5. Extract the coolant/oil pump shaft by pushing it from outside PTO housing cover.

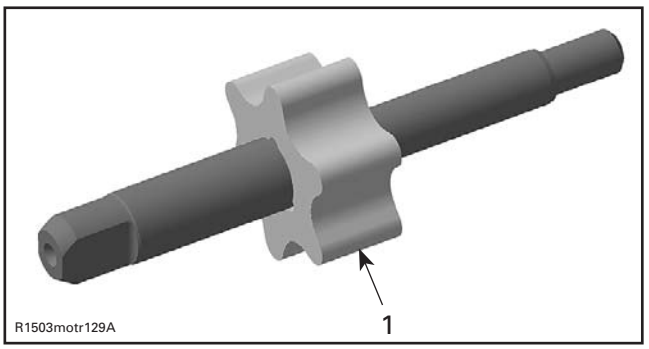


1. Pusher
2. Coolant/oil pump shaft

6. Remove rotary seal and oil seal. Refer to *ROTARY SEAL* further in this subsection.

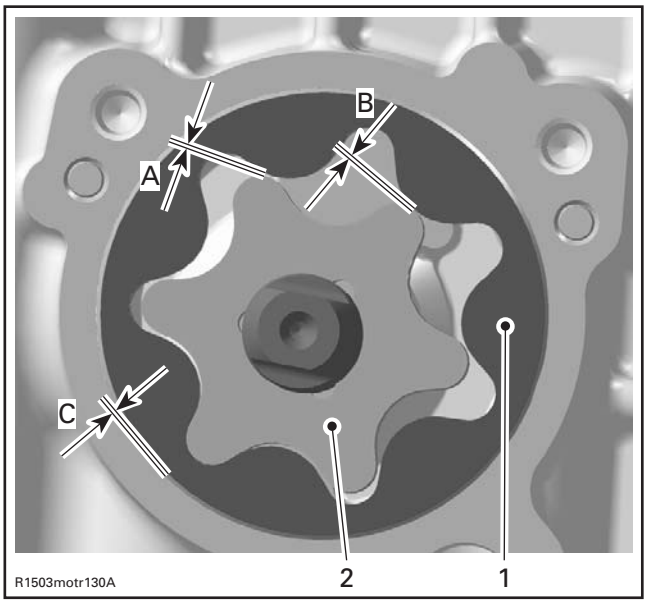
Inspecting the Oil Pressure Pump

1. Inspect the coolant/ oil pump shaft, housing and cover for marks or other damages.
2. Check the inner rotor for corrosion pin-holes or other damages. If so, replace the coolant/ oil pump shaft. Ensure to also check oil pump housing and cover, and replace if damaged.



1. Pittings on the teeth

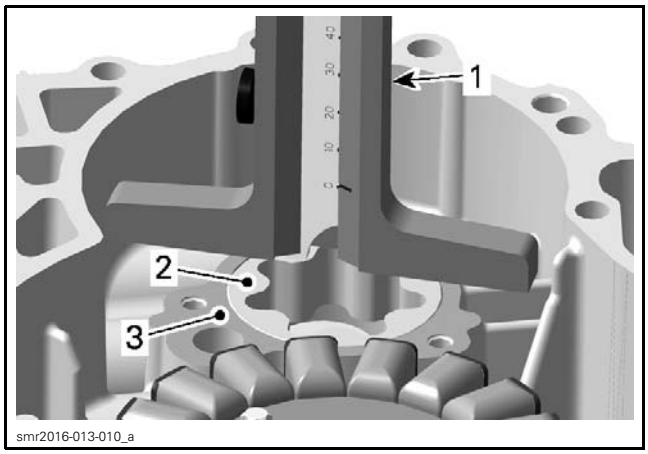
3. Using a feeler gauge, measure the clearance between the inner and outer rotors.



1. Outer rotor
2. Inner rotor

OIL PUMP RADIAL CLEARANCE	
SERVICE LIMIT	
A	0.25 mm (.0098 in)
B	
C	

4. If clearance between inner and outer rotors exceeds the tolerance, replace the coolant/ oil pump shaft.
5. If clearance between the outer rotor and its bore in the oil pump exceeds the tolerance, replace the complete oil pump and the PTO housing.
6. Using a depth gauge, measure axial clearance as shown.



1. Depth gauge
2. Oil pump outer rotor surface
3. PTO housing surface

Clearance between pump housing and outer rotor should not exceed the following specification. If so, replace the complete oil pump assembly.

CLEARANCE BETWEEN PUMP HOUSING AND OUTER ROTOR
0.1 mm (.004 in)

NOTE: When the axial clearance of the coolant/ oil pump shaft increases, the oil pressure decreases.

7. Check the inside of oil pump housing and its cover for scoring or other damages. Replace if damaged.

Installing the Oil Pressure Pump

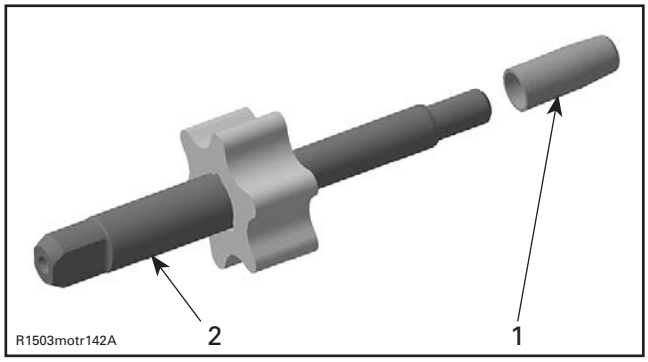
The installation is the reverse of the removal procedure. However, pay attention to the following.

1. Install a NEW rotary seal and a NEW oil seal. Refer to *ROTARY SEAL* in this subsection.
2. Install the coolant/ oil pump shaft.

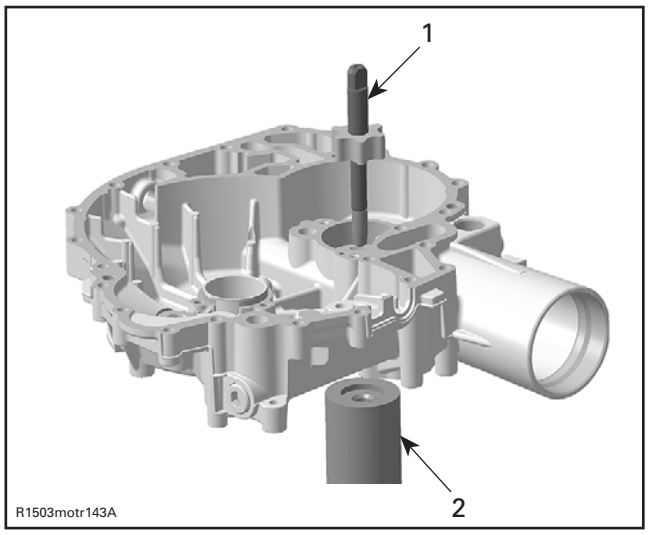
NOTICE **Never use a hammer for the coolant/ oil pump shaft installation. Only use a press to avoid damaging the ceramic component of the rotary seal.**

NOTICE **During oil pump shaft installation support ceramic seal using the designated service tool to achieve correct rotary seal preload.**

REQUIRED TOOLS	
OIL SEAL GUIDE (P/N 529 035 822)	
WATER PUMP SEAL PUSHER (P/N 529 035 823)	



1. Oil seal guide
2. Coolant/oil pump shaft



1. Coolant/oil pump shaft with oil seal guide
2. Rotary seal pusher to support PTO housing

3. Tighten oil pump cover screws to specification.

TIGHTENING TORQUE	
Oil pump cover screws	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)

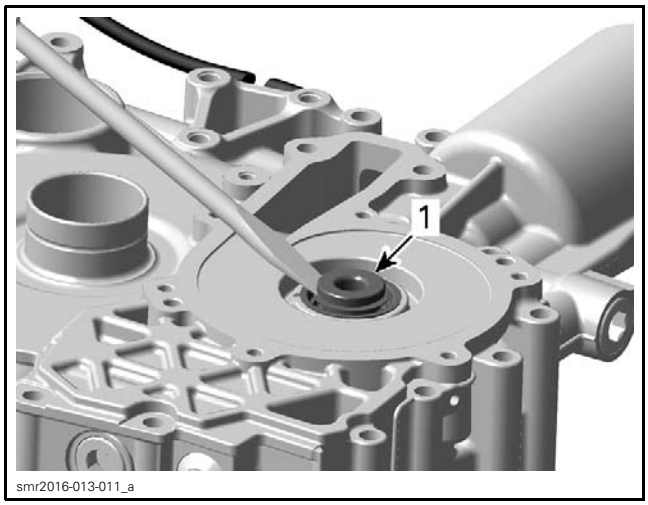
After engine reassembly:

4. Refill the engine oil to proper level.
5. Ensure the oil pressure is within specifications.

ROTARY SEAL

Removing the Rotary Seal

1. Remove the coolant/ oil pump shaft. Refer to *OIL PRESSURE PUMP* in this subsection.
2. Carefully remove the inner ring of the rotary seal with a screwdriver.

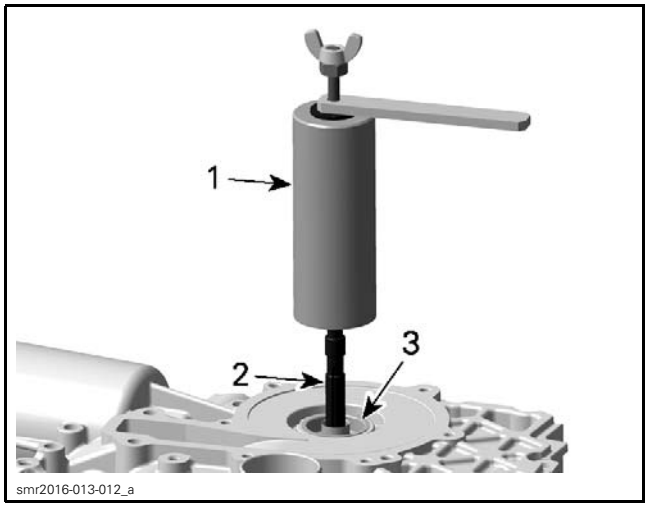


1. Inner ring of rotary seal

NOTICE Be careful not to damage the surface of the rotary seal bore or the sealing surface of the water pump housing in PTO housing.

REQUIRED TOOL	
CERAMIC SEAL PULLER (P/N 529 036 365)	

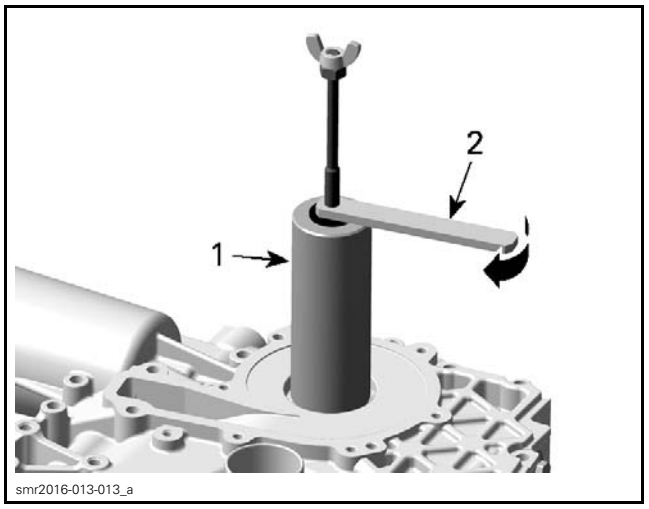
3. Put the ceramic seal puller into the ceramic seal and turn the bearing puller until it's clamping.



1. Ceramic seal puller
2. Bearing puller
3. Ceramic seal

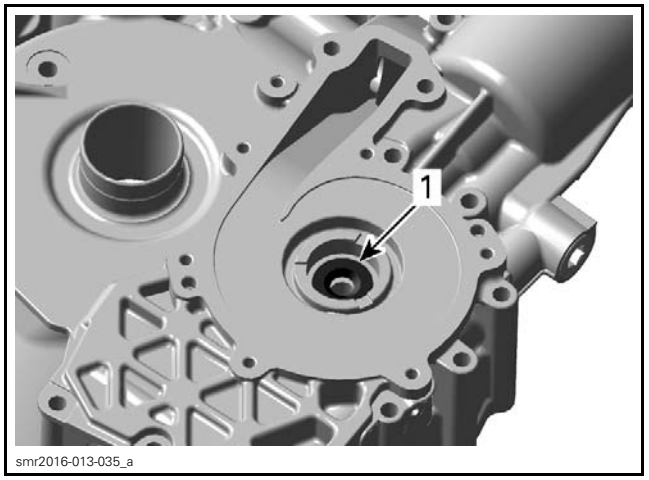
NOTE: Take care that the bearing puller end is exactly positioned between the oil seal and the ceramic seal.

4. Start turning the lever clockwise until the ceramic seal is completely pulled out the PTO housing.



1. Ceramic seal puller
2. Bearing puller lever

5. Remove the ceramic seal from bearing puller and discard it.
6. Remove the oil seal behind the rotary seal.



1. Oil seal

7. Discard the rotary seal and oil seal.

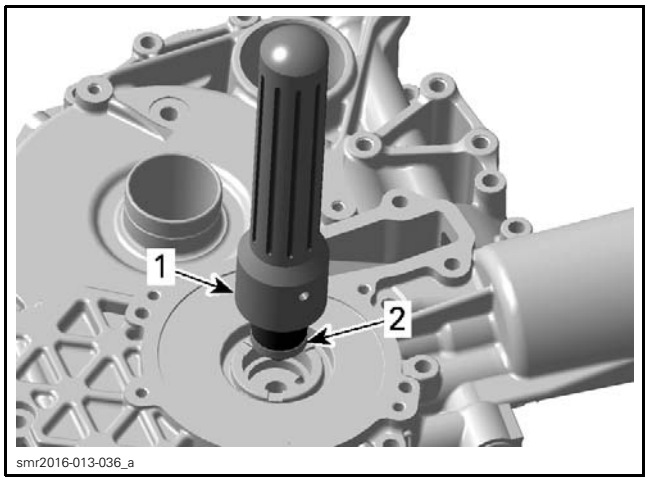
Installing the Rotary Seal

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

NOTICE Never use oil in the press fit area of the oil seal and rotary seal.

1. Install a NEW oil seal.

REQUIRED TOOLS	
OIL SEAL PUSHER (P/N 529 035 757)	
HANDLE (P/N 420 877 650)	

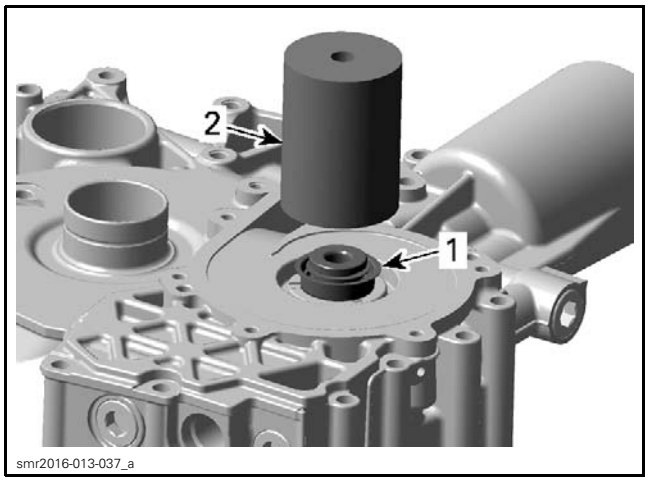


1. Handle with oil seal pusher
2. Oil seal

2. Install a NEW rotary seal.

REQUIRED TOOL	
WATER PUMP SEAL PUSHER (P/N 529 035 823)	

NOTICE Never use a hammer for the rotary seal installation. Only use a press to avoid damaging the ceramic component.

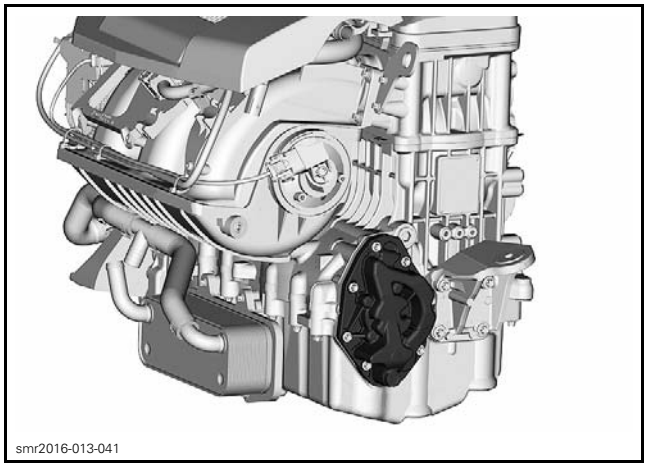


1. Rotary seal
2. Rotary seal installer

3. Install the coolant/ oil pump shaft. Refer to *OIL PRESSURE PUMP* in this subsection.

OIL SUCTION PUMP

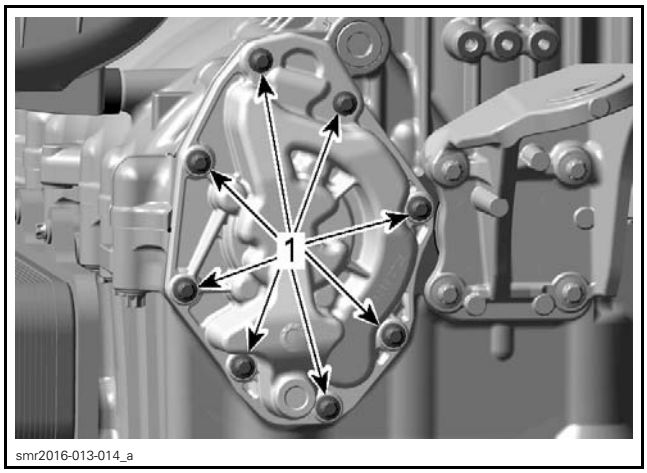
Oil Suction Pump Location



TYPICAL - LOCATION OF OIL SUCTION PUMP

Removing the Oil Suction Pump

1. Remove retaining screws.

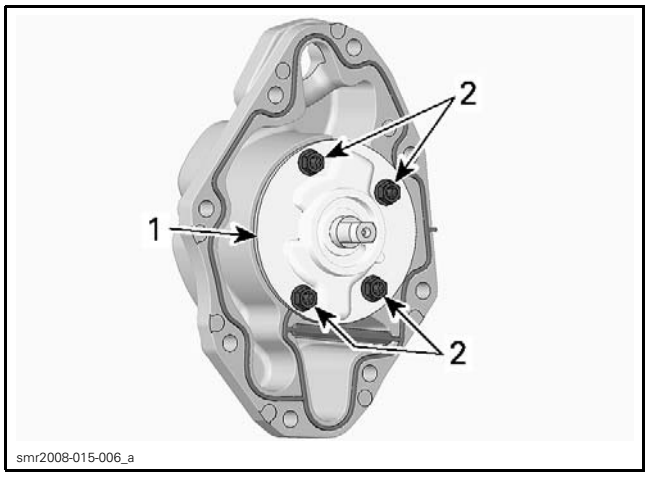


1. Suction pump cover screws

2. Place rags under cover to prevent spillage. If spillage occurs, clean immediately.

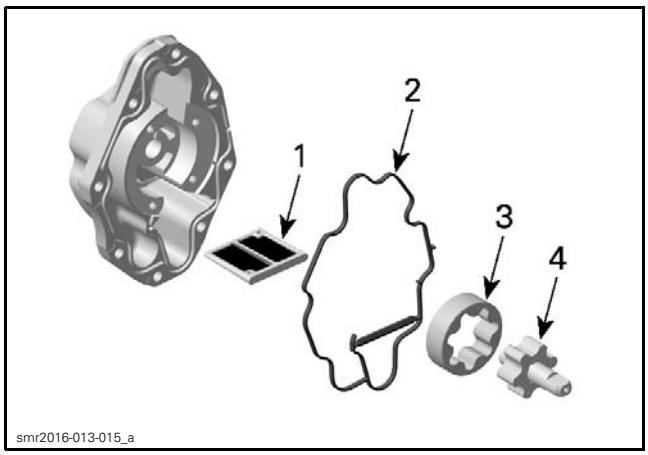
SERVICE PRODUCT
BRAKE AND PARTS CLEANER PRO S2 (P/N 779245)

3. Remove the oil suction pump housing.
4. Remove:
   – Oil pump screws
   – Cover.



1. Oil pump cover
2. Oil pump screws

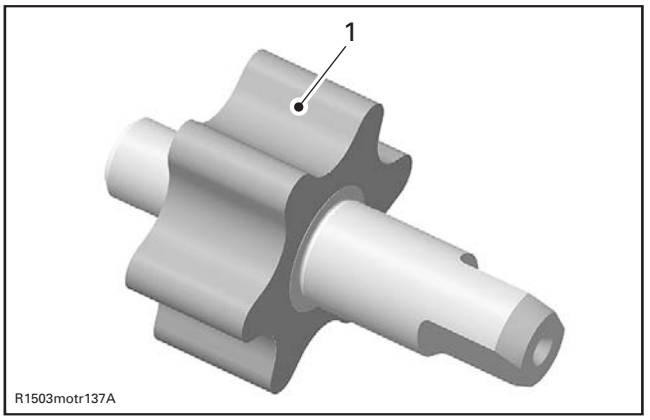
5. Remove the outer rotor and the strainer.



1. Oil strainer
2. Cover gasket
3. Outer rotor
4. Oil pump shaft

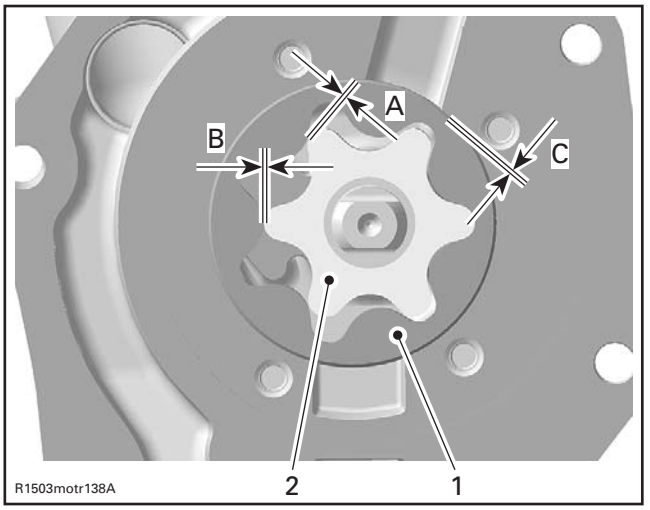
Inspecting the Oil Suction Pump

1. Inspect the oil pump shaft, housing and cover for marks or other damages.
2. Check the inner rotor for corrosion, pin-holes or other damages. If so, replace the oil pump shaft.
3. Check the oil pump housing and cover. Replace if damaged.



1. Pittings on the teeth

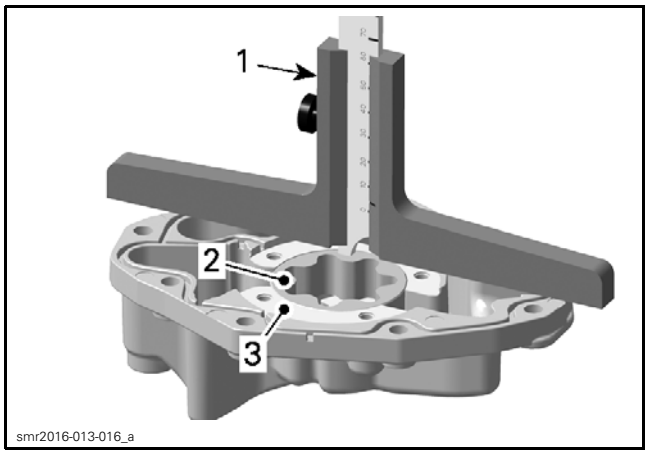
4. Using a feeler gauge, measure the clearance between the inner and outer rotors.



1. Outer rotor
2. Inner rotor

OIL PUMP RADIAL CLEARANCE	
SERVICE LIMIT	
A	0.25 mm (.0098 in)
B	
C	

5. If the clearance between the inner and outer rotors exceeds the tolerance, replace the oil pump shaft.
6. If the clearance between the outer rotor and its bore in the oil pump exceeds the tolerance, replace the complete oil pump and the PTO housing.
7. Using a depth gage, measure side wear as shown.



1. Depth gage
2. Oil pump outer rotor surface
3. Oil pump housing surface

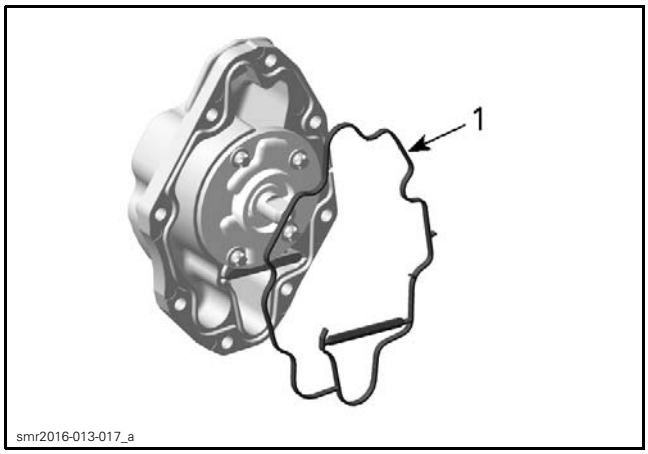
8. Clearance between pump housing and outer rotor should not exceed the following specification. If so, replace the complete oil pump assembly.

CLEARANCE BETWEEN PUMP HOUSING AND OUTER ROTOR
0.1 mm (.004 in)

NOTE: When the axial clearance of the oil pump shaft assembly increases, the oil pressure decreases.

9. Check the inside of oil pump housing and its cover for scoring or other damages. Replace if damaged.

10. Inspect suction pump cover gasket.



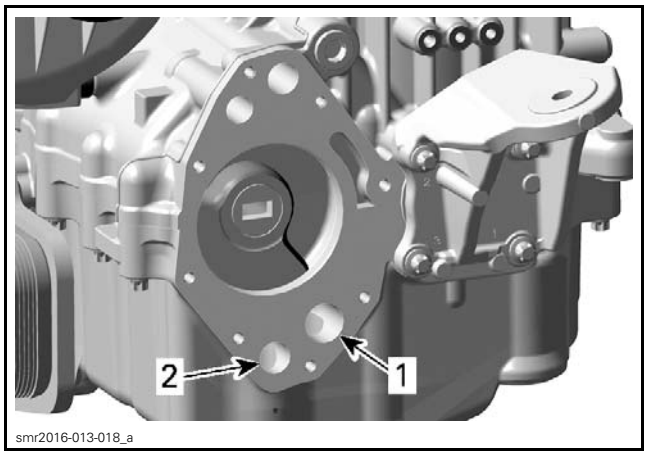
1. Cover gasket

11. If gasket is brittle, cracked or hard, replace it.

Installing the Oil Suction Pump

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

1. Clean both contact surfaces of oil suction pump cover.
2. Check and clean the oil inlet and outlet area for dirt and other contaminations.

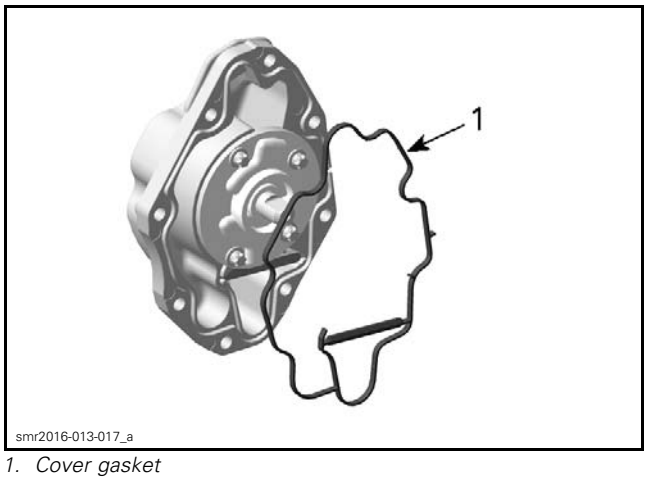


1. Oil inlet
2. Oil outlet

3. Apply threadlocker on the oil pump screw threads.
4. Tighten oil pump screws to specification.

TIGHTENING TORQUE	
Oil pump screws	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)

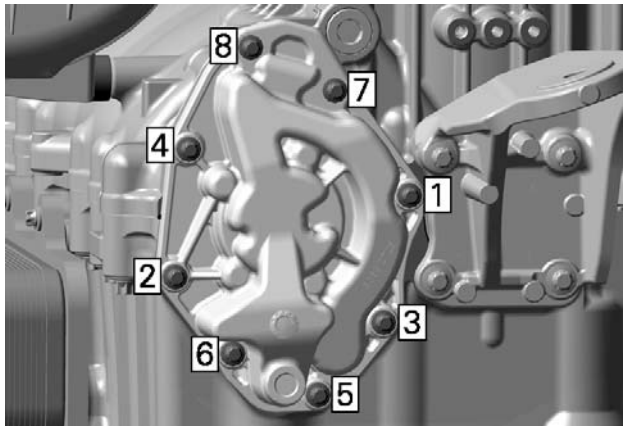
5. Make sure the oil strainer is properly installed in the oil suction pump cover.
6. Apply engine oil on rubber ring gasket.



1. Cover gasket

7. Apply threadlocker on the suction pump cover screw threads.
8. Tighten the suction pump cover screws to specification as per following sequence.

TIGHTENING TORQUE	
Suction pump cover screws	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)



TIGHTENING SEQUENCE

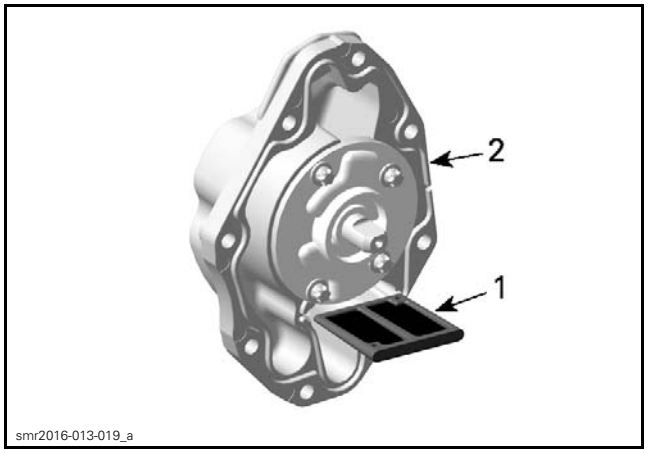
9. Refer to the appropriate procedures and install all other removed parts.

SUCTION PUMP OIL STRAINER

NOTE: The oil strainer does not need to be cleaned at every oil change. Clean it during other inspections, especially when the engine is disassembled.

Removing the Suction Pump Oil Strainer

1. Remove the oil strainer from the suction pump cover. Refer to *REMOVING THE OIL SUCTION PUMP* in this subsection.



1. *Oil strainer*
2. *Suction pump cover*

Inspecting the Suction Pump Oil Strainer

1. Clean the oil strainer with a part cleaner then use compressed air to dry it.
2. Check the oil strainer for tear or other damages. Replace if necessary.

Installing the Suction Pump Oil Strainer

To install the suction pump cover, refer to *OIL SUCTION PUMP* in this subsection.

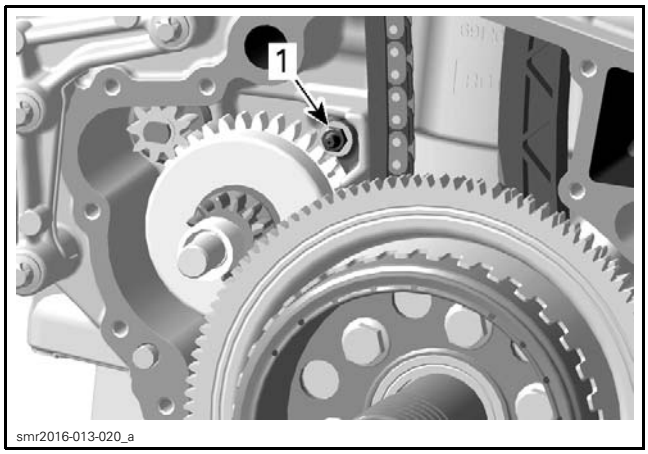
SUPERCHARGER OIL SPRAY NOZZLE

Supercharger Oil Spray Nozzle Location

The supercharger oil spray nozzle is located in the cylinder block right hand side above the sprag clutch

Removing the Supercharger Oil Spray Nozzle

1. Remove the PTO housing. Refer to *PTO HOUSING, MAGNETO AND STARTER* subsection.
2. Unscrew the oil spray nozzle.



1. Oil spray nozzle

Inspecting the Supercharger Oil Spray Nozzle

1. Check oil spray nozzle for dirt or other damages. Replace if necessary.

Installing the Supercharger Oil Spray Nozzle

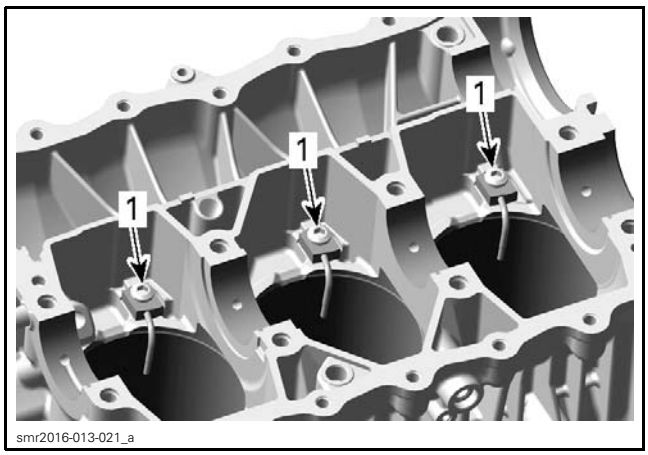
The installation is the reverse of the removal procedure. However, pay attention to the following.

1. Apply threadlocker on the oil spray nozzle thread.
2. Tighten to specification.

TIGHTENING TORQUE	
Oil spray nozzle	4.5 N•m ± 0.5 N•m (40 lbf•**in** ± 4 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)

PISTON OIL SPRAY NOZZLES

The piston oil spray nozzles are located on the upper half of cylinder block.



1. Piston oil spray nozzles

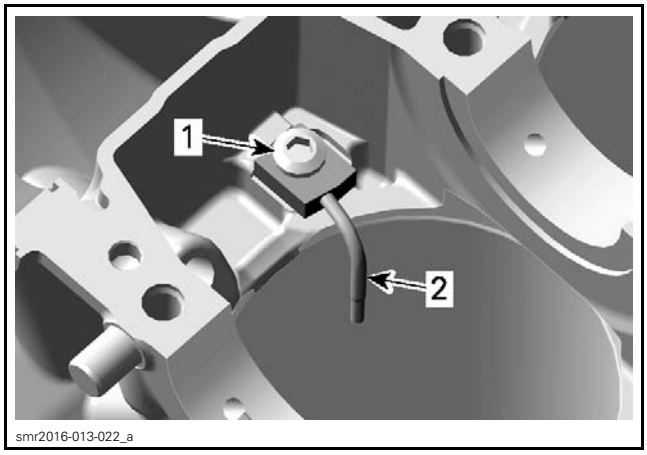
NOTE: When the scope of repair work obligates you to split the cylinder block, take this opportunity to clean the oil spray nozzles.

Inspecting the Piston Oil Spray Nozzle

1. Check if the oil spray nozzle is damaged or bent.
2. Check for cracks at soldering.
3. If damaged, replace immediately.

Removing the Piston Oil Spray Nozzle

1. Remove the cylinder block lower half. Refer to *CYLINDER BLOCK* subsection.
2. Remove the oil spray nozzle and Banjo fitting and discard it.

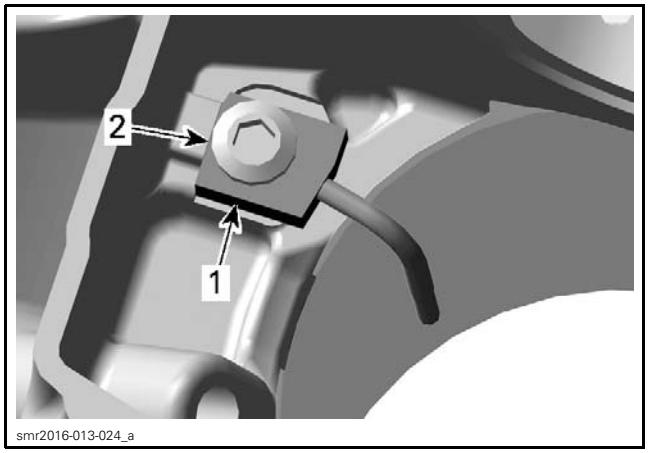


1. Banjo fitting
2. Oil spray nozzle

Installing the Piston Oil Spray Nozzle

1. Install a NEW oil spray nozzle and Banjo fitting.

NOTICE **At assembly make sure the contact surface of the oil spray nozzle is well fitted onto the cylinder block. If this is not ensured, the oil spray direction will change, causing potential engine damage.**



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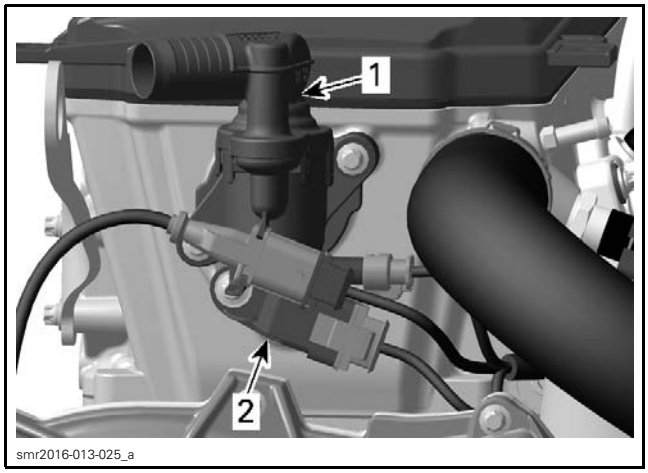
1. Oil spray nozzle
2. Contact surface

TIGHTENING TORQUE	
Piston oil spray nozzle banjo bolt	19 N•m ± 2 N•m (168 lbf•**in** ± 18 lbf•**in**)

OIL SEPARATOR COVER

Removing the Oil Separator Cover

1. Remove the blow-by valve. See procedure in this subsection.
2. Refer to *CYLINDER HEAD* subsection and remove:
   – Valve cover
   – Camshaft position sensor.



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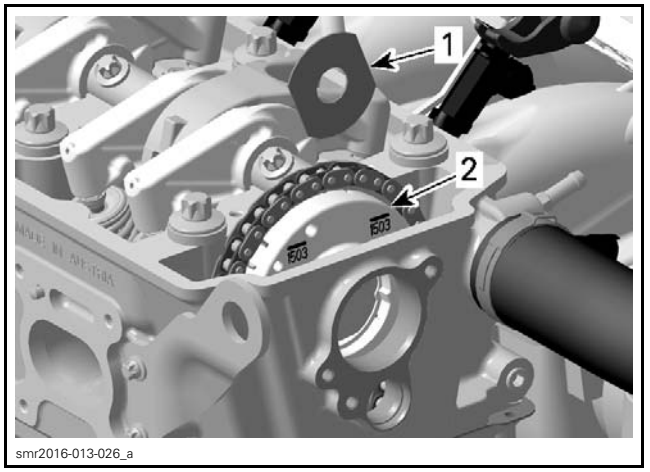
1. Blow-by valve
2. Camshaft position sensor

3. Remove the thrust washer from the oil separator cover.

NOTE: Make sure not to loose thrust washer when removing it from oil separator cover, otherwise thrust washer would fall into the PTO housing.



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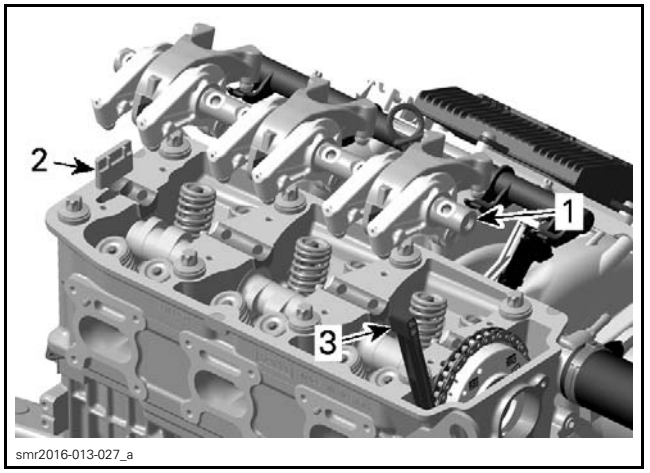
1. Thrust washer
2. Oil separator cover

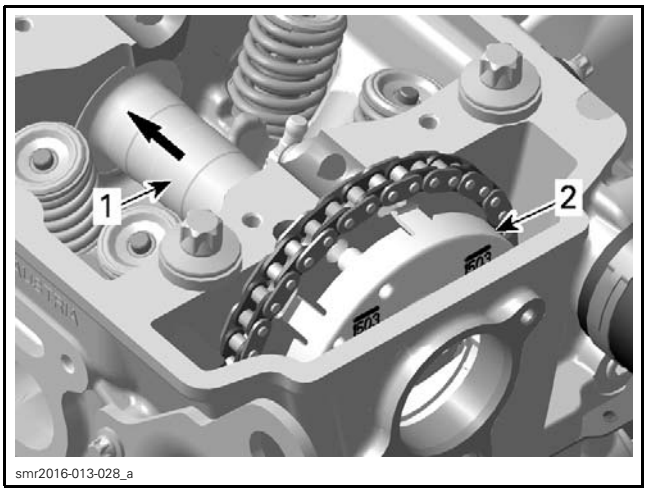
4. Refer to *CYLINDER HEAD* subsection and remove:
   – Spark plug tube
   – Rocker arm shaft together with rocker arms
   – Chain guide
   – Camshaft lock.



smr2016-013-027_a

1. Rocker arm shaft with rocker arms
2. Camshaft lock
3. Chain guide

5. Move the camshaft backwards as far as possible.
6. Remove the oil separator cover from the timing gear by releasing the holding clips.

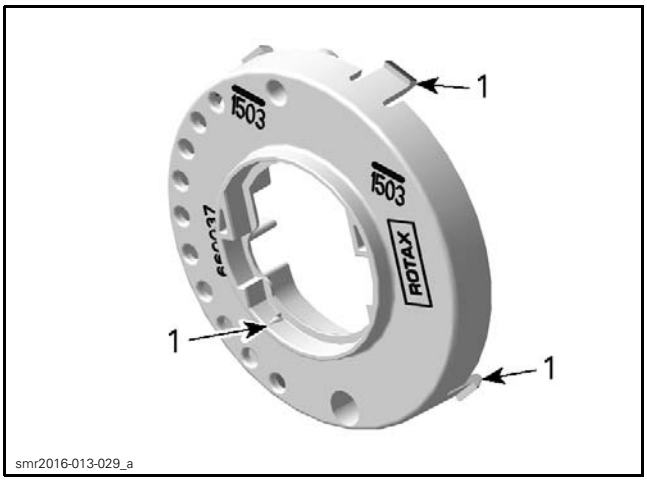


1. Camshaft
2. Oil separator cover

NOTE: Be careful not to break the holding clips from oil separator cover when its removed from the timing gear.

Inspecting the Oil Separator Cover

1. Inspect the thrust washer for marks.
2. Inspect the oil separator cover for marks or other damages.
3. Inspect the holding clips of the oil separator cover.



1. Holding clips

4. If any damage is visible replace oil separator cover.

Installing the Oil Separator Cover

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

1. Properly install the oil separator cover and thrust washer. They need to be in a perfect even position with timing gear.

NOTE: Make sure not to lose thrust washer when installed on oil separator cover.

2. Install all other removed parts.

BLOW-BY VALVE

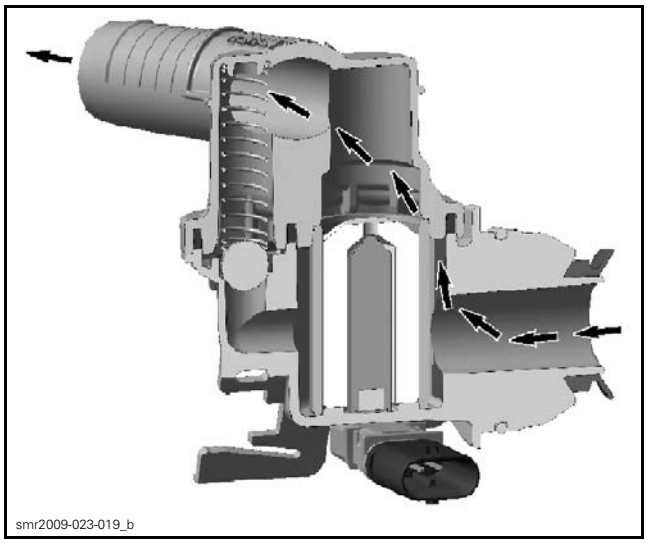
Blow-By Valve Description

The function of the blow-by valve is the circulation of the oil vapors.

Blow-By Valve Operation

Normal Operation

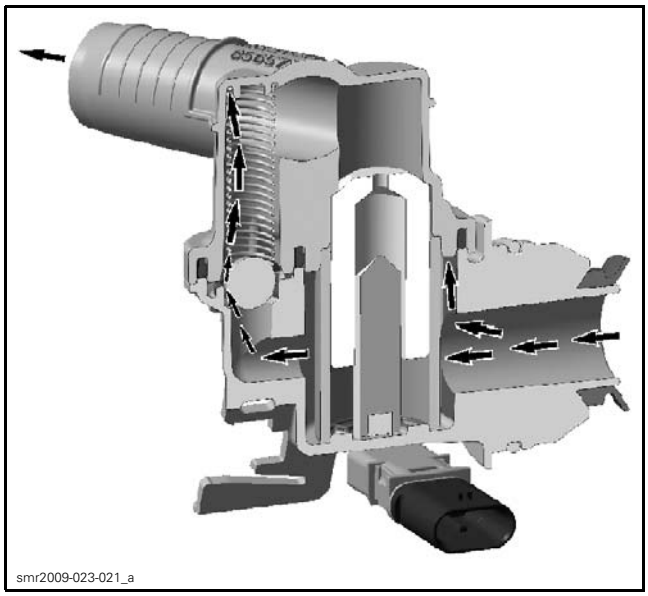
During its normal operation, the blow-by valve allows crankcase vapors to return in the intake system where they are harmlessly burned.



NORMAL OPERATION

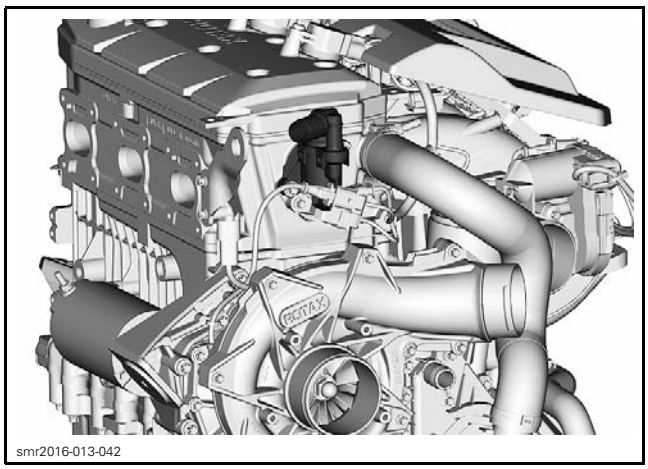
By-Pass Function

If, for any reason, the valve piston gets stuck at normal operation and the crankcase pressure exceeds 40 kPa (6 PSI), the pressure unseats a check ball and crankcase vapors can bypass the valve piston.



BY-PASS FUNCTION

Blow-By Valve Location



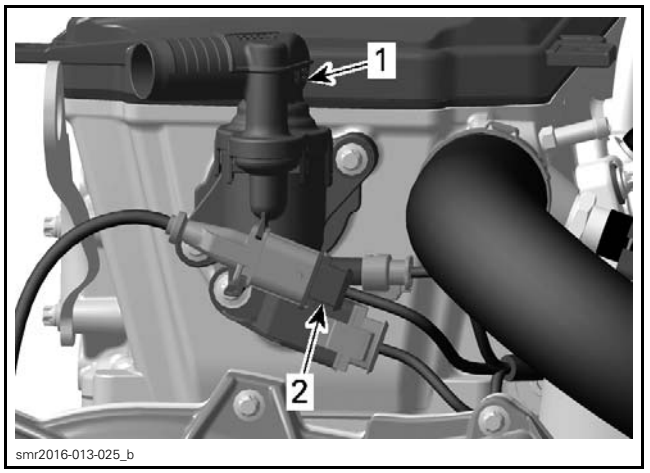
TYPICAL

Removing the Blow-By Valve

1. Remove the ventilation hose from blow-by valve.

Engines with TOPS

2. Remove the CPS connector from its support on blow-by valve.

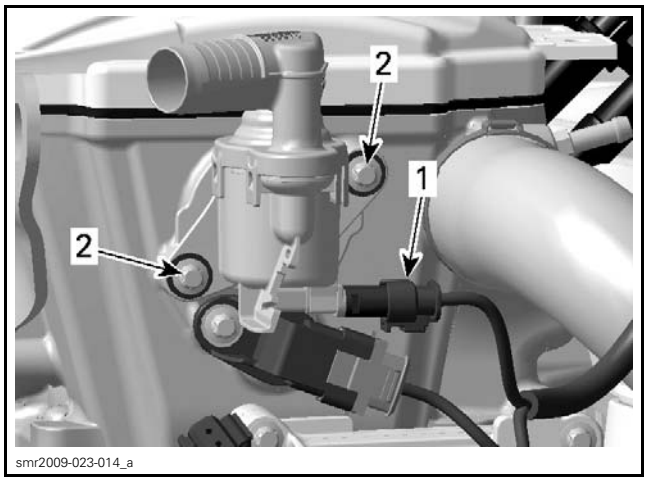


1. Blow-by valve
2. CPS connector

3. Disconnect the TOPS switch connector of the blow-by valve.

All Engines

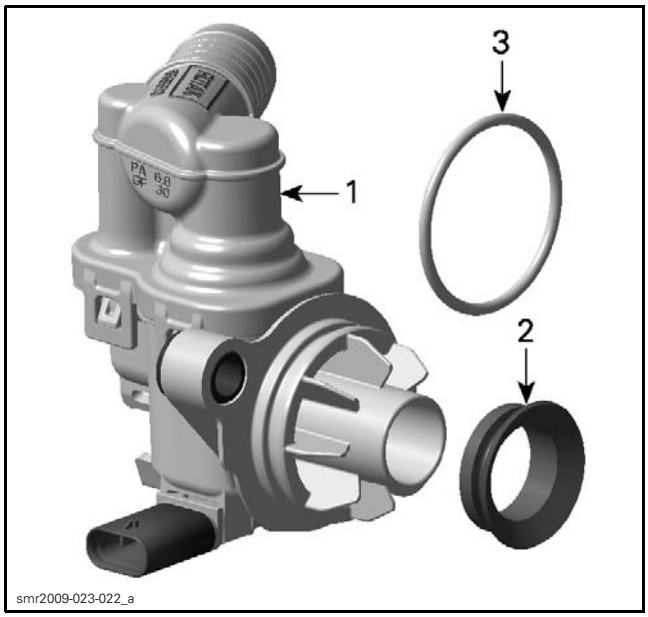
4. Unscrew and remove the blow-by valve.



1. TOPS switch connector (if equipped)
2. Retaining screws

5. Remove and discard the O-ring and V-ring.

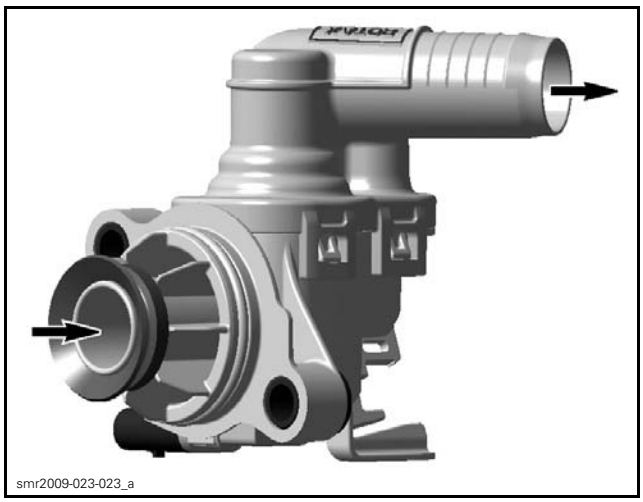
NOTE: The blow-by valve can not be disassembled.



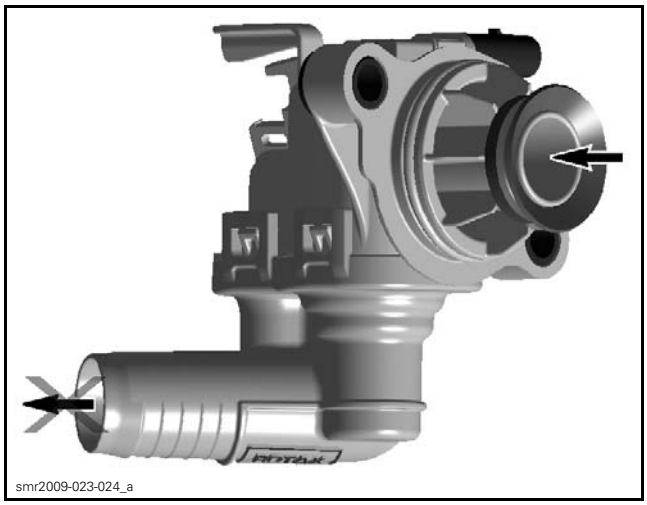
1. Blow-by valve
2. V-ring
3. O-ring

Inspecting the Blow-By Valve

1. If blow-by valve is damaged, replace it.
2. Clean all contact surfaces of blow-by valve.
3. Place a clean rag on valve inlet.
4. Blow air through inlet port. Air must flow freely to the outlet port.



5. Turn the valve upside down and blow air again. Air must not flow out.



6. If test fails, replace blow-by valve.

Installing the Blow-By Valve

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

1. Install the blow-by valve with **NEW** O-ring and V-ring.
2. Tighten the blow-by valve screws to specification.

TIGHTENING TORQUE	
Blow-by valve screws	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)

3. Reinstall remaining removed parts.

TIP OVER PROTECTION SWITCH (TOPS) (WATERCRAFT ONLY)

TOPS Function

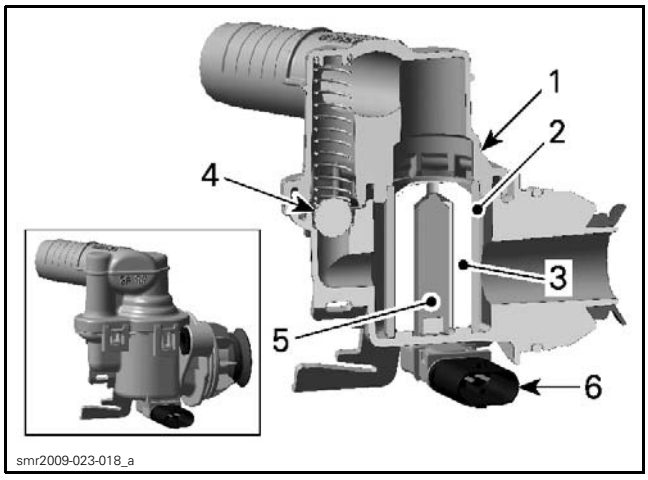
The function of the TOPS is the engine protection in the event the watercraft tip over.

During normal operation the TOPS state is OFF, no signal to the ECM.

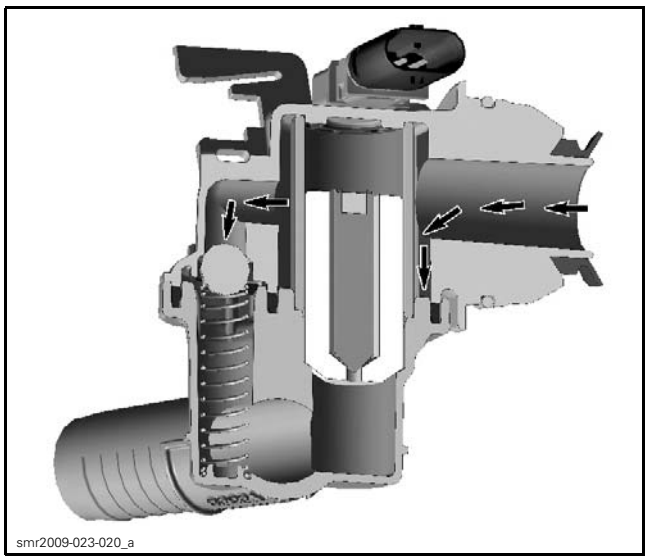
If the watercraft tips over, gravity causes a valve piston to close and no engine oil will leak out of the blow-by valve.

In this event, a pin (with magnet) opens a gap to the TOPS (Hall effect sensor) and the TOPS changes its state to ON and sends a signal to the ECM.

The ECM will shut down the engine by cutting the ignition and the fuel injection.



BLOW-BY VALVE CUT-AWAY
1. *Valve housing*
2. *Valve sleeve*
3. *Valve piston*
4. *Check ball*
5. *Valve pin (with magnet)*
6. *TOPS of the blow-by valve*

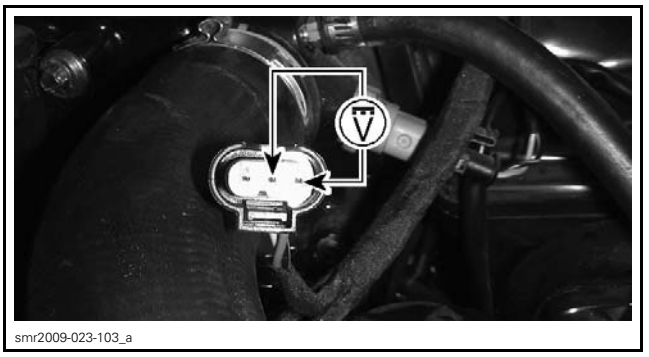


TIP OVER FUNCTION

Testing the TOPS Input Voltage

1. Disconnect the TOPS connector of the blow-by valve.
2. Briefly press the START/STOP button to wake-up the ECM.
3. Probe terminals as shown to check the voltage output from the ECM.

TOPS INPUT VOLTAGE TEST		
TOPS CONNECTOR PIN		SPECIFICATION
2	3	5 Vdc

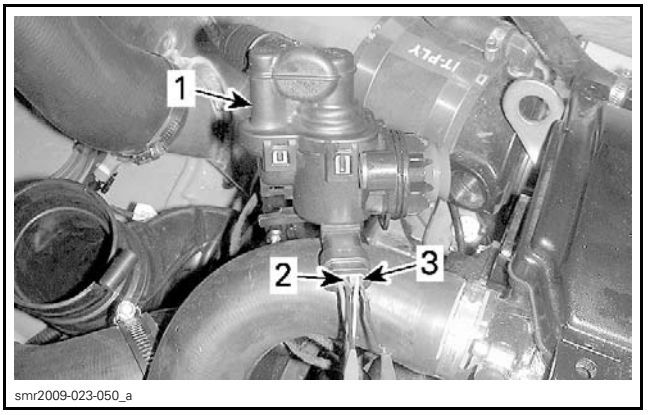


4. If voltage test is good, check the TOPS output voltage.
5. If voltage test is not good, check the continuity of the blow-by valve TOPS switch circuit.

NOTE: After voltage test, clear the fault codes in the ECM using the BRP diagnostic software (BUDS2).

Testing the TOPS Output Voltage

1. Remove the blow-by valve.
2. Back-probe TOPS connector and check voltage.



BLOW-BY VALVE IN NORMAL POSITION
1. *Blow-by valve*
2. *RED probe into pin 2*
3. *BLACK probe into pin 1*

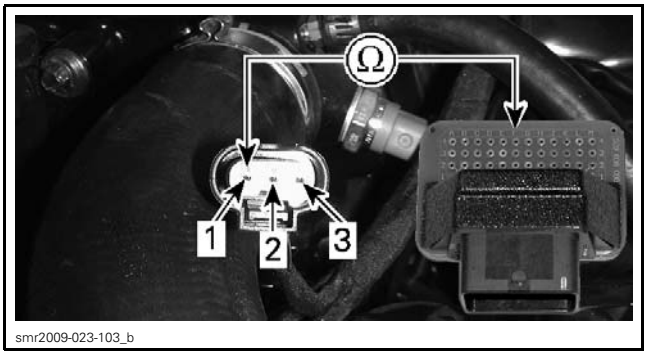
TOPS OUTPUT VOLTAGE TEST		
TOPS CONNECTOR PIN	BLOW BY VALVE	SPECIFICATION
1 and 2	Normal position	0.4 ± 0.1 Vdc
1 and 2	Upside down	4.4 ± 0.2 Vdc
2 and 3	Normal position or upside down	5 Vdc

3. Replace the TOPS if not within specification.

Testing the TOPS Circuit Continuity

1. Disconnect the TOPS switch connector of the blow-by valve.
2. Disconnect the ECM-A connector from the ECM.
3. Connect the ECM-A connector on the ECM adaptor tool.
4. Check continuity of the blow-by valve TOPS switch circuit as per following table.

TOPS CIRCUIT CONTINUITY TEST		
TOPS CONNECTOR PIN	ECM ADAPTER	SPECIFICATION
1	A-F4	Close to 0 Ω
2	A-G1	
3	A-C4	



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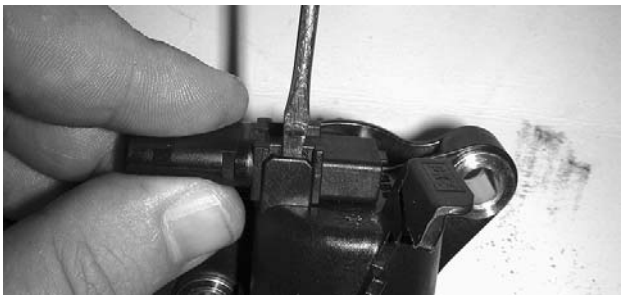
1. Pin 1
2. Pin 2
3. Pin 3

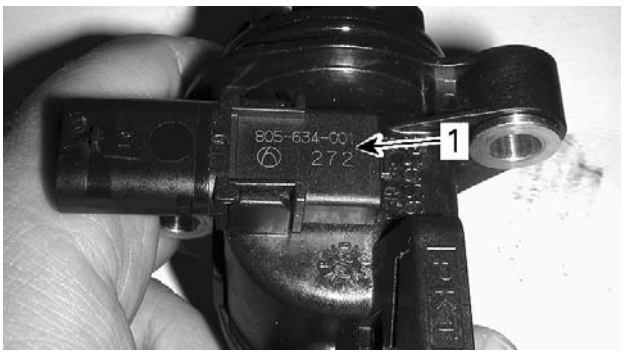
5. If continuity test is good, check ECM. Refer to *ELECTRONIC CONTROL MODULE* subsection.
6. If continuity test is not good, repair or replace defective wires or connectors.

Replacing the TOPS

1. Remove the blow-by valve and turn it upside down.
2. Insert a small screwdriver between TOPS and its retaining tab. Twist and hold the TOPS then release the other retaining tab.


smr2009-023-051

3. When installing the TOPS, make sure printed information is visible.



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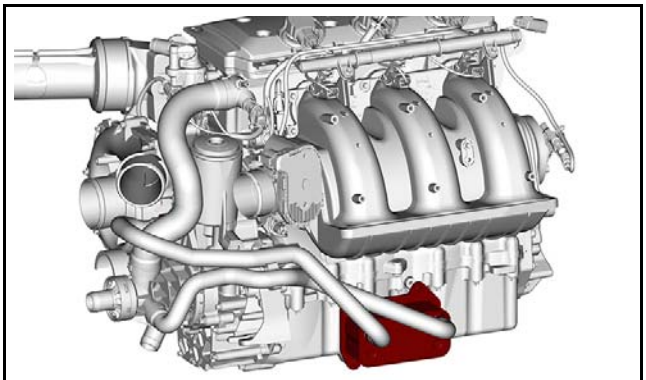
1. TOPS valve inscriptions

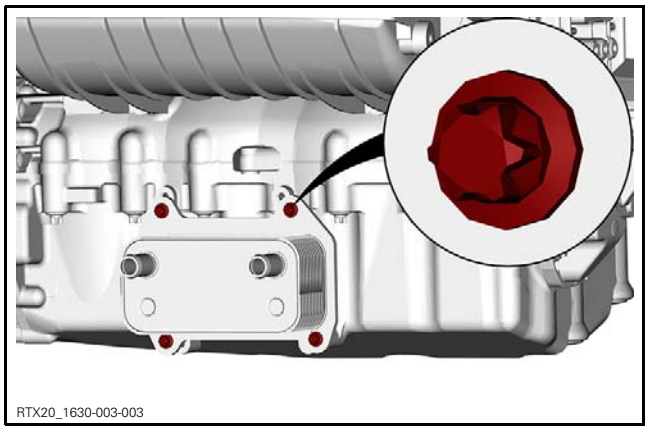
OIL COOLER

Oil Cooler Location

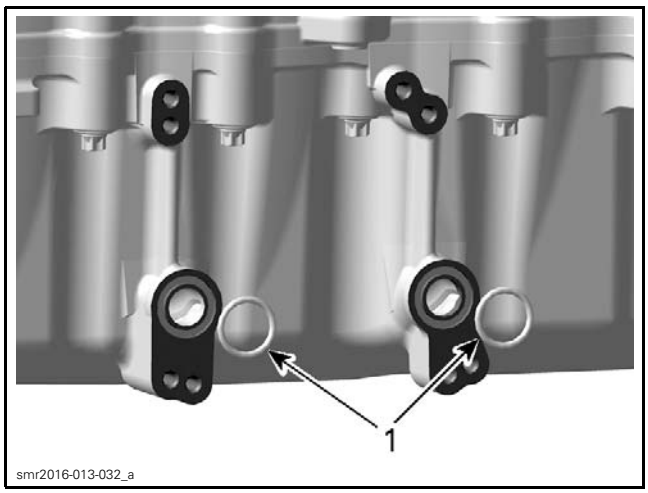

RTX20_1630-003-002

Removing the Oil Cooler

1. Remove the engine from vehicle. Refer to *REMOVING AND INSTALLING THE ENGINE* subsection.
2. Disconnect the cooling hoses from oil cooler.
3. Remove the oil cooler screws.


RTX20_1630-003-003

4. Ensure not to lose the O-rings located between the oil cooler and the engine.



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1. O-rings

Inspecting the Oil Cooler

1. If the O-rings are brittle, cracked or hard, replace them.
2. Clean both contact surfaces of oil cooler.
3. Check and clean the oil inlet and outlet area for dirt and other contaminations.

Installing the Oil Cooler

1. The installation is the reverse of the removal procedure. However, pay attention to the following.
2. Apply engine oil on O-rings.
3. Apply threadlocker to the oil cooler screw threads.
4. Tighten oil cooler screws to specification.

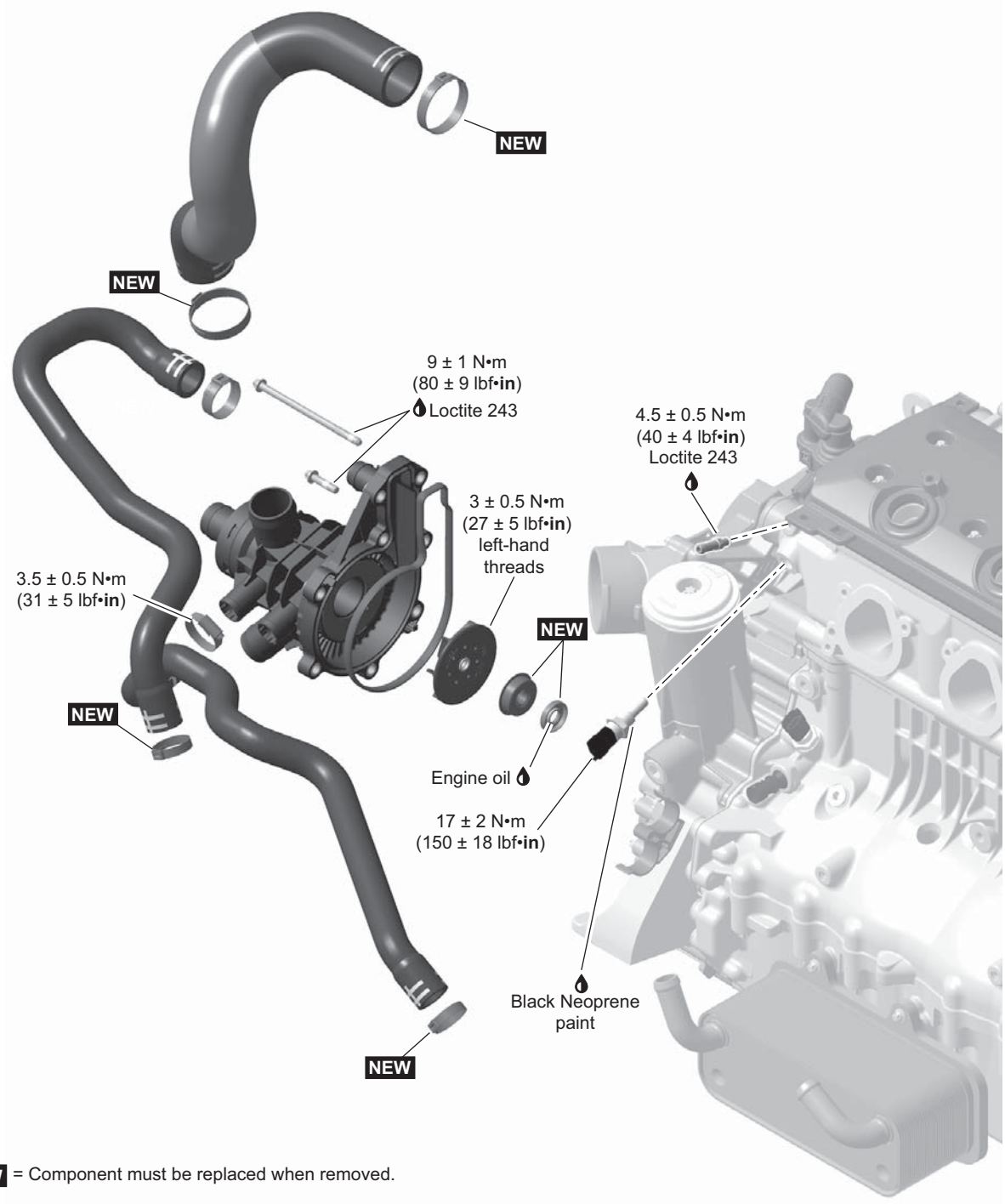
TIGHTENING TORQUE	
Oil cooler screws	11 N•m ± 1 N•m (97 lbf•**in** ± 9 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)

COOLING SYSTEM - ENGINE COMPONENTS

SERVICE PRODUCTS

Description	Part Number	Page
BLACK NEOPRENE PAINT	909570	55
LOCTITE 243 (BLUE)	293 800 060	57

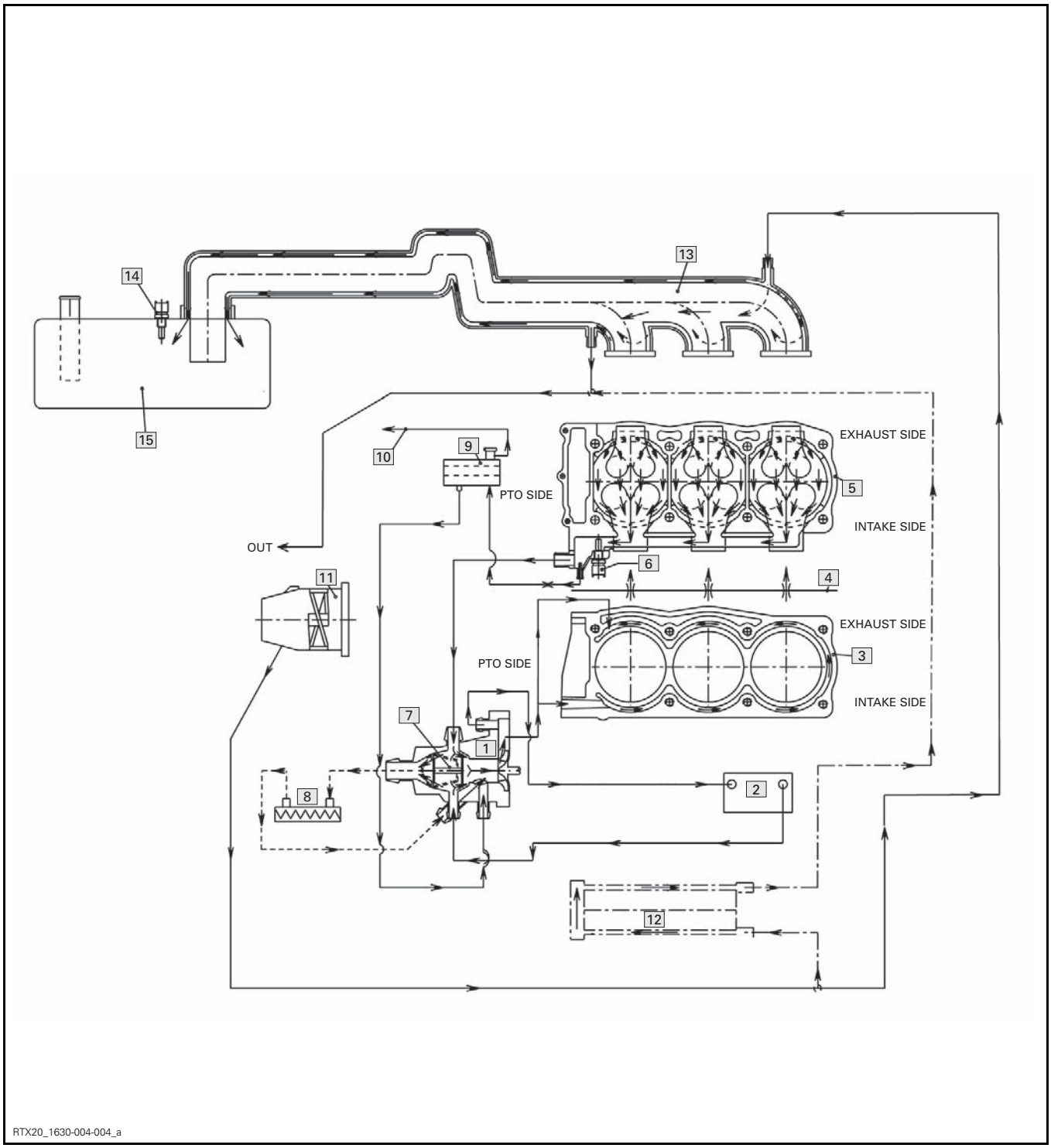
COOLING SYSTEM COMPONENTS



NEW = Component must be replaced when removed.

RTX20_1630-004-001_a

ENGINE COOLING CIRCUIT



1. *Water pump*
2. *Oil cooler*
3. *Cylinder block*
4. *Cylinder head gasket*
5. *Cylinder head*
6. *Coolant temperature sensor*
7. *Thermostat*
8. *Ride plate (heat exchanger)*
9. *Expansion coolant tank*
10. *Spillway*
11. *Jet pump*
12. *Intercooler (230 and 300 only)*
13. *Exhaust manifold*
14. *Exhaust temperature sensor*
15. *Muffler*

GENERAL

NOTICE Never start the engine without coolant. Some engine parts can be damaged.

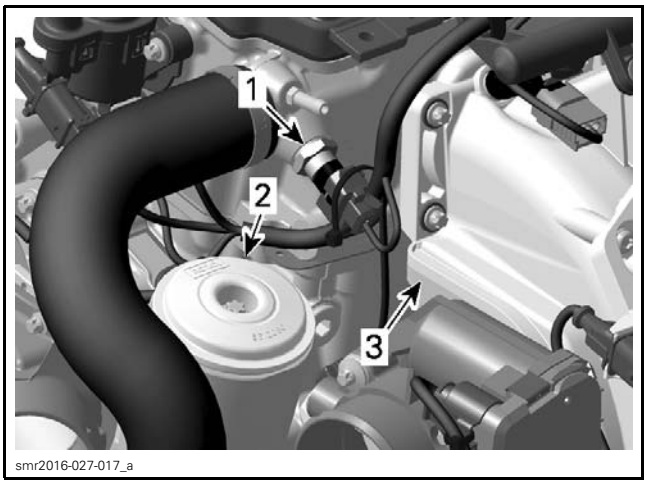
⚠ WARNING

To avoid potential burns, do not remove the coolant tank cap or loosen the coolant drain plug if the engine is hot.

PROCEDURES

COOLANT TEMPERATURE SENSOR (CTS)

The CTS is located between the intake manifold and the oil filter cover.



1. Coolant temperature sensor (CTS)
2. Oil filter cover
3. Intake manifold

NOTE: The CTS will cause the engine overheat warning to come on when the coolant temperature is above:

ENGINE TYPE	OVERHEAT TEMPERATURE
100 130 170 230	Above 102°C (216°F)
300 Boat	Above 98°C (208°F)
300 Watercraft	Above 97°C (207°F)

Check for debris or blockage in cooling system.

CTS Quick Test

1. Connect the vehicle to the BRP diagnostic software (BUDS2).
2. Install the tether cord on the engine cut-off switch.
3. Start the engine
4. In BUDS2, go to:
   – **Measurements** page
   – **ECM** button
   – **ECM - Basic** tab
   – **Engine Temperature**
5. Look for the engine temperature indication.

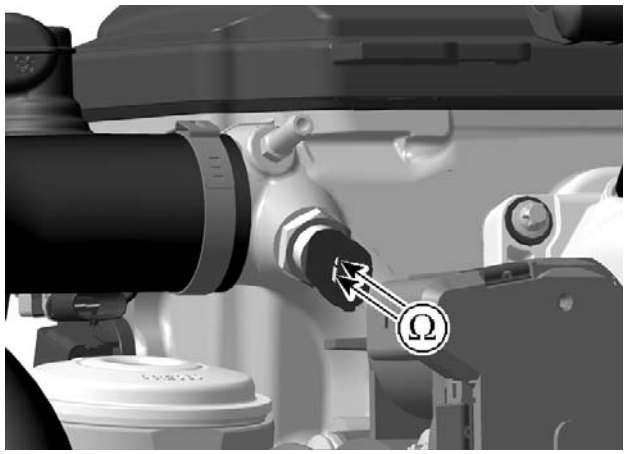
The engine temperature gauge in BUDS2 should provide an indication of the actual engine coolant temperature. Otherwise, test the *CTS RESISTANCE*.

Testing the CTS Resistance

1. Remove parts required to access ECM connectors.
2. Disconnect ECM-A connector from the ECM and install it on the ECM adapter tool.
3. Set the multimeter to Ω.
4. Check the CTS circuit resistance as per table.

CTS RESISTANCE TEST		
ECM ADAPTER PIN		SPECIFICATION
A-A1	A-J2	Refer to *CTS TEMPERATURE SENSOR TABLE*

5. If resistance test is good, replace the ECM.
6. If resistance is out of specification, proceed with the following steps.
7. Remove the parts required to access the CTS.
8. Disconnect the CTS connector.
9. Check continuity of wiring between ECM and CTS connector, refer to *WIRING DIAGRAM*. If there is an open circuit, repair or replace wiring and connectors.
10. If continuity of wiring is good, test the resistance of the sensor as per following tables.



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CTS RESISTANCE TEST		
CTS SENSOR PIN		SPECIFICATION
1	2	Refer to *CTS TEMPERATURE SENSOR TABLE*

CTS TEMPERATURE SENSOR TABLE			
TEMPERATURE		**RESISTANCE (OHMS)**	
°C	°F	LOW	HIGH
- 40	- 40	38457	52630
- 10	14	8208	10656
20	68	2233	2780
80	176	297	349
120	248	105	122

NOTE: To test sensor at various temperatures, remove sensor and use a heat gun, ice and a thermometer. Refer to *REPLACING THE CTS*.

11. If the resistance value measured is as specified, repair the connectors or replace the wiring harness between ECM connector and CTS connector.
12. If the resistance value is not within specification replace CTS.

Replacing the CTS

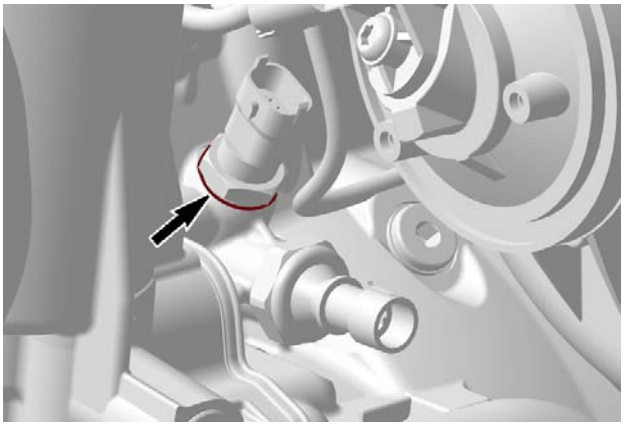
1. Drain engine coolant to below CTS level, refer to *COOLING SYSTEM - VEHICLE COMPONENTS* subsection.
2. Cut locking tie on wiring harness and move wiring aside for access. Be sure to take note of their position.
3. Disconnect CTS connector and remove CTS.
4. Install the new CTS and tighten to specification.

TIGHTENING TORQUE	
Coolant temperature switch	17 N•m ± 2 N•m (150 lbf•**in** ± 18 lbf•**in**)

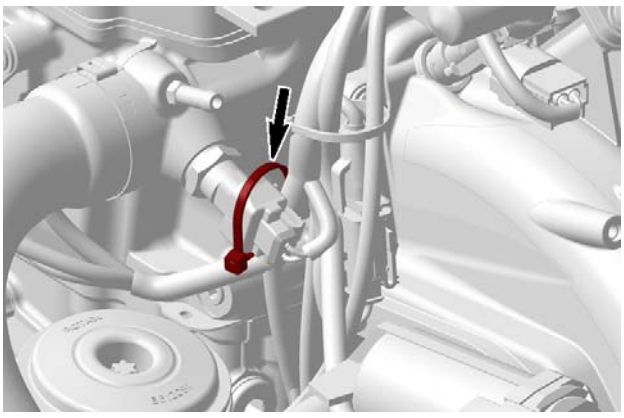
5. Apply sealant around CTS as defined in the illustration.

NOTE: Gasket ring of OTS must be coated completely.

SERVICE PRODUCT
BLACK NEOPRENE PAINT (P/N 909570)

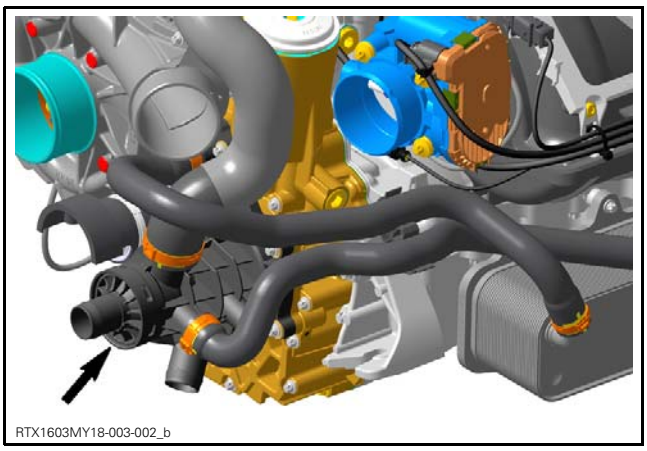

RTX20_1630-010-007_a

6. Secure wiring harness to CTS.


RTX20_1630-010-008_a

7. Reinstall remaining removed parts.
8. Refill and bleed the cooling system, refer to *COOLING SYSTEM - VEHICLE COMPONENTS* subsection.
9. Reinstall remaining removed parts.

WATER PUMP HOUSING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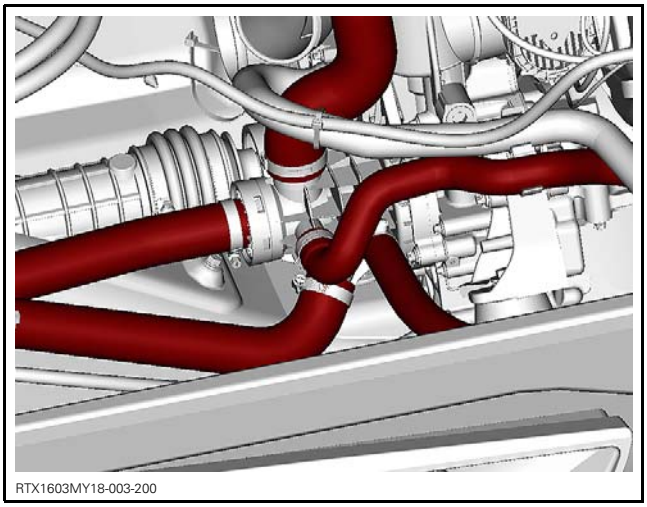
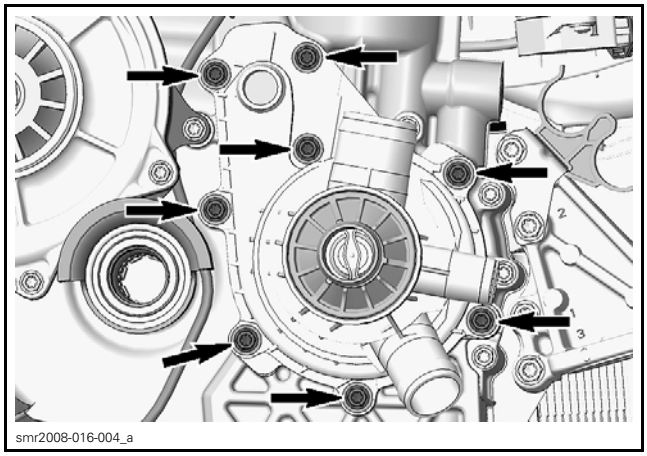
Removing the Water Pump Housing

IMPORTANT: The water pump housing can be removed with the engine installed in the vehicle.

1. Drain cooling system. Refer to *COOLING SYSTEM - VEHICLE COMPONENTS* subsection.
2. Disconnect all hoses from water pump housing.


RTX1603MY18-003-200

3. Remove water pump housing screws.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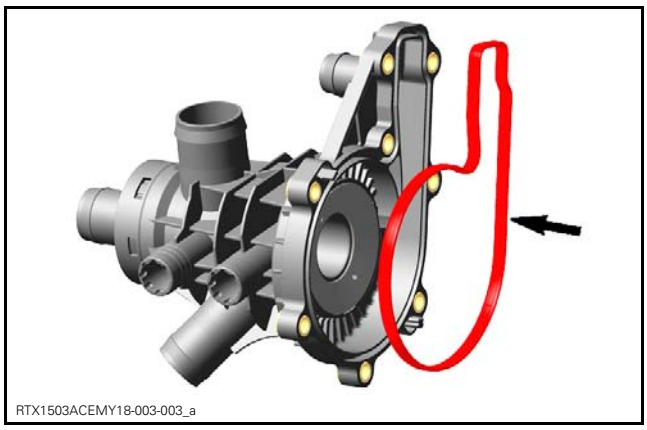
TYPICAL

4. Pull the water pump housing to remove it.

Inspecting the Water Pump Housing

1. Check if gasket is brittle, hard or damaged and replace as necessary.


RTX1503ACEMY18-003-003_a

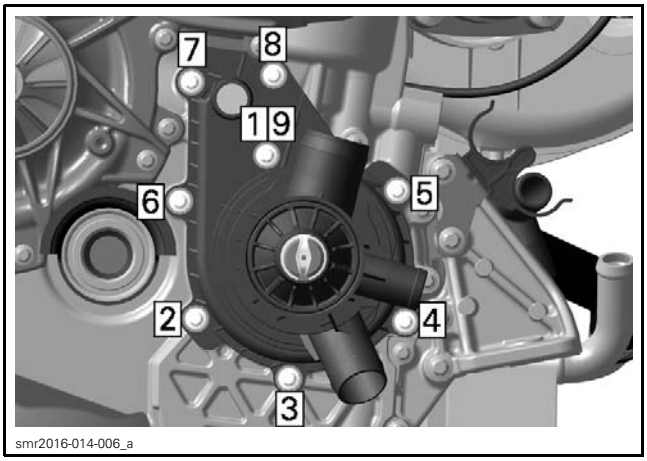
2. Check if thermostat is in good condition. Refer to *THERMOSTAT* in this subsection.

Installing the Water Pump Housing

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

NOTICE Take care that the gaskets are exactly in groove when reinstalling the water pump housing.

1. Apply threadlocker to the water pump housing screw threads.
2. Tighten screws to specification using the following sequence.



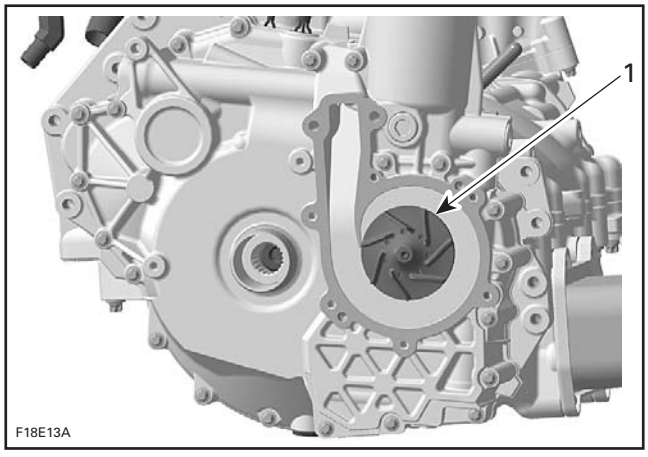
TIGHTENING SEQUENCE

TIGHTENING TORQUE	
Water pump housing screws	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)

WATER PUMP IMPELLER

Removing the Water Pump Impeller

1. Remove the *WATER PUMP HOUSING*. Refer to procedure in this subsection.
2. Unscrew the impeller clockwise.



1. Impeller

NOTICE Coolant/ oil pump shaft and impeller have left-hand threads.

Inspecting the Water Pump Impeller

1. Check impeller for cracks or other damage. Replace impeller if damaged.

Installing the Water Pump Impeller

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

NOTICE Be careful not to damage impeller wings during installation.

1. Tighten the impeller to specification.

TIGHTENING TORQUE	
Water pump impeller (left hand threads)	3 N•m ± 0.4 N•m (27 lbf•**in** ± 4 lbf•**in**)

THERMOSTAT

The thermostat is a single action type.

Removing the Thermostat

1. Remove the *WATER PUMP HOUSING*. Refer to procedure in this subsection.
2. Remove the thermostat.

Testing the Thermostat

1. To check the operation of the thermostat, put it in water and heat water.
2. Look inside the cylinder head return hose connection to see the movement of the thermostat.

THERMOSTAT OPENING TEMPERATURE	
Water pump housing thermostat	80°C (176°F)

3. If there is no operation, replace the thermostat with its housing.

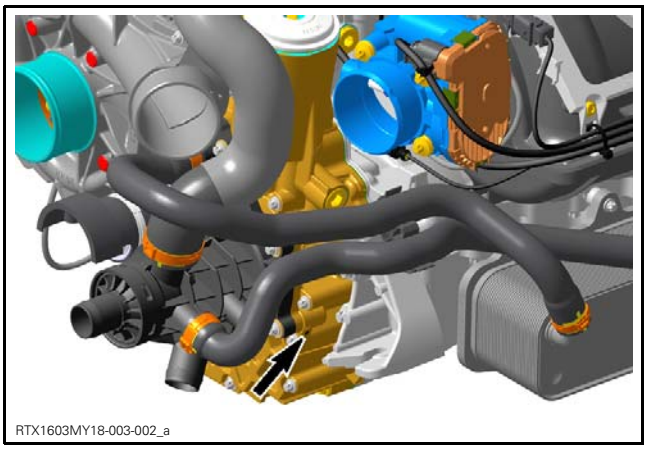
Installing the Thermostat

Refer to *WATER PUMP HOUSING* in this subsection.

ROTARY SEAL

Inspecting the Rotary Seal

1. Check leak indicator hole for oil or coolant leak:
   – Leaking coolant indicates a defective rotary seal
   – Leaking oil indicates a faulty oil seal.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2. Rotary seal and oil seal must be replaced together.

Replacing the Rotary Seal

Refer to *LUBRICATION SYSTEM* subsection.

PTO HOUSING, MAGNETO AND STARTER

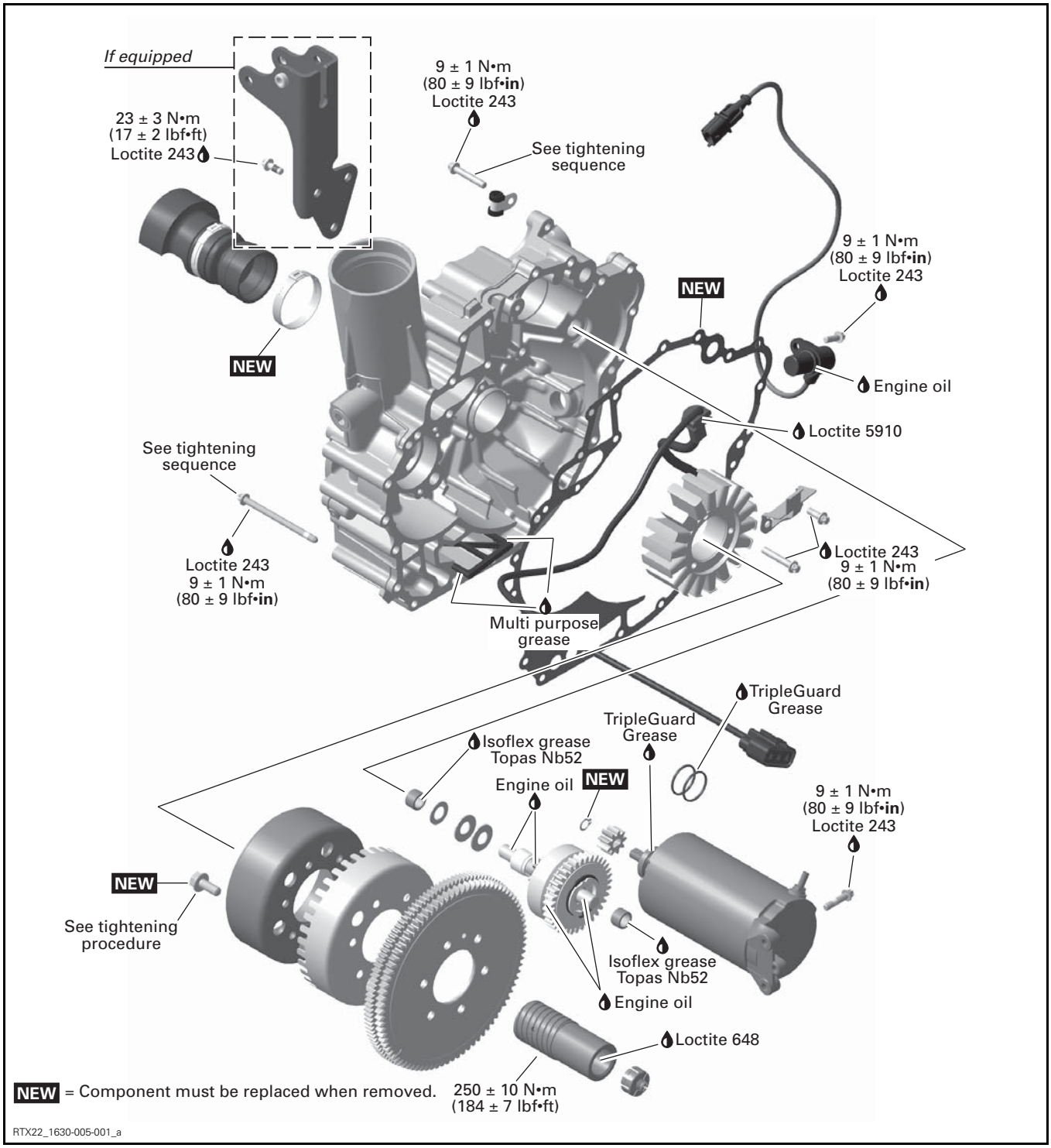
SERVICE TOOLS

Description	Part Number	Page
CRANKSHAFT LOCKING TOOL	529 036 553	69
HANDLE	420 877 650	78
IDF BEARING PUSHER	529 036 526	67
IMPELLER REMOVER/INSTALLER	529 035 820	70, 73
OETIKER PLIER	295 000 070	72
PTO SLEEVE REMOVER/INSTALLER	529 036 554	69–70, 73
STARTER DRIVE SEAL PUSHER	420 876 502	78
SUCTION PUMP	529 035 880	64

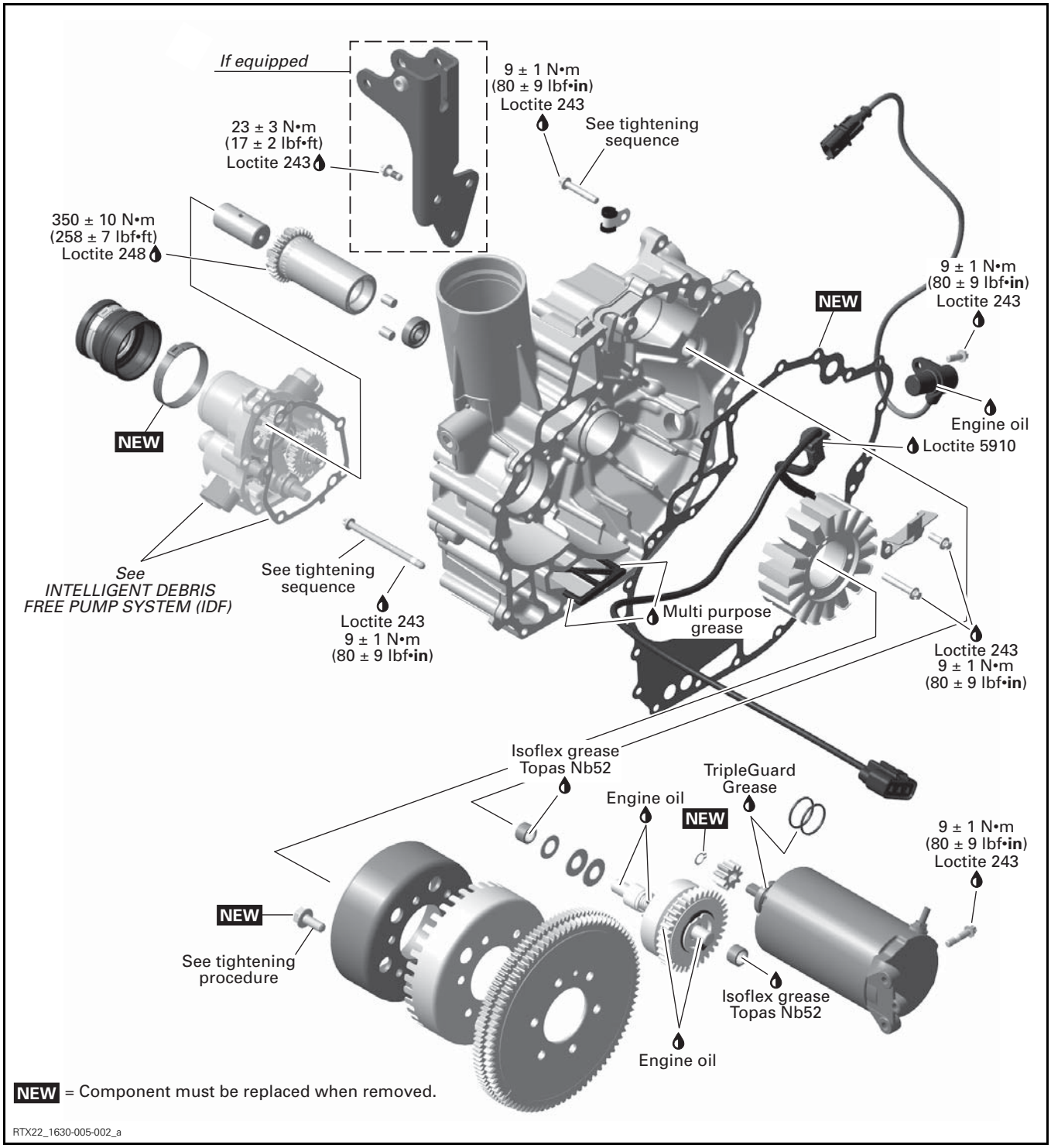
SERVICE PRODUCTS

Description	Part Number	Page
CLUTCH AND PULLEY FLANGE CLEANER PRO S1	779244	67, 70, 73
DIELECTRIC GREASE	293 550 004	81
ISOFLEX GREASE TOPAS NB 52	293 550 021	78
LOCTITE 243 (BLUE)	293 800 060	64, 68–69, 74–75, 81
LOCTITE 248	296 000 443	70
LOCTITE 5910	293 800 081	67
LOCTITE 648 (GREEN)	413 711 400	73
SYNTHETIC GREASE	779162	80

Engine without iDF



Engine with iDF



GENERAL

It is good practice to check for fault codes using the BRP diagnostic software (BUDS2) as a first troubleshooting step. Refer to the *DIAGNOSTIC AND FAULT CODES* subsection.

Always carry out electrical tests on components before removing or installing them.

PROCEDURES

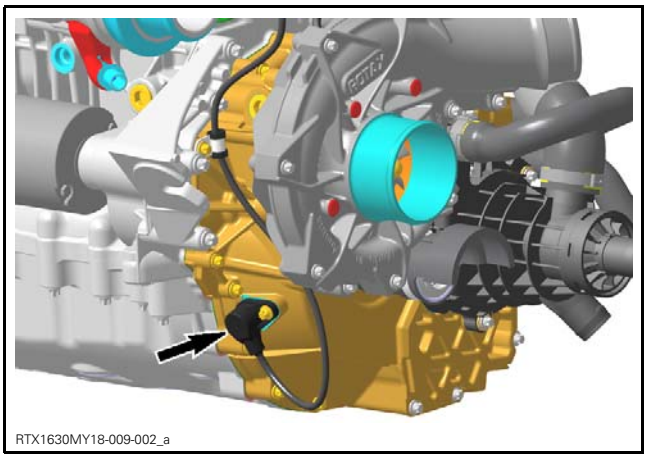
CRANKSHAFT POSITION SENSOR (CPS)

Troubleshooting the CPS

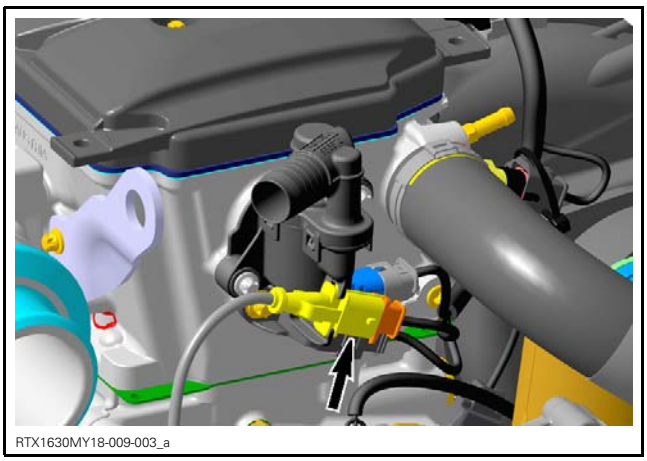
Take into account that a CPS fault can be triggered by electronic or mechanical fault:

1. Check for fault codes
2. Test the CPS as per following procedure
3. If it tests good, check trigger wheel teeth condition. Refer to procedure in this subsection.

CPS and CPS Connector Location


RTX1630MY18-009-002_a

TYPICAL -CRANKSHAFT POSITION SENSOR (CPS)

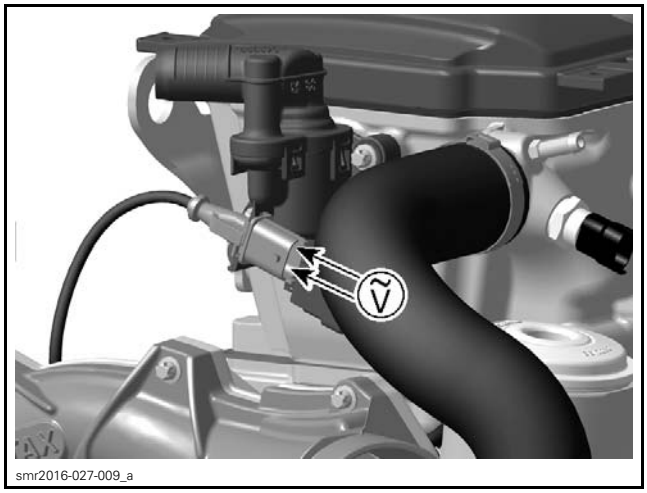

RTX1630MY18-009-003_a

TYPICAL - CPS CONNECTOR - SUPERCHARGER REMOVED FOR CLARITY

Testing the CPS Voltage

1. Disconnect CPS wiring harness connector.
2. Press the START button to wake up the ECM.
3. Install the tether cord on the engine cut-off switch.
4. Pull the throttle lever completely in to the handlebar and hold (drowned mode).
5. While cranking the engine, probe CPS terminals.

CPS OUTPUT VOLTAGE TEST		
CPS CONNECTOR PIN		SPECIFICATION
1	2	3.7 Vac



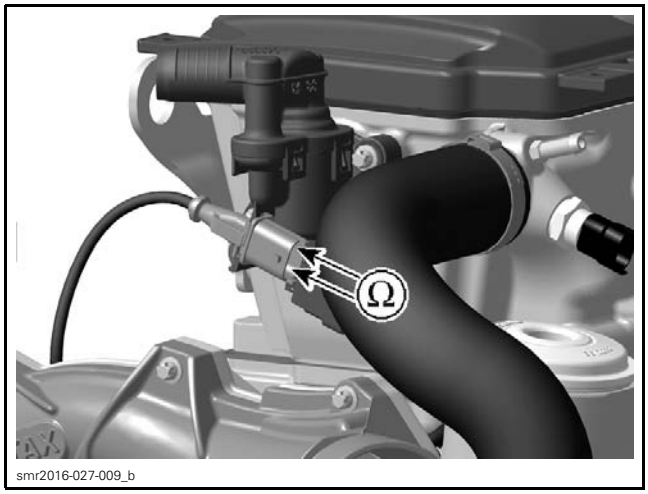
smr2016-027-009_a

6. If voltage is not as specified, carry out *TESTING THE CPS RESISTANCE AT CPS CONNECTOR*.
7. If voltage is as specified, check continuity of wiring between CPS connector and ECM connector. Refer to *TESTING THE CPS RESISTANCE AT ECM CONNECTOR*.

Testing the CPS Resistance at CPS Connector

1. Probe CPS connector terminals as per following table.

CPS RESISTANCE TEST		
CPS CONNECTOR PIN		SPECIFICATION @ 20°C (68°F)
1	2	775 - 950 Ω



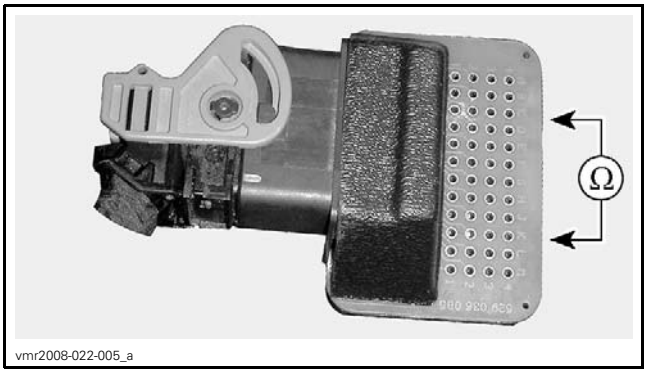
smr2016-027-009_b

2. If resistance is not within specifications, replace the CPS.
3. If resistance tests good carry out *TESTING THE CPS RESISTANCE AT ECM CONNECTOR*.

Testing the CPS Resistance at ECM Connector

1. Remove parts required to access ECM-A connector.
2. Disconnect the ECM-A connector from the ECM and install it on the ECM adapter tool.
3. Set the multimeter to Ω.
4. Probe CPS terminals as per following table.

CPS RESISTANCE TEST		
ECM ADAPTER PIN		SPECIFICATION @ 20°C (68°F)
A-H1	A-K2	775 - 950 Ω



vmr2008-022-005_a

5. If resistance measured is as specified, check ECM. Refer to *ENGINE CONTROL MODULE* subsection.
6. If resistance measured is not as specified, repair or replace wiring and connectors between ECM and the CPS.

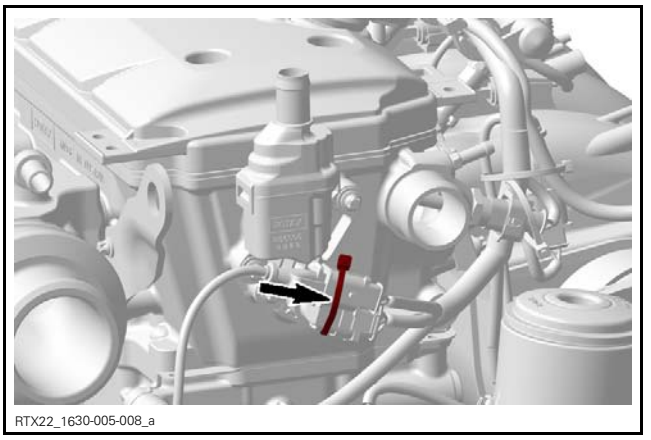
Replacing the CPS

1. Drain oil from PTO housing. Refer to procedure in this subsection.

NOTE: It is not necessary to drain oil from engine.

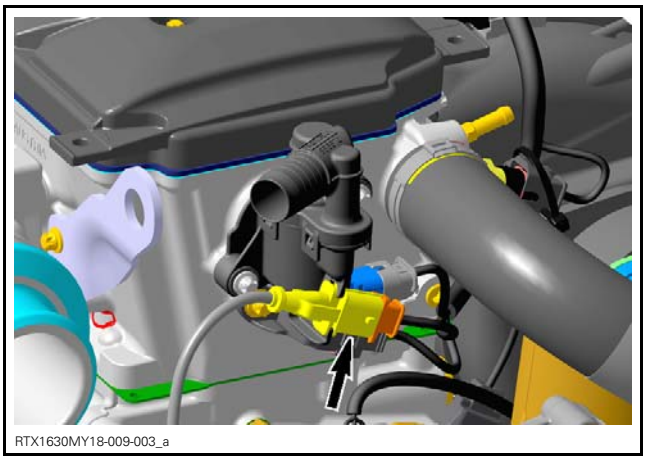
Engine without TOPS

2. Cut locking tie securing the CPS connector.

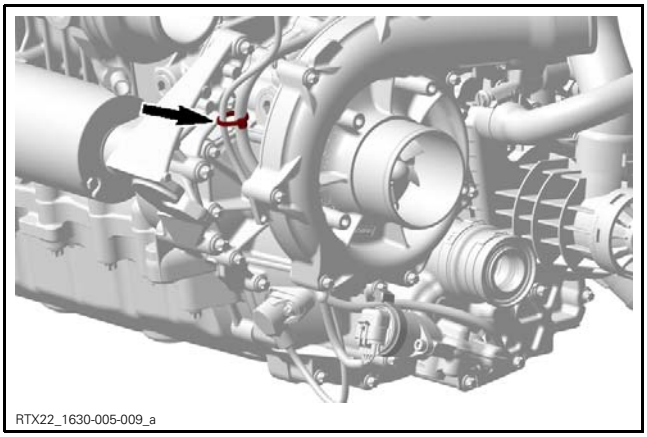

RTX22_1630-005-008_a

All Engines

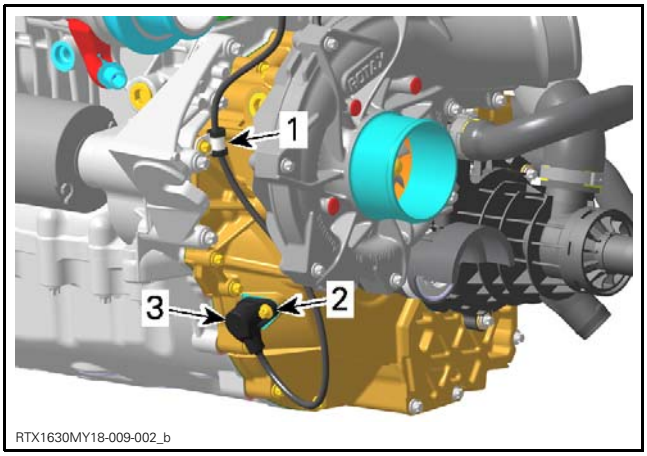
3. Disconnect CPS connector.


RTX1630MY18-009-003_a

TYPICAL - SUPERCHARGER REMOVED FOR CLARITY


RTX22_1630-005-009_a

4. Remove CPS harness retaining clamp.
5. Remove CPS retaining screw.



RTX1630MY18-009-002_b

TYPICAL
1. *CPS harness retaining clamp*
2. *CPS retaining screw*
3. *CPS*

6. Pull out CPS.
7. Install the new CPS.
8. Apply a drop of threadlocker on threads of the CPS screw.

SERVICE PRODUCT
LOCTITE 243 (BLUE) (P/N 293 800 060)

9. Tighten CPS retaining screw to specification.

TIGHTENING TORQUE	
CPS retaining screw	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**)

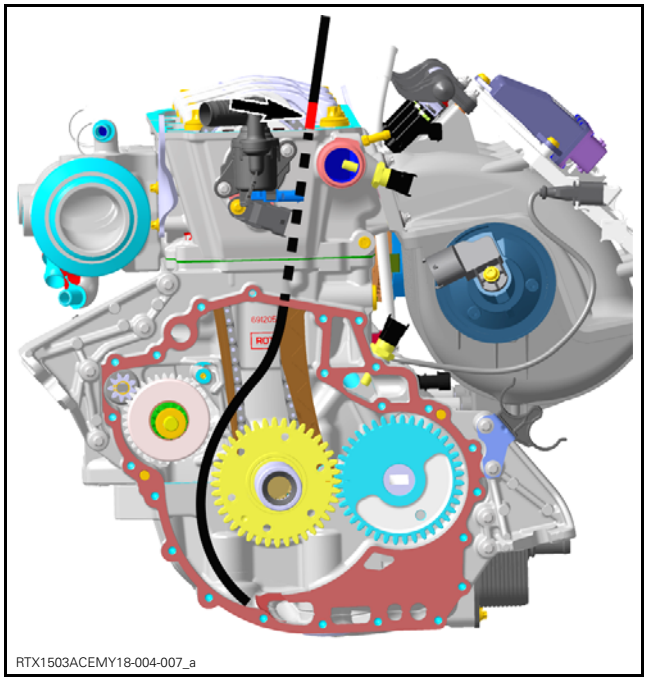
10. Reinstall CPS harness retaining clamp and connect the connector.
11. Refill engine oil and check oil level.

PTO HOUSING

Removing the PTO Housing

1. Remove the engine from the vehicle.
2. Syphon engine oil through oil dipstick tube.
3. Remove the supercharger (if applicable).
4. Remove the valve cover.
5. Syphon remaining oil out of the lower timing chain case:
   - 5.1 Put some electrical tape on suction pump hose at 450 mm (17.72 in) from its end.
   - 5.2 Insert the suction pump hose in the lower area of the timing chain until the tape flushes with the edge of the cylinder head.

REQUIRED TOOL	
SUCTION PUMP (P/N 529 035 880)	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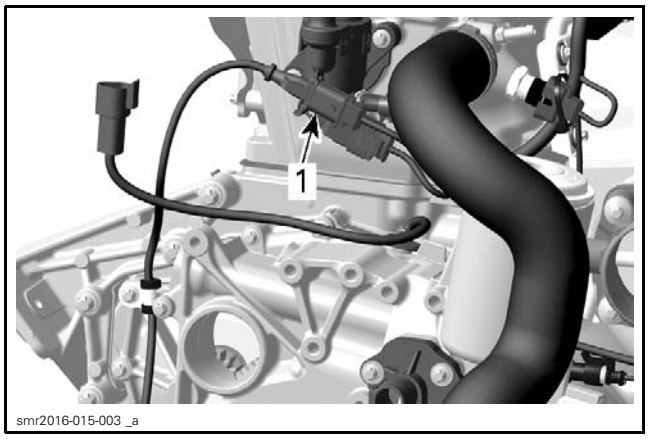
6. Disconnect CPS connector from wiring harness.



1. CPS connector

7. Disconnect the stator connector.

Engine with iDF

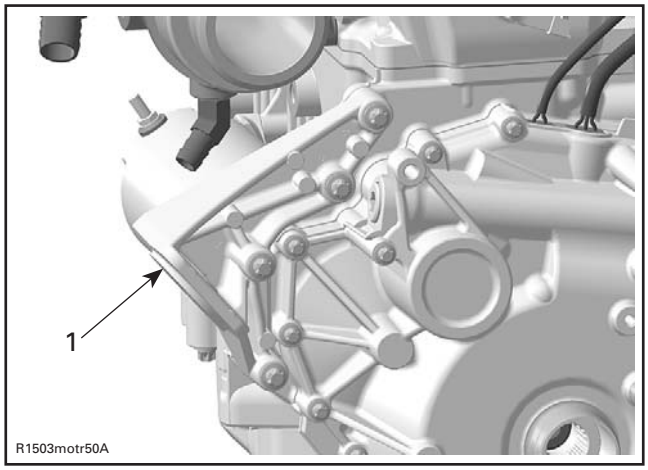
8. Remove iDF gearbox.

All Engines

9. Place rags under PTO housing to prevent oil spillage.

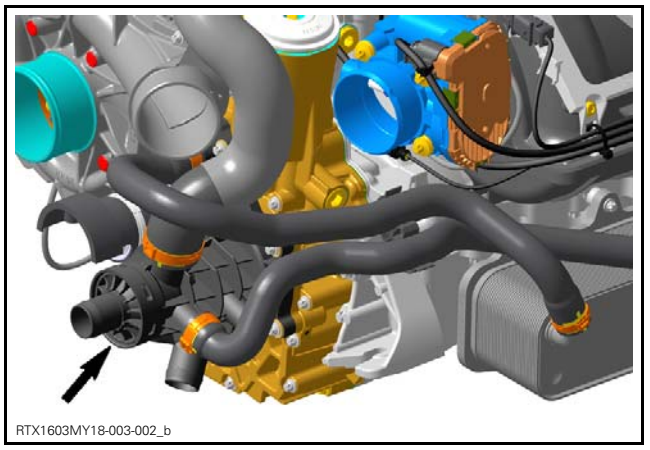
NOTE: Up to 250 ml (8 U.S. oz) of oil could flow out when removing PTO housing.

10. Remove LH rear engine support.



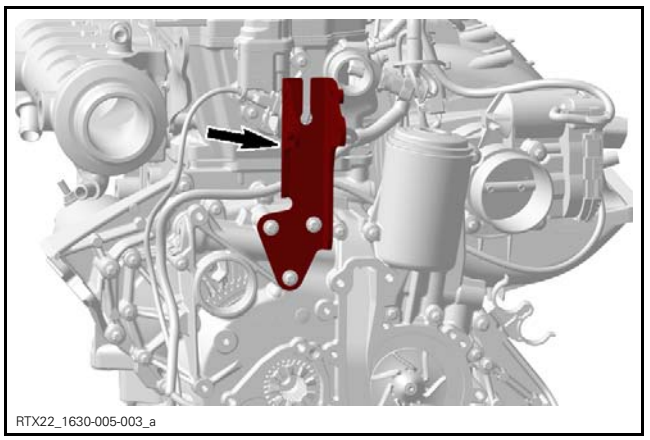
1. Engine support

11. Remove water pump housing.



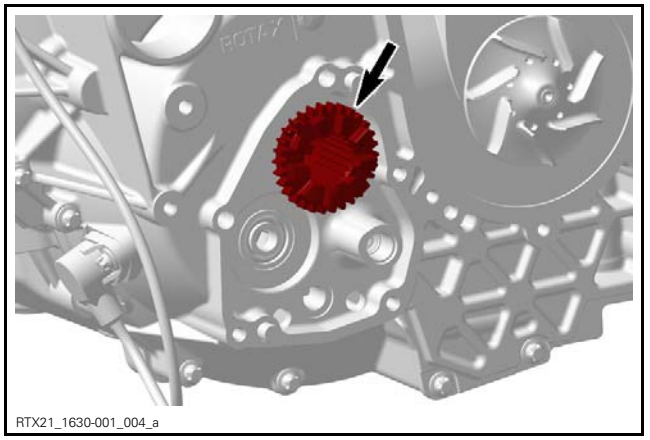
Engine with CATALYST

12. If necessary remove catalyst support.



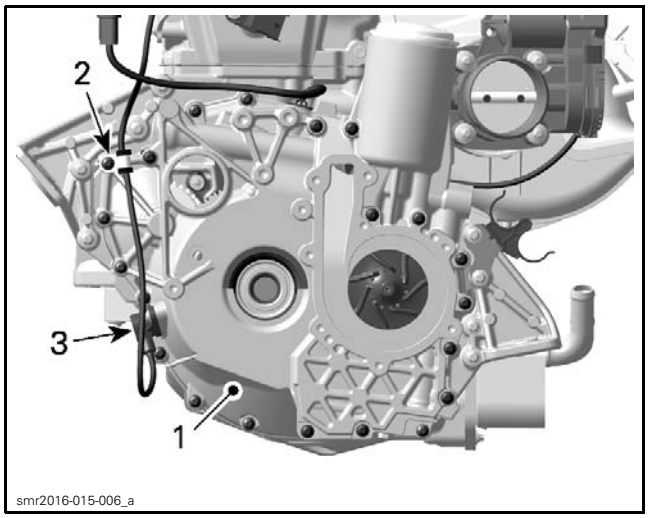
Engine with iDF

13. Remove input shaft, refer to procedure in this subsection.



All Engines

14. Remove PTO housing retaining screws and CPS harness retaining clamp.

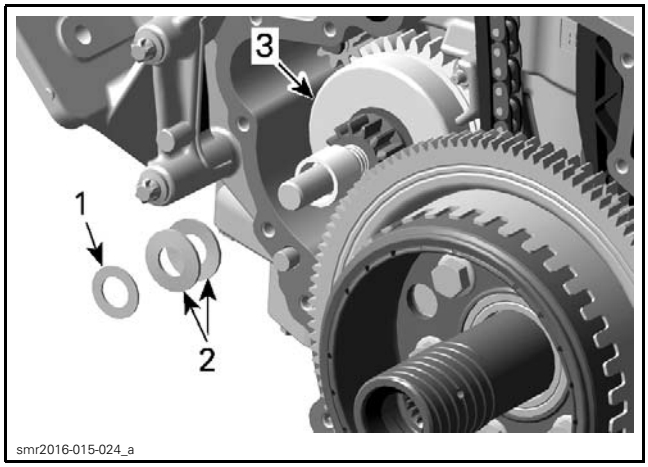


1. PTO housing
2. CPS harness retaining clamp
3. CPS

15. Pry off PTO housing from engine using two flat screwdrivers.

NOTICE Avoid scoring or damaging contact surfaces.

NOTICE Be careful not to lose the disc springs and thrust washer located on the starter drive shaft.

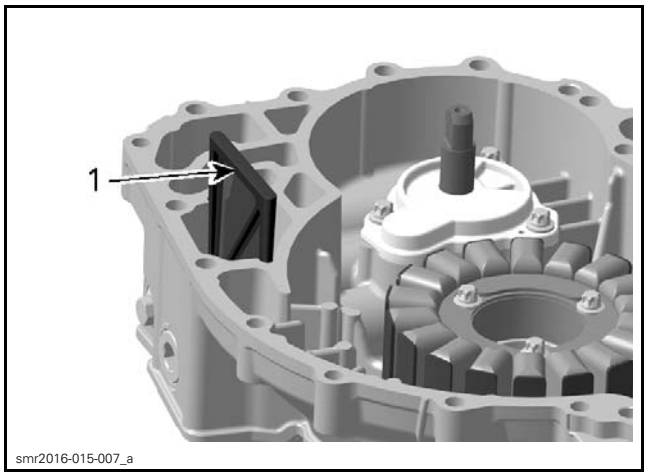


1. Thrust washer
2. Disc springs
3. Starter drive

16. Remove PTO housing gasket and discard it.
17. If necessary remove following parts from PTO housing:
    - Stator
    - Oil filter
    - Oil pressure pump
    - Engine oil pressure regulator
    - Crankshaft position sensor (CPS).

Inspecting the PTO Housing

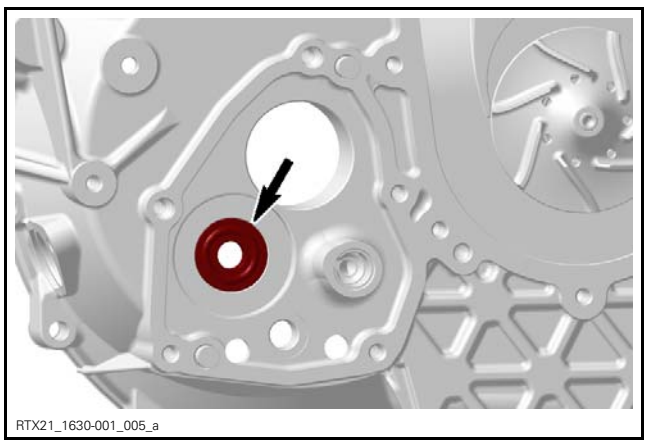
1. Inspect PTO housing for cracks or any other damages. Replace if necessary.
2. Inspect starter drive needle bearing in the PTO housing.
3. Clean all disassembled metal components in a non-ferrous metal cleaner.
4. Inspect oil strainer for contaminants, debris or other particles. Clean as required.



1. PTO oil strainer

Engine with iDF

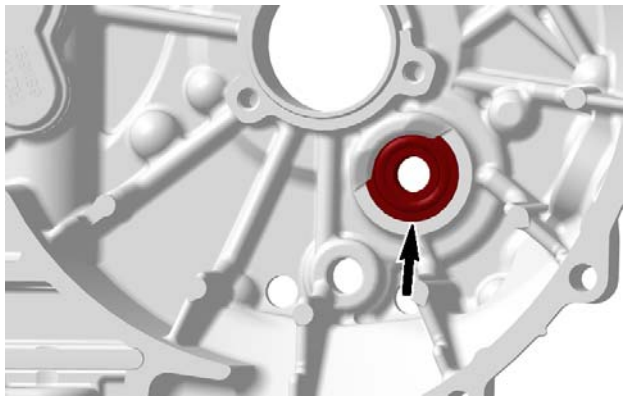
5. Check ball bearings for contamination and/or metal shavings.
6. Check iDF gearbox ball bearing for smooth operation, excessive play and/or pitting. Replace if necessary.



Replacing the iDF Gearbox Ball Bearing

1. Remove stator, refer to procedure in this subsection.
2. Press ball bearing from inside out and discard it.

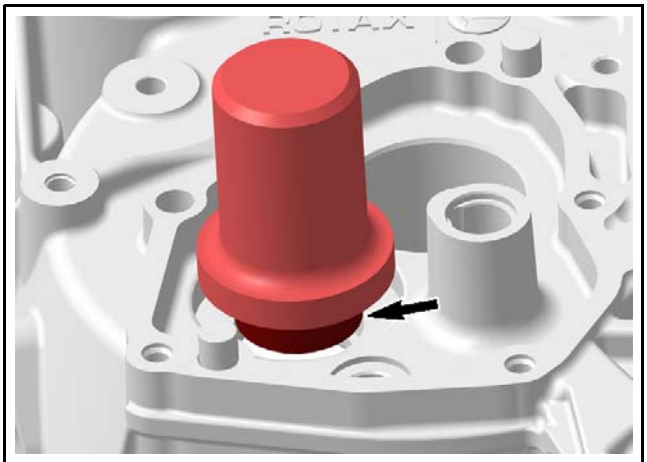
NOTICE Support PTO housing properly to avoid damages.


RTX21_1630-001_006_a

3. Install **NEW** ball bearing on block.

NOTICE To avoid damages on the PTO cover the recommended service tool must be used.

REQUIRED TOOL	
IDF BEARING PUSHER (P/N 529 036 526)	


RTX21_1630-001_007_a

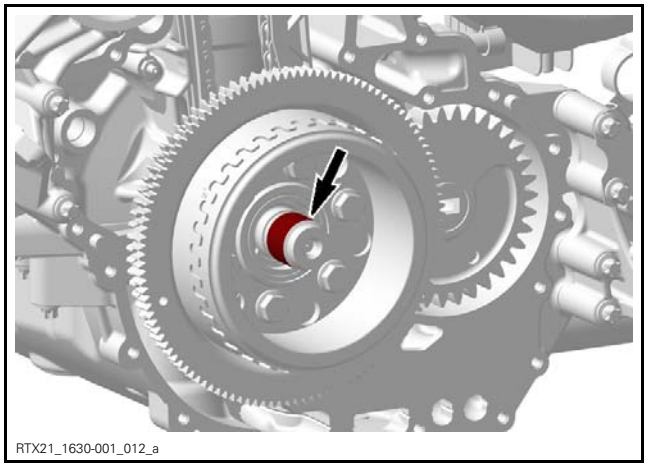
Installing the PTO Housing

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

Engine with iDF

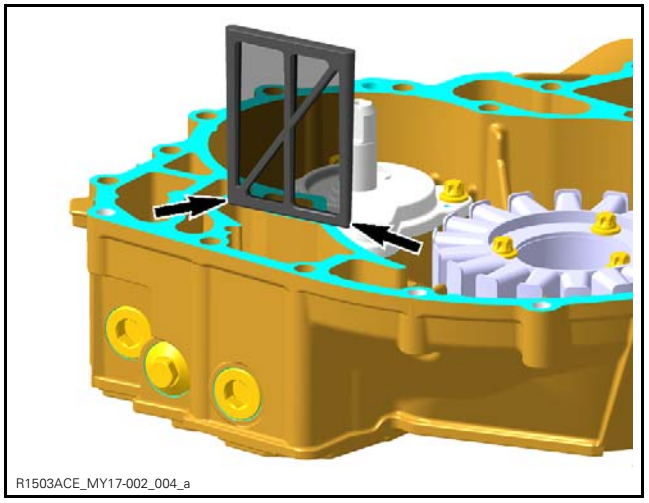
1. Clean thread on crankshaft.

SERVICE PRODUCT
CLUTCH AND PULLEY FLANGE CLEANER PRO S1 (P/N 779244)


RTX21_1630-001_012_a

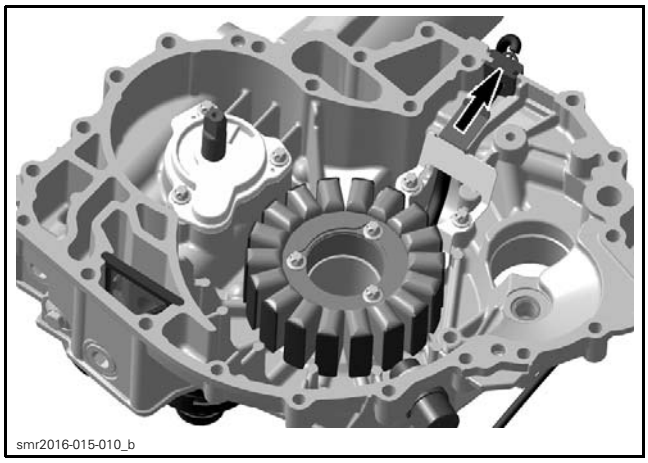
All Engines

2. Install disc springs and thrust washer of starter drive.
3. Install a **NEW** PTO housing gasket.
4. Apply a small amount of grease on the frame of the oil strainer to keep it in place while installing the PTO cover.


R1503ACE_MY17-002_004_a

5. Clean stator cable grommet and cylinder block to remove all remaining silicone residues in oil strainer area.
6. Apply sealing compound on stator cable grommet.

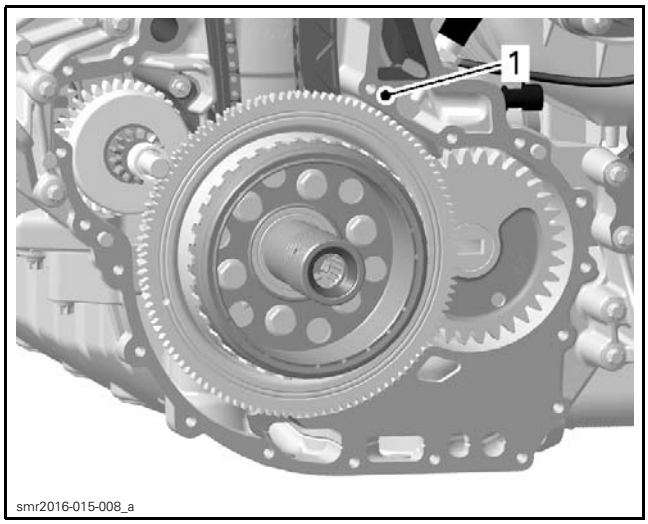
SERVICE PRODUCT
LOCTITE 5910 (P/N 293 800 081)



APPLY SEALING COMPOUND HERE

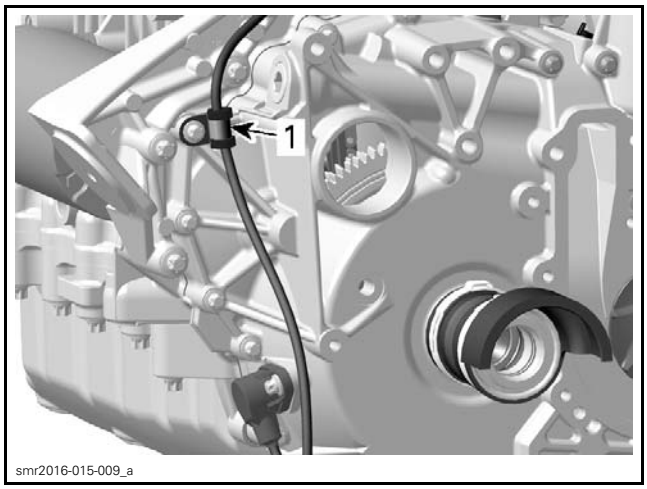
7. Install PTO housing.

NOTICE During installation ensure:
- that thrust washer and spring discs are placed on starter drive shaft
- oil/water pump shaft alignment with balance shaft (rotate shaft slightly)
- starter drive gear alignment with the needle bearing
- proper PTO housing gasket alignment.



1. *Pay attention that gasket remains properly positioned on this surface*

8. Install the CPS harness retaining clamp (if equipped).



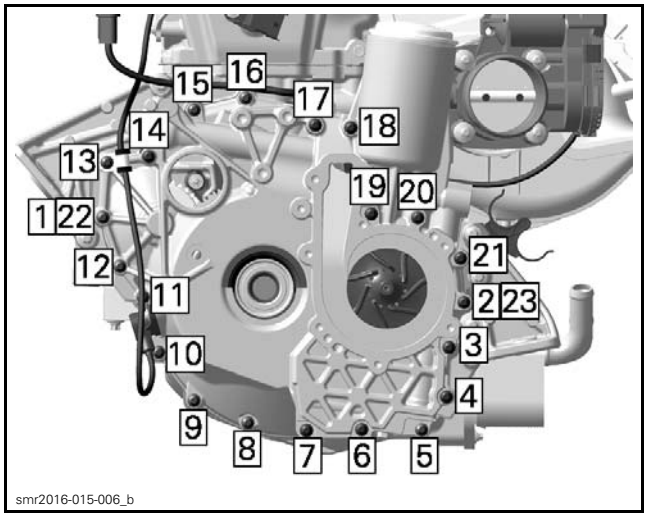
1. *CPS harness retaining clamp*

9. Apply a drop of threadlocker on threads of the PTO screws.

SERVICE PRODUCT
LOCTITE 243 (BLUE) (P/N 293 800 060)

10. Tighten PTO housing screws as per following sequence.

TIGHTENING TORQUE	
PTO housing screws	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**)



TIGHTENING SEQUENCE

11. Apply a drop of threadlocker on threads of the engine support screws.

SERVICE PRODUCT
LOCTITE 243 (BLUE) (P/N 293 800 060)

12. Reinstall LH engine support as per following table.

TIGHTENING TORQUE	
Engine support screws	23 N•m ± 3 N•m (17 lbf•ft ± 2 lbf•ft)

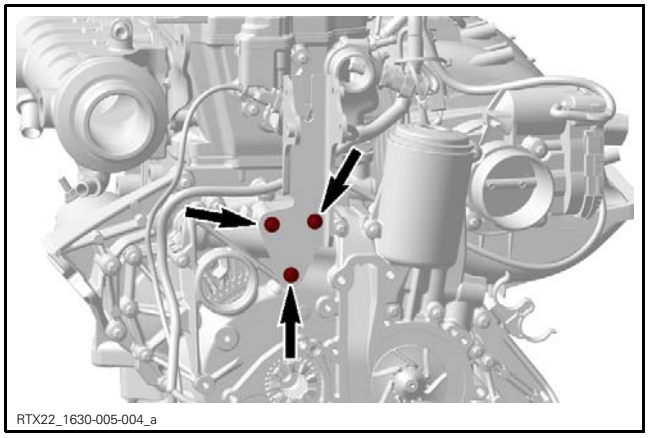
Engine with CATALYST

13. Apply a drop of threadlocker on threads of the catalyst support screws.

SERVICE PRODUCT
LOCTITE 243 (BLUE) (P/N 293 800 060)

14. If removed install catalyst support and tighten retaining screws to specification.

TIGHTENING TORQUE	
Catalyst support retaining screws	23 N•m ± 3 N•m (17 lbf•ft ± 2 lbf•ft)


RTX22_1630-005-004_a

All Engines

15. Carry out an engine alignment.

NOTICE An engine alignment procedure must be carried, otherwise severe component damage may occur.

16. Install all remaining parts, reconnect hoses and electrical connectors. Refer to applicable subsections for procedures.
17. Refill engine oil and coolant.

INPUT SHAFT (ENGINE WITH IDF)

Removing the Input Shaft

1. Remove the iDF gearbox.
2. Lock the crankshaft.

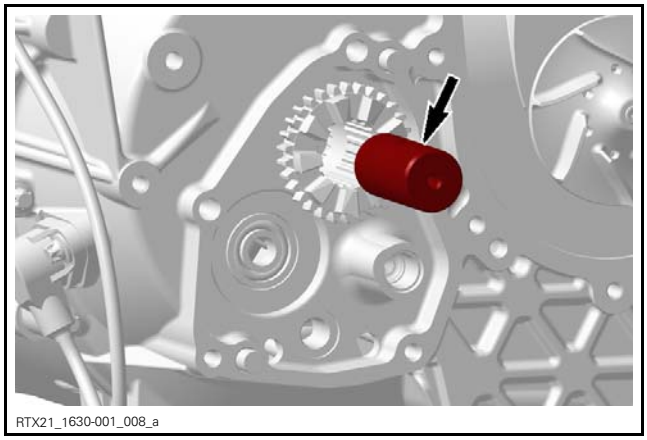
NOTICE Ensure to use reinforced crankshaft locking bolt.

REQUIRED TOOL	
CRANKSHAFT LOCKING TOOL (P/N 529 036 553)	

NOTICE Strictly adhere to the tightening torque. A hand tighten locking tool could cause damage to the cylinder block during the input shaft removal.

TIGHTENING TORQUE	
Crankshaft locking tool	20 N•m ± 2 N•m (15 lbf•ft ± 1 lbf•ft)

3. Remove spacer from input shaft using a M5 screw.


RTX21_1630-001_008_a

4. Unscrew input shaft from crankshaft.

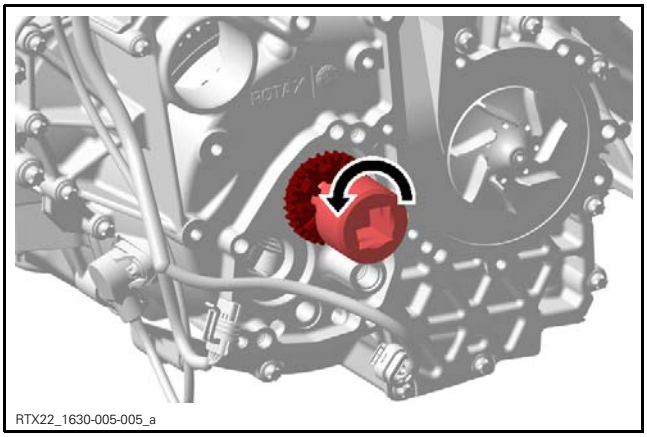
NOTICE Breakaway torque can be very high. Use reinforced service tool as indicated only.

NOTICE BRP does NOT recommend the use of an impact tool to remove the input shaft.

REQUIRED TOOL	
PTO SLEEVE REMOVER/INSTALLER (P/N 529 036 554)	

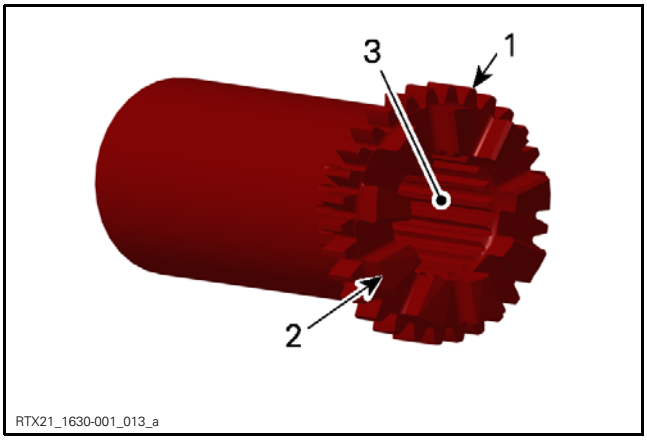
NOTE: The use of a torque multiplier can ease the input shaft removal.

NOTICE If a high breakaway torque requires the use of a torque multiplier or a breaker bar extension, it is recommended to remove the engine from the vehicle to prevent engine mount or hull damage and/or engine misalignment.


RTX22_1630-005-005_a

Inspecting the Input Shaft

1. Check the following when inspecting the input shaft:
   – Gear teeth for damage and wear
   – Rounded edges of engagement dogs
   – Worn or damaged inner splines.



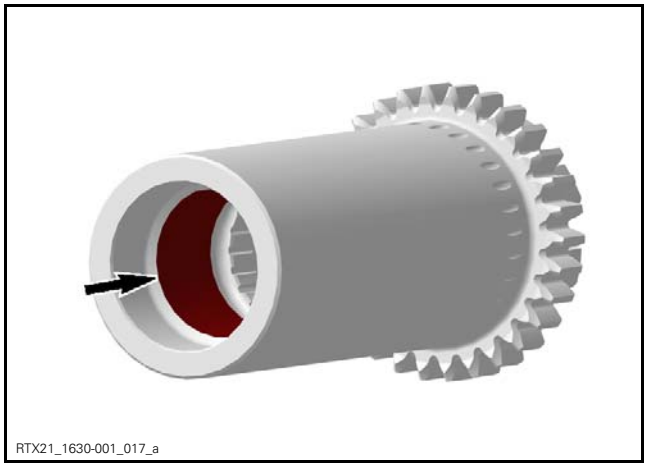
RTX21_1630-001_013_a

1. Reverse drive gear
2. Engagement dogs
3. Inner splines

Installing the Input Shaft

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

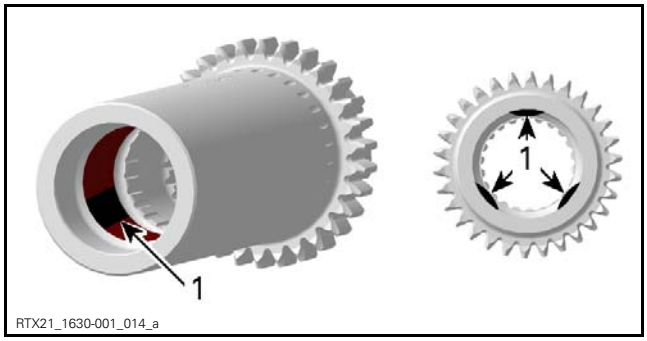
1. Clean thread inside input shaft.


RTX21_1630-001_017_a

SERVICE PRODUCT
CLUTCH AND PULLEY FLANGE CLEANER PRO S1 (P/N 779244)

2. Apply threadlocker on inner thread.

SERVICE PRODUCT
LOCTITE 248 (P/N 296 000 443)



RTX21_1630-001_014_a

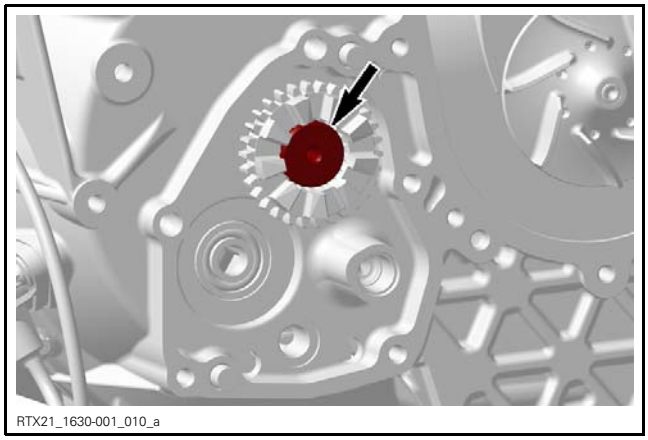
1. Apply 3 beads of threadlocker

3. Tighten input shaft to specification using one of these tools.

REQUIRED TOOL	
IMPELLER REMOVER/INSTALLER (P/N 529 035 820)	
PTO SLEEVE REMOVER/INSTALLER (P/N 529 036 554)	

TIGHTENING TORQUE	
PTO coupling	350 N•m ± 10 N•m (258 lbf•ft ± 7 lbf•ft)

4. Install spacer in input shaft.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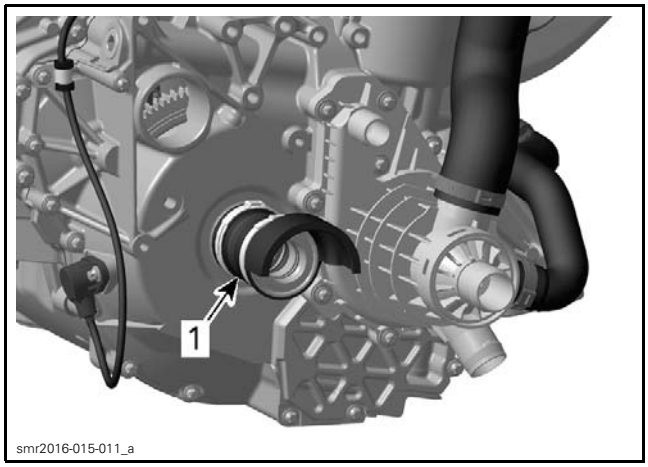
PTO SEAL

PTO Seal Location

The PTO seal is located over the PTO coupling.

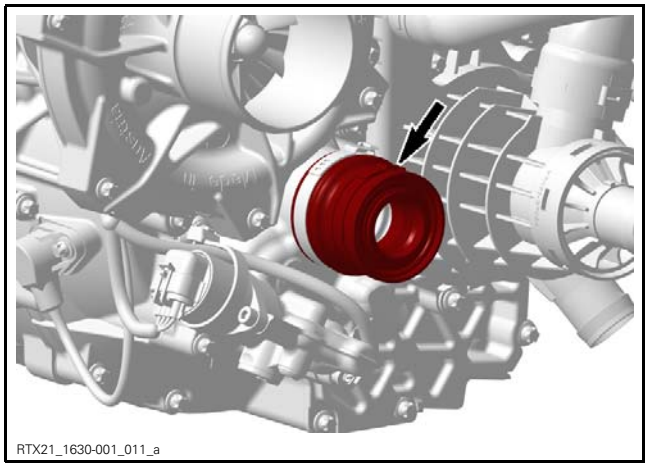
Engine without iDF



smr2016-015-011_a

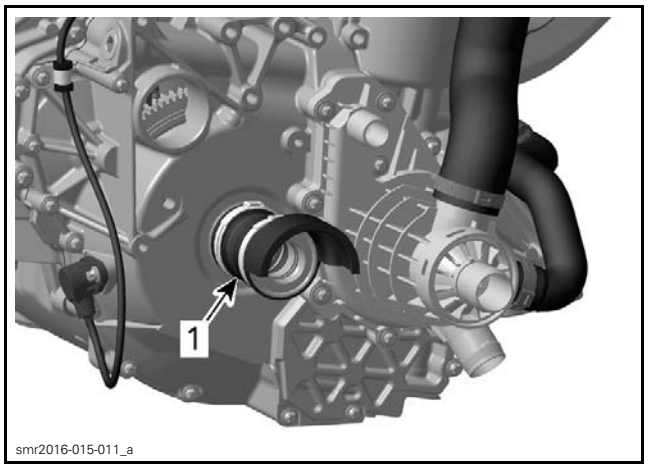
TYPICAL
1. PTO seal

Engine with iDF


RTX21_1630-001_011_a

Inspecting the PTO Seal

1. Inspect the PTO seal. If brittle, hard, damaged or leaking, replace it.
2. Inspect ball bearing within PTO seal for excessive play and smooth operation.
3. Replace PTO seal if oil seal or ball bearing is damaged.



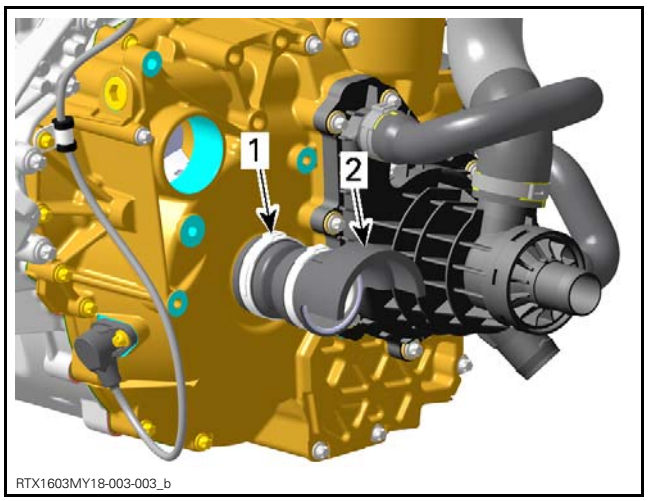
smr2016-015-011_a

TYPICAL
1. PTO seal

Removing the PTO Seal

1. Remove drive shaft.
2. Remove supercharger (if applicable).
3. Remove the Oetiker clamp retaining the seal.

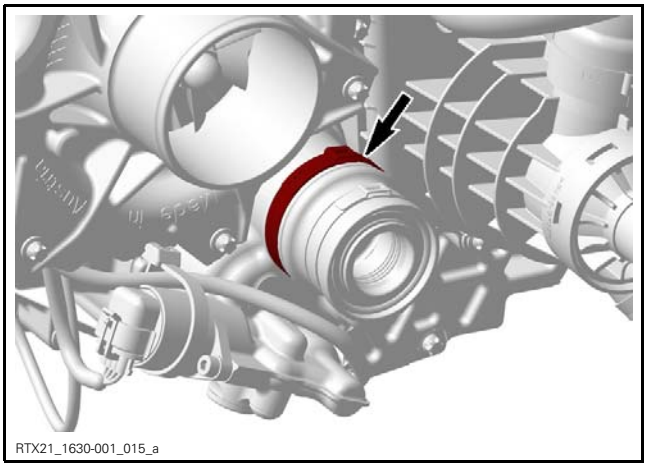
Engine without iDF



RTX1603MY18-003-003_b

TYPICAL
1. Oetiker clamp
2. PTO seal

Engine with iDF


RTX21_1630-001_015_a

All Engines

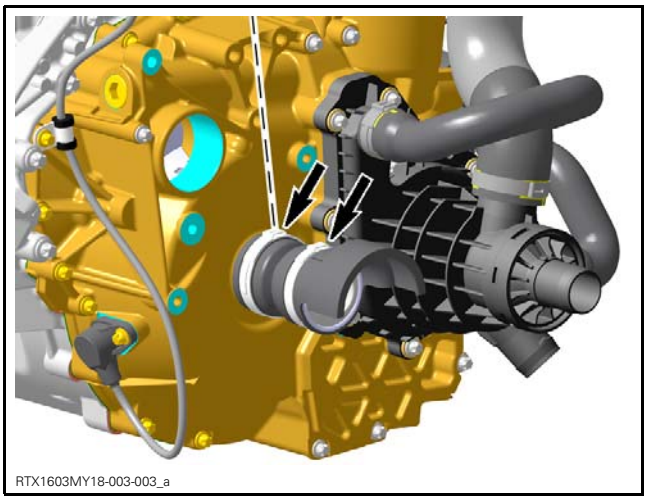
4. Pull off PTO seal.

Installing the PTO Seal

1. Insert a **NEW** Oetiker clamp over the seal.
2. Push seal onto PTO socket. Be sure to align seal and clamp as noted at removal.

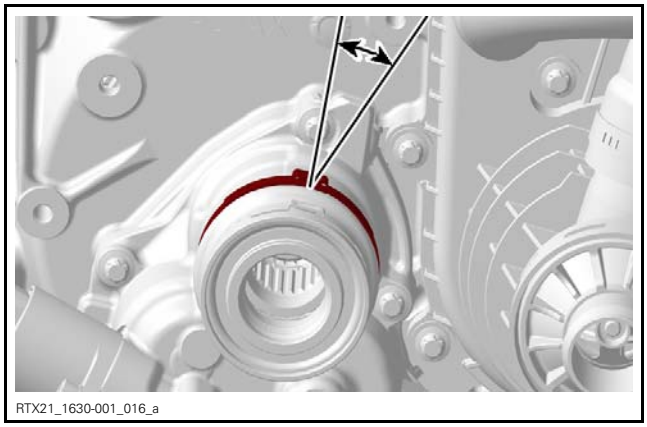
Engine without iDF

NOTICE Ensure to position the Oetiker clamps facing to the cylinder head.


RTX1603MY18-003-003_a

Engine with iDF

NOTICE Ensure to position the Oetiker clamp within the specified range.

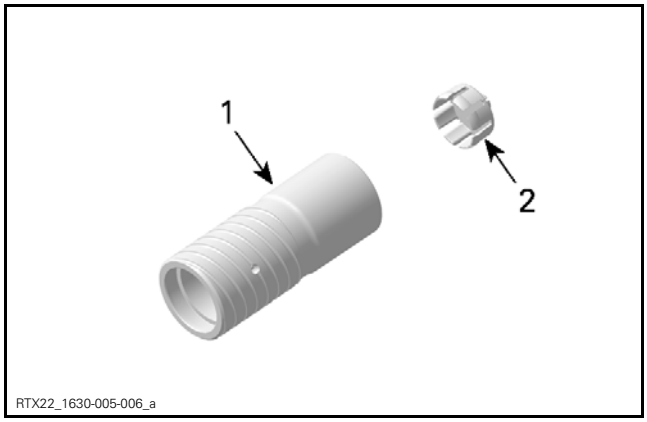

RTX21_1630-001_016_a

All Engines

3. Crimp Oetiker clamp.

REQUIRED TOOL	
OETIKER PLIER (P/N 295 000 070)	

PTO COUPLING (ENGINE WITHOUT IDF)



RTX22_1630-005-006_a

1. PTO coupling
2. Stop sleeve

Inspecting the PTO Coupling

1. Check coupling for worn or damaged splines. Replace as required.

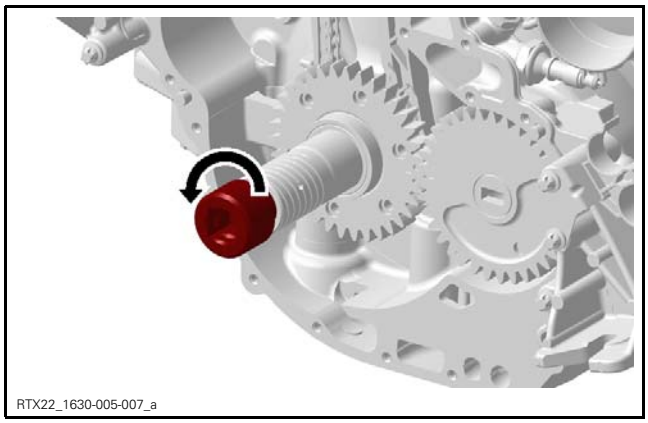
Removing the PTO Coupling

1. Remove engine from vehicle.
2. Lock crankshaft.
3. Remove:
   - PTO housing
   - Rotor and trigger wheel
   - Ring gear
   - Starter drive.

.

4. Heat up PTO coupling with a heat gun to break threadlocker.
5. Unscrew coupling from crankshaft using one of these tools.

REQUIRED TOOLS	
IMPELLER REMOVER/INSTALLER (P/N 529 035 820)	
PTO SLEEVE REMOVER/INSTALLER (P/N 529 036 554)	



TURN COUNTERCLOCKWISE TO REMOVE

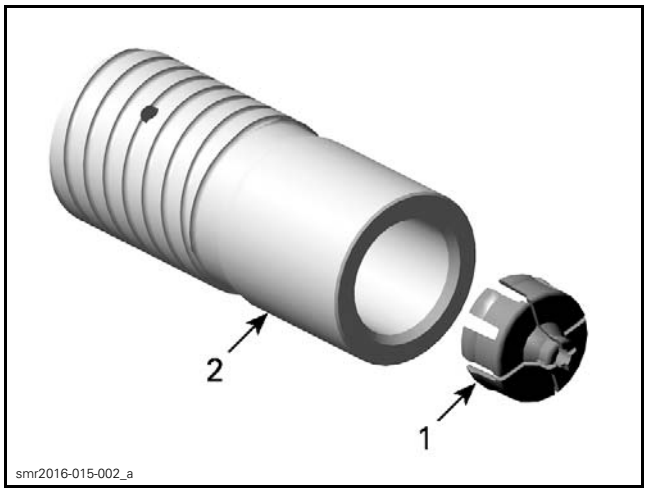
Installing the PTO Coupling

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

1. Clean following:
   - Thread inside PTO coupling
   - Thread on crankshaft.

SERVICE PRODUCT
CLUTCH AND PULLEY FLANGE CLEANER PRO S1 (P/N 779244)

2. Install stop sleeve in PTO coupling.



1. Stop sleeve
2. PTO coupling

3. Apply a drop of threadlocker on threads of the PTO coupling

SERVICE PRODUCT
LOCTITE 648 (GREEN) (P/N 413 711 400)

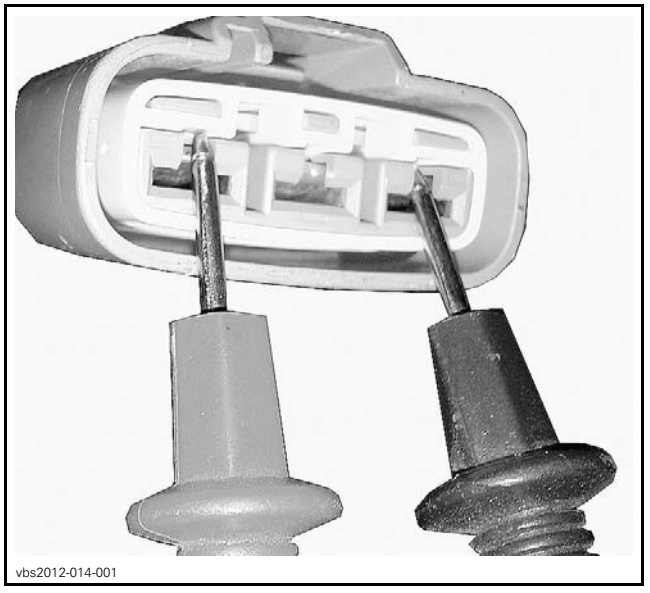
4. Tighten the PTO coupling to specification.

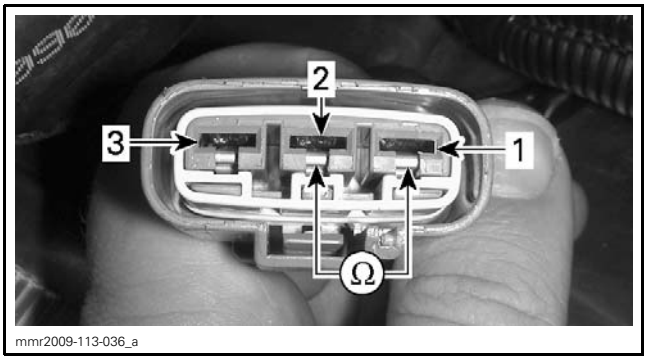
TIGHTENING TORQUE	
PTO coupling	250 N•m ± 10 N•m (184 lbf•ft ± 7 lbf•ft)

STATOR

Testing the Stator Continuity

1. Probe each pair of YELLOW wires by touching (NOT inserting) terminals lock tabs as shown.





mmr2009-113-036_a

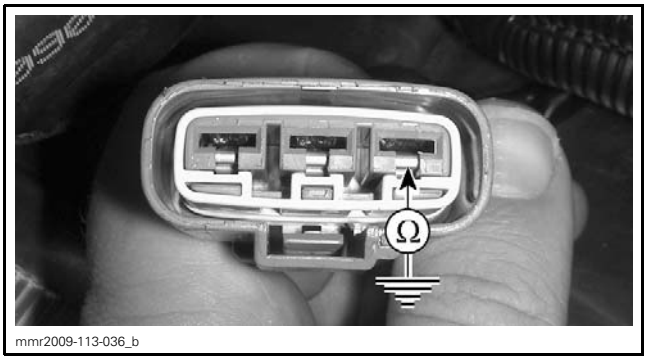
1. Pin #1
2. Pin #2
3. Pin #3

STATOR CONTINUITY TEST		
STATOR CONNECTOR PIN		SPECIFICATION @ 20°C (68°F)
1	2	0.1 - 1 Ω
1	3	
2	3	

2. If any resistance reading is not as specified, the stator or the wiring (including connector) is open and needs to be repaired or replaced.
3. If resistance is good, perform the stator insulation test.

Testing the Stator Insulation

1. Connect a multimeter between any YELLOW wire and engine ground.



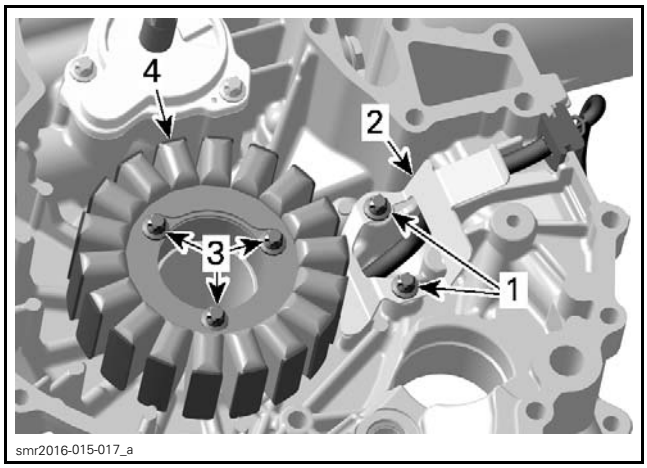
mmr2009-113-036_b

STATOR INSULATION TEST	
TERMINAL	SPECIFICATION @ 20°C (68°F)
Any YELLOW wire and engine ground	OL (open circuit)

2. If there is a resistance or continuity to engine ground, the stator coils and/or the wiring is grounded and need to be repaired or replaced.

Removing the Stator

1. Remove PTO housing, see procedure in this subsection.
2. Remove the following components:



smr2016-015-017_a

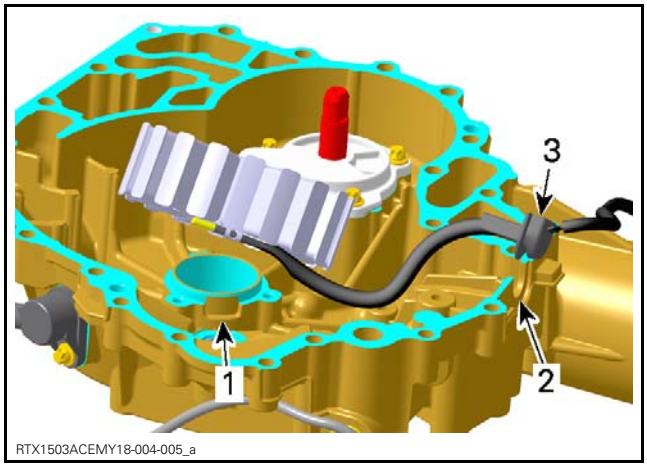
1. Screws
2. Holding plate
3. Stator screws
4. Stator

3. Clean cable grommet from sealing compound.

Installing the Stator

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

There is only one position for the stator (notch in the PTO housing).



RTX1503ACEMY18-004-005_a

1. Notch for stator
2. PTO housing notch
3. Stator cable grommet

1. Apply a drop of threadlocker on threads of the stator screws

SERVICE PRODUCT
LOCTITE 243 (BLUE) (P/N 293 800 060)

2. Tighten the stator screws to specification.

TIGHTENING TORQUE	
Stator retaining screws	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**)

3. Apply a drop of threadlocker on threads of the cable holding screws

SERVICE PRODUCT
LOCTITE 243 (BLUE) (P/N 293 800 060)

4. Tighten the cable holding screws to specification.

TIGHTENING TORQUE	
Cable holding screws	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**)

5. Install PTO housing.

ROTOR AND TRIGGER WHEEL

Rotor and Trigger Wheel Access

1. Remove PTO housing.

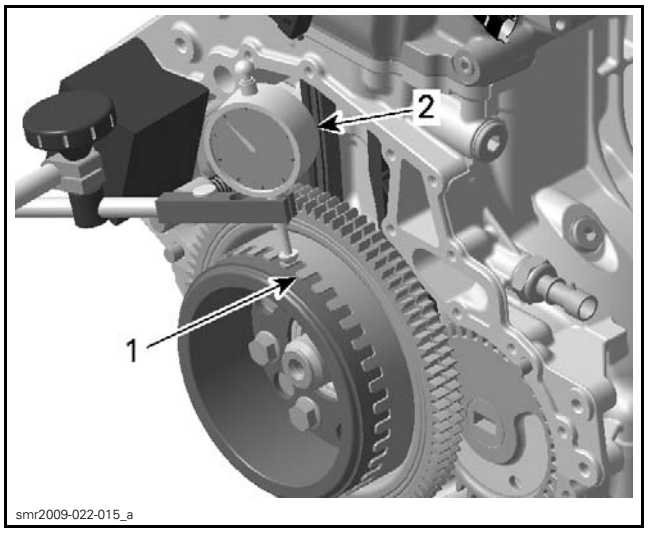
Inspecting the Rotor

1. Inspect rotor condition. Pay particular attention to the inside of the rotor for:
   - Cracks
   - Rub marks
   - Discoloration.
2. If damaged, replace it.

Inspecting Trigger Wheel

1. Inspect the trigger wheel condition.
2. Check the trigger wheel for bent teeth using the following procedure.
   1. Check the trigger wheel for bent teeth by installing a dial indicator on crankcase casting.
   2. Position the gauge on a tooth and set it to zero (0). Be sure to lock the indicator dial to prevent movement of the dial during the remainder of the procedure.
   3. Mark the first measured tooth (reference tooth).
   4. Gently lift the gauge contact point off the tooth and rotate the rotor to the next tooth. When lifting contact point off the tooth for rotor rotation, be careful not to move gauge position or test readings taken on next tooth will not be accurate with reference to the reference tooth.
   5. Gently set the gauge contact point on the next tooth and read the dial indicator.
   6. Repeat this procedure taking a reading at each tooth.
   7. Recheck reading on reference tooth to ensure gauge has not changed position (gauge should still read zero).

TRIGGER WHEEL TEETH INSPECTION
MAXIMUM ALLOWABLE DIFFERENCE
0.15 mm (.006 in)

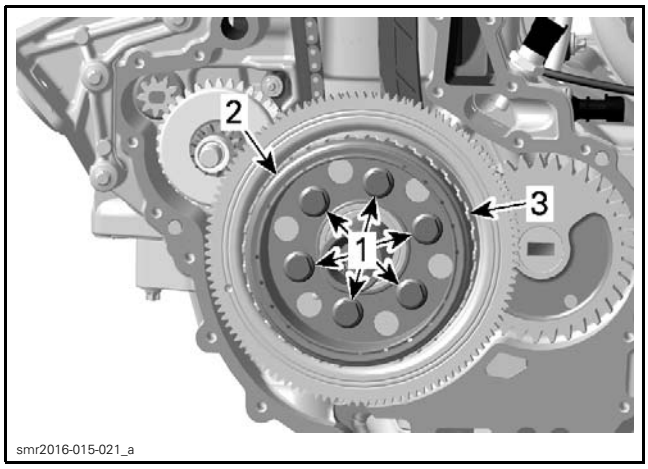


1. Trigger wheel
2. Dial indicator

3. If the reading exceeds the maximum allowable tolerance, straighten the tooth or replace the trigger wheel.
4. Properly reinstall PTO housing.

Removing the Rotor and Trigger Wheel

1. Lock crankshaft.
2. Remove the rotor.

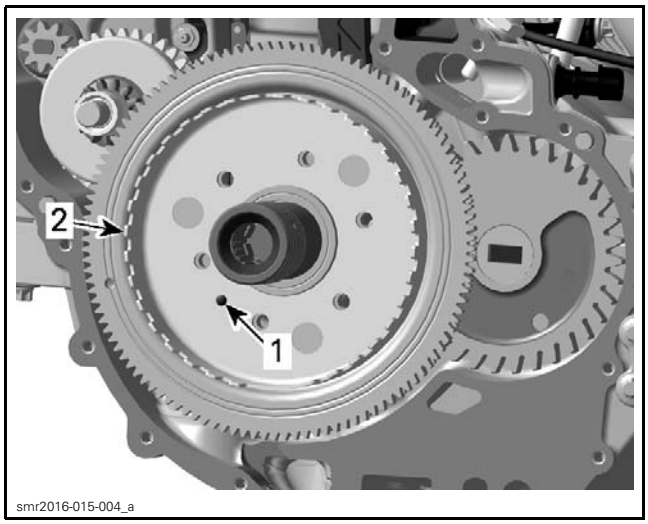


1. Rotor retaining screws
2. Rotor
3. Trigger wheel

Installing the Rotor and Trigger Wheel

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

1. Align the trigger wheel with the location pin on the crankshaft end.



1. Location pin
2. Trigger wheel

2. Install **NEW** OEM rotor screws and tighten them in a crisscross pattern as per following procedure.

NOTICE This assembly uses stretch screw with pre-applied threadlocker. Always use NEW OEM screws and strictly adhere to the tightening procedure.

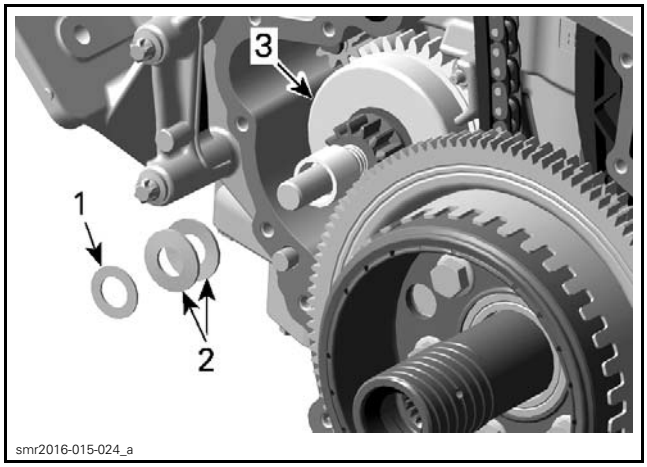
NOTICE Always follow the following sequence.

TIGHTENING TORQUE		
Rotor screws	STEP A	15 N•m ± 1 N•m (133 lbf•**in** ± 9 lbf•**in**)
	STEP B	Additional 50° ± 5°

RING GEAR

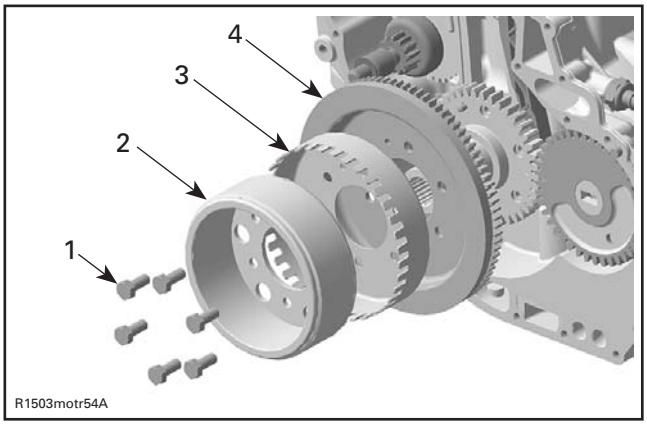
Removing the Ring Gear

1. Lock crankshaft.
2. Remove the PTO housing, see procedure in this subsection.
3. Remove thrust washer and disc springs from starter drive shaft.



1. Thrust washer
2. Disc springs
3. Starter drive

4. Remove the rotor.



1. Rotor retaining screws (discard)
2. Rotor
3. Trigger wheel
4. Ring gear

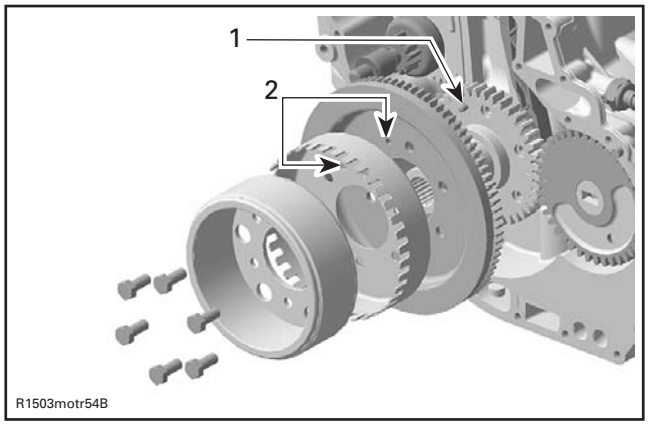
Inspecting the Ring Gear

1. Inspect ring gear for damages. Pay particular attention to teeth condition. If badly worn, cracked, or broken teeth are found, replace ring gear.

Installing the Ring Gear

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

1. Align the ring gear with the location pin on the crankshaft end.



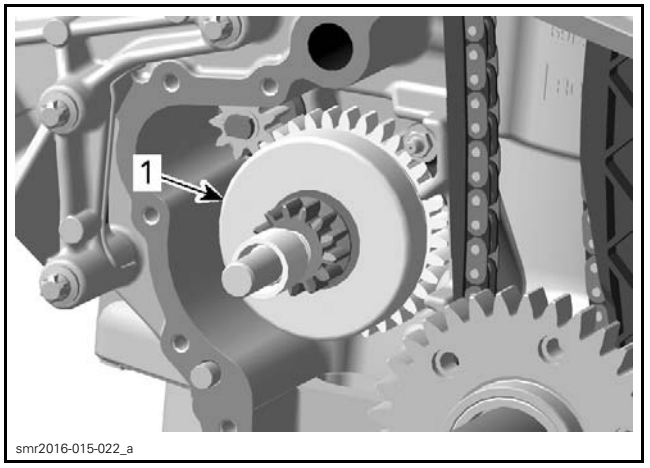
1. Location pin
2. Location pin holes

2. Install rotor and trigger wheel.
3. Install disc springs and thrust washer of starter drive.

STARTER DRIVE

Removing the Starter Drive

1. Remove the following parts:
   – PTO housing
   – Rotor and trigger wheel
   – Ring gear.
2. Remove starter drive.

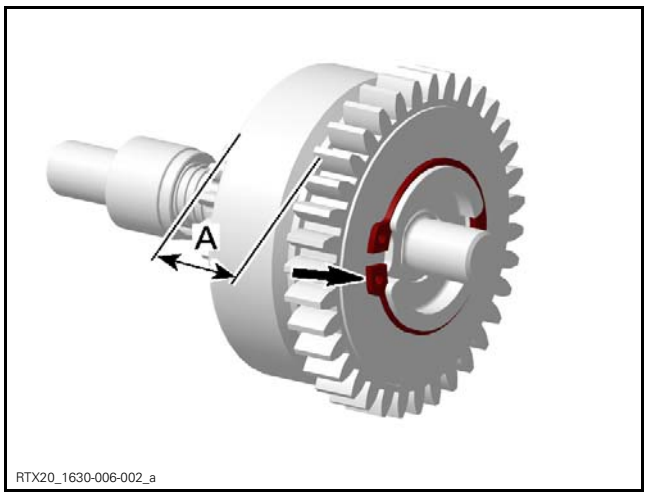


1. Starter drive

Inspecting the Starter Drive

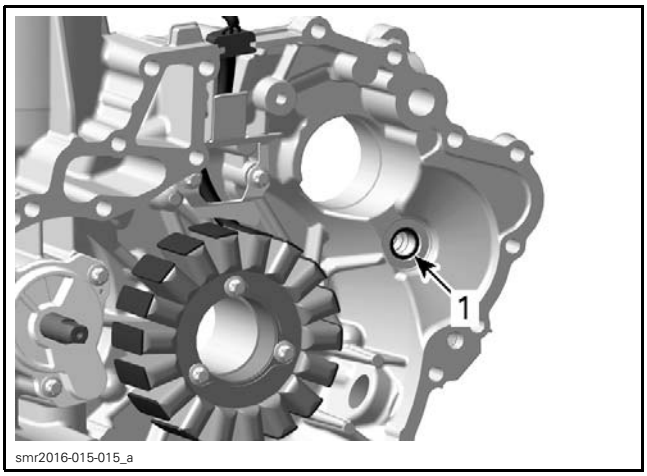
1. Inspect all starter drive parts for excessive wear, cracks and other defects. Pay attention to the condition of the drive gear teeth.
2. Ensure proper operation of the starter drive sprag clutch.

NOTICE **Retaining ring of the friction clutch must face towards outer side of starter drive.**

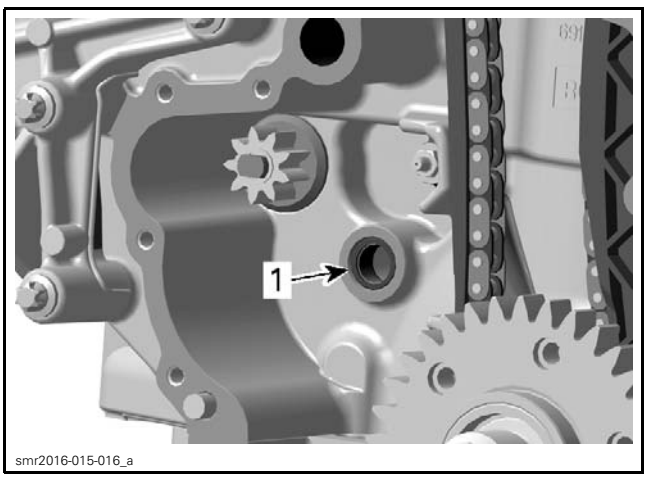


RETAINING RING FACING TOWARDS OUTSIDE
A. Width of centrifugal weight: 22.6 mm (.89 in)

3. If any part of the assembly shows signs of abnormal wear, cracks, broken teeth or malfunction (sprag clutch), replace the faulty part.
4. Check needle bearings for excessive play and smooth operation. If damaged see *REPLACING THE STARTER DRIVE BEARING*.



PTO HOUSING
1. Starter drive bearing



CYLINDER BLOCK
1. Starter drive bearing

Replacing the Starter Drive Bearing

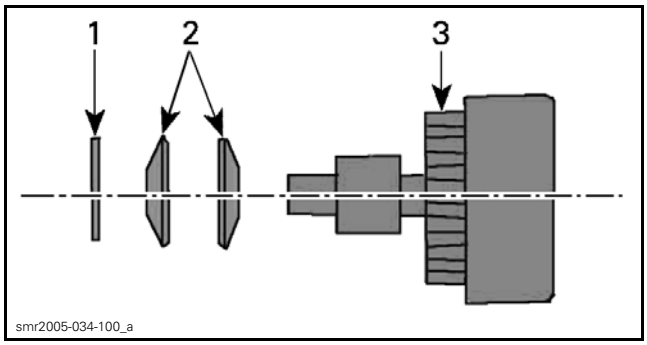
1. Remove starter drive bearing from PTO housing and/or cylinder block using a blind hole puller.
2. Install starter drive bearing in the PTO housing or in the cylinder block.

REQUIRED TOOLS	
STARTER DRIVE SEAL PUSHER (P/N 420 876 502)	
HANDLE (P/N 420 877 650)	

Installing the Starter Drive

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

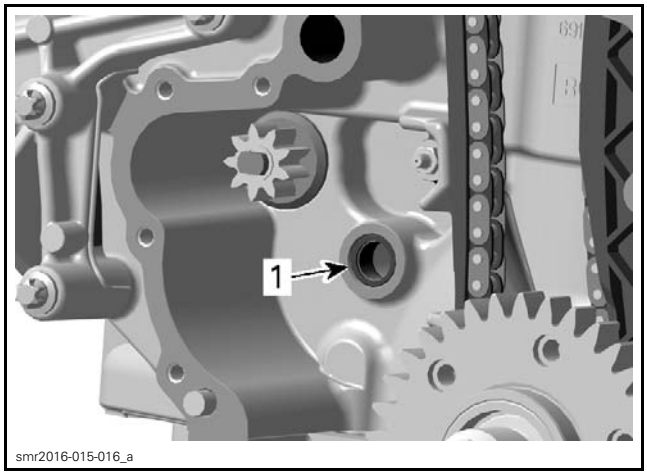
1. Position the spring discs and thrust washer onto the starter drive shaft as per following illustration.



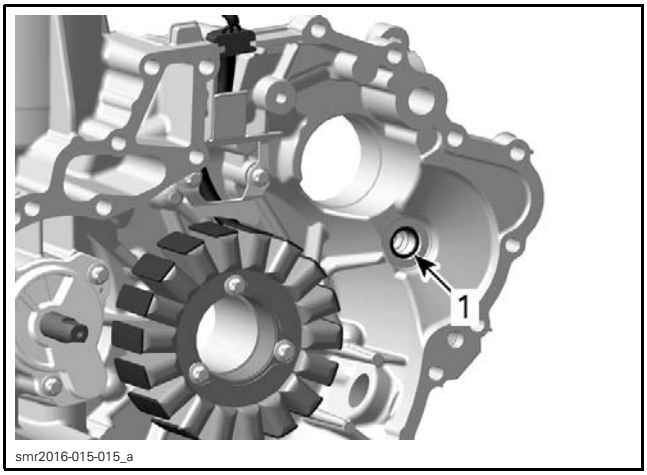
TYPICAL
1. Thrust washer
2. Spring discs
3. Starter drive

2. When installing a **new** starter drive, apply engine oil on:
   – Shaft
   – Gear teeth
   – Splines.
3. Lubricate starter drive needle bearings.

SERVICE PRODUCT
ISOFLEX GREASE TOPAS NB 52 (P/N 293 550 021)



CYLINDER BLOCK
1. Starter drive bearing



PTO HOUSING
1. Starter drive bearing

STARTER

Starter Quick Test

To easily bypass the starter solenoid and the start control circuits, proceed as follows.

– Use a fully charged 12 V battery with a capacity of at least 30 A-h.
– Use a set of booster cables to power the starter.

This procedure tests the following:

– Electric starter
– Starter power cable
– Battery to engine ground cable.

⚠ WARNING

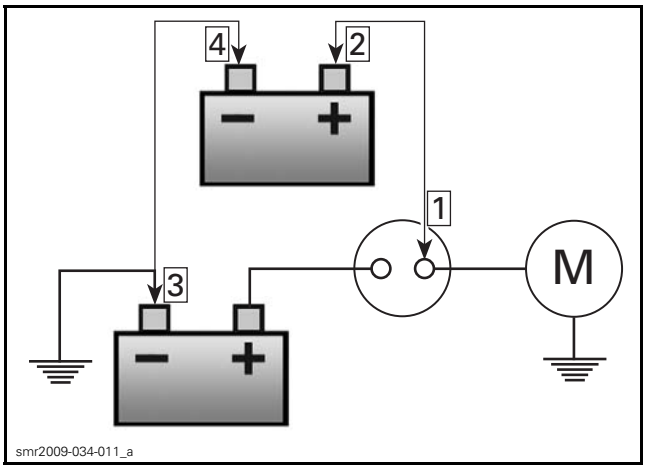
Fuel, oil, or electrolyte vapors are flammable and may become explosive if certain conditions are met. These vapors may collect near the bottom of the hull when present. All types of ignition including electrical sparks are to be avoided when maintaining or testing vehicle.

NOTICE **Connect booster cables in this strict order:**

1. Connect one **RED** clip to the starter post on the starter solenoid.
2. Connect the other **RED** clip to the positive (+) terminal on the external battery.
3. Connect one **BLACK** clip to the negative (-) battery terminal in the **vehicle**.
4. Momentarily apply the second **BLACK** clip to the negative (-) terminal of the **external** battery.

⚠ WARNING

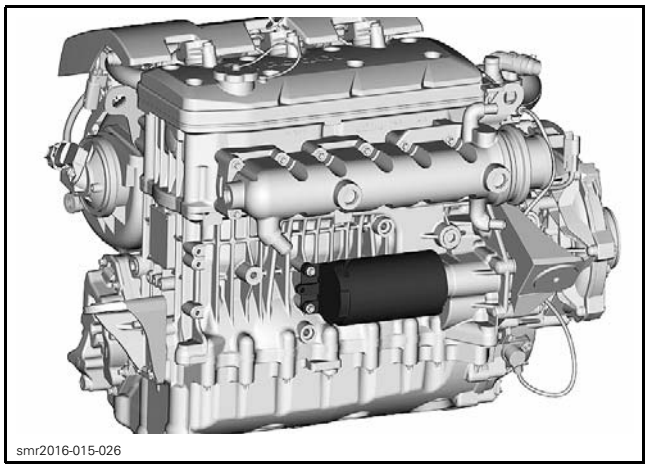
Always use an external battery for this test to prevent any electrical sparks from occurring within the hull. Always make the final connection to the external battery negative (-) terminal using the BLACK booster cable clip. Do not short starter solenoid contacts across the main power connections on the relay with a tool that would cause electrical sparks. Failure to follow this procedure may result in an explosion.



Step 1: Connect cable to solenoid starter post
Step 2: Connect cable to external battery positive post
Step 3: Connect cable to vehicle battery negative post
Step 4: Make a momentary contact

5. If engine does not crank (or cranks slowly), check the following:
   – Booster cable connections
   – Vehicle battery ground cable connections to engine
   – Starter power cable/connections from solenoid to starter
   – Carry out a *SOLENOID DYNAMIC TEST*.
6. If the above items all test good, replace the starter.

Starter Location

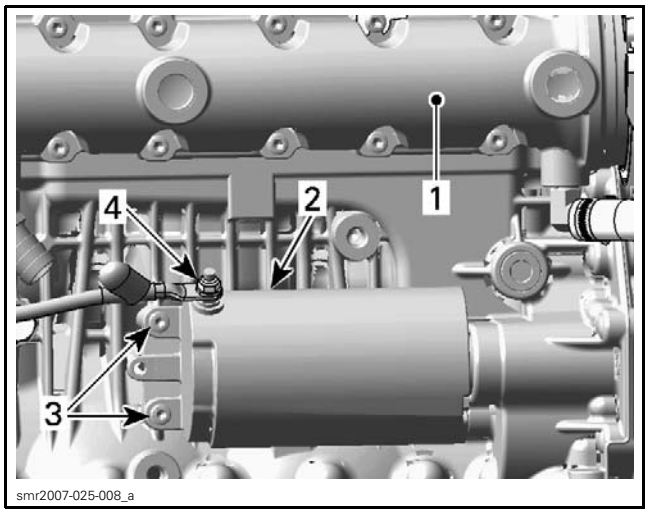

smr2016-015-026

Removing the Starter

1. Disconnect battery.

NOTE: For better access to the starter, work from RH side and lay across the watercraft.

2. Disconnect starter power cable.
3. Remove starter retaining screws.

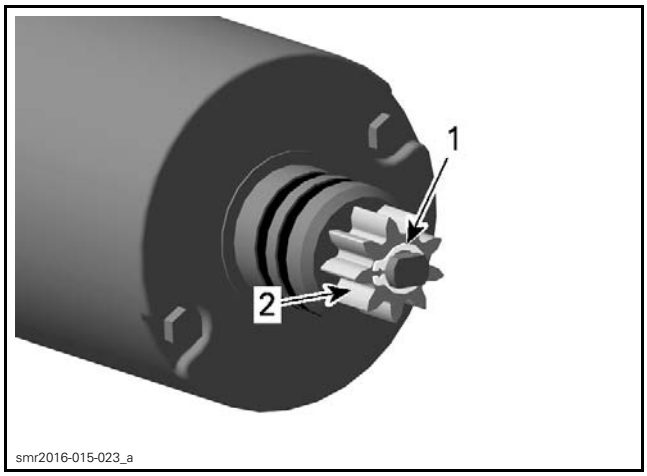


smr2007-025-008_a

1. Exhaust manifold
2. Starter
3. Starter retaining screws
4. Starter power cable retaining nut

Removing the Starter Gear

1. Remove starter.
2. Remove the starter gear.



smr2016-015-023_a

1. Circlip
2. Starter gear

Installing the Starter Gear

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

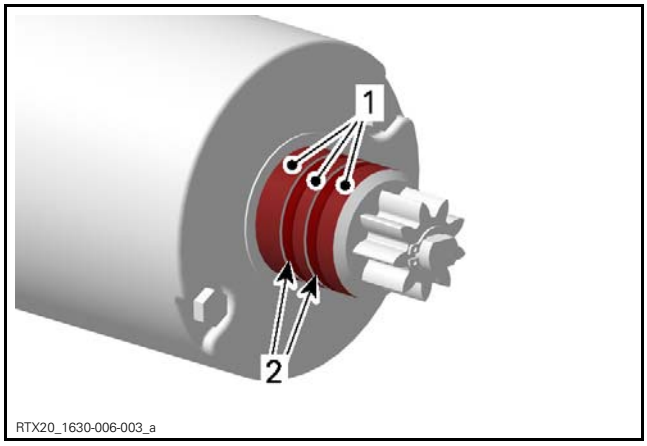
1. Install a **NEW** circlip.

Installing the Starter

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

1. Ensure starter and engine mating surfaces are free of debris. Serious problems may arise if starter is not properly aligned.
2. Lubricate:
   – Starter end
   – Starter O-rings.

SERVICE PRODUCT
SYNTHETIC GREASE (P/N 779162)



RTX20_1630-006-003_a

1. Lubricate starter end
2. Lubricate starter O-rings

3. Install starter.
4. Apply threadlocker on threads of the starter screws.

SERVICE PRODUCT
LOCTITE 243 (BLUE) (P/N 293 800 060)

5. Tighten the starter screws to specification.

TIGHTENING TORQUE	
Starter retaining screws	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**)

6. Install the starter cable and tighten the retaining nut to specification.

TIGHTENING TORQUE	
Starter cable retaining nut	7 N•m ± 1 N•m (62 lbf•**in** ± 9 lbf•**in**)

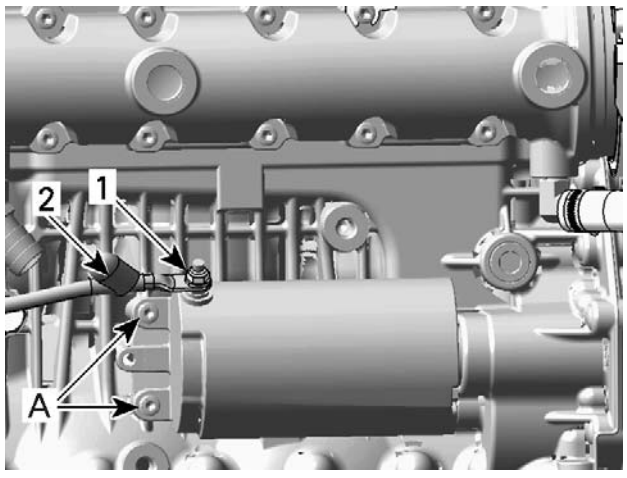
⚠ WARNING

To prevent electric shock whenever connecting the RED power cable to the starter motor, ensure the BLACK (-) battery cable is disconnected.

7. Apply dielectric grease on terminal and nut.

SERVICE PRODUCT
DIELECTRIC GREASE (P/N 293 550 004)

8. Install rubber protector over starter power cable retaining nut.



smr2007-025-008_b

1. Cable retaining nut
2. Rubber protector

9. Reinstall all remaining removed parts.

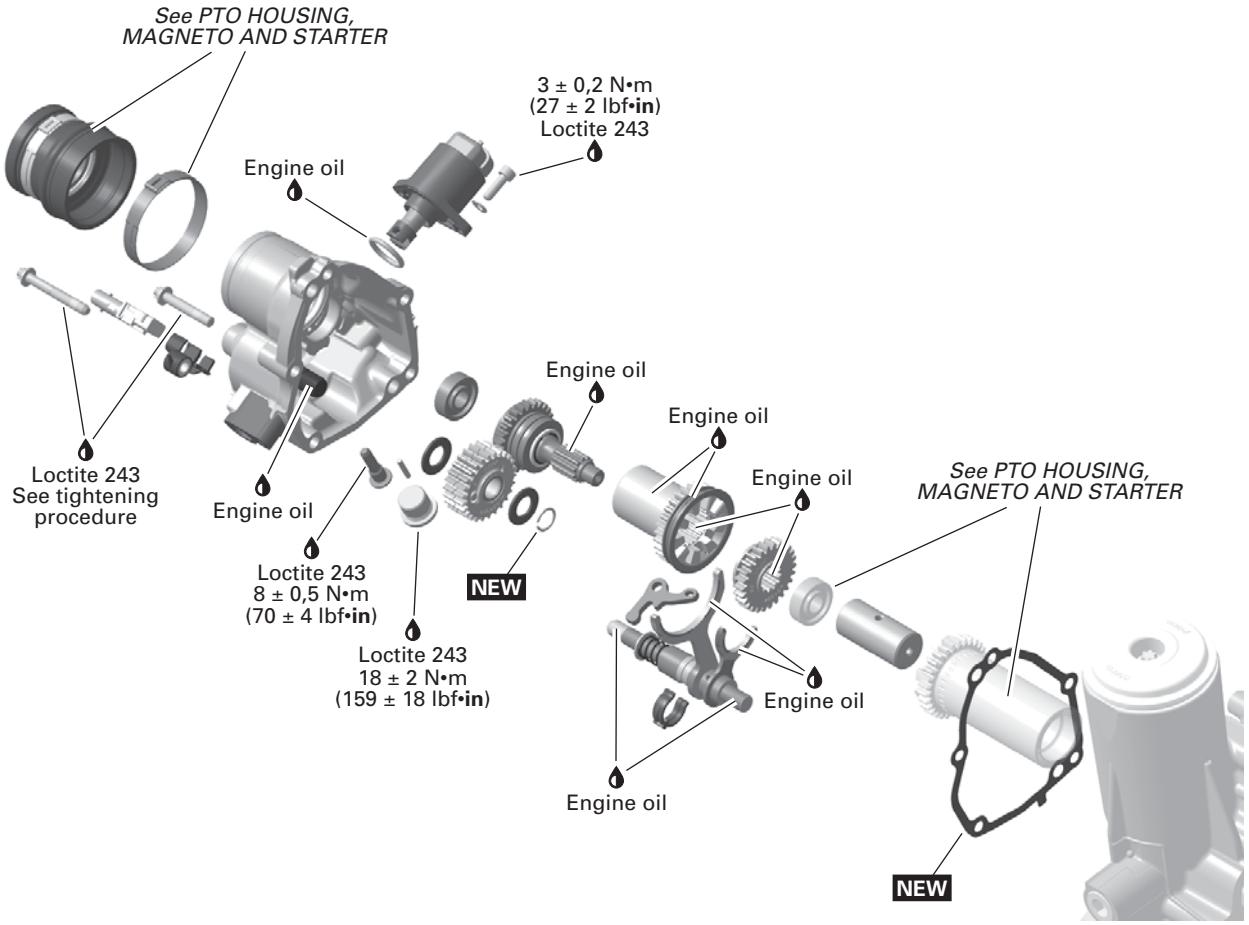
INTELLIGENT DEBRIS FREE PUMP SYSTEM (iDF)

SERVICE TOOLS

Description	Part Number	Page
ECM ADAPTER TOOL	529 036 166	85
FLUKE 115 MULTIMETER	529 035 868	85
WATER PUMP BEARING PUNCH	529 036 417	96

SERVICE PRODUCTS

Description	Part Number	Page
LOCTITE 243 (BLUE)	293 800 060	88, 90, 92–93, 98



NEW = Component must be replaced when removed.

RTX21_1630-002-001_b

GENERAL

The following tools are required to test the electrical components.

REQUIRED TOOL	
FLUKE 115 MULTIMETER (P/N 529 035 868)	
ECM ADAPTER TOOL (P/N 529 036 166)	

TROUBLESHOOTING

For any problem start trouble shooting by checking fault codes using B.U.D.S.

IDF GEARBOX DOES NOT SHIFT TO FORWARD POSITION

NOTICE Symptom occurs in conjunction with failure code P1915.

1. Actuator defective.
   - *Shift to forward position by pressing the START button to wake up the ECM. Listen or feel if actuator moves or remove drive shaft to see movement of the iDF gearbox output shaft.*
   - *Check iDF actuator wiring, refer to procedure in this subsection.*

NOTICE When shifting into forward position, the actuator is only energized until the forward position is reached.

2. Linear position sensor defective or generating erratic signals.
   - *Check if sensor and retaining screw are installed correctly.*
   - *Check linear position sensor wiring and power supply, refer to procedure in this subsection.*
   - *Replace sensor and check again.*
   - *Clean magnet from debris. Refer to GEARBOX in this subsection.*
3. iDF gearbox output shaft can not engage to the input shaft located on crankshaft.
   - *Press the START button to wake up the ECM and listen if multiple electric starter kicks are applied to avoid dog to dog position. If forward position can not engage perform following procedure:*
   – Start testing routine using B.U.D.S. to move iDF actuator to reverse position.
   – When actuator reaches reverse position press START button to shift gearbox to forward position.
   – If forward position still can not be reached remove gearbox and check for mechanical failure.
4. Drive shaft splines damaged.
   - *Check if drive shaft moves freely in the iDF gearbox output shaft splines.*
   - *Check splines of drive shaft and iDF gearbox output shaft for wear or damaged.*

IDF GEARBOX DOES NOT SHIFT TO REVERSE POSITION

NOTICE Symptom occurs in conjunction with failure code P1914.

1. Actuator defective.
   - *Start iDF testing routine using B.U.D.S. to move actuator to reverse position. Listen or feel if actuator moves or remove drive shaft to see movement of the iDF gearbox output shaft.*
   - *Check iDF actuator wiring, refer to procedure in this subsection.*

NOTICE When shifting to reverse position, the actuator is energized permanent.

2. Linear position sensor defective or generating erratic signals.
   - *Check if sensor and retaining screw are installed correctly.*
   - *Check linear position sensor wiring and power supply, refer to procedure in this subsection.*
   - *Replace sensor and check again.*
   - *Clean magnet from debris. Refer to GEARBOX in this subsection.*
3. iDF gearbox shift gear can not engage to the input shaft located on crankshaft.
   - *Start testing routine using B.U.D.S. to move actuator to reverse position. Listen if multiple electric starter kicks are applied to avoid tooth on tooth position.*
4. iDF gearbox mechanical failure.
   - *Remove iDF gearbox and check for mechanical failure.*
   - *Check if split gear moves easily and returns to center position, refer to procedure in this subsection.*

5. Drive shaft splines damaged.
   - *Check if drive shaft moves freely in the iDF gearbox output shaft splines.*
   - *Check splines of drive shaft and iDF gearbox output shaft for wear or damaged.*

ENGINE STALLS AND IDF GEARBOX MOVES TO FORWARD POSITION WHEN IDF IS ACTIVATED

NOTICE Symptom occurs in conjunction with failure code P894.

1. Blocked jet pump.
   - *Inspect and clean jet pump. Refer to JET PUMP subsection.*
2. Defective ratchet clutch.
   - *Replace counter shaft with ratchet clutch, refer to procedure in this subsection.*

PROCEDURES

IDF GEARBOX

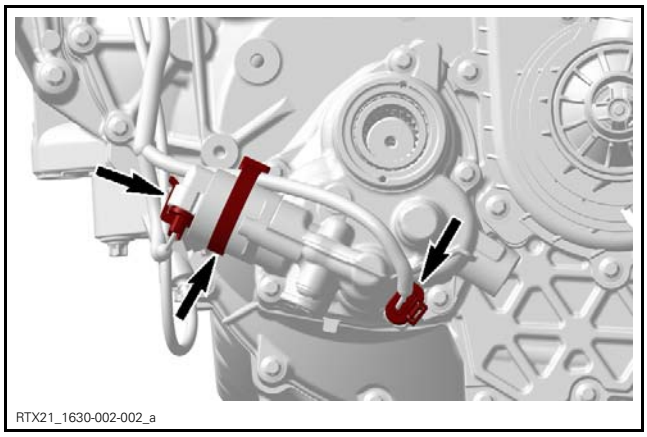
Removing the iDF Gearbox

NOTICE Ensure the gearbox is set to forward position before removing it.

1. Remove drive shaft. Refer to *DRIVE SHAFT* subsection.
2. Lift rear of vehicle to reduce oil spillage.

NOTICE Ensure the vehicle is safely secured prior to starting the procedure.

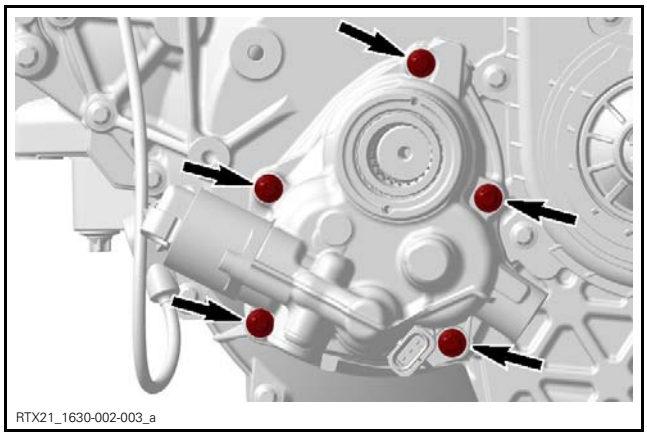
3. Syphon remaining oil out of the lower timing chain case, refer to *PTO HOUSING* in the *PTO HOUSING, MAGNETO AND STARTER* subsection.
4. If applicable remove supercharger, refer to *SUPERCHARGER* subsection.
5. If necessary, remove PTO seal, refer to *PTO HOUSING, MAGNETO AND STARTER* subsection.
6. Cut locking tie and disconnect:
   – Linear position sensor
   – iDF actuator.


RTX21_1630-002-002_a

7. Place rags under iDF gearbox housing to prevent oil spillage.

NOTICE Up to 1 L (33.81 U.S. oz) of engine oil could flow out when removing the iDF gearbox.

8. Remove iDF gearbox retaining screws.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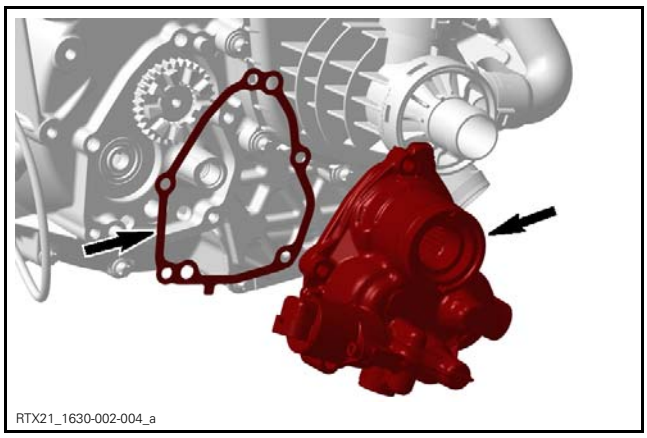
9. Withdraw:
   – iDF gearbox
   – Gasket.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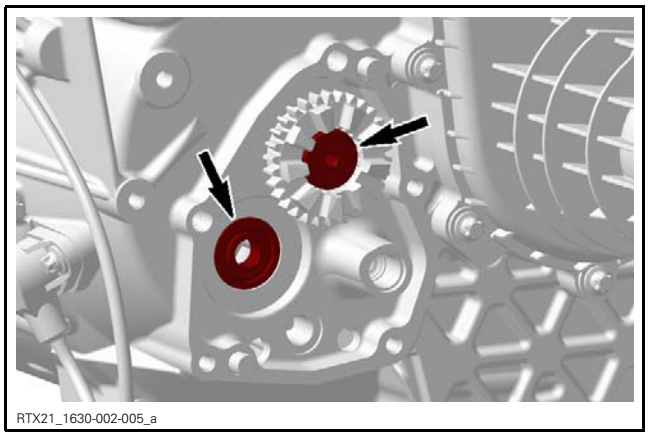
10. Whenever the iDF gearbox is removed, inspect:
    – Spacer for heavy damages, refer to procedure in this subsection.
    – iDF gearbox ball bearing in the PTO cover, refer to *PTO HOUSING, MAGNETO AND STARTER* subsection.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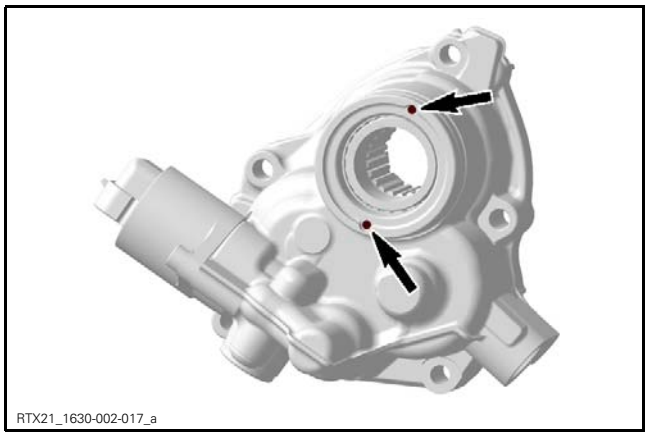
Inspecting the iDF Gearbox

1. Blow out the oil and ventilation bores and check if they are not clogged.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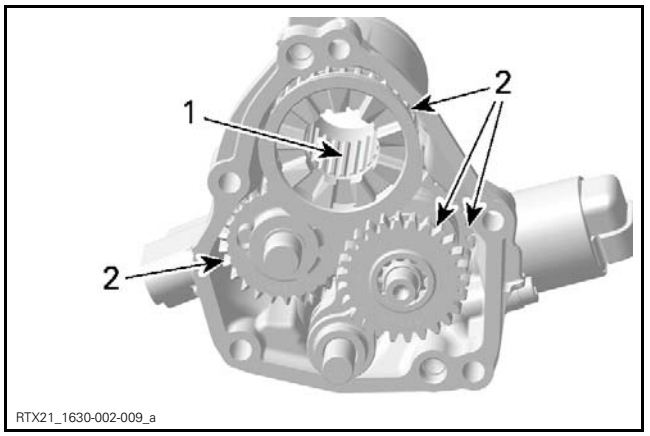
2. Check gearbox drive shaft inner splines if worn or damaged.
3. Check gear teeth for wear or damages.



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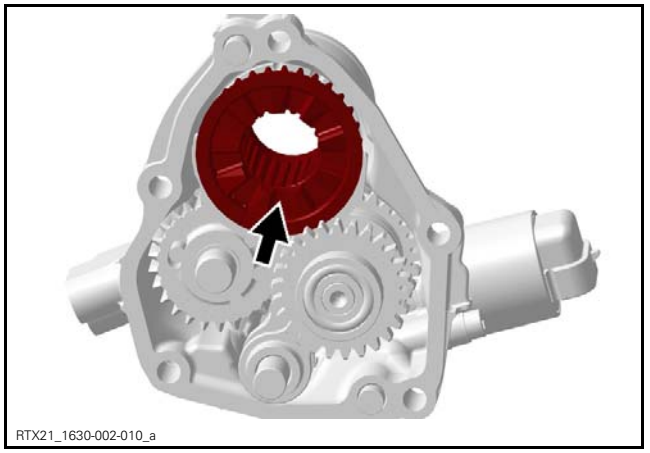
4. Check shifting fork for free movement.
5. Check split gear for free movement and proper function:
6. Push iDF gearbox output shaft in and hold it in this position.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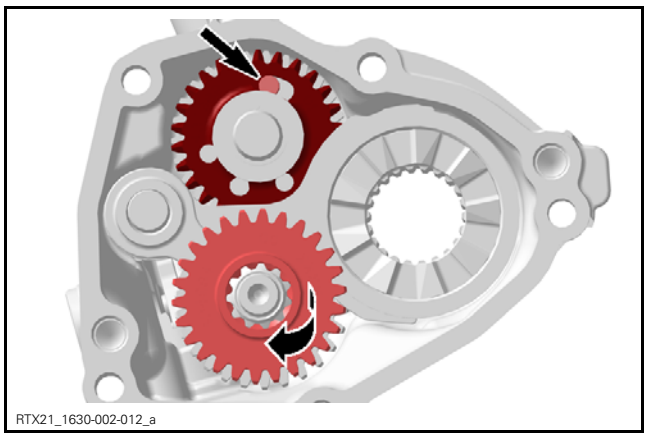
7. Turn shift gear back and forth.

Split gear must move easily until it is stopped by the pin.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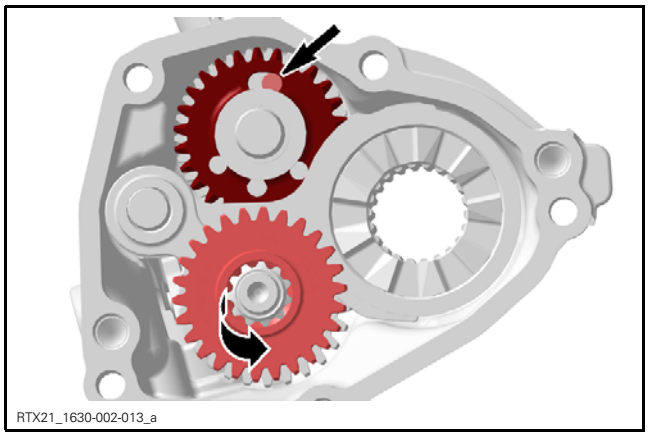
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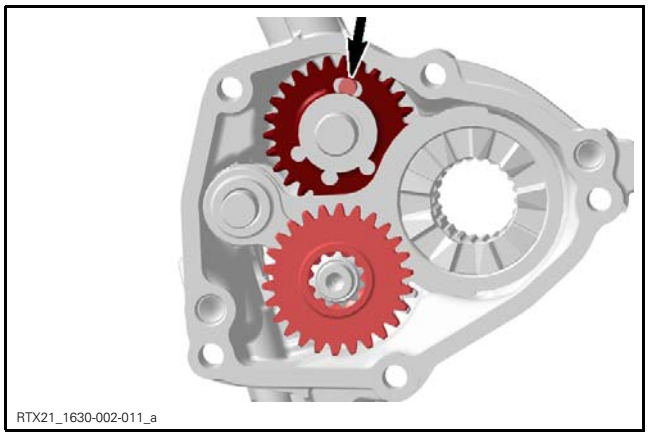
8. Lift iDF gearbox output shaft.

Split gear must move back to center position of the pin.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9. Replace split gear if necessary. Refer to *GEARBOX* in this subsection.

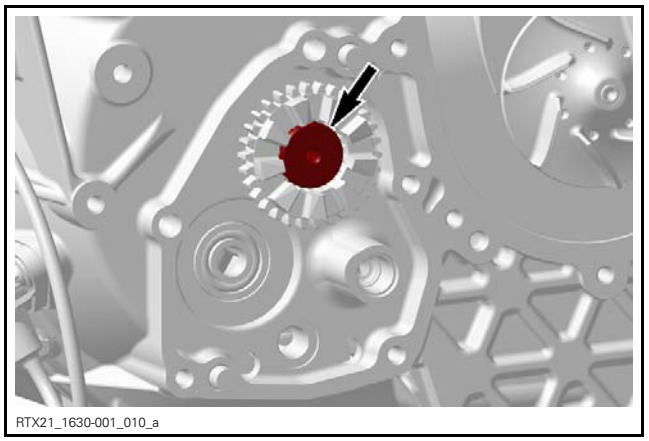
Installing the iDF Gearbox

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

NOTICE **The gearbox must be set in forward position for reinstallation. When carefully reinstalling the drive shaft, rotate it to ensure a proper engagement between the input shaft located on the crankshaft, and the iDF output shaft.**

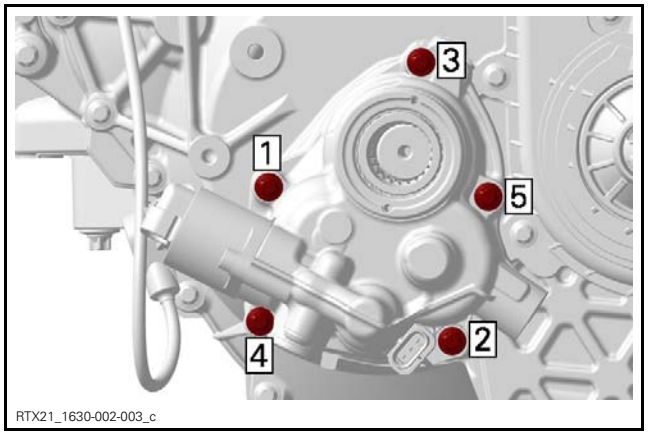
1. Prior installing the gearbox ensure that spacer is installed.

NOTICE **A missing spacer will cause severe damage to the iDF gearbox.**


RTX21_1630-001_010_a

2. Install a **NEW** iDF gearbox housing gasket.
3. Tighten the gearbox housing screws as per the following procedure.

NOTICE **Apply tightening torque of the step A on all gearbox housing screws before going to step B.**



RTX21_1630-002-003_c

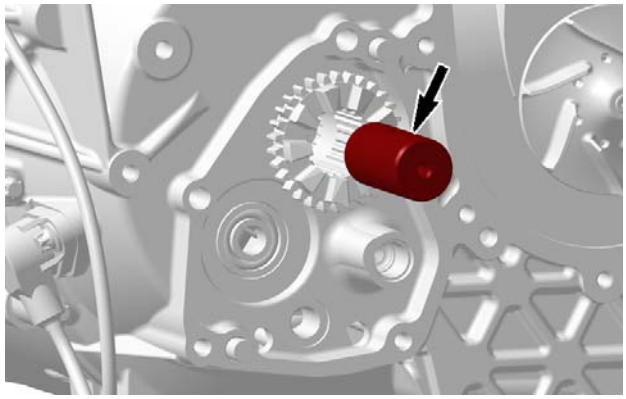
TIGHTENING PROCEDURE		
Gearbox housing screws	Step A	5 N•m ± 0.6 N•m (44 lbf•**in** ± 5 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)
	Step B	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**)

4. Refill engine oil and verify engine oil level, refer to *LUBRICATION SYSTEM* subsection.

SPACER

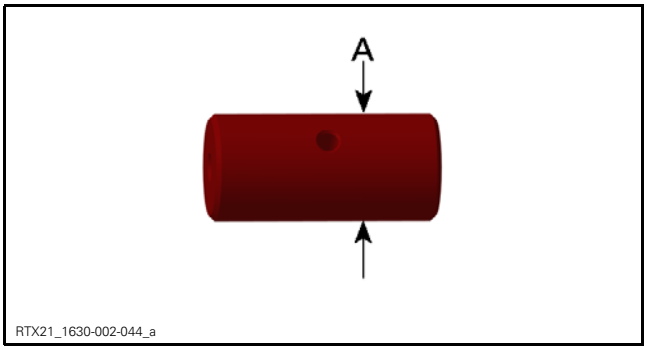
Removing the Spacer

1. Remove spacer from input shaft using a M5 screw.


RTX21_1630-001_008_a

Inspecting the Spacer

1. Inspect spacer for wear or damages. Replace if heavily worn or damaged.



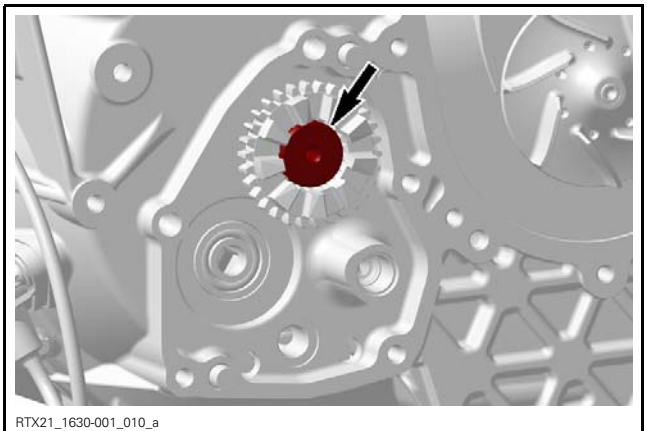
RTX21_1630-002-044_a

A. Spacer outer diameter

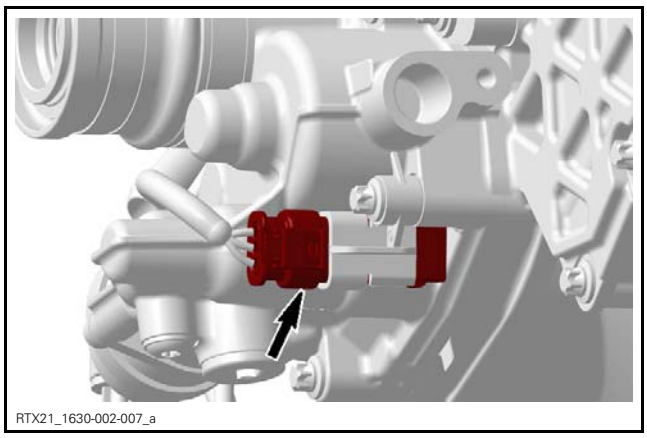
SPACER OUTER DIAMETER	
NEW	21.896 mm to 21.980 mm (.862 in to .8654 in)
SERVICE LIMIT	21.790 mm (.8579 in)

Installing the Spacer

1. Install spacer in input shaft.


RTX21_1630-001_010_a

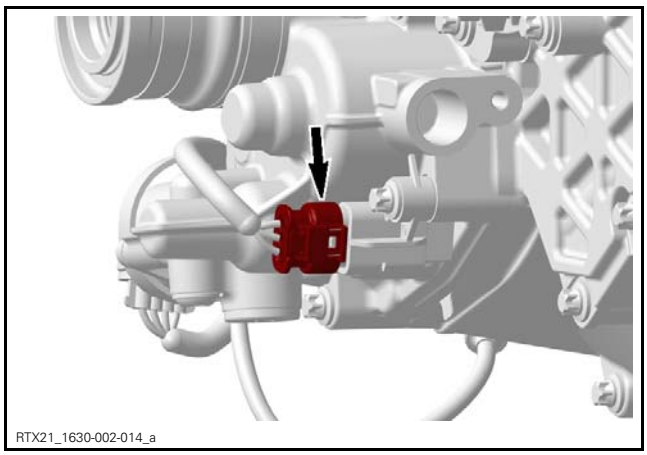
LINEAR POSITION SENSOR


RTX21_1630-002-007_a

Inspecting the Linear Position Sensor

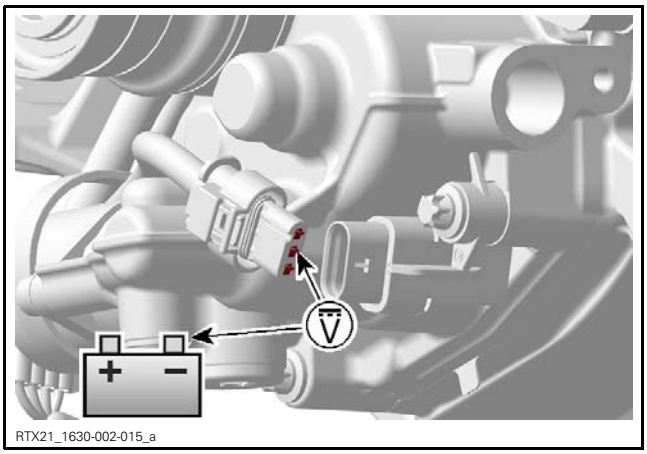
Testing the Linear Position Sensor Input Voltage

1. Remove the parts required to access the linear position sensor.
2. Disconnect linear position sensor connector.


RTX21_1630-002-014_a

3. Press the START button to wake up the ECM.
4. Install the tether cord on the engine cut-off switch.
5. Set the multimeter to Vdc.
6. Read voltage as per following table.

LINEAR POSITION SENSOR INPUT VOLTAGE TEST		
WIRING HARNESS CONNECTOR PIN	BATTERY	SPECIFICATION
3	Negative (-) post	5V
2		0V
1		0V



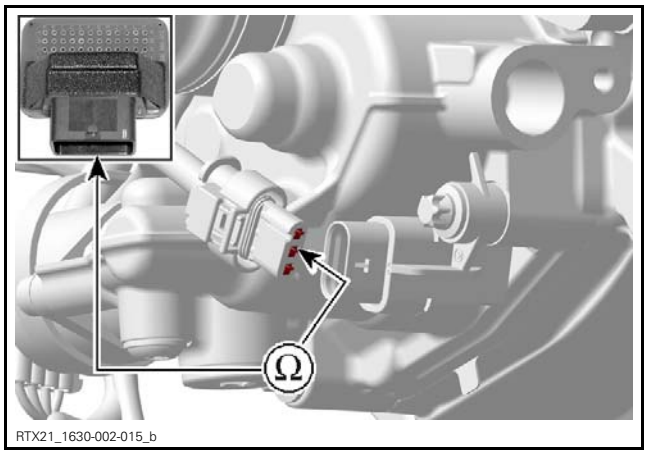
RTX21_1630-002-015_a

7. If voltage measured is as specified, replace the linear position sensor.
8. If voltage measured is not as specified, refer to *TESTING THE LINEAR POSITION SENSOR CIRCUIT CONTINUITY*.

Testing the Linear Position Sensor Circuit Continuity

1. Install the ECM adapter tool on the ECM-A connector.
2. Set the multimeter to Ω.
3. Test for circuit continuity as per the following table.

LINEAR POSITION SENSOR CIRCUIT CONTINUITY TEST		
LINEAR POSITION SENSOR CONNECTOR PIN	ECM ADAPTER PIN	SPECIFICATION
1	A-G3	Close to 0 Ω
2	A-G1	
3	A-C4	

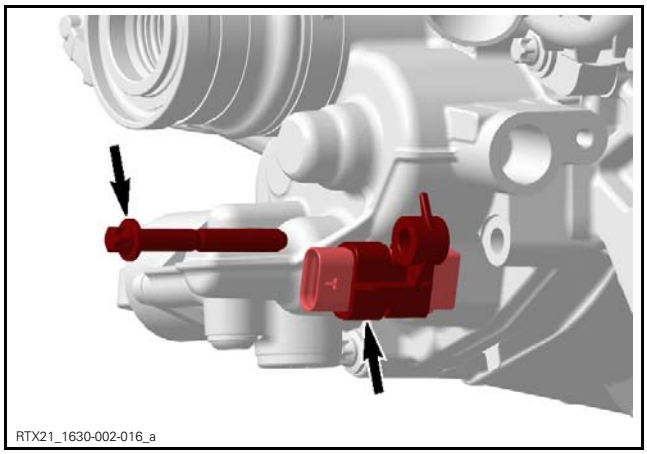


RTX21_1630-002-015_b

4. If resistance is not within specification, repair or replace the wiring harness between ECM connector and the linear position sensor. Refer to *WIRING DIAGRAM*.

Removing the Linear Position Sensor

1. Disconnect the linear position sensor connector.
2. Remove the linear position sensor and its support.


RTX21_1630-002-016_a

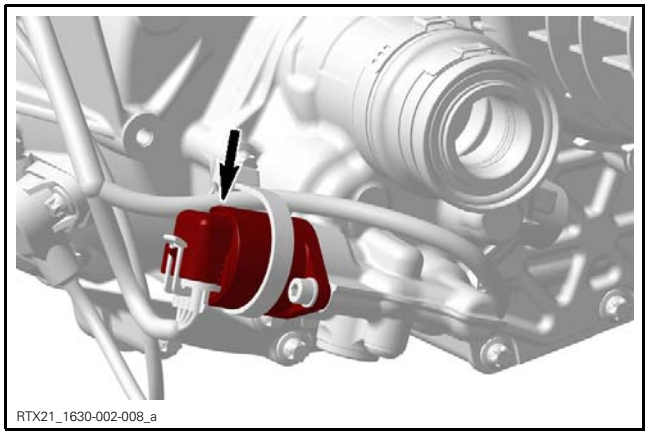
Installing the Linear Position Sensor

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

1. Apply threadlocker on the sensor screw thread.
2. Tighten gearbox housing screw to specification.

TIGHTENING TORQUE	
Linear position sensor screws	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)

iDF ACTUATOR


RTX21_1630-002-008_a

Inspecting the iDF Actuator

Testing the iDF Actuator Resistance

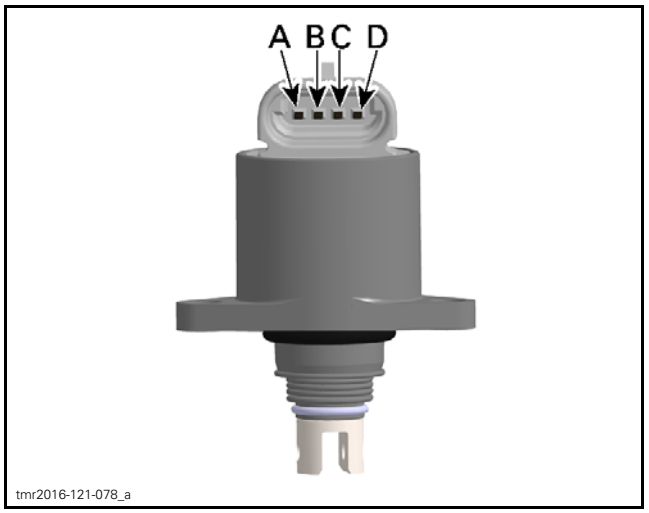
1. Install the ECM adapter tool on the ECM-A connector.
2. Set multimeter to Ω.
3. Check resistance as per table.

IDF ACTUATOR RESISTANCE TEST		
ECM ADAPTOR PIN		SPECIFICATION @ 20°C (68°F)
A-C2	A-C1	28 - 34 Ω
A-B2	A-A4	

4. If resistance is not within specifications, disconnect iDF actuator and check wiring harness continuity.

IDF ACTUATOR WIRING HARNESS CONTINUITY		
ECM ADAPTOR PIN	ACTUATOR CONNECTOR PIN	SPECIFICATION @ 20°C (68°F)
A-A4	C	Close to 0 Ω
A-B2	B	
A-C1	D	
A-C2	A	

5. If resistance value is incorrect, repair the connectors or replace the wiring harness between ECM connector and the actuator.
6. If resistance value is correct, remove actuator and check resistance per following table.



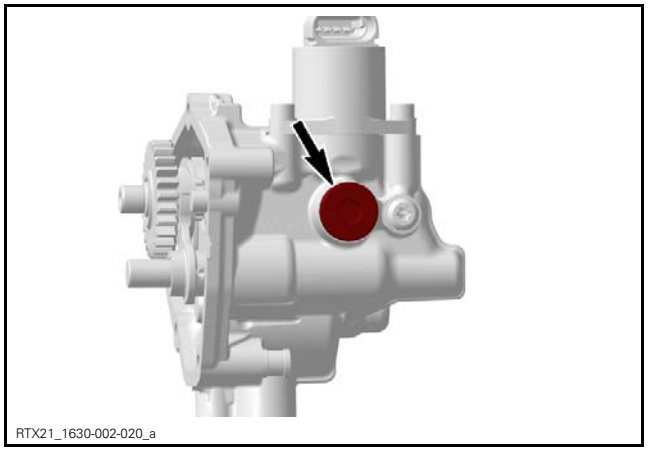
tmr2016-121-078_a

IDF ACTUATOR RESISTANCE TEST		
ACTUATOR PIN		SPECIFICATION @ 20°C (68°F)
A	D	28 - 34 Ω
B	C	

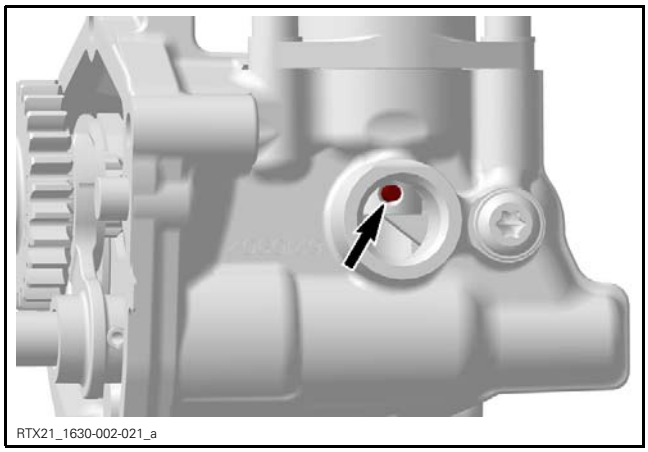
7. If resistance is not within specifications, replace the actuator.
8. If resistance value is correct replace ECM, refer to *ELECTRONIC CONTROL MODULE* subsection.

Removing the Actuator

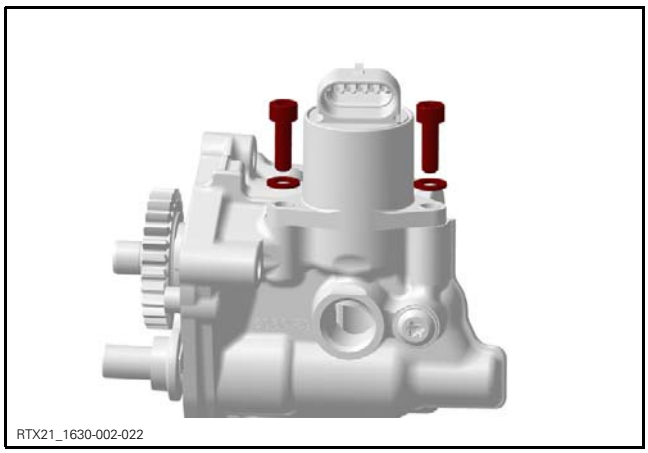
1. Remove the iDF gearbox from the engine. Refer to procedure in this subsection.
2. Remove the plug screw.


RTX21_1630-002-020_a

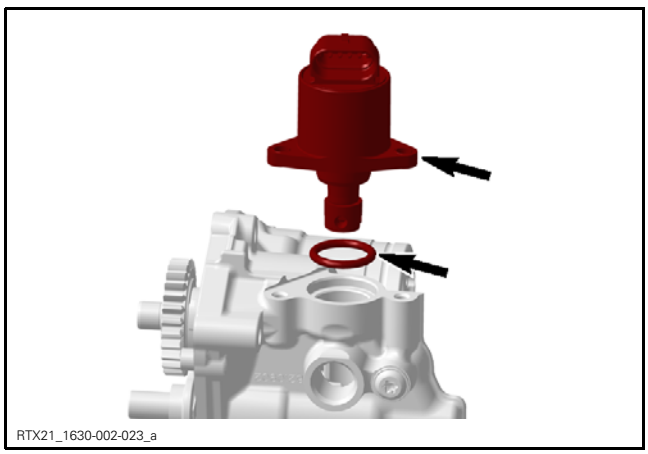
3. Remove the retaining pin by using a magnet.


RTX21_1630-002-021_a

4. Remove:
   – Retaining screws
   – Washers.


RTX21_1630-002-022

5. Withdraw:
   – Actuator
   – O-ring.

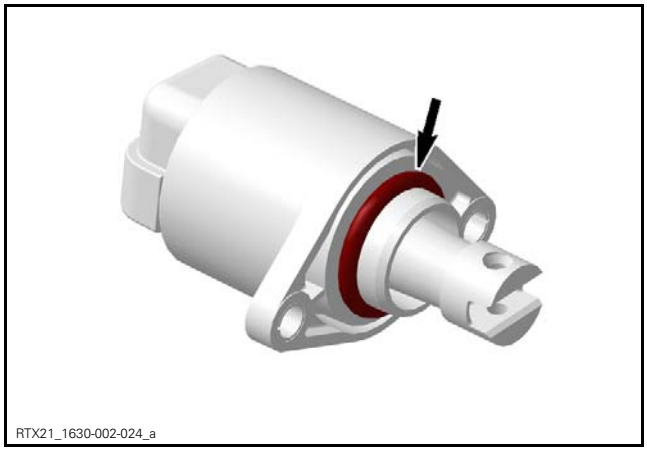

RTX21_1630-002-023_a

Installing the Actuator

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

1. Lubricate the O-ring.

SERVICE PRODUCT
Engine oil

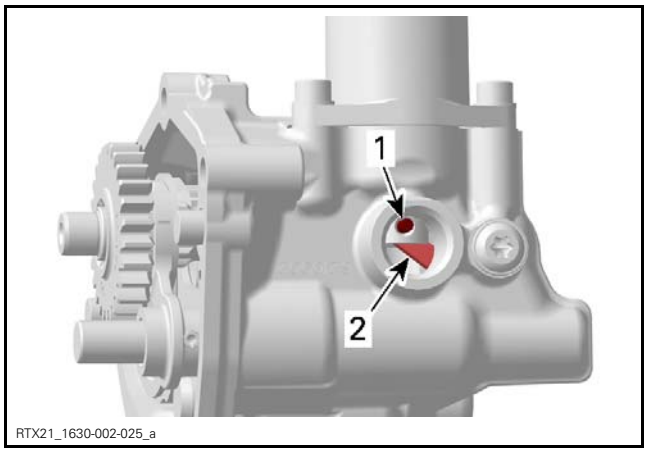

RTX21_1630-002-024_a

2. Tighten actuator retaining screws to specification.

TIGHTENING TORQUE	
Actuator retaining screws	3 N•m ± 0.2 N•m (27 lbf•**in** ± 2 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)

3. Install retaining pin.

NOTICE **Ensure retaining pin is threaded into the rocker arm bore.**



RTX21_1630-002-025_a

1. Retaining pin
2. Rocker arm

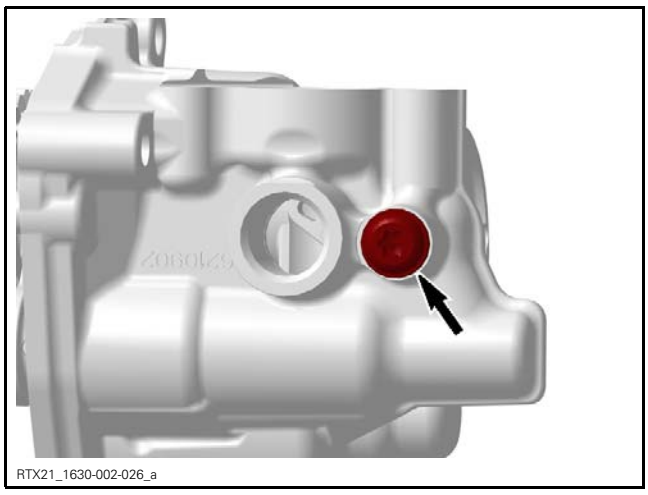
4. Tighten plug screw to specification.

TIGHTENING TORQUE	
Plug screw	18 N•m ± 2 N•m (159 lbf•**in** ± 18 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)

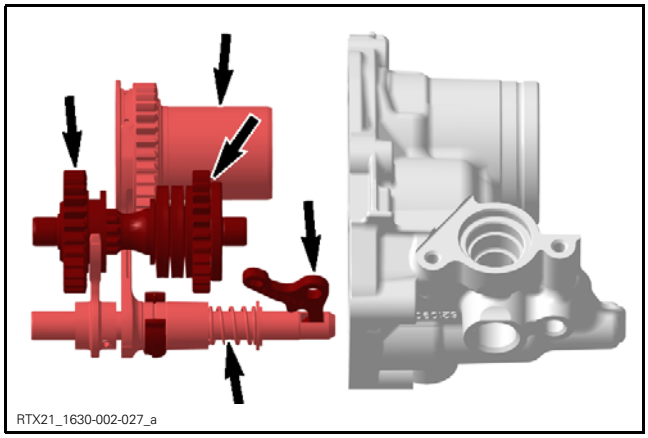
GEARBOX

Removing the Gearbox

1. Refer to procedures in this subsection to remove:
   – iDF gearbox from engine
   – Actuator.
2. Remove bearing bolt.


RTX21_1630-002-026_a

3. Withdraw gearbox components from the gearbox housing.

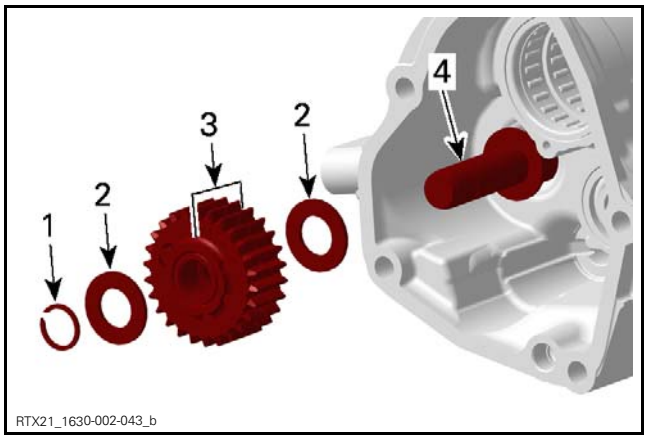

RTX21_1630-002-027_a

4. If necessary remove:
   – Retaining ring (discard it)
   – Washers (2x)
   – Split gear.

NOTE: Prior to removal check for proper split gear function, refer to *INSPECTING THE GEARBOX.*

NOTICE **Take care that split gear assembly does not fall apart during removal.**

NOTE: Split gear shaft can have a slide fit.



RTX21_1630-002-043_b

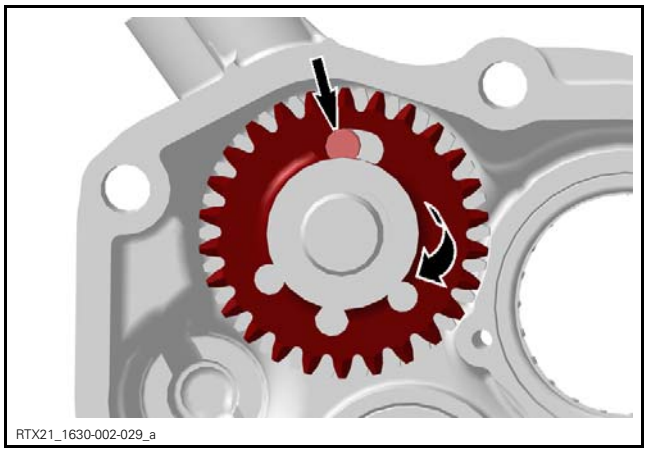
1. Retaining ring
2. Washer (2x)
3. Split gear
4. Split gear shaft

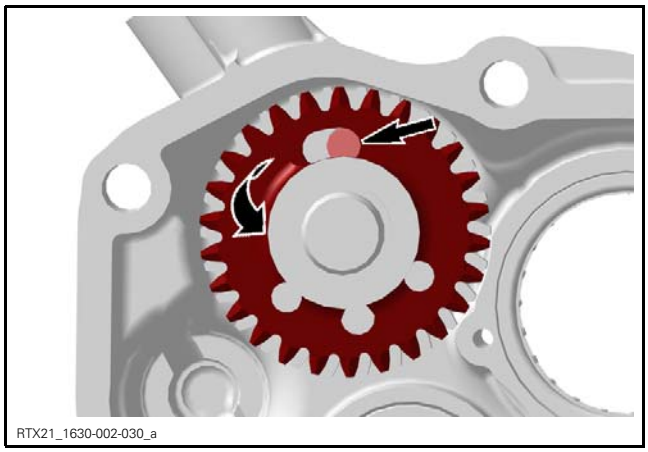
Inspecting the Gearbox

Split Gear

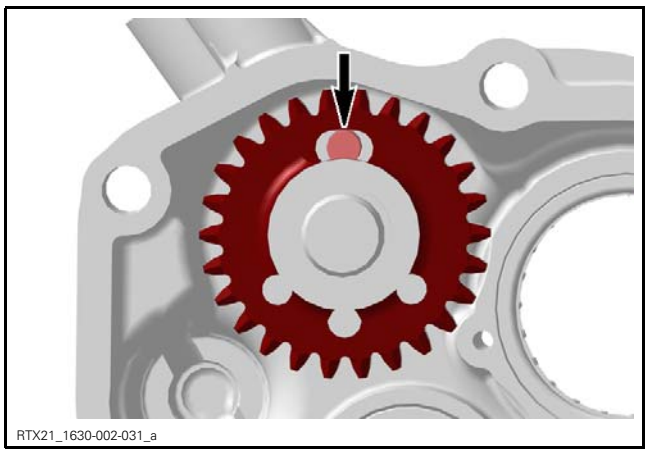
1. Check split gear for free movement and proper function.
2. Turn shift gear back and forth.

Split gear must move easily until it is stopped by the pin.

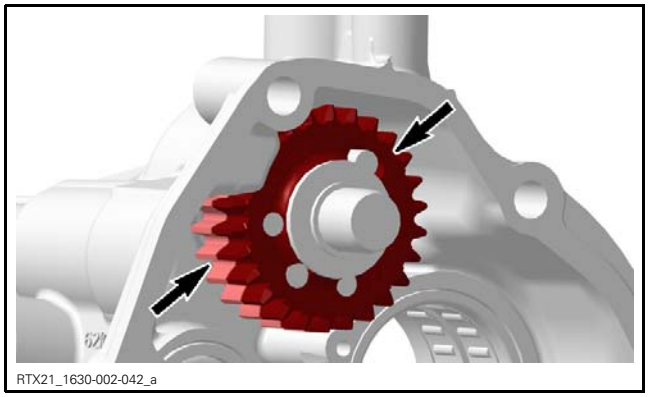

RTX21_1630-002-029_a


RTX21_1630-002-030_a

3. After releasing, split gear must move back to center position of the pin.


RTX21_1630-002-031_a

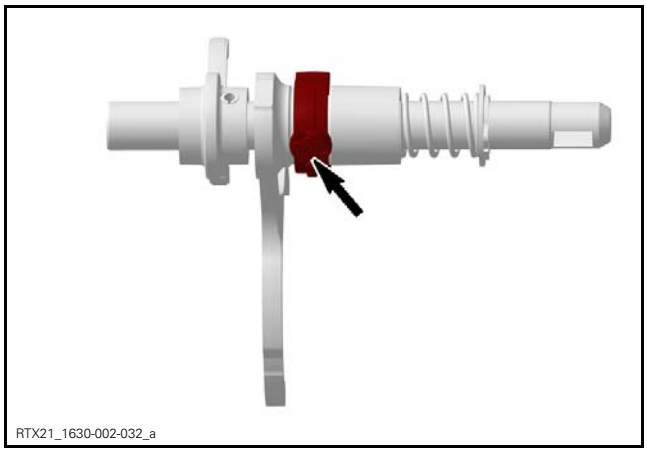
4. Inspect split gear upper and lower part for damaged teeth.


RTX21_1630-002-042_a

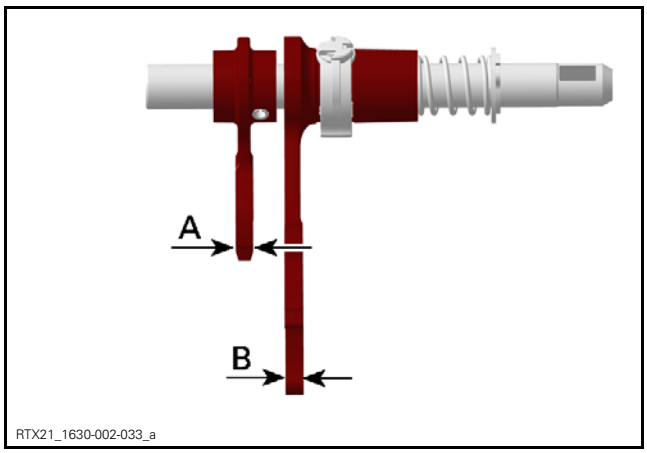
Shifting Fork assembly with Magnet

1. Clean the magnet from metal shavings and debris.

Magnet must not be removed for cleaning.


RTX21_1630-002-032_a

2. Check shifting fork for free movement.
3. Measure the shift fork claw thickness.



RTX21_1630-002-033_a

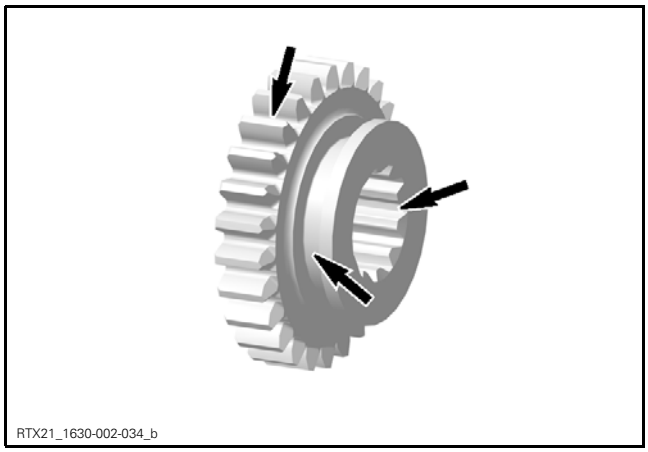
A. Shift fork claw thickness - shift gear
B. Shift fork claw thickness - output shaft

SHIFT FORK CLAW THICKNESS - SHIFT GEAR	
NEW	3.79 mm to 3.91 mm (.149 in to .154 in)
SERVICE LIMIT	3.70 mm (.146 in)

SHIFT FORK CLAW THICKNESS. OUTPUT SHAFT	
NEW	3.94 mm to 4.06 mm (.155 in to .16 in)
SERVICE LIMIT	3.80 mm (.15 in)

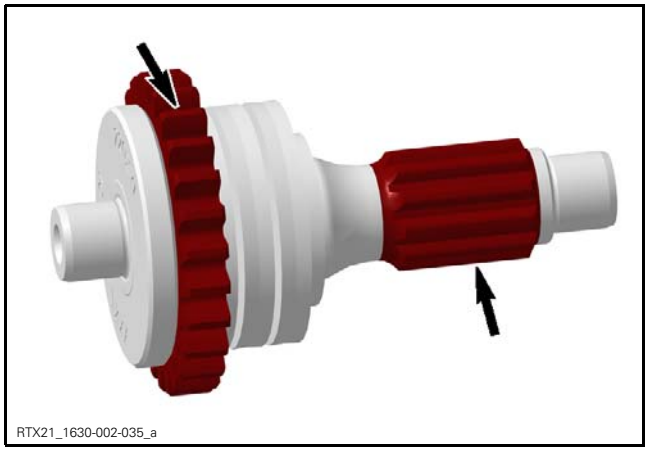
Shift Gear

Inspect shift gear for:
– damaged teeth
– damaged inner splines
– worn or scored shift fork engagement groove.


RTX21_1630-002-034_b

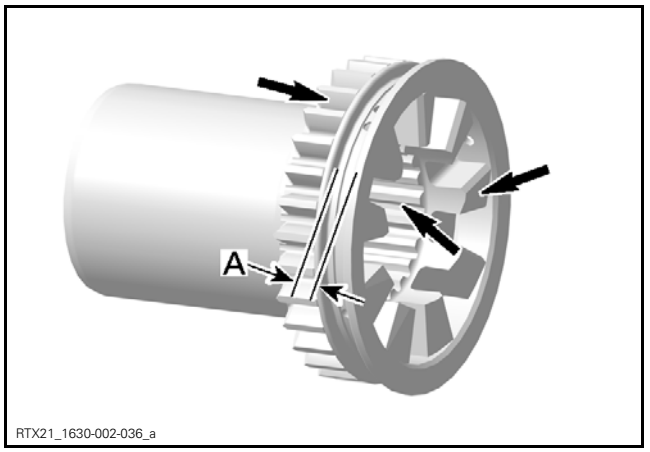
Counter Shaft with Ratchet Clutch

Inspect counter shaft for:
- damaged teeth of clutch gear
- damaged splines.


RTX21_1630-002-035_a

Output Shaft

Inspect output shaft for:
- damaged teeth
- damaged inner splines
- worn or scored bearing surfaces
- worn, scored or discolored shift fork engagement groove.



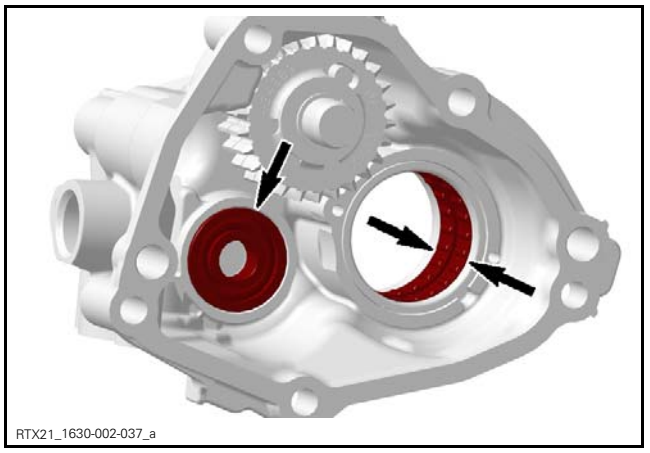
RTX21_1630-002-036_a

A. Shift fork engagement groove width

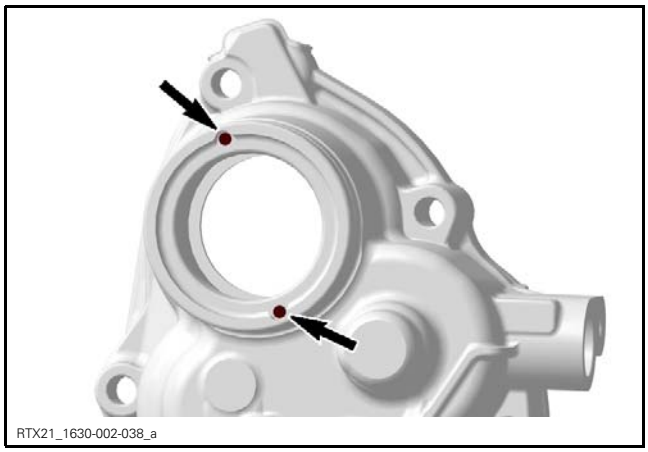
SHIFT FORK ENGAGEMENT GROOVE WIDTH - OUTPUT SHAFT	
NEW	4.10 mm to 4.20 mm (.161 in to .165 in)
SERVICE LIMIT	4.30 mm (.169 in)

Gearbox housing

1. Check ball bearing and needle bearings for smooth operation, excessive play and/ or pitting. Replace if necessary.


RTX21_1630-002-037_a

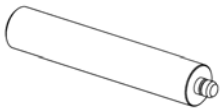
2. Blow out the oil and ventilation bores and check if they are not clogged.

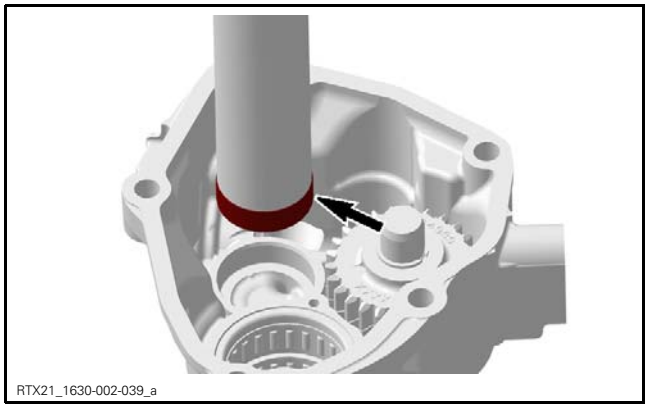

RTX21_1630-002-038_a

Replacing the Ball Bearing

1. Remove ball bearing using a blind hole bearing puller.
2. Heat up gearbox housing half to 80°C (176°F).
3. Press in **NEW** ball baring.

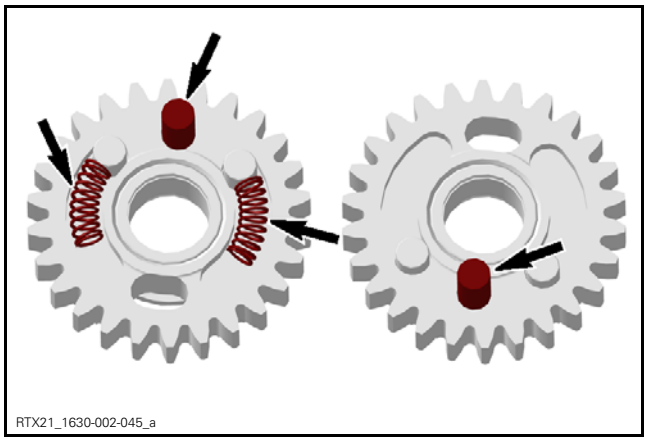
NOTICE **Always support the gearbox housing properly when installing the ball bearing. Damages to the gearbox housing may occur if this procedure is not performed correctly.**

REQUIRED TOOL	
WATER PUMP BEARING PUNCH (P/N 529 036 417)	


RTX21_1630-002-039_a

Assembling the Split Gear

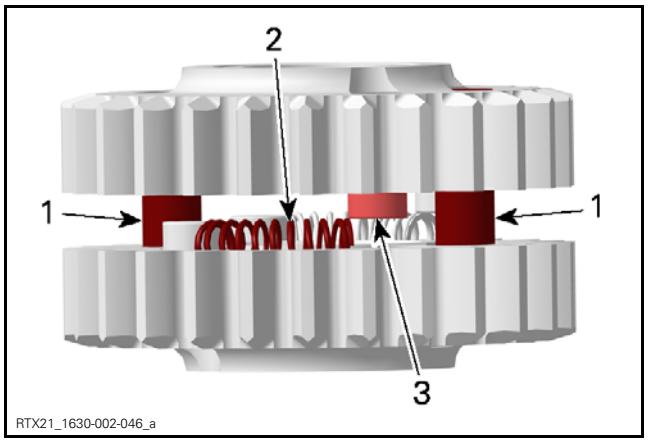
1. Place springs and loose needle pins in the gear halves as illustrated.


RTX21_1630-002-045_a

2. Carefully put both gear halves together and engage the loose needle pins.

NOTICE **Ensure not to squeeze the springs by the fixed needle pins.**

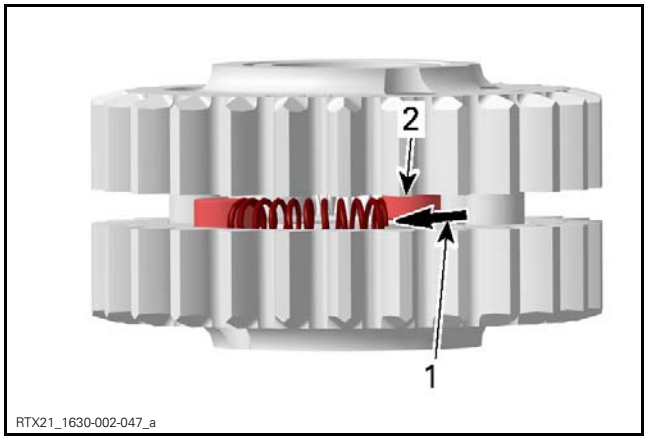
Use a rubber ring to hold both halves together.



RTX21_1630-002-046_a

1. Loose needle pins
2. Spring
3. Fixed needle pin

3. Compress springs using a flat screwdriver to allow engagement of fixed needle pins.

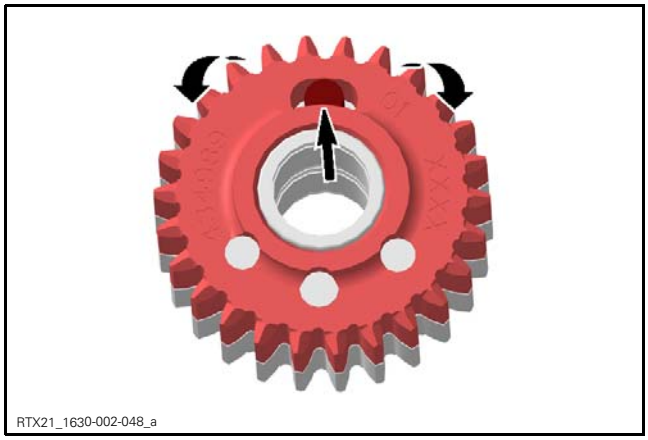


RTX21_1630-002-047_a

Step 1: Compress spring
Step 2: Engage fixed needle pin

4. Check split gear:
   4.1 Hold lower half of split gear.
   4.2 Turn upper split gear half to both sides and release it.

   NOTE: Upper split gear half must move back to center position easiliy.

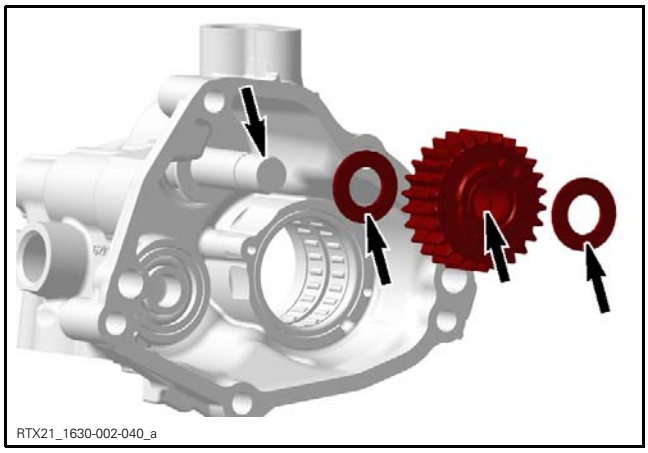

RTX21_1630-002-048_a

Installing the Gearbox

NOTICE The gearbox must be reassembled in forward drive position.

1. Lubricate shaft prior to split gear installation.

SERVICE PRODUCT
Engine oil

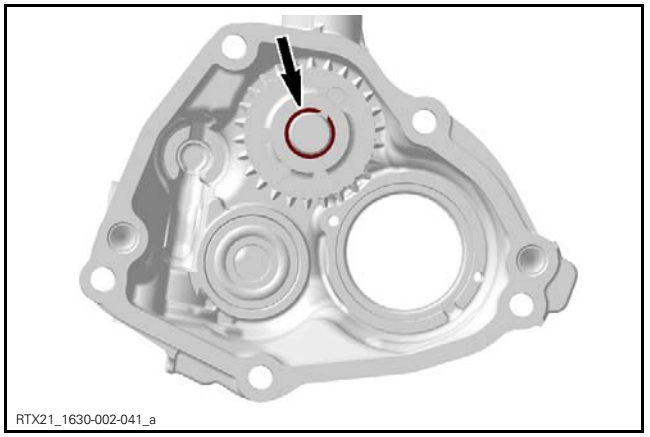

RTX21_1630-002-040_a

LUBRICATE

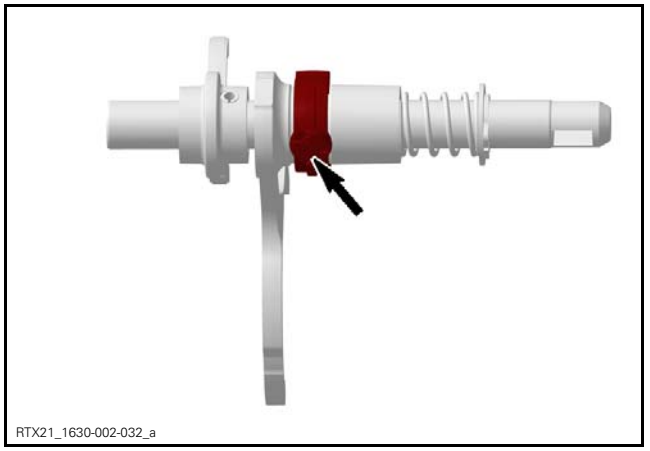
NOTICE Take care that split gear assembly does not fall apart during installation.

2. Install NEW retaining ring to secure split gear.

NOTICE Do not overstress retaining ring during installation. Retaining ring must not turn easily after installation.


RTX21_1630-002-041_a

NOTICE Ensure magnet clip is:
– seated properly in the shift fork shaft groove
– free of any debris.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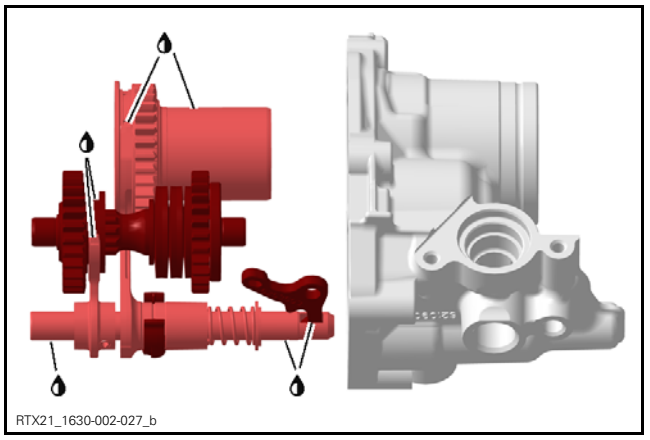
3. Lubricate gearbox components and complete the assembly as illustrated.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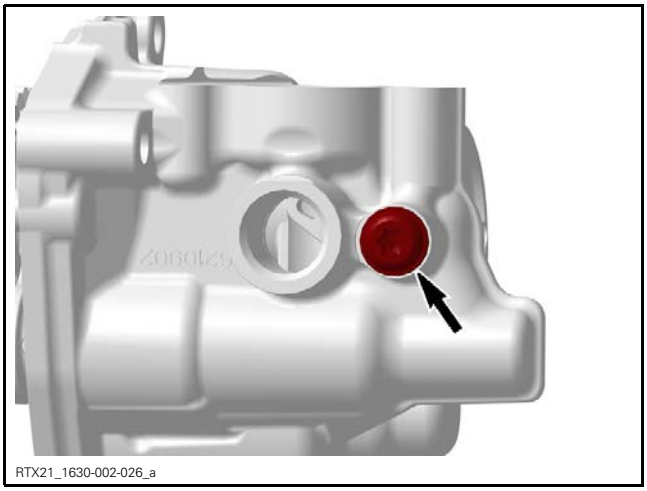
4. Apply threadlocker on the bearing bolt thread.
5. Tighten bearing bolt to specification.



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TIGHTENING TORQUE	
Bearing bolt	8 N•m ± 0.5 N•m (71 lbf•**in** ± 4 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)

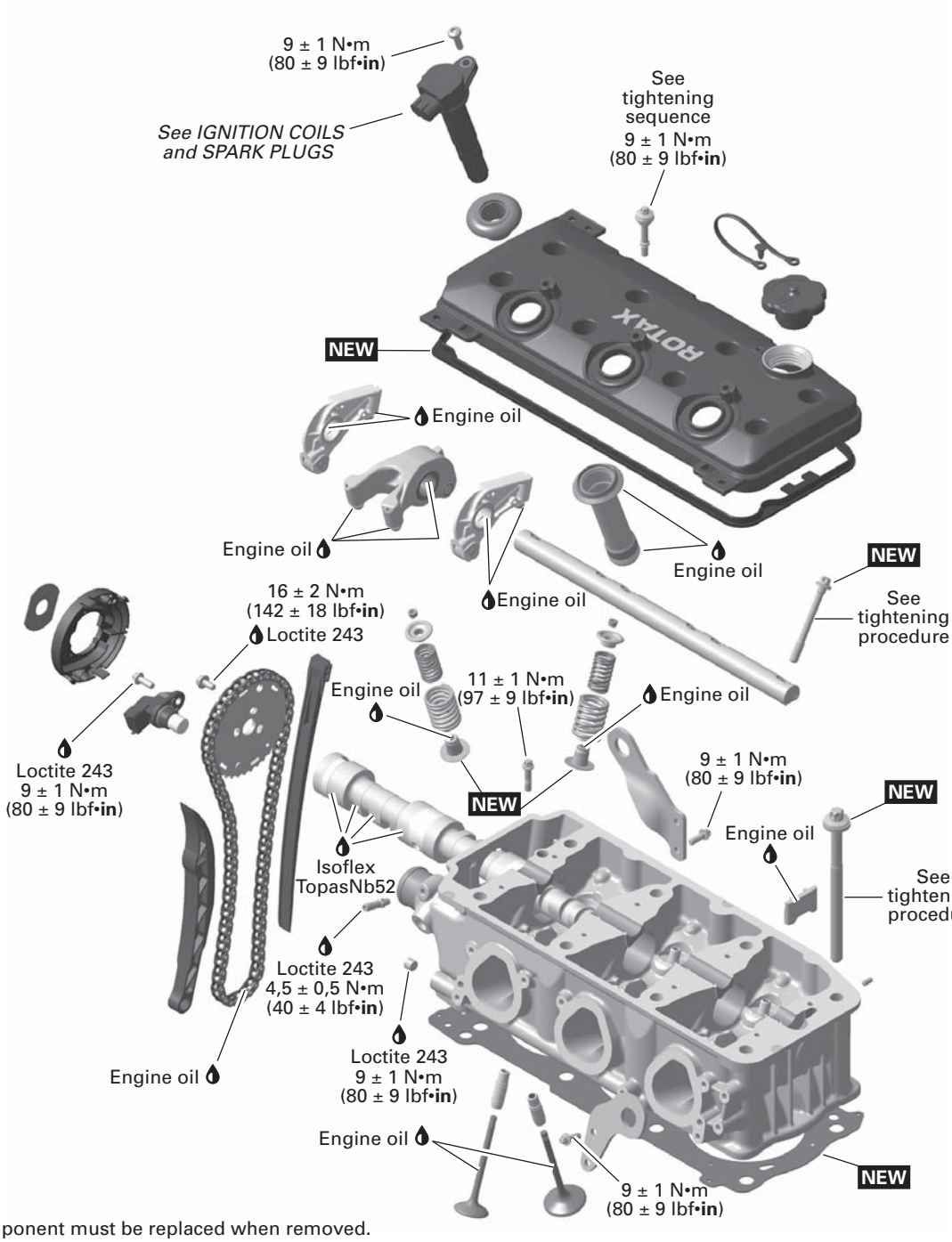
CYLINDER HEAD

SERVICE TOOLS

Description	Part Number	Page
CAMSHAFT LOCKING TOOL	529 035 839	112
DRIVE SHAFT ADAPTER	529 035 985	101
ENGINE LEAK DOWN TEST KIT	529 035 661	102
VALVE GUIDE PUSHER (6 MM)	529 036 087	121
VALVE GUIDE REMOVER (6 MM)	529 036 086	121
VALVE SPRING COMPRESSOR CUP	529 036 073	116
VALVE SPRING COMPRESSOR	529 035 724	116

SERVICE PRODUCTS

Description	Part Number	Page
ISOFLEX GREASE TOPAS NB 52	293 550 021	113
LOCTITE 243 (BLUE)	293 800 060	107, 111, 116
MOLYKOTE G-N	420 297 433	121



NEW = Component must be replaced when removed.

RTX22_1630-007-001_a

GENERAL

NOTE: When diagnosing an engine problem, always perform an engine leak test. This will help to pin-point a problem. Refer to *ENGINE LEAK TEST* in this subsection for procedures.

When disassembling parts that are duplicated in the engine, (e.g.: valves, bushings), it is strongly recommended to note their position and to keep them 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".

INSPECTION

ENGINE LEAK TEST

The procedure has to be done when engine operating temperature of approximately 70°C (158°F) is reached.

⚠ WARNING

Be careful to burns when working on a hot engine.

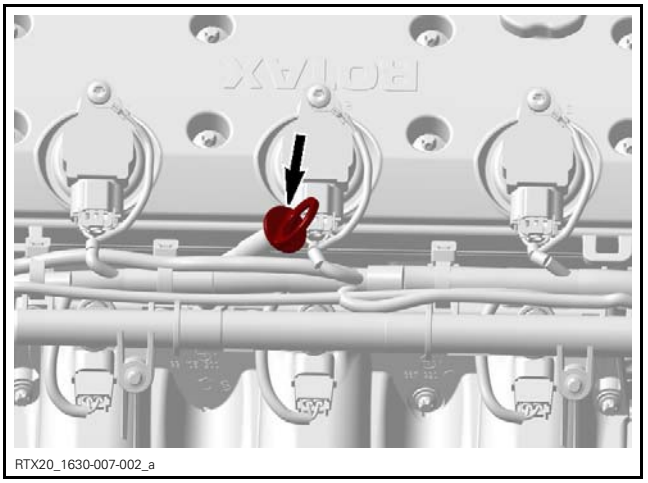
Preparation

1. Remove any required parts to give access to engine.
2. Remove the tether cord.
3. Remove jet pump (refer to *JET PUMP* subsection).
4. Remove coolant pressure cap.

⚠ WARNING

To avoid potential burns, only remove the coolant pressure cap by wearing the appropriate safety equipment.

5. Remove oil dipstick.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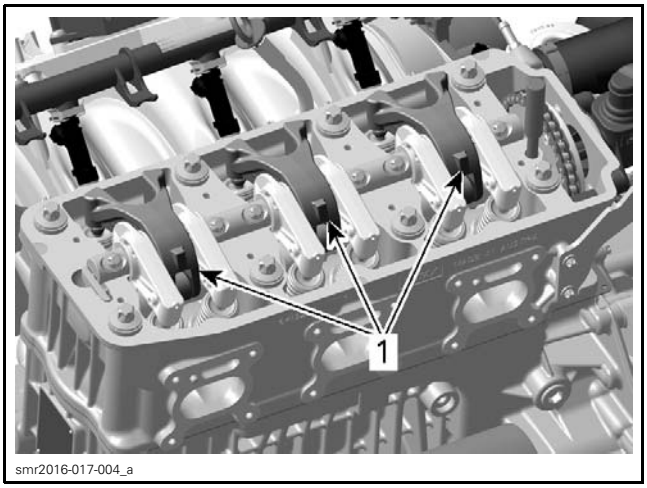
6. Refer to *IGNITION COILS AND SPARK PLUGS* and remove:
   – Ignition coils
   – Spark plugs.
7. Remove *VALVE COVER*, see procedure in this subsection.
8. Install the drive shaft adapter and an appropriate wrench lever on drive shaft end.

REQUIRED TOOL	
DRIVE SHAFT ADAPTER (P/N 529 035 985)	

Leak Test Procedure

NOTE: Cylinder numbers are molded on valve cover.

1. Rotate engine crankshaft counterclockwise until the cylinder 1 is at Top Dead Center (TDC) compression stroke.
   1.1 As the engine crankshaft is turned over, observe the movement of intake rocker arm of the cylinder to be checked.
   1.2 After piston completes its cycle and the intake valve closes, observe the piston.
   1.3 When it reaches its uppermost position **this is TDC compression stroke**.



1. Intake rocker arms

2. Secure the wrench lever, at the end of the drive shaft, against hull to prevent further crankshaft rotation.
3. Install the leak down test tool.

REQUIRED TOOL	
ENGINE LEAK DOWN TEST KIT (P/N 529 035 661)	

3.1 Install the appropriate gauge adapter into spark plug hole.

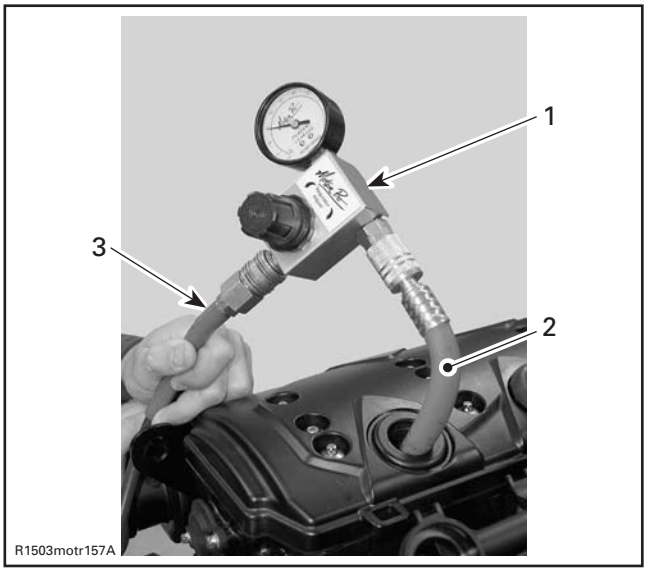
3.2 Connect the leak down tester gauge to the gauge adapter.

3.3 Connect to an adequate pressurized air supply.

3.4 Set needle of measuring gauge to zero (0).

NOTE: Each tester will have specific instruction on the gauge operation and required pressure. Refer to manufacturer's instructions.

4. Supply combustion chamber with air.



TYPICAL
1. Leak down tester gauge
2. Gauge adapter
3. Air supply hose

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

LEAKAGE PERCENTAGE	ENGINE CONDITION
Up to 15%	Excellent condition
16% to 25%	Good condition
26% to 40%	Fair condition; engine will run and performance might be down in some cases
41% and higher	Poor condition, diagnose and repair engine

6. Proceed the same way with remaining cylinders.

Diagnostic

Pressurize area to be tested, spray soap/water solution at the indicated location and look and/or listen for air bubbles.

OBSERVATION	CAUSE
Air escaping on intake port	Leaking intake valve(s)
Air escaping on exhaust port	Leaking exhaust valve(s)
Air escaping into crankcase	Excessively worn and/or broken piston rings
Air bubbles out of coolant tank	Leaking cylinder head gasket

OBSERVATION	CAUSE
Air/water escaping from cylinder-block/head	Damaged gasket and/or loosened screws
Coolant escaping from water pump housing	Damaged gasket and/or loosened screws (refer to *COOLING SYSTEM* - ENGINE COMPONENTS)
Coolant escaping from leak indicator hole	Damaged rotary seal on water pump shaft (refer to *COOLING SYSTEM - ENGINE COMPONENTS*)
Oily contamination on leak indicator hole	Damaged oil seal on water pump shaft

Reassembly

For reassembly, reverse the preparation procedure. Use torque values and service products from the exploded views (refer to proper *ENGINE* subsections).

Properly install ignition coils. Refer to *IGNITION COILS AND SPARK PLUGS* subsection.

TROUBLESHOOTING

The following is provided to help in diagnosing the probable source of problems. It is a guideline and it should not be assumed to list all possible problems.

Always check for fault codes. If a fault code is detected, service the fault code first. Refer to *DIAGNOSTIC AND FAULT CODES* subsection.

UNUSUAL ENGINE NOISE OR VIBRATIONS

1. Incorrect camshaft timing adjustment
   - *Replace damaged components and readjust camshaft timing.*
2. Camshaft timing gear screws got loose
   - *Retighten screws with the recommended torque.*
3. Rocker arm(s) hydraulic element is broken or worn out (improper valve adjustment).
   - *Replace faulty rocker arm(s).*
4. Rocker arm screw not properly tightened
   - *Retighten screws with recommended torquing procedure.*
5. Faulty chain tensioner
   - *Replace chain tensioner.*
6. Chain guide is worn out
   - *Replace chain guide.*
7. Stretched timing chain or worn out sprocket
   - *Replace timing chain and sprocket.*
8. Camshaft is worn out
   - *Check if camshaft radial clearance is out of specification.*

OIL LEAKAGE FROM CYLINDER HEAD

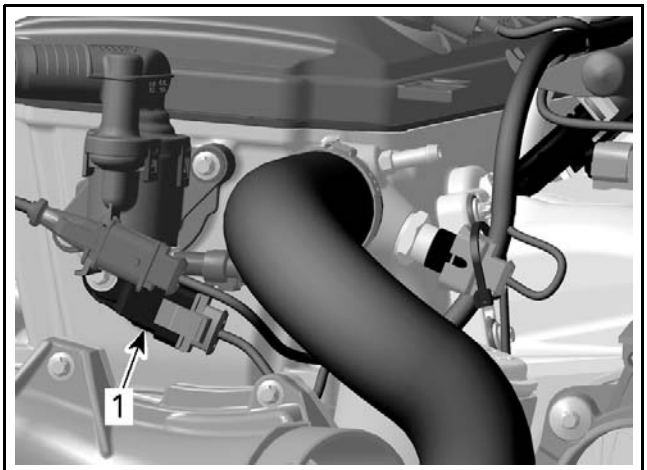
1. Valve cover gasket is leaking
   - *Replace valve cover gasket and retighten screws with recommended torque.*
   - *Check valve cover for cracks or other damage. Replace if necessary.*
2. Valve cover screws are leaking
   - *Replace valve cover screws.*
3. Spark plug tube gasket is leaking
   - *Remove valve cover and replace spark plug tube gasket.*
   - *Clean spark plug area from oil spillage.*
4. Blow by valve is leaking
   - *Replace blow by valve O-ring.*
5. Camshaft sensor O-ring is leaking
   - *Replace camshaft sensor O-ring.*
6. Cylinder head gasket is leaking
   - *Remove cylinder head and check for damage.*
   - *Replace cylinder head gasket and retighten screws with recommended torquing procedure.*

ENGINE LACKS ACCELERATION OR POWER

1. Incorrect camshaft timing adjustment
   - *Replace damaged components and readjust camshaft timing.*
2. Intake or exhaust valves are leaking
   - *Perform ENGINE LEAK TEST.*
   - *Check if valve seats properly in valve seat.*
   - *Repair or replace damaged components.*
3. Broken valve spring(s)
   - *Replace defective parts.*
4. Broken rocker arm(s)
   - *Replace defective parts.*

PROCEDURES

CAMSHAFT POSITION SENSOR (CAPS)



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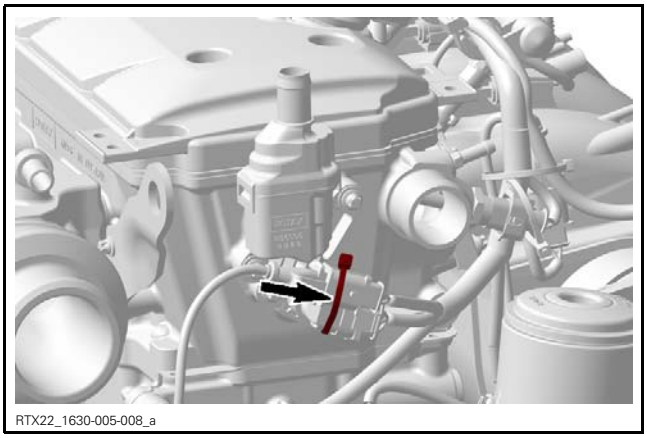
TYPICAL
1. CAPS

Testing the CAPS Voltage (Harness Side)

1. First check fuse F11 in fuse box. Replace as required.
2. Remove the parts required to access the CAPS.

Engine without TOPS

3. Cut locking tie securing the CPS connector.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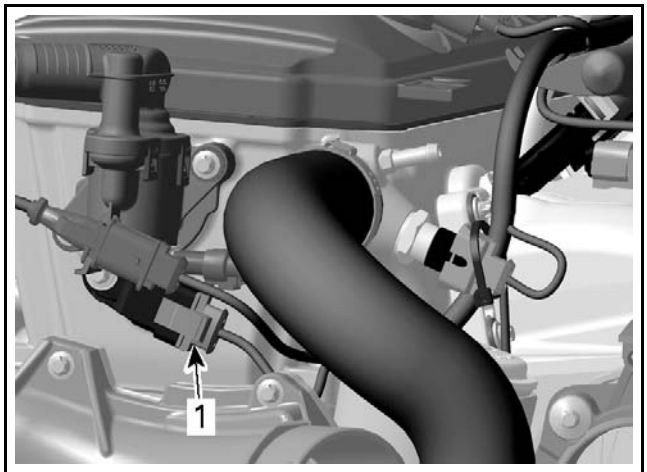
All Engines

4. Disconnect CAPS connector.



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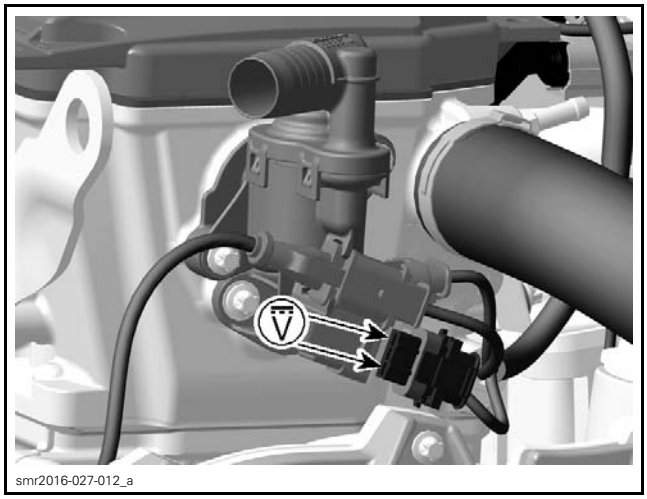
TYPICAL
1. CAPS connector

5. Press the START button to wake up the ECM.
6. Install tether cord on engine cut-off switch.
7. Probe harness connector terminals as per following table.

CAPS INPUT VOLTAGE TEST		
CAPS CONNECTOR PIN		SPECIFICATION
1	3	Battery voltage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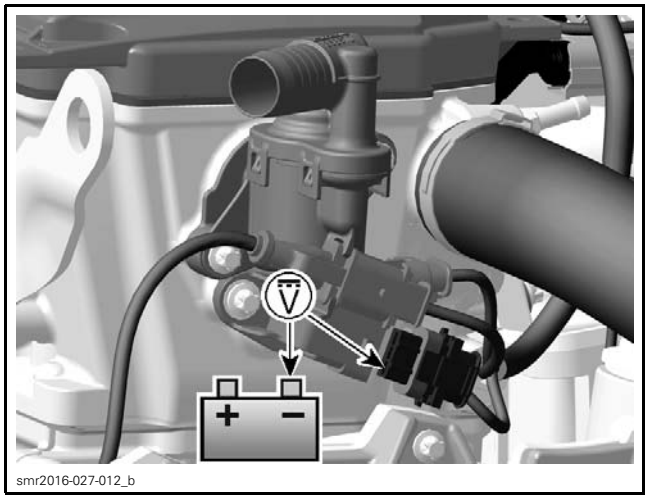
8. If battery voltage is read, proceed with *TESTING THE CAPS (DYNAMIC)* in this subsection.
9. If battery voltage is not read, probe circuit as per following table.

CAPS INPUT VOLTAGE TEST (DYNAMIC)		
CAPS CONNECTOR PIN	BATTERY	SPECIFICATION
3	Negative (-) post	Battery voltage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10. If voltage is read to battery ground, check continuity of CAPS ground circuit. Repair or replace wiring and connectors.

CAPS GROUND CIRCUIT CONTINUITY		
CAPS CONNECTOR PIN	ECM ADAPTER PIN	SPECIFICATION
1	A-D4	Close to 0 Ω

11. If voltage is not read to battery ground, carry out *TESTING THE CONTINUITY OF CAPS POWER CIRCUIT*.

Testing the Continuity of CAPS Power Circuit

1. Set the multimeter to Ω.
2. Read resistance of the CAPS circuit as per following table.

CAPS POWER CIRCUIT CONTINUITY TEST		
CAPS CONNECTOR PIN	FUSE BOX TERMINAL	SPECIFICATION
3	E1	Close to 0 Ω

3. If continuity is good, wiring and connectors are functional.
4. If a high resistance or an open circuit is measured, check the short bus bar in fuse box, repair or replace wiring and connectors from fuse box terminal to CAPS connector.

Testing the CAPS (Dynamic)

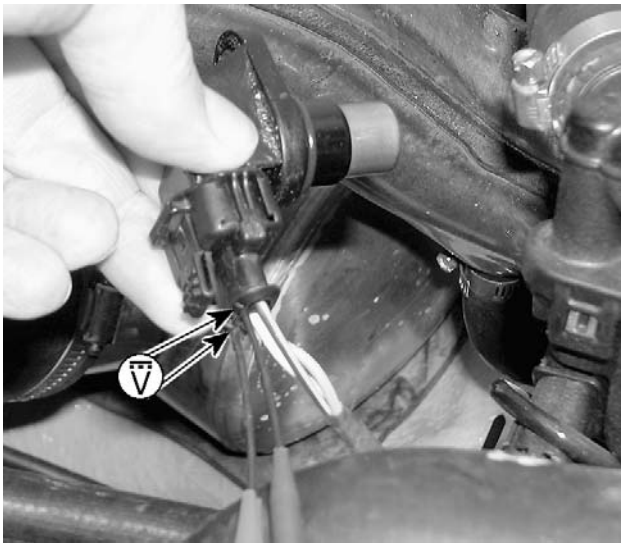
1. Remove the parts required to access the CAPS.
2. Remove CAPS sensor from engine.
3. Back-probe connector and read voltage as follows.

NOTE: To safely probe wire terminals through the back of the connector, using following tools or equivalent. Care must be taken not to damage connector seals.

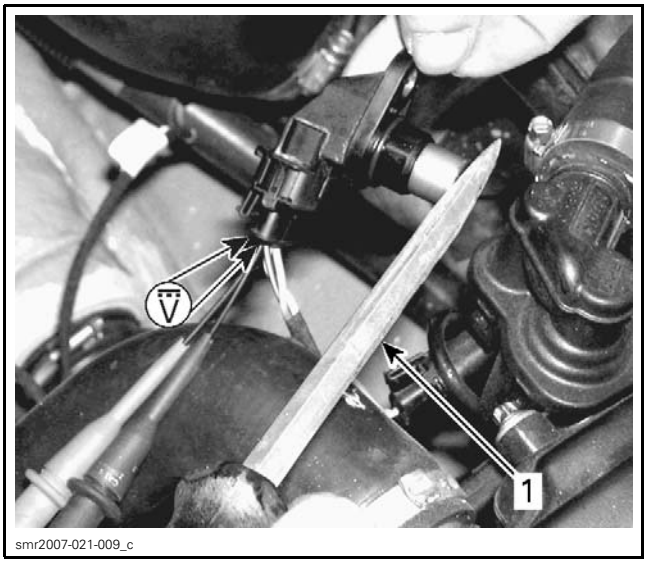
REQUIRED TOOL	
Back probe pin	
Insulated test leads	

NOTICE **Do not use sharp end probes. They could damage the connector seal.**

CAPS TEST (DYNAMIC)			
CAPS CONDITION	CAPS CONNECTOR PIN		SPECIFICATION
Free	1	2	Close to 12 Vdc


smr2007-021-010_a
TYPICAL

CAPS TEST (DYNAMIC)			
CAPS CONDITION	CAPS CONNECTOR PIN		SPECIFICATION
Metallic object on sensor just for a few seconds	1	2	Close to 12 Vdc



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1. Metallic object

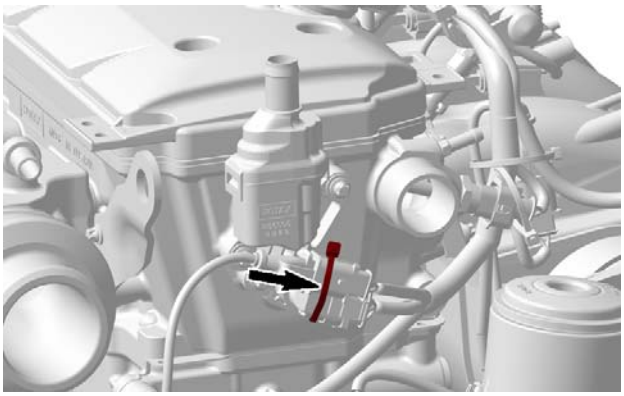
NOTE: Check several times if voltage follows the placement of the metallic object. Voltage must change each time.

4. If voltage is as specified, repair or replace wiring and connectors between sensor and ECM.
5. If wiring is good, check ECM. Refer to *ENGINE CONTROL MODULE*.
6. If voltage is not measured as specified, try a new CAPS.

Replacing the CAPS

Engine without TOPS

1. Cut locking tie securing the CPS connector.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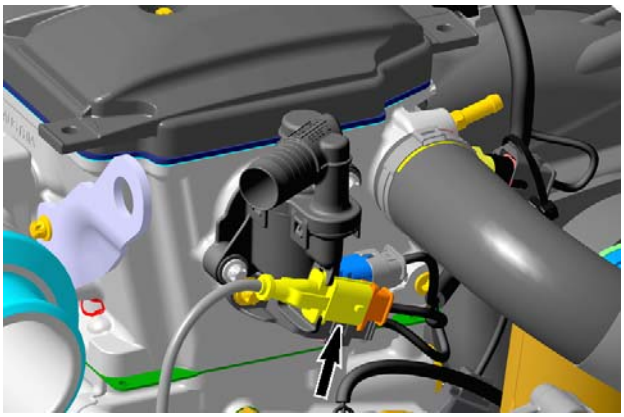
Engine with TOPS

2. Detach CPS connector from its holder.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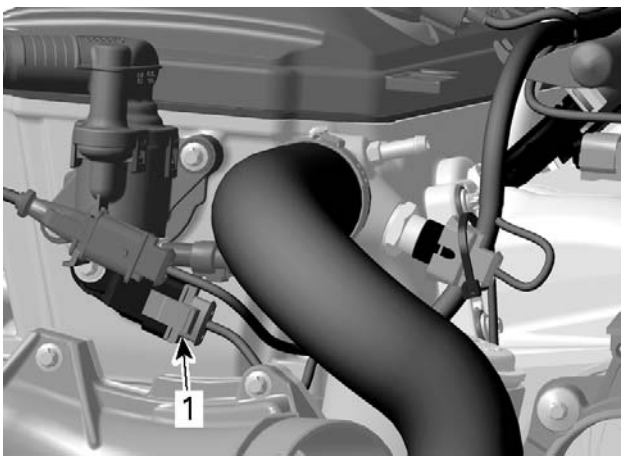
TYPICAL - SUPERCHARGER REMOVED FOR CLARITY

All Engines

3. Disconnect CAPS connector.



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TYPICAL
1. CAPS connector

4. Unscrew the CAPS retaining screw.
5. Pull CAPS from engine.

6. Install the CAPS.

NOTICE Be sure to install NEW O-ring on a reused CAPS.

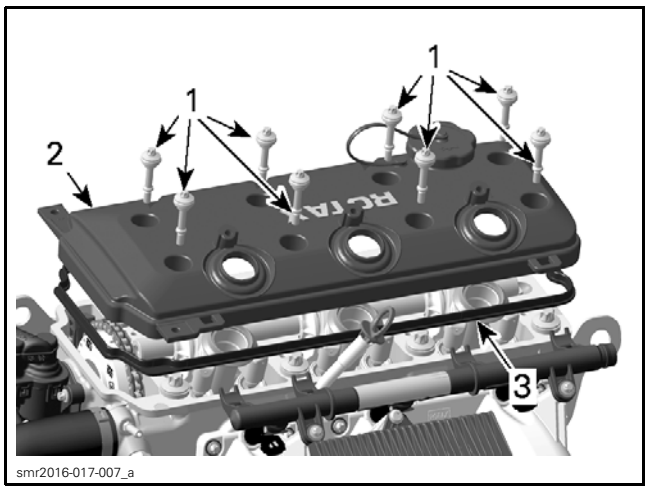
7. Tighten CAPS retaining screw to specification.

TIGHTENING TORQUE	
CAPS retaining screw	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)

VALVE COVER

Removing the Valve Cover

1. Remove ignition coils. Refer to *IGNITION COILS AND SPARK PLUGS* subsection.
2. Remove the valve cover.



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1. *Valve cover screws*
2. *Valve cover*
3. *Gasket (discard)*

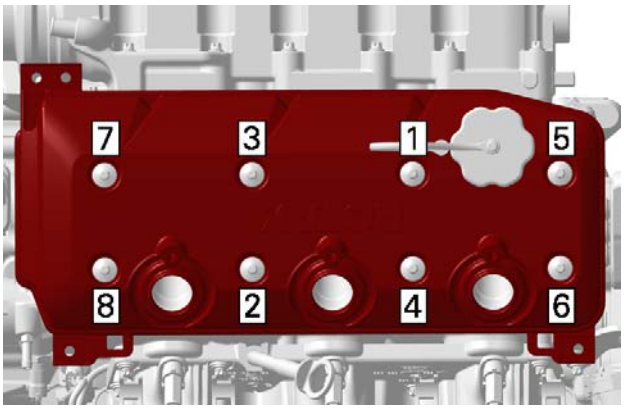
Inspecting the Valve Cover

1. Check the valve cover for cracks or other damage.
2. Check if rubber bushing on the valve cover screws are brittle, cracked or hard. If so, replace valve cover screw accordingly.

Installing the Valve Cover

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

1. Properly seat **NEW** gasket in the cover groove.
2. Install the valve cover screws according to following sequence.



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TIGHTENING SEQUENCE

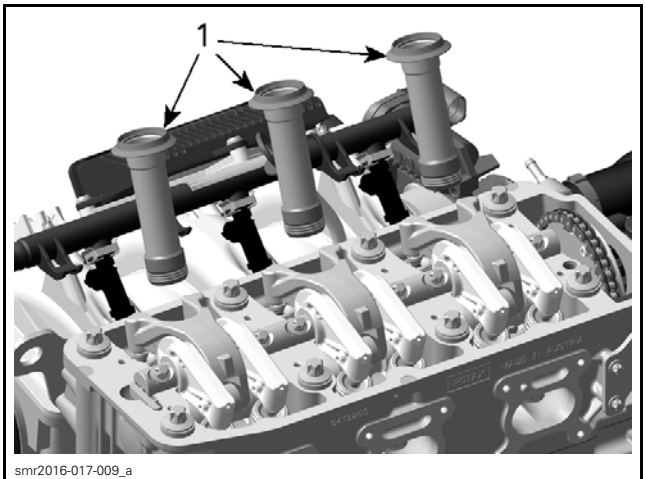
TIGHTENING TORQUE		
Valve cover screws	STEP A (screws 1 to 8)	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**)
	STEP A (screws 1 to 4)	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**)

3. Install the ignition coils, refer to *IGNITION COILS AND SPARK PLUGS* subsection.
4. Install all other removed parts. Refer to proper subsection for procedure.

SPARK PLUG TUBES

Removing the Spark Plug Tube

1. Remove the *VALVE COVER*, see procedure in this subsection.
2. Pull spark plug tubes to remove them.



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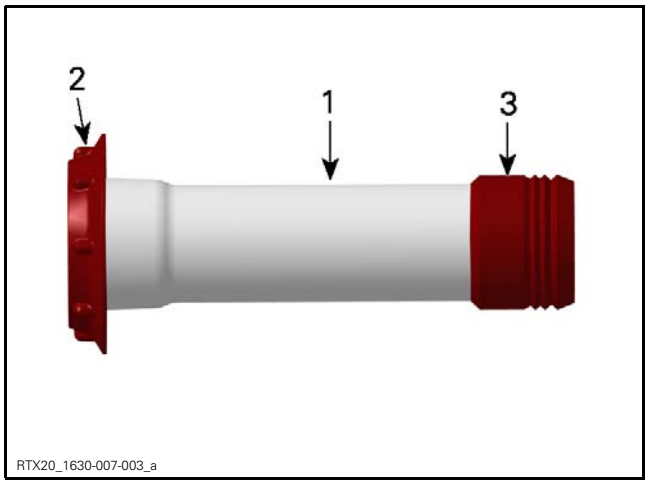
1. *Spark plug tubes*

Inspecting the Spark Plug Tube

Check seals on spark plug tube. If seals are brittle, cracked or hard, replace spark plug tube.



1. Spark plug tube
2. Seal to the valve cover
3. Seal to the cylinder head

Installing the Spark Plug Tube

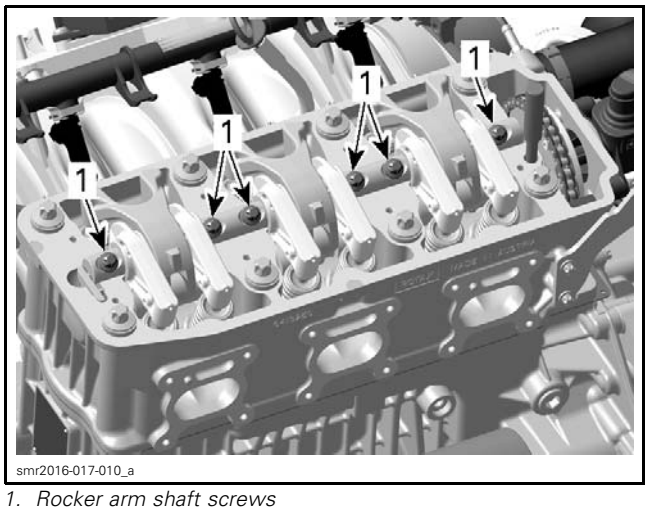
The installation is the reverse the removal procedure. However, pay attention to the following.

Apply engine oil on seals.

ROCKER ARMS

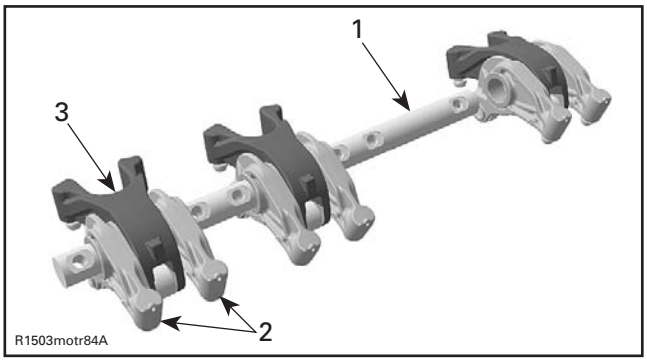
Removing the Rocker Arm

1. Refer to procedure in this subsection to remove:
   – Valve cover
   – Spark plug tubes.
   .
2. Remove and discard the rocker arm shaft screws.



1. Rocker arm shaft screws

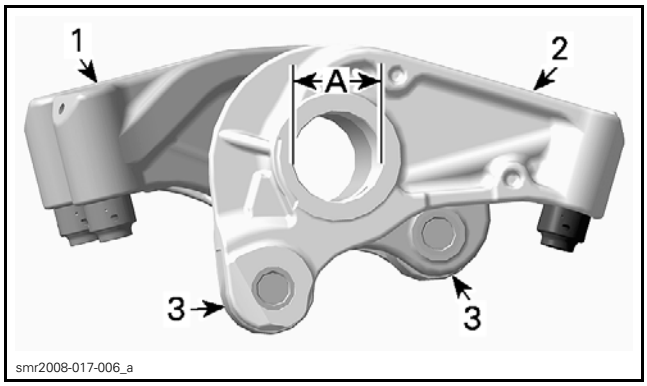
3. Remove rocker arm shaft with rocker arms.



1. Rocker arm shaft
2. Rocker arms (exhaust side)
3. Rocker arm (intake side)

Inspecting the Rocker Arm

1. Inspect each rocker arm for cracks and scored friction surfaces. If so, replace rocker arm assembly.
2. Check the rocker arm rollers for free movement, wear and excessive radial play. Replace rocker arm assembly as necessary.



1. Rocker arm (intake side)
2. Rocker arm (exhaust side)
3. Rollers
A. Rocker arm inside diameter

3. Measure rocker arm inside diameter. If diameter is out of specification, change the rocker arm assembly.

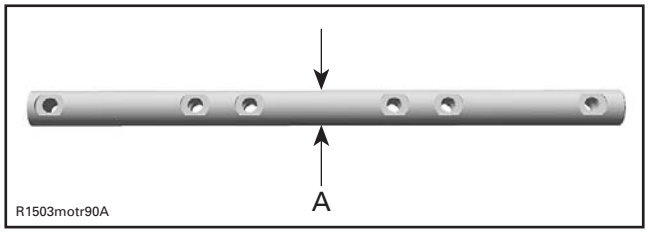
ROCKER ARM INSIDE DIAMETER	
New	20.007 mm to 20.020 mm (.7877 in to .7882 in)
Service limit	20.050 mm (.7894 in)

4. Press the hydraulic lifter with your thumb. If the hydraulic lifter can be fully pressed in, replace rocker arm. Lifter must turn freely in rocker arm bore. Otherwise, replace.

Inspecting the Rocker Arm Shaft

1. Check for scored friction surfaces, if so, replace parts.

2. Measure rocker arm shaft diameter.

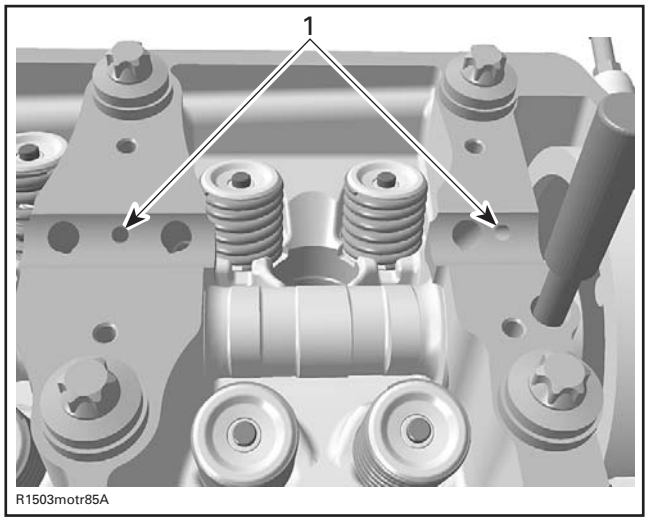


A. Measure rocker arm shaft diameter here

ROCKER ARM SHAFT DIAMETER	
New	19.980 mm to 19.993 mm (.7866 in to .7871 in)
Service limit	19.970 mm (.7862 in)

Any area worn excessively will require parts replacement.

3. Verify and clean oil orifices to ensure a good rocker arm shaft lubrication.



1. Oil orifices from the camshaft to the rocker arm shaft, then to the rocker arms and finally to the valve adjustment

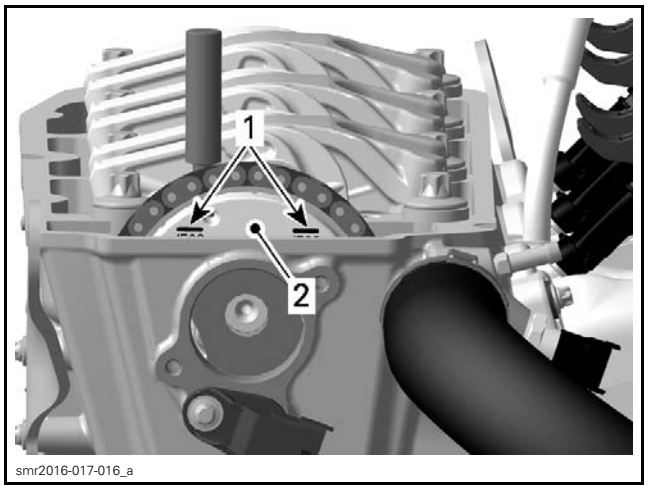
Installing the Rocker Arm

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

The rocker arm shaft can only be installed in one specific position. Therefore strictly adhere to following procedure.

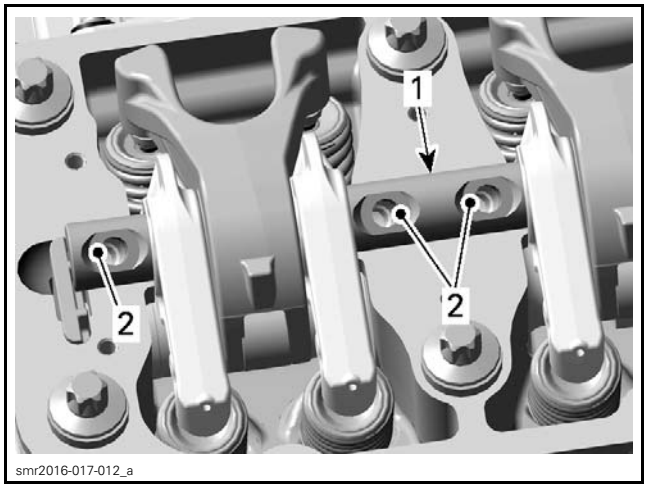
1. Lock camshaft. Refer to *CAMSHAFT* in this subsection.

NOTICE **Make sure the printed marks on oil separator cover are parallel to the cylinder head base.**



1. Printed marks
2. Oil separator cover

2. Apply engine oil on rocker arm shaft.
3. Position the rocker arm shaft with the notches on top.



1. Rocker arm shaft
2. Rocker arm shaft notches

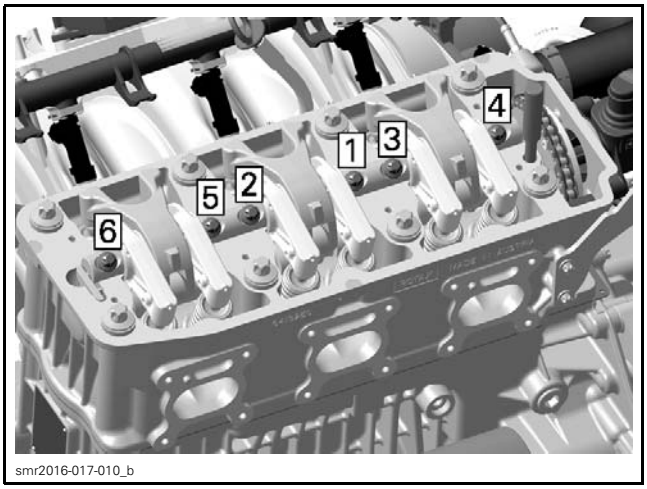
4. Install NEW rocker arm shaft screws.

NOTICE **This assembly uses stretch screws. Always use NEW screws and strictly adhere to the tightening procedure.**

5. Tighten screws according to following sequence.

NOTICE **Apply tightening torque of the step A on ALL rocker arm shaft screws before going to the step B.**

TIGHTENING PROCEDURE		
Rocker arm shaft screws	Step A	20 N•m ± 2 N•m (15 lbf•ft ± 1 lbf•ft)
	Step B	Additional 90° ± 5°



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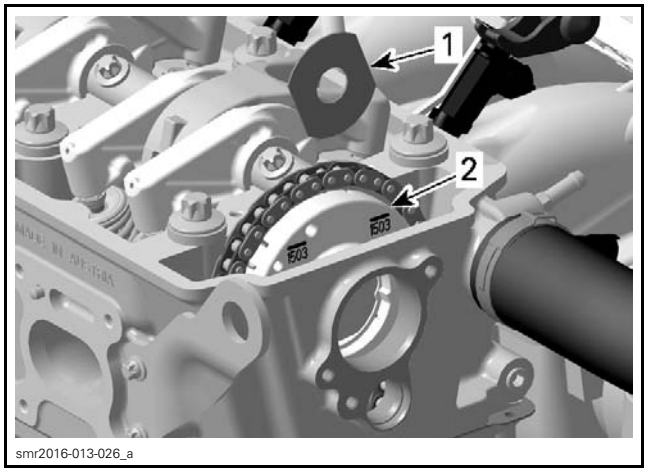
TIGHTENING SEQUENCE

CAMSHAFT TIMING GEAR

Removing the Camshaft Timing Gear

1. Lock the crankshaft. Refer to *CYLINDER BLOCK* subsection.
2. Remove:
   - *VALVE COVER*. Refer to the procedure in this subsection
   - *CAMSHAFT POSITION SENSOR*. Refer to the procedure in this subsection
   - Blow-by valve. Refer to *LUBRICATION SYSTEM* subsection.
3. Lock the camshaft. Refer to *CAMSHAFT* in this subsection.
4. Remove the thrust washer from the oil separator cover.



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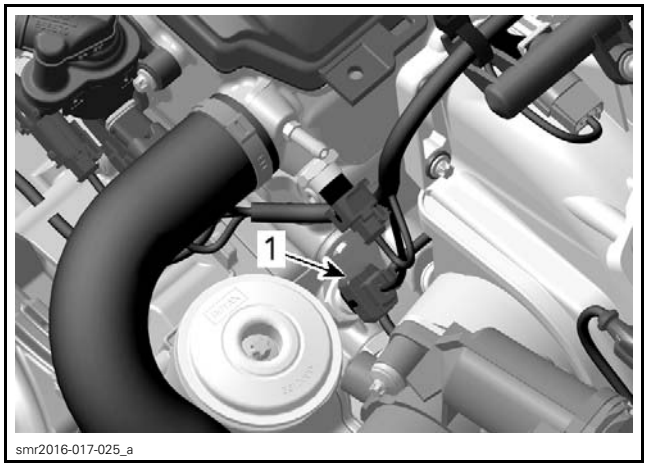
1. Thrust washer
2. Oil separator cover

5. Unplug the oil temperature sensor.



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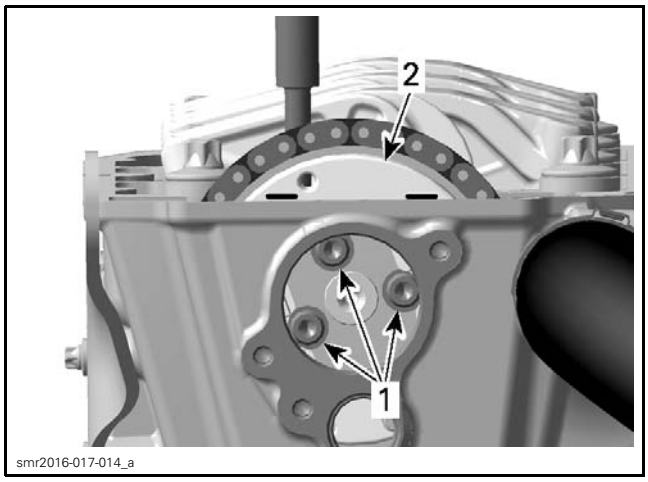
1. Oil temperature sensor connector

6. Remove the chain tensioner. Refer to *CYLINDER BLOCK* subsection.
7. Remove:
   - Chain guide
   - Camshaft timing gear with oil separator cover.



1. Timing gear screws
2. Camshaft timing gear with oil separator cover

8. Secure the timing chain with a retaining wire.

Inspecting the Camshaft Timing Gear

Check the camshaft timing gear for wear or deterioration.

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

NOTE: For crankshaft timing gear replacement, refer to *CYLINDER BLOCK* subsection.

Installing the Camshaft Timing Gear

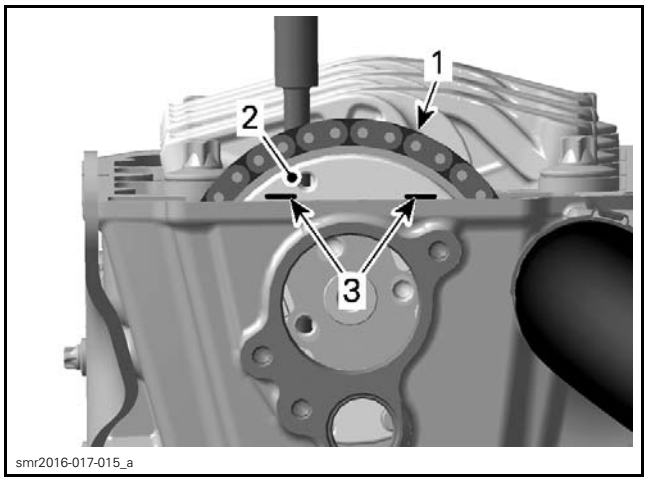
The installation is reverse of the removal procedure. However, pay attention to the following.

1. Install the oil separator cover on the camshaft timing gear.

NOTICE **Crankshaft and camshaft must be locked on TDC position.**

2. Place the camshaft timing gear along with the timing chain on the camshaft.

NOTE: The printed marks on the oil separator cover must be parallel to the cylinder head base.



1. Timing chain
2. Oil separator cover
3. Printed marks

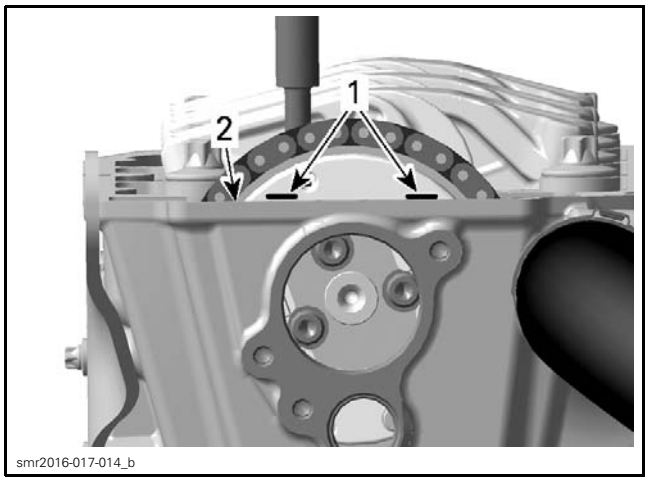
3. Ensure the chain guides are properly installed.
4. Loosely install the timing gear screws.
5. Install the chain tensioner.

NOTE: There can be 2 different positions to install the timing gear on the camshaft. To find the best position strictly follow the procedure.

6. Check if the timing gear screws are still loose. If screws are squeezed by the timing gear, remove the chain tensioner again and rotate the timing gear by one tooth clockwise.
7. Install the chain tensioner again.
8. Remove the timing gear screws and apply thread locker on threads.
9. Tighten the timing gear screws to specification.

TIGHTENING TORQUE	
Camshaft timing gear screws	16 N•m ± 2 N•m (142 lbf•**in** ± 18 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)

NOTICE **Printed marks on the oil separator cover must be parallel to the cylinder head surface.**



1. Printed marks
2. Cylinder head surface

10. Remove the crankshaft and camshaft locking tools.
11. Install all other removed parts.

CAMSHAFT

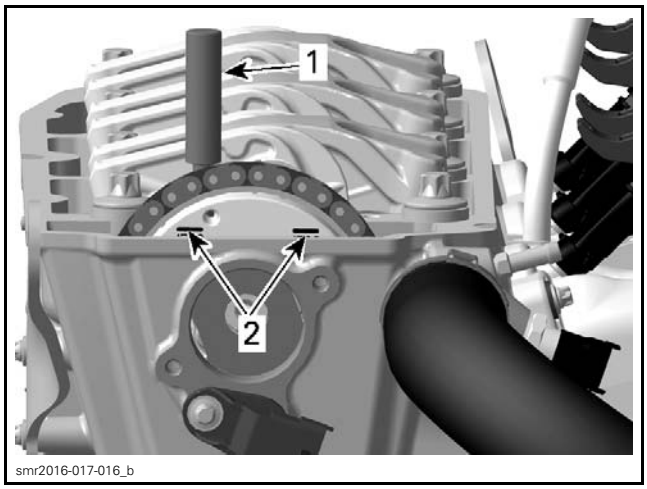
Camshaft Locking Procedure

1. Remove the valve cover. Refer to the procedure in this subsection.
2. Lock the crankshaft. Refer to the procedure in *CYLINDER BLOCK* subsection.

NOTE: Make sure that printed marks on the oil separator cover are parallel to the cylinder head base.

3. Insert the camshaft locking tool into the hole behind the camshaft timing gear to lock the camshaft.

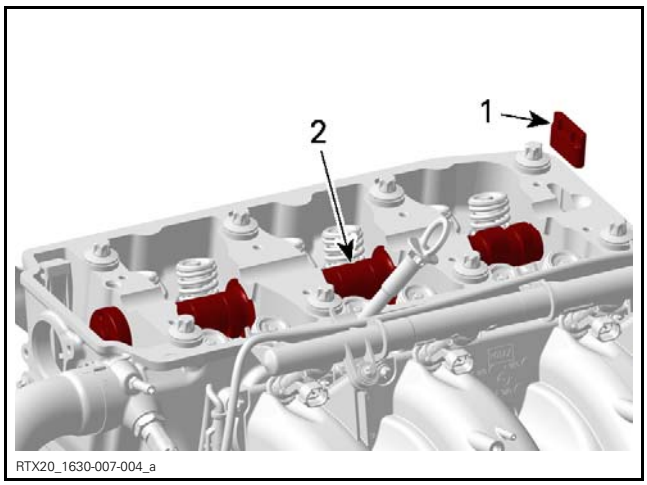
REQUIRED TOOL	
CAMSHAFT LOCKING TOOL (P/N 529 035 839)	



1. Camshaft locking tool
2. Printed marks

Removing the Camshaft

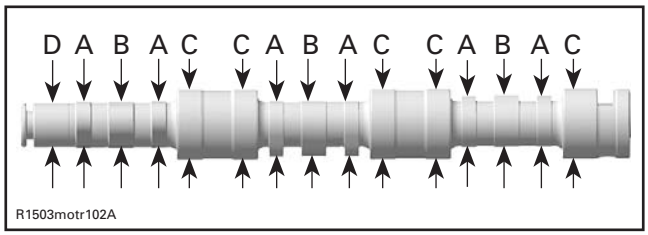
1. Refer to the procedure in this subsection and remove:
   – Camshaft timing gear
   – Rocker arms.
2. Remove the camshaft.



1. Camshaft lock
2. Camshaft

Inspecting the Camshaft

1. Check each lobe and bearing journal of camshaft for:
   – Scoring
   – Scuffing
   – Cracks
   – Other signs of wear.
2. Measure camshaft bearing journal and lobe height using a micrometer.
3. Measure clearance between both ends of camshaft and cylinder head.



A. Camshaft lobe (exhaust valves)
B. Camshaft lobe (intake valves)
C. Camshaft bearing journal
D. Camshaft bearing journal — engine front

ENGINE TYPE	CAMSHAFT LOBE HEIGHT — EXHAUST VALVE (A)	
100 130 170	New	31.720 mm to 31.920 mm (1.2488 in to 1.2567 in)
	Service limit	31.670 mm (1.2469 in)
230	New	30.630 mm to 30.830 mm (1.2059 in to 1.2138 in)
	Service limit	30.580 mm (1.2039 in)
300	New	31.430 mm to 31.630 mm (1.2374 in to 1.2453 in)
	Service limit	31.380 mm (1.2354 in)

ENGINE TYPE	CAMSHAFT LOBE HEIGHT — INTAKE VALVE (B)	
100 130 170	New	31.710 mm to 31.910 mm (1.2484 in to 1.2563 in)
	Service limit	31.660 mm (1.2465 in)
230	New	30.513 mm to 30.713 mm (1.2013 in to 1.2092 in)
	Service limit	30.460 mm (1.1992 in)
300	New	31.540 mm to 31.740 mm (1.2417 in to 1.2496 in)
	Service limit	31.500 mm (1.2402 in)

CAMSHAFT BEARING JOURNAL (C)	
New	39.892 mm to 39.905 mm (1.5706 in to 1.5711 in)
Service limit	39.880 mm (1.5701 in)

CAMSHAFT BEARING JOURNAL (ENGINE FRONT) (D)	
New	24.909 mm to 24.940 mm (.9807 in to .9819 in)
Service limit	24.880 mm (.9795 in)

CAMSHAFT BEARING INNER DIAMETER	
New	40.000 mm to 40.020 mm (1.5748 in to 1.5756 in)
Service limit	40.050 mm (1.5768 in)

CAMSHAFT BEARING INNER DIAMETER (ENGINE FRONT)	
New	25.000 mm to 25.013 mm (.9843 in to .9848 in)
Service limit	25.050 mm (.9862 in)

4. Replace parts that are not within specifications.

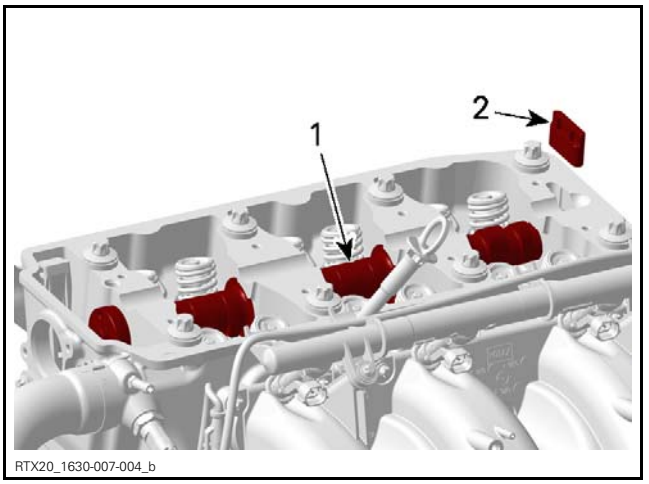
Installing the Camshaft

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

1. Lubricate the camshaft bearing journals.

SERVICE PRODUCT
ISOFLEX GREASE TOPAS NB 52 (P/N 293 550 021)

2. Install the camshaft, then turn and check if it moves freely. Place the camshaft lock in its slot.



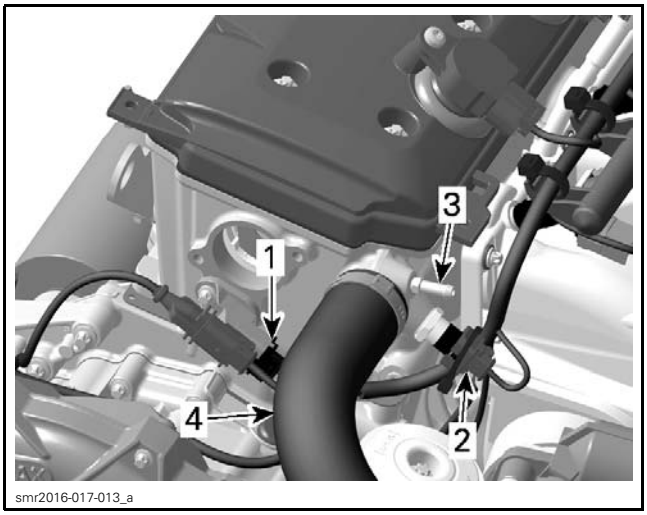
1. Camshaft
2. Camshaft lock

3. For other parts, refer to the proper installation procedures in this subsection.

CYLINDER HEAD

Removing the Cylinder Head

1. Lock the crankshaft. Refer to *CYLINDER BLOCK* subsection.
2. Drain the coolant. Refer to *COOLING SYSTEM - VEHICLE COMPONENTS* subsection.
3. Remove the blow-by valve from the cylinder head. Refer to *LUBRICATION SYSTEM* subsection.
4. Unplug:
   – Camshaft position sensors (CAPS)
   – Coolant temperature sensor (CTS).
5. Disconnect:
   – Bleeding hose
   – Cylinder head outlet hose.



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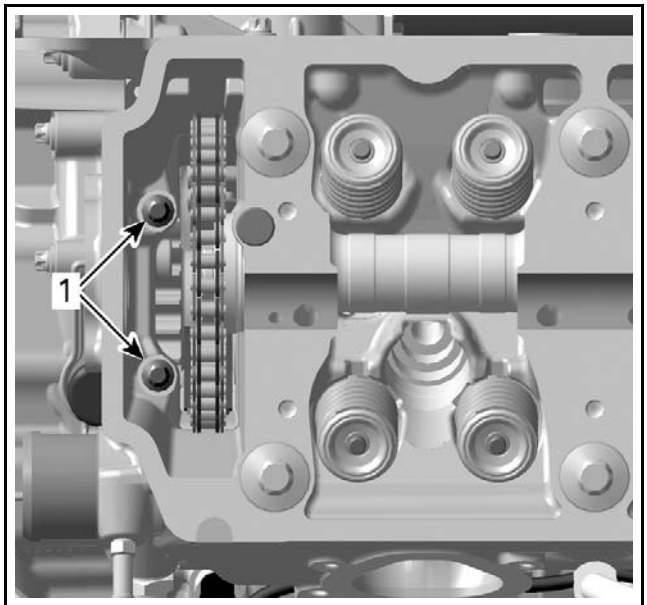
1. Camshaft position sensors (CAPS) connector
2. Coolant temperature sensor (CTS) connector
3. Bleeding nipple
4. Cylinder head outlet hose

6. Remove the intake manifold. Refer to *INTAKE MANIFOLD* subsection.
7. Remove the exhaust manifold. Refer to *EXHAUST MANIFOLD* subsection.
8. Remove the *CAMSHAFT TIMING GEAR*. Refer to the procedure in this subsection.
9. Remove the M6 cylinder head screws.



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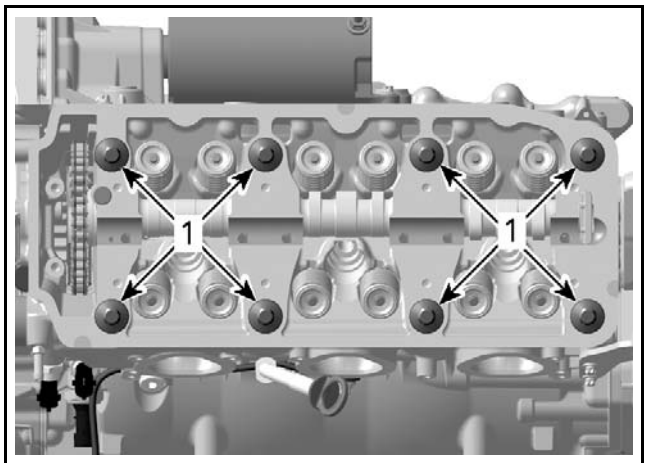
1. M6 cylinder head screws

10. Remove and discard the M11 cylinder head screws.



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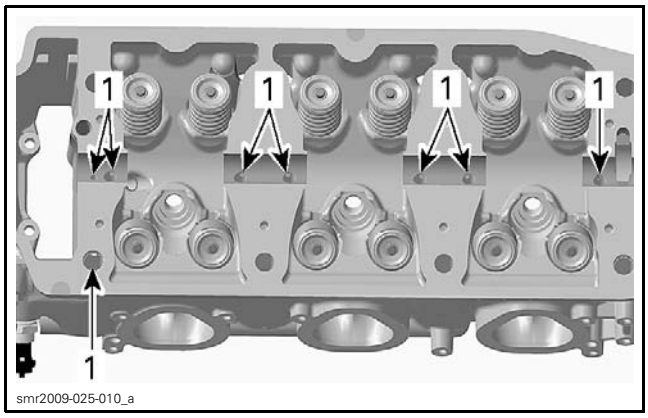
1. M11 cylinder head screws

11. Remove:
   – Cylinder head
   – Cylinder head gasket (discard it).

Cleaning the Cylinder Head

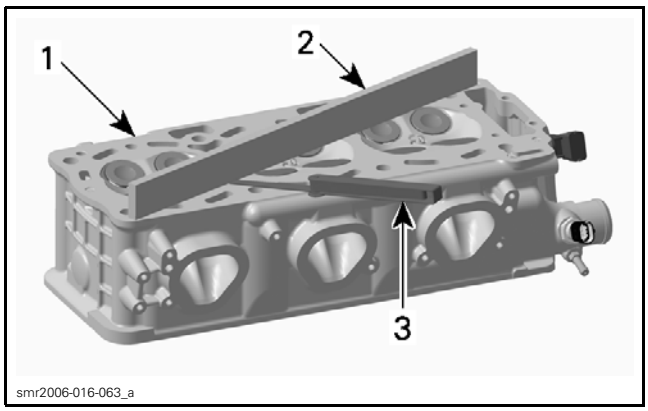
1. Remove carbon deposits from the combustion chamber, exhaust port and piston top.
2. Clean the cylinder head, especially cylinder head screw surface from oil spillage.
3. Blow out the oil orifices and check if they are not clogged.



1. Oil orifices

Inspecting the Cylinder Head

1. Check for cracks between valve seats or other damages, if so, replace cylinder head.
2. Check cylinder head mating surface for flatness, using a straight edge.



1. Cylinder head
2. Flat bar
3. Feeler gauge

3. Check cylinder head warpage.

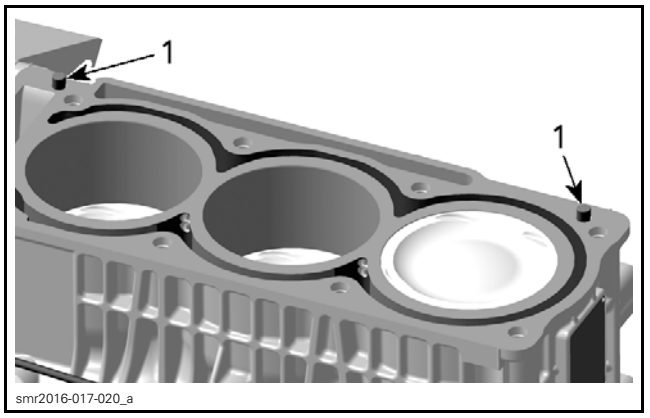
CYLINDER HEAD WARPAGE	
Maximum	0.100 mm (.004 in)

4. If warpage exceeds specification, replace cylinder head.

Installing the Cylinder Head

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

1. Ensure dowel pins are in place.



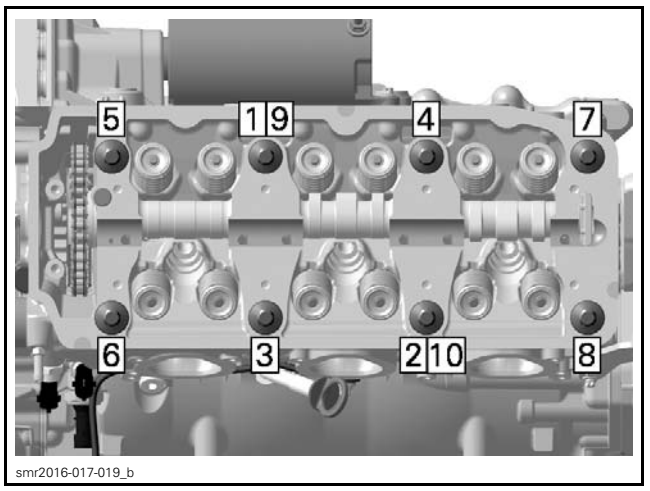
1. Dowel pins

2. Install NEW cylinder head gasket.

NOTICE Each installation of the cylinder head requires a new cylinder head gasket. Using a gasket twice will cause engine damage.

3. Install NEW M11 cylinder head screws and tighten as per following procedure.

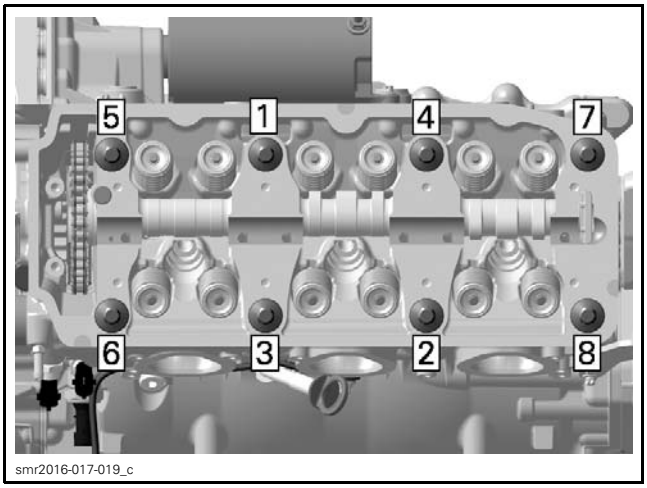
NOTICE This assembly uses stretch screws. Always use NEW screws and strictly adhere to the tightening procedure.



TIGHTENING SEQUENCE - STEP A

NOTICE Apply tightening torque of the step A on ALL M11 cylinder head screws before going to the step B.

TIGHTENING PROCEDURE		
M11 cylinder head screws	Step A	40 N•m ± 3 N•m (30 lbf•ft ± 2 lbf•ft)



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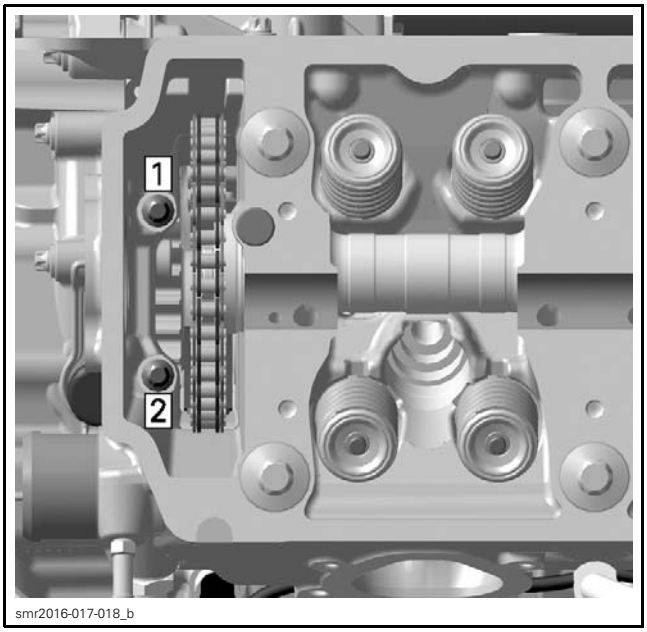
TIGHTENING SEQUENCE - STEP B AND C

NOTICE Apply tightening torque of the step B on ALL M11 cylinder head screws before going to the step C.

TIGHTENING PROCEDURE		
M11 cylinder head screws	Step B	Additional 120° ± 5°
	Step C	Additional 120° ± 5°

4. Tighten M6 cylinder head screws to specification.



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TIGHTENING SEQUENCE

TIGHTENING TORQUE	
M6 cylinder head screws	11 N•m ± 1 N•m (97 lbf•**in** ± 9 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)

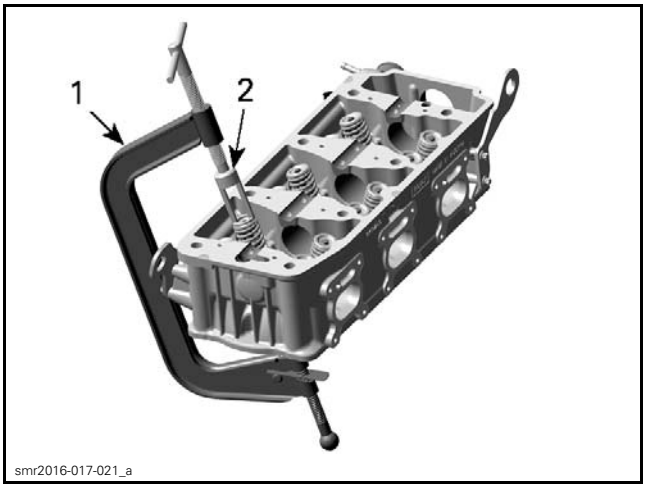
5. Remove crankshaft and camshaft locking tools.
6. Install all removed parts.

VALVE SPRINGS

Removing the Valve Spring

1. Refer to procedures in this subsection to remove:
   – *ROCKER ARMS*
   – *CAMSHAFT*
   – *CYLINDER HEAD*.
2. Compress the valve springs.

REQUIRED TOOL	
VALVE SPRING COMPRESSOR (P/N 529 035 724)	
VALVE SPRING COMPRESSOR CUP (P/N 529 036 073)	



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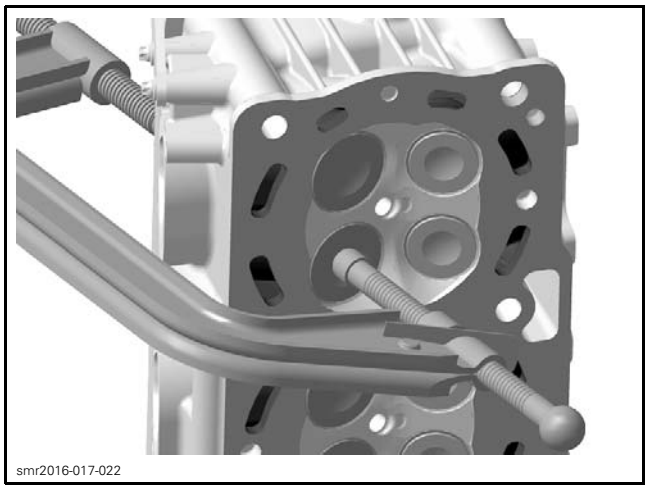
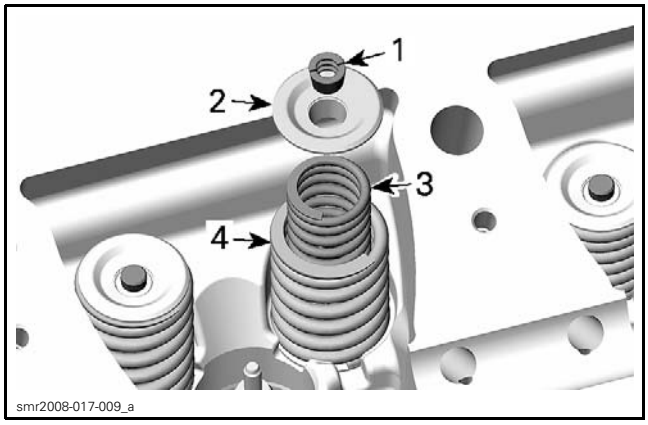
1. Valve spring compressor clamp
2. Valve spring compressor cup



LOCATE VALVE SPRING COMPRESSOR CLAMP IN CENTER OF THE VALVE

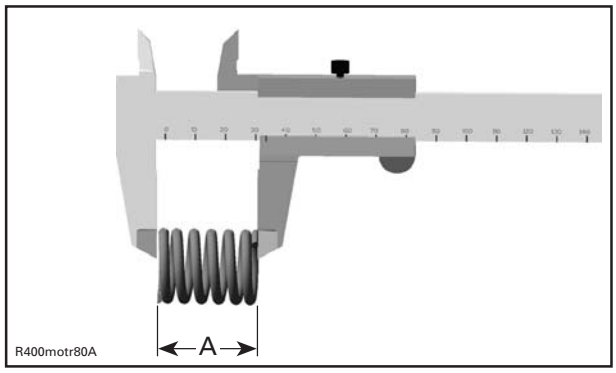
3. Remove the valve cotters.
4. Withdraw the valve spring compressor tools.
5. Remove valve springs.



1. *Valve cotters*
2. *Valve spring retainer*
3. *Inner valve spring*
4. *Outer valve spring*

Inspecting the Valve Spring

1. Check valve springs for rust, corrosion or other visible damages. If so, replace faulty valve springs.
2. Check valve springs for free length and straightness.
3. Replace valve springs if not within specifications.



A. Valve spring length

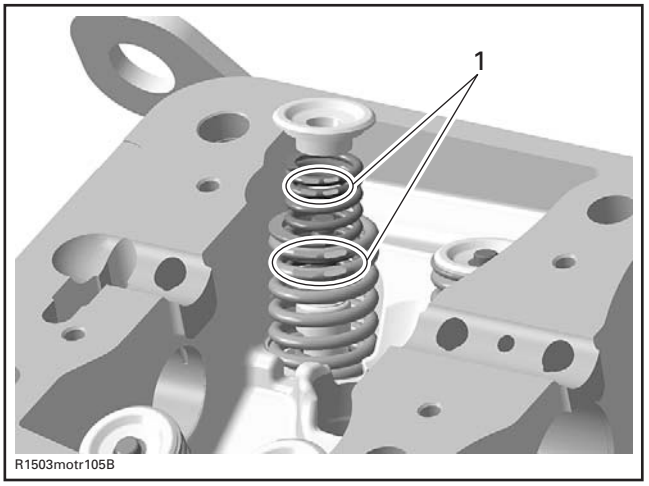
OUTER VALVE SPRING FREE LENGTH	
New	45.45 mm (1.789 in)
Service limit	43.00 mm (1.693 in)

INNER VALVE SPRING FREE LENGTH	
New	41.02 mm (1.615 in)
Service limit	38.80 mm (1.528 in)

Installing the Valve Spring

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

1. Colored area of the valve spring must be placed on top.
2. Make sure valve cotters are properly engaged in valve stem grooves.



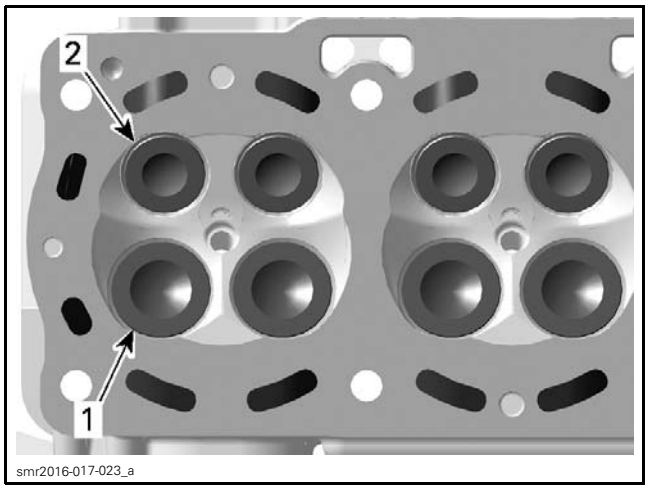
1. *Position of the valve spring*

VALVES

Removing the Valve

1. Remove valve spring.

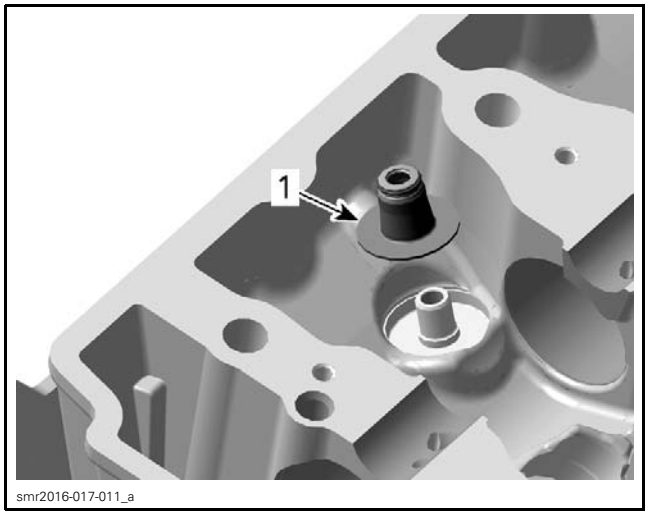
2. Push valve stem then pull valves out of valve guides.



1. Intake valve 38 mm
2. Exhaust valve 31 mm

3. Remove and discard valve stem seal.

REQUIRED TOOL
Valve stem seal pliers



1. Valve stem seal

Inspecting the Valve

Valve Stem Seal

1. Always install **NEW** seals whenever valves are removed.
2. Inspection of valve stem seals is not needed because **NEW** seals should always be installed whenever cylinder head is removed.

Valve

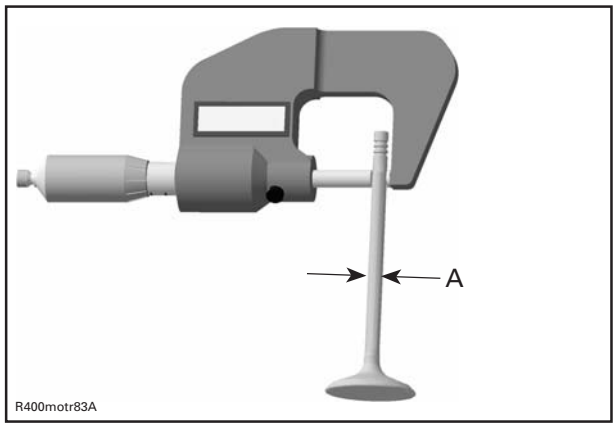
Inspect valve surface, check for abnormal stem wear and bending. If so, replace by a new one.

Valve Stem and Valve Guide Clearance

1. Measure valve stem and valve guide in three places, using a micrometer and a small bore gauge.

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

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



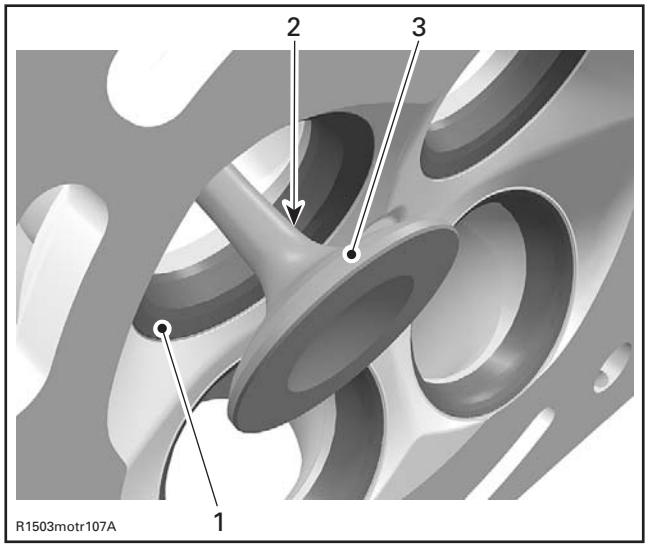
A. Valve stem diameter

VALVE STEM DIAMETER		
Intake valve	New	5.961 mm to 5.975 mm (.2347 in to .2352 in)
	Service limit	5.930 mm (.2335 in)
Exhaust valve	New	5.946 mm to 5.960 mm (.2341 in to .2346 in)
	Service limit	5.930 mm (.2335 in)

3. Replace valve guide if it is out of specification or has other damages such as wear or friction surface. Refer to *VALVE GUIDE* in this subsection.

VALVE GUIDE INNER DIAMETER (INTAKE AND EXHAUST VALVES)	
New	5.994 mm to 6.018 mm (.236 in to .2369 in)
Service limit	6.060 mm (.2386 in)

Valve Face and Seat



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

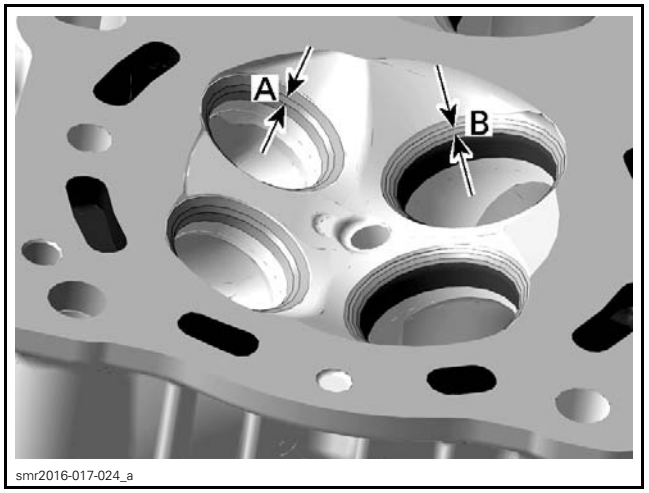
1. Check valve face and seat for burning or pittings and replace valve or cylinder head if there are signs of damage.
2. Ensure to seat valves properly. Apply some lapping compound on valve face and work valve on its seat with a lapping tool.

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

3. Measure valve seat width, using a caliper.

VALVE SEAT CONTACT WIDTH		
Intake valve	New	1.05 mm to 1.35 mm (.041 in to .053 in)
	Service limit	1.60 mm (.063 in)
Exhaust valve	New	1.25 mm to 1.55 mm (.049 in to .061 in)
	Service limit	1.80 mm (.071 in)

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

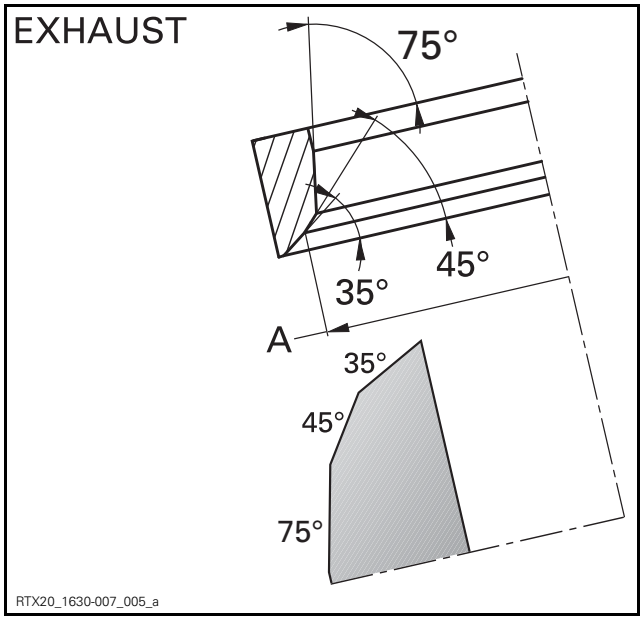


A. Valve seat contact width - Exhaust valve
B. Valve seat contact width - Intake valve

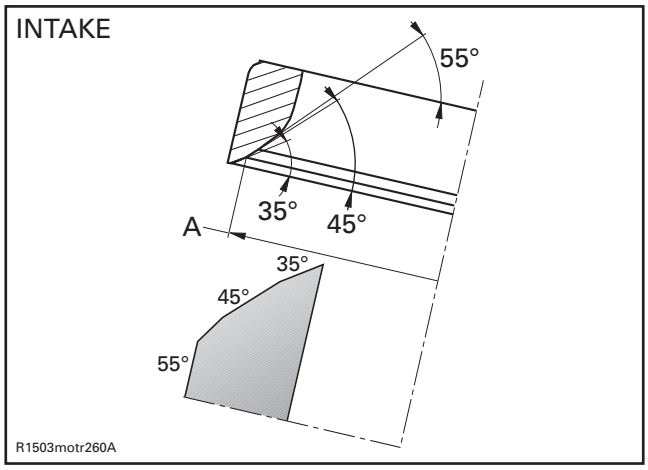
Valve Seat Grinding

NOTE: The valve seats may be reground with a valve seat grinder which centers on the valve guide.

1. Grind the valve seat at 45°. Remove no more material than absolutely necessary to clean the seat up.
2. Using a 35° stone, narrow the valve seat until the appropriate outer diameter is obtained.



A. Valve seat outer diameter EXHAUST



A. Valve seat outer diameter INTAKE

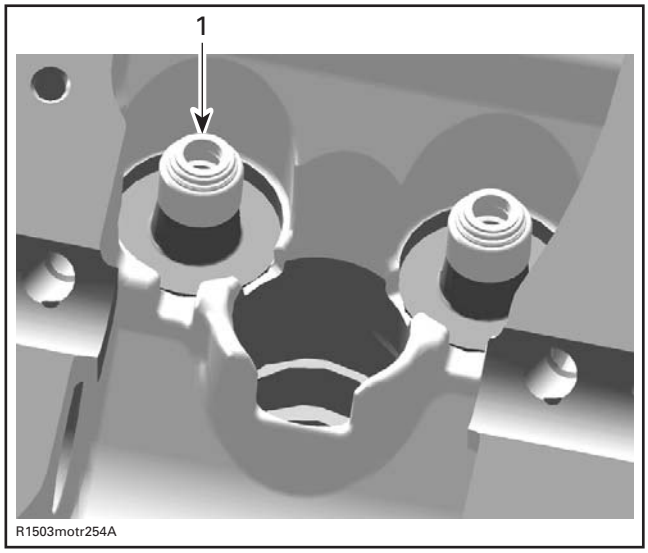
VALVE SEAT OUTER DIAMETER	
INTAKE	37.35 mm (1.4705 in)
EXHAUST	30.30 mm (1.1929 in)

3. Using a 55° stone for the intake and an 75° stone for the exhaust valve, reduce the valve seat contact width to the appropriate value mentioned above.
4. Finally, coat the valve seating surface with a fine paste of valve grinding compound using a manual valve grinding mandrel. Lightly grind the valves until a smooth, even, uniform sealing surface of the appropriate inside and outside diameter is obtained on both the valve and the seat. Use only a hand held valve grinding mandrel with a suction cup, rotating the valve back and forth through about 45°, and then advancing the valve 45° before repeating this operation.

Installing the Valve

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

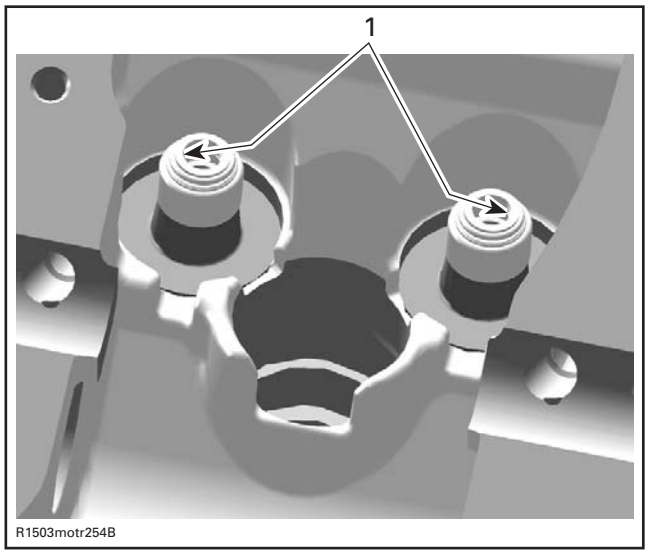
1. Install NEW valve stem seal.



1. Valve stem seal

2. Apply engine oil on valve stem and install valve.

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



1. Sealing lips of valve stem seal

3. To ease installation of cotters, apply oil or grease on them so that they remain in place while releasing the spring.
4. After springs are installed, ensure valve springs and valve spring retainer are properly locked by tapping on valve stem end with a soft hammer so that valve opens and closes a few times.

NOTICE An improperly locked valve spring will cause engine damage.

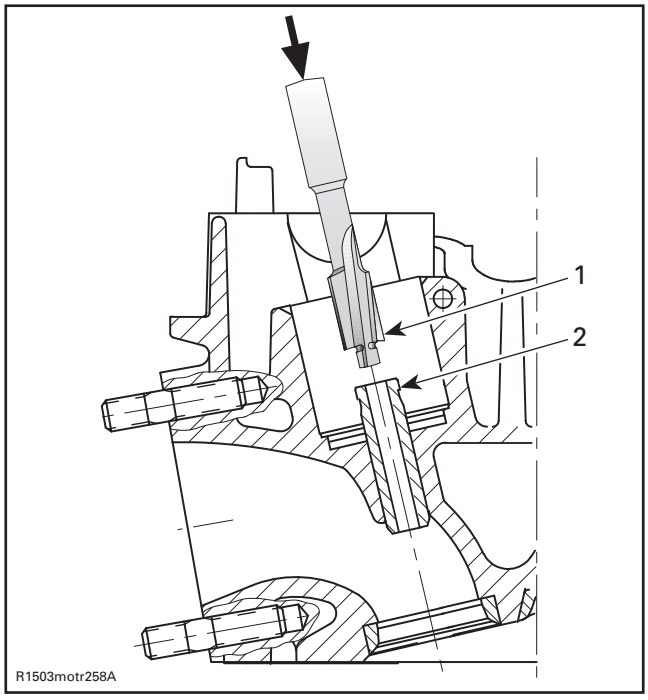
VALVE GUIDE

Replacing a Valve Guide

NOTICE Do not heat cylinder head for this procedure.

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 cylinder head and destroy the cylinder head, as the valve guide is removed.

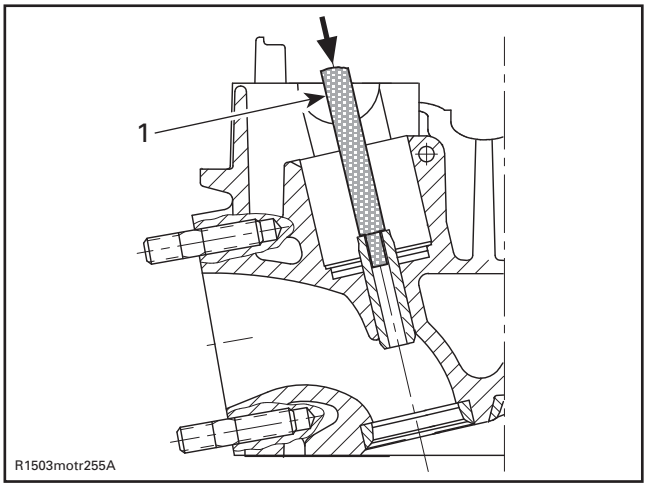
1. Use a special reamer as far as the top of the notch.



TYPICAL
1. Special reamer
2. Notch

2. Push valve guide out of the cylinder head towards combustion chamber.

REQUIRED TOOL	
VALVE GUIDE REMOVER (6 MM) (P/N 529 036 086)	



TYPICAL
1. Punch

3. Check valve guide bore for scratches.

NOTE: If valve guide has caused scoring during extraction, replace the cylinder head.

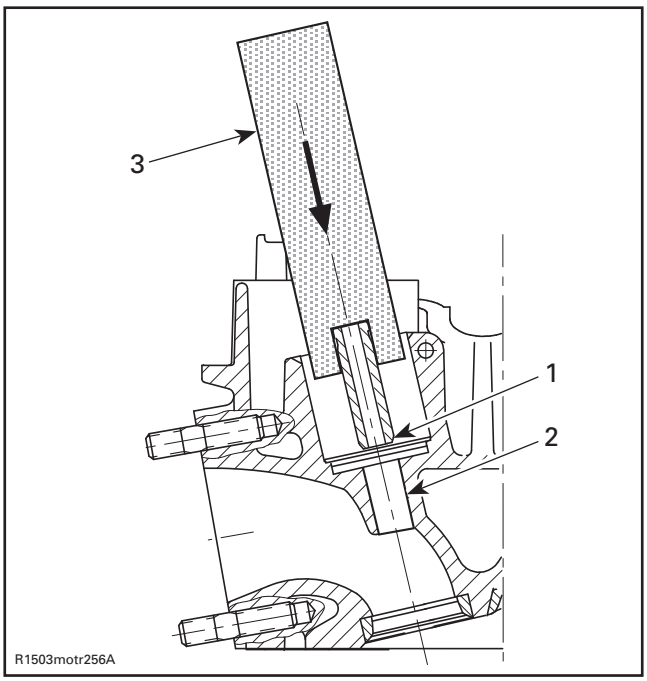
4. Grease the bore in cylinder head and the leading end of valve guide.

SERVICE PRODUCT
MOLYKOTE G-N (P/N 420 297 433)

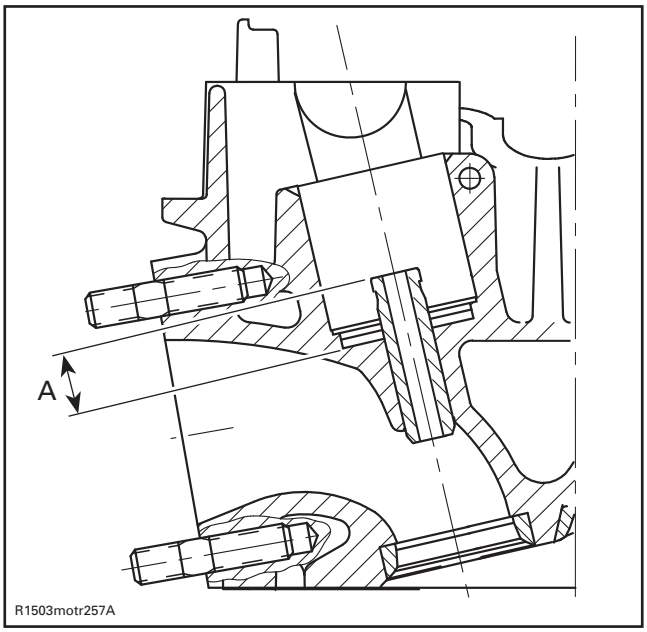
5. Press the valve guide into the COLD cylinder head as shown.

NOTE: The inlet and exhaust valve guides have the same length and are interchangeable.

REQUIRED TOOL	
VALVE GUIDE PUSHER (6 MM) (P/N 529 036 087)	



TYPICAL
1. Valve guide leading end
2. Cylinder head bore
3. Jig



TYPICAL
A. Protrusion

VALVE GUIDE PROTRUSION (MEASUREMENT "A")
12.4 MM TO 12.8 MM (.488 IN TO .504 IN)

NOTE: After installing new guides, they must be reamed with a standard 6 mm reamer tool. These are available from various tool suppliers.

6. Clean the cylinder head carefully. Check that the valve seat is concentric with the new guide axis (check contact surface with engineer's blue).

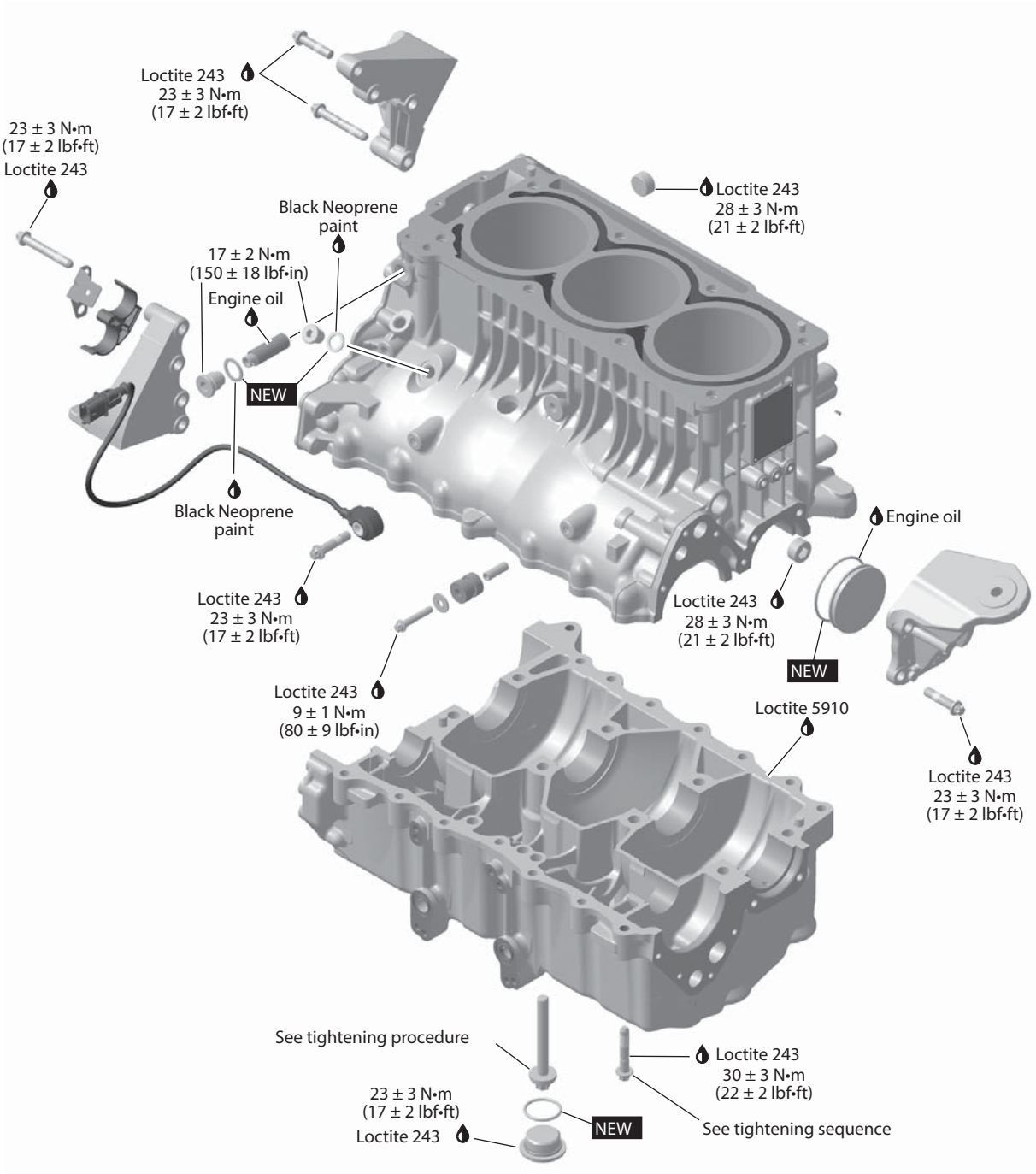
CYLINDER BLOCK

SERVICE TOOLS

Description	Part Number	Page
CRANKSHAFT LOCKING TOOL	529 035 821	137, 140, 148
CRANKSHAFT LOCKING TOOL	529 036 553	137, 140, 148
PISTON CIRCLIP INSTALLER	529 036 368	133

SERVICE PRODUCTS

Description	Part Number	Page
BLACK NEOPRENE PAINT	909570	129, 138
LOCTITE 243 (BLUE)	293 800 060	128, 147
LOCTITE 5910	293 800 081	146
LOCTITE CHISEL (GASKET REMOVER)	413 708 500	144



NEW = Component must be replaced when removed.

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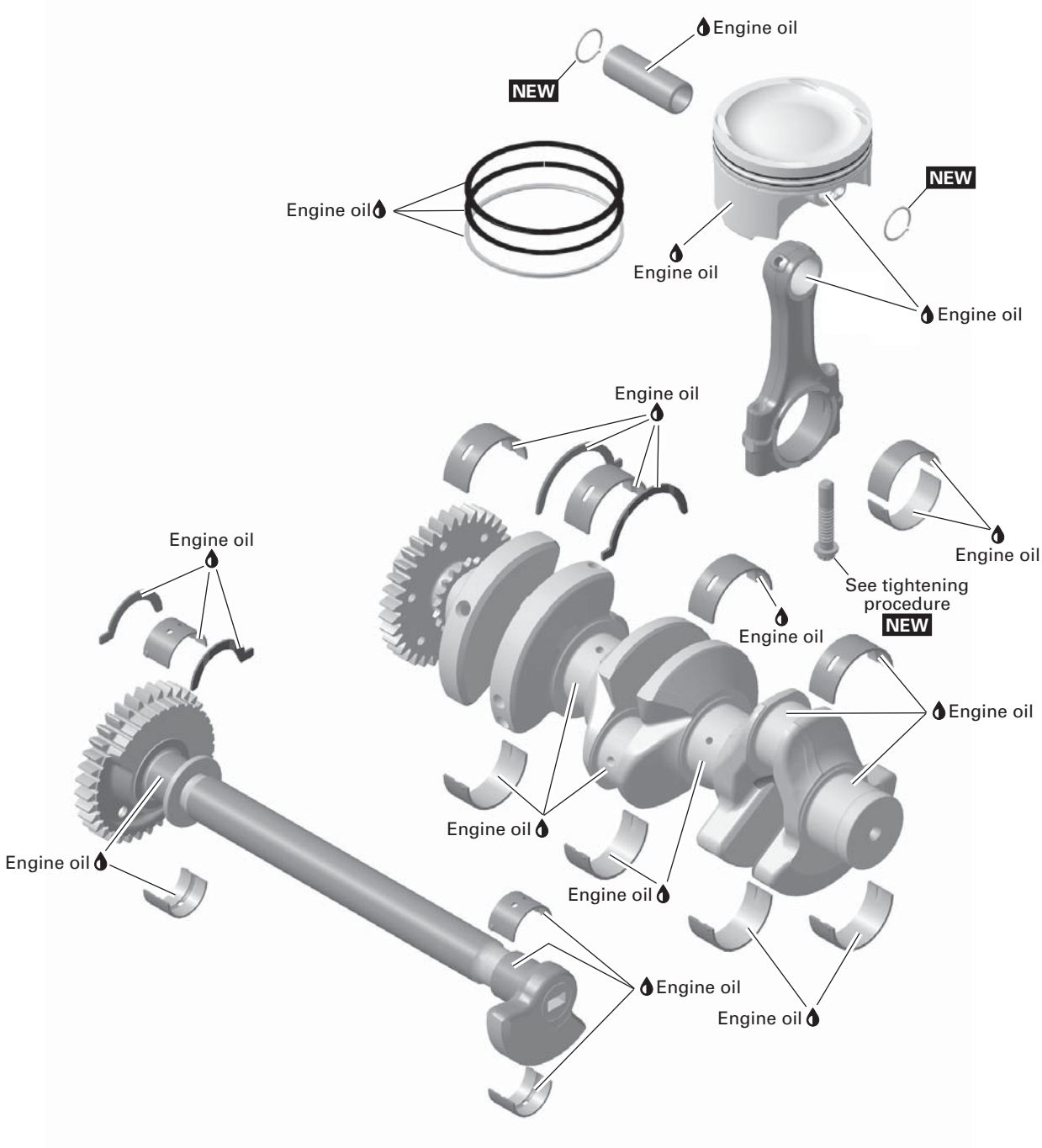

NEW = Component must be replaced when removed.

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GENERAL

When disassembling parts that are duplicated in the engine, (e.g.: pistons, connecting rods etc.), it is strongly recommended to note their position and to keep them 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".

TROUBLESHOOTING

The following is provided to help in diagnosing the probable source of troubles. It is a guideline and it should not be assumed to list all possible problems.

Always check for fault codes. If a fault code is detected, service the fault code first. Refer to *DIAGNOSTIC AND FAULT CODES* subsection.

UNUSUAL ENGINE NOISE OR VIBRATIONS

1. Heavy wear on plain bearings
   - *Check radial play of plain bearings.*
   - *Replace plain bearings if out of specification.*
2. Crankshaft and balancer shaft are not properly aligned
   - *Disassemble cylinder block and check if marks are properly aligned.*
3. Crankshaft or balancer shaft axial play out of specification
   - *Measure crankshaft and balancer shaft axial play.*
   - *If axial play is out of specification, replace thrust washers.*
4. Connecting rod axial play out of specification
   - *Measure connecting rod axial play on crankshaft.*
   - *Replace connecting rod or crankshaft if out of specification.*
5. Connecting rod screws got loose
   - *Replace damaged components and retighten screws with the recommended torque.*

BLUE SMOKE IN THE EXHAUST

1. Oil scrapper rings worn out
   - *Replace piston rings.*

ENGINE SUDDENLY TURNS OFF (POOR IDLING)

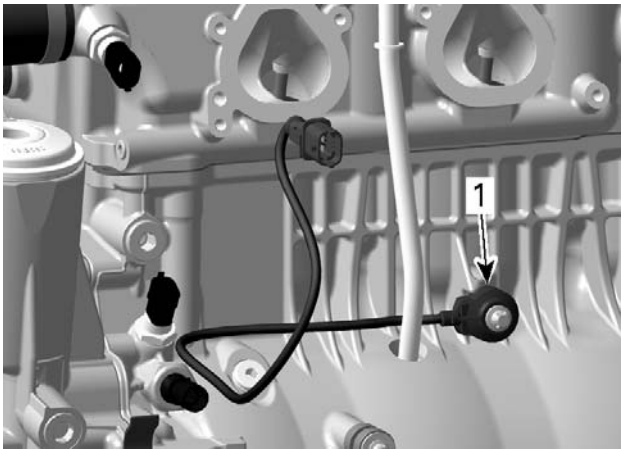
1. Piston rings worn out
   - *Replace piston rings.*
2. Piston/cylinder wall clearance out of specification
   - *Check piston/cylinder wall clearance.*
   - *Replace if out of specification.*
3. Melted or broken piston
   - *Check if oil spray nozzle is not clogged. Refer to LUBRICATION SYSTEM subsection.*
   - *Replace piston and cylinder block if necessary.*

PROCEDURES

KNOCK SENSOR (KS)

Knock Sensor Location

The KS is located in the cylinder block behind the intake manifold.



1. Knock sensor (KS)

Testing the KS (Dynamic)

1. Connect the vehicle to the BRP diagnostic software (BUDS2).
2. In BUDS2, go to:
   – Faults page
   – ECM button.
3. Start engine and throttle it to above 5000 RPM.

NOTICE **The engine must not run out of the water without providing proper cooling to the exhaust system. Maximum engine run time out of water is 2 minutes. Failure to do so may result in damage to the exhaust system and engine. Refer to *EXHAUST SYSTEM* subsection.**

4. Using the BUDS2, monitor the knock sensor for a fault code.

If no fault occurs, the knock sensor is good.

If a fault occurs, carry out the following steps.

5. Ensure sensor and cylinder block contact surfaces are clean.
6. Ensure the correct mounting bolt and washer are used and are properly torqued.

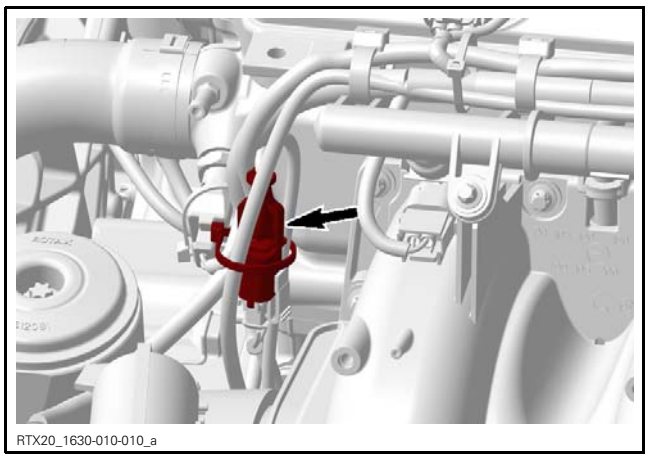
NOTE: It is necessary to remove the intake manifold to inspect the contact surfaces. Refer to *INTAKE MANIFOLD* subsection.

7. Check the knock sensor resistance. Refer to *TESTING THE KS RESISTANCE*.

Testing the KS Resistance

1. Remove parts required to access knock sensor.
2. Cut locking tie and disconnect the knock sensor connector.

Engines with ECM on the Air Intake Silencer



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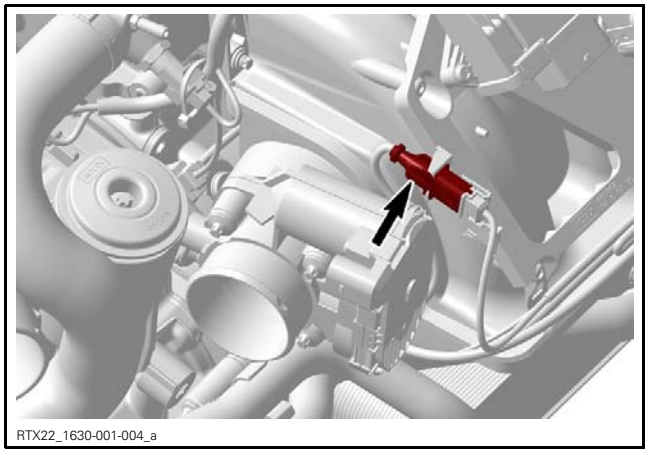
Engines with ECM on the Intake Manifold



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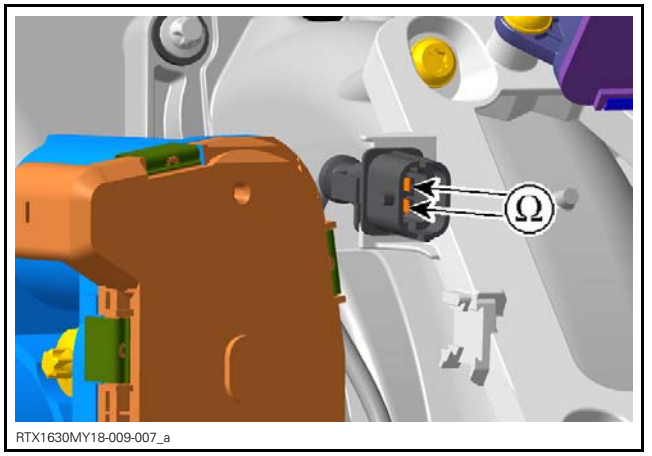
All Engines

3. Set the multimeter to Ω.
4. Measure the resistance between the knock sensor terminals.



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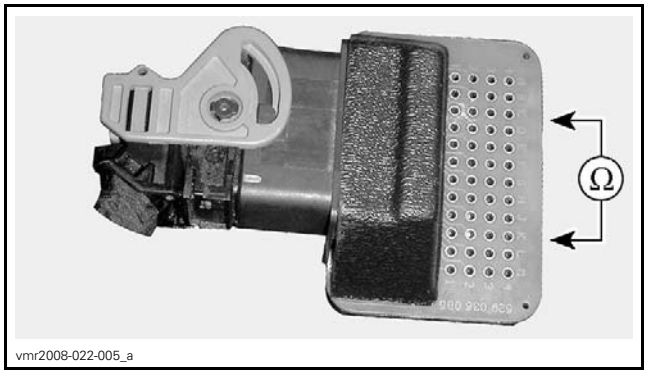
KS RESISTANCE TEST		
KS PIN		SPECIFICATION @ 20°C (68°F)
1	2	5 MΩ

5. If resistance is not as specified, replace the knock sensor.
6. If resistance is as specified, carry on with the following steps.
7. Reconnect the knock sensor connector.
8. Disconnect ECM-A connector from the ECM and install it on the ECM adapter tool.
9. Check circuit resistance through the knock sensor as per following table.

KS RESISTANCE TEST AT ECM		
ECM ADAPTER PIN		SPECIFICATION @ 20°C (68°F)
A-C3	A-G2	5 MΩ



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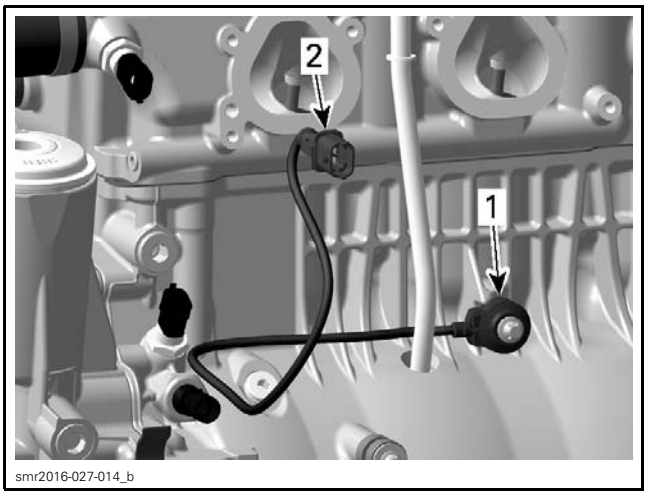
10. If wiring harness is good, check the ECM. Refer to *ENGINE CONTROL MODULE* section.
11. If an open circuit is measured, repair or replace wiring and connectors between ECM and knock sensor.

Replacing the KS

1. Disconnect KS sensor connector.



TYPICAL - INTAKE MANIFOLD REMOVED
1. Knock sensor
2. Knock sensor connector

2. Unscrew and remove knock sensor from engine.
3. Clean contact surfaces.
4. Apply thread locker in threaded hole.
5. Install the new knock sensor and tighten retaining screw to specification.

NOTICE **Improper torque may interfere with knock sensor operation and lead to severe internal engine damage.**

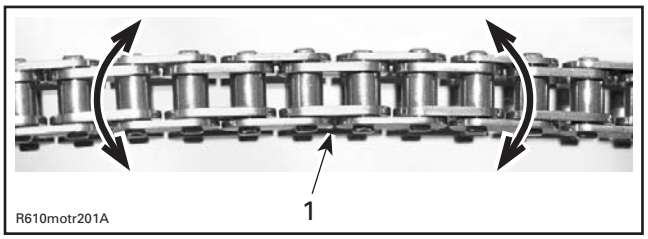
TIGHTENING TORQUE	
KS retaining screw	23 N•m ± 3 N•m (17 lbf•ft ± 2 lbf•ft) + LOCTITE 243 (BLUE) (P/N 293 800 060)

6. Reconnect knock sensor connector.
7. Reinstall remaining removed parts, refer to applicable subsections.

TIMING CHAIN

Inspecting the Timing Chain

1. Check timing chain on camshaft gear for excessive radial play.
2. Check chain condition for wear and rollers condition.



1. Timing chain

3. If chain is excessively worn or damaged, replace it as a set (camshaft timing gear and timing chain).

Removing the Timing Chain

Remove:
– Engine from vehicle. Refer to *ENGINE REMOVAL AND INSTALLATION* subsection
– Cylinder head. Refer to *CYLINDER HEAD* subsection
– PTO housing. Refer to *PTO HOUSING, MAGNETO AND STARTER* subsection
– Crankshaft. Refer to *CRANKSHAFT* in this subsection
– Timing chain.

Installing the Timing Chain

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

1. Ensure to perform proper valve timing. Refer to *CAMSHAFT TIMING GEAR* in the *CYLINDER HEAD* subsection.

NOTICE **Improper valve timing will damage engine components.**

2. Lock:
   – Crankshaft at TDC ignition. Refer to *CRANKSHAFT LOCKING PROCEDURE* in this subsection
   – Camshaft, refer to *CAMSHAFT LOCKING PROCEDURE* in the *CYLINDER HEAD* subsection.

CHAIN TENSIONER

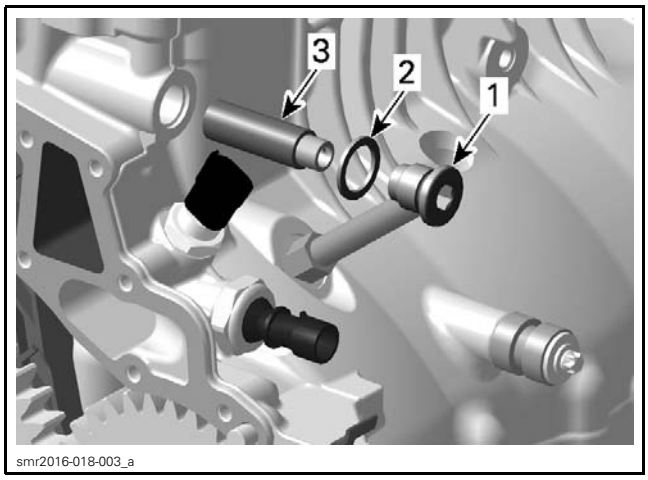
Chain Tensioner Access

NOTE: Removal of the intake manifold allows easier access to the chain tensioner, but is not necessary. Refer to *INTAKE MANIFOLD* subsection.

Removing the Chain Tensioner

1. Lock the crankshaft. Refer to *CRANKSHAFT LOCKING PROCEDURE* in this subsection.

2. Remove the chain tensioner.



1. *Plug screw*
2. *Gasket ring (discard)*
3. *Chain tensioner*

Inspecting the Chain Tensioner

Check the chain tensioner for:

– excessive wear
– cracks
– free movement of the chain tensioner piston.

Installing the Chain Tensioner

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

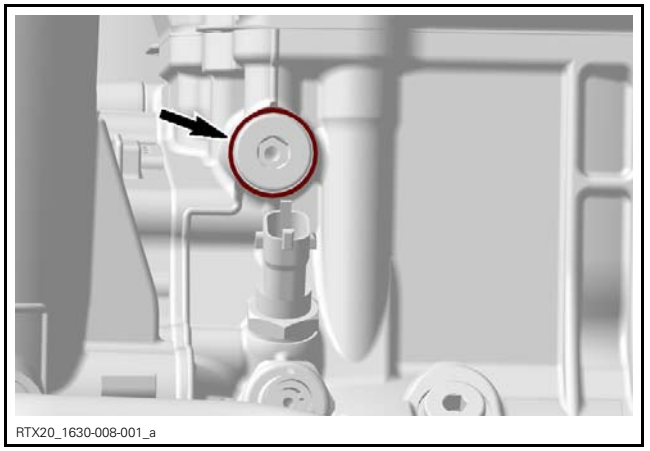
1. Install the plug screw with a NEW gasket ring.
2. Tighten the chain tensioner plug screw to specification.

TIGHTENING TORQUE	
Chain tensioner plug screw	17 N•m ± 2 N•m (150 lbf•**in** ± 18 lbf•**in**)

3. Apply sealant around the gasket ring as defined in the illustration.

NOTE: Gasket ring of must be coated completely.

SERVICE PRODUCT
BLACK NEOPRENE PAINT (P/N 909570)



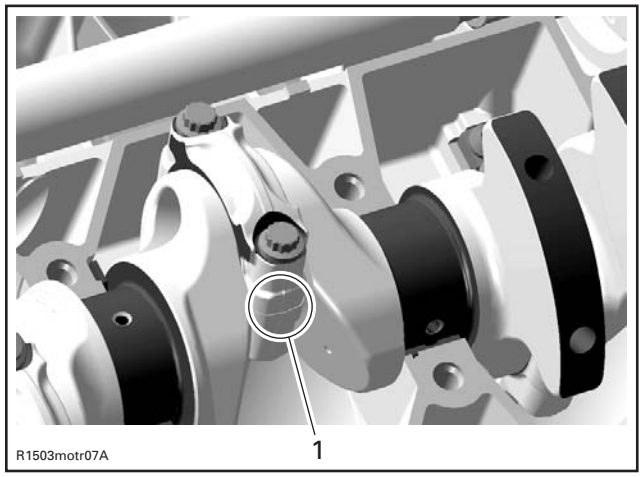
PISTONS AND CONNECTING RODS

Removing the Piston and Connecting Rod

1. Disassemble *CYLINDER BLOCK* as per procedure in this subsection.

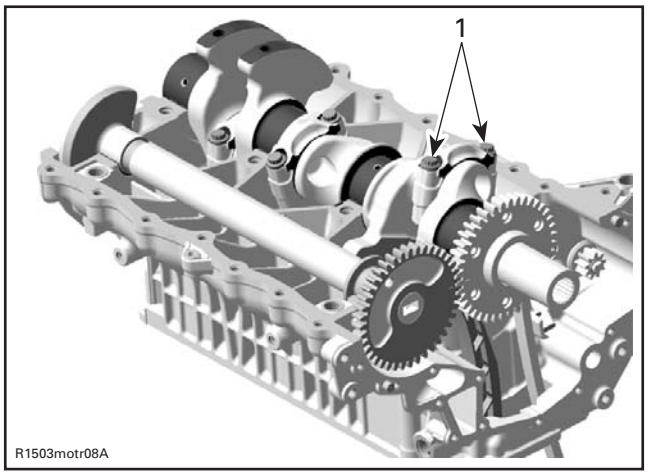
NOTE: It is recommended to measure connecting rod big end axial play prior to remove connecting rod. Refer to *INSPECTION* below.

2. Mark the connecting rod caps to remember the right position when reassembling.



1. *Connecting rod mark*

3. Remove connecting rod caps.



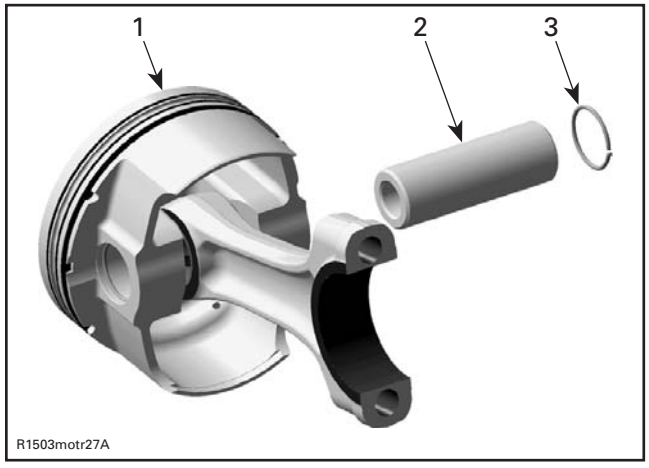
1. Connecting rod screws

4. Pull piston with connecting rod out of the cylinders.
5. Remove one piston circlip and discard it.

1. Piston circlip

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

6. Push piston pin out of piston.



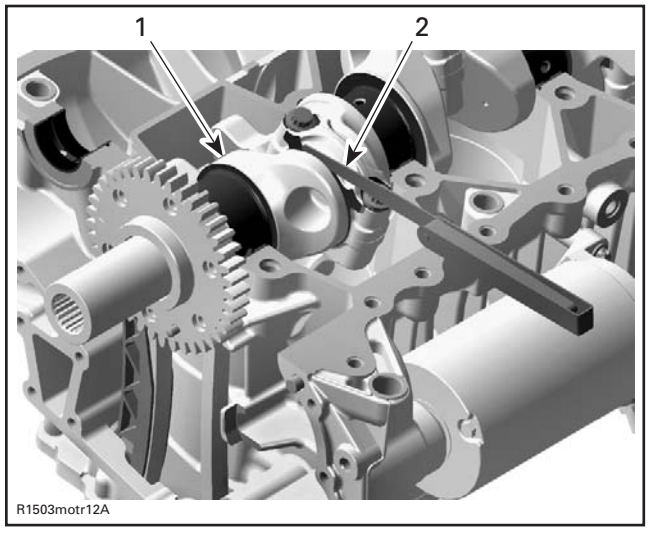
1. Piston
2. Piston pin
3. Circlip

7. Detach piston from connecting rod.

Inspecting the Connecting Rod

Connecting Rod Big End Axial Play

Using a feeler gauge, measure the distance between the butting face of connecting rod and the crankshaft counterweight. If the distance exceeds the specified tolerance, replace the worn part.

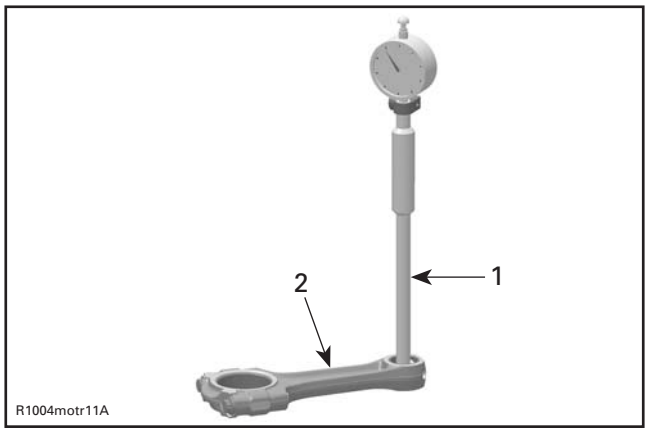


1. Crankshaft
2. Feeler gauge

CONNECTING ROD BIG END AXIAL PLAY	
New	0.100 mm to 0.452 mm (.004 in to .018 in)
Service limit	0.500 mm (.02 in)

Connecting Rod Small End Radial Play

1. Measure connecting rod small end.



TYPICAL
1. Bore gauge
2. Connecting rod

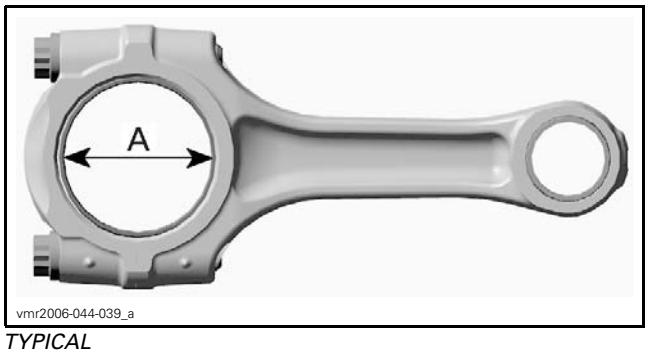
CONNECTING ROD SMALL END DIAMETER	
New	22.01 mm to 22.02 mm (.8665 in to .8669 in)
Service limit	22.07 mm (.8689 in)

2. If the connecting rod small end diameter is out of specification, replace the connecting rod.
3. Measure piston pins, refer to *INSPECTING THE PISTON PIN* in this subsection. Compare to inside diameter of connecting rod to obtain connecting rod small end radial play.

CONNECTING ROD SMALL END RADIAL PLAY	
Service limit	0.080 mm (.003 in)

Connecting Rod Big End Radial Play

1. Measure inside diameter of connecting rod big end. Compare to crankshaft pin.
2. To measure the connecting rod big end diameter, use the **OLD** screws.
3. Install the **OLD** bearings as they were mounted initially.
4. Tighten connecting rod screws, refer to *INSTALLING THE PISTON AND CONNECTING ROD* in this subsection.



TYPICAL
A. Connecting rod big end bearing

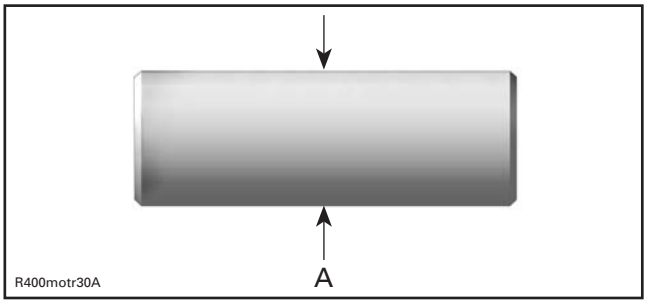
CONNECTING ROD BIG END DIAMETER	
Service limit	45.080 mm (1.7748 in)

CONNECTING ROD BIG END RADIAL PLAY	
Service limit	0.090 mm (.0035 in)

5. Use **NEW** bearings, when connecting rod big end diameter is out of specification.

Inspecting the Piston Pin

1. Clean the piston pin from deposits using a synthetic abrasive woven.
2. Inspect the piston pin for scoring, cracking or other damages.
3. Measure the piston pin as per the following illustration.



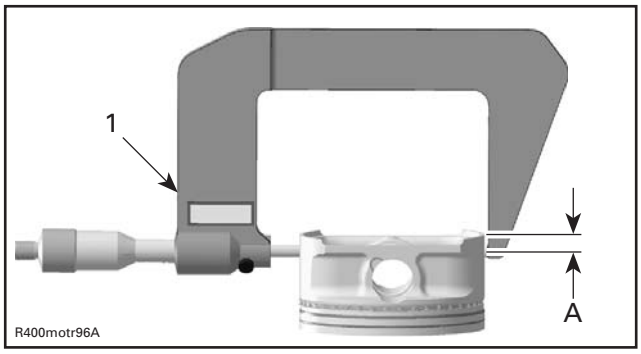
TYPICAL
A. Piston pin diameter here

PISTON PIN DIAMETER	
New	21.996 mm to 22.000 mm (.866 in to .8661 in)
Service limit	21.990 mm (.8657 in)

4. Measure the connecting rod small end diameter. Refer to *CONNECTING RODS INSPECTION* in this subsection to check the connecting rod small end radial play.

Inspecting the Piston

1. Inspect piston for scoring, cracking or other damages. Replace piston and piston rings if necessary.
2. Using a micrometer, measure piston at 18 mm (.709 in) perpendicularly (90°) to piston pin axis.



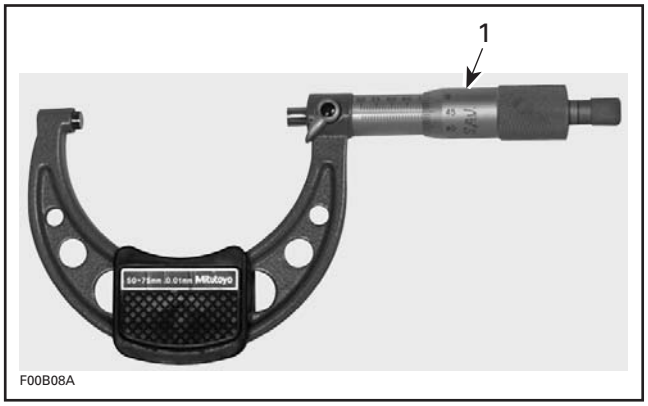
TYPICAL
1. Measuring perpendicularly (90°) to piston pin axis
A. 18 mm (.709 in)

3. Replace the piston if measure is not to specification.

ENGINE TYPE	PISTON DIAMETER SPECIFICATION	
100 130 170 230	New	99.951 mm to 99.969 mm (3.9351 in to 3.9358 in)
	Service limit	99.900 mm (3.9331 in)
300	New	99.931 mm to 99.949 mm (3.9343 in to 3.935 in)
	Service limit	99.900 mm (3.9331 in)

Piston/Cylinder Wall Clearance

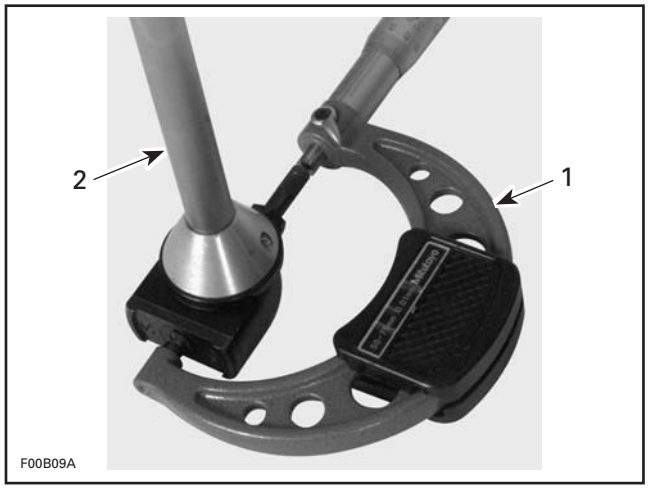
1. Adjust and lock a micrometer to the piston dimension.



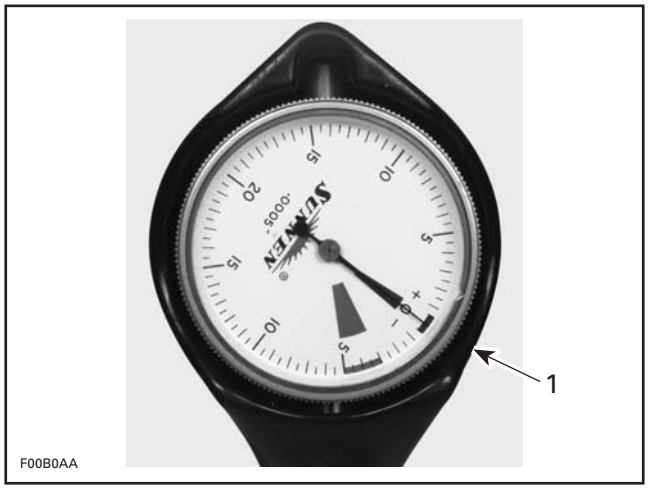
1. Micrometer set to the piston dimension

NOTE: Make sure used piston is not worn.

2. 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)

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.

3. Position the dial bore gauge 62 mm (2.44 in) above cylinder base, measuring perpendicularly (90°) to piston pin axis.
4. Read the measurement on the cylinder bore gauge. The result is the exact piston/cylinder wall clearance.

ENGINE TYPE	PISTON/CYLINDER CLEARANCE SPECIFICATION	
100 130 170 230	New	0.024 mm to 0.056 mm (.0009 in to .0022 in)
	Service limit	0.100 mm (.0039 in)
300	New	0.044 mm to 0.076 mm (.0017 in to .003 in)
	Service limit	0.100 mm (.0039 in)

5. If clearance exceeds specified tolerance, replace cylinder block and pistons.

Piston and Connecting Rod Assembly

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

1. Apply engine oil on the piston pin.
2. Insert piston pin into piston and connecting rod.

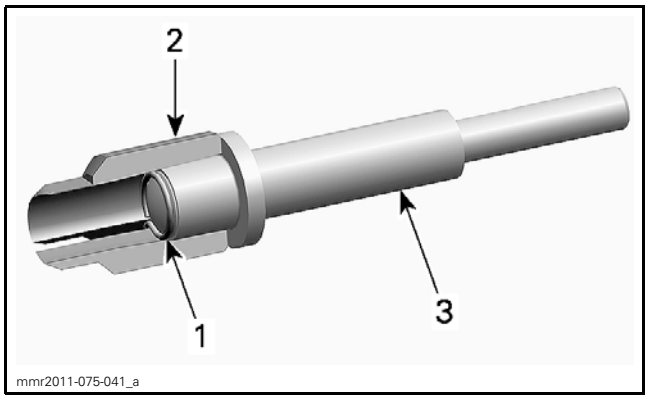
NOTE: Be sure to reinstall all parts in their original position as marked during removal.

3. Install NEW piston circlip.

REQUIRED TOOL	
PISTON CIRCLIP INSTALLER (P/N 529 036 368)	

NOTICE Always replace removed piston pin circlips by NEW ones.

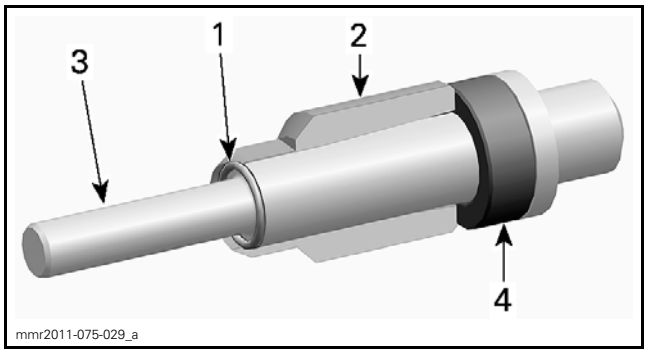
3.1 Place the circlip in the sleeve and push piston circlip installer handle until circlip reaches the mid position in the sleeve.



TYPICAL
1. *Circlip*
2. *Sleeve*
3. *Installer handle*

3.2 Put the distance sleeve on the installer handle.

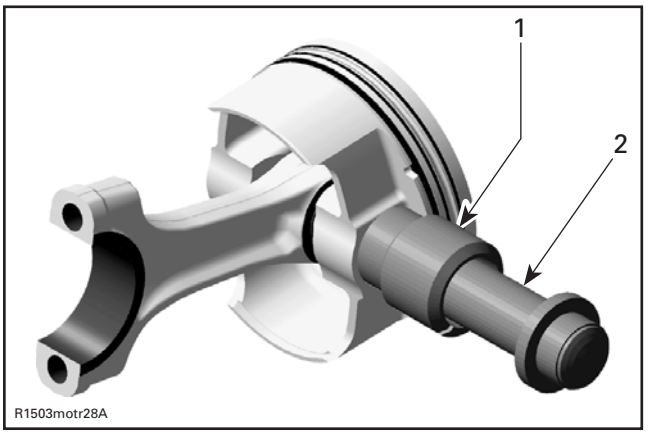
3.3 Push piston circlip installer handle until distance sleeve makes contact with the sleeve.



TYPICAL
1. *Circlip*
2. *Sleeve*
3. *Installer handle*
4. *Distance sleeve*

3.4 Remove distance sleeve and insert installer handle into the sleeve.

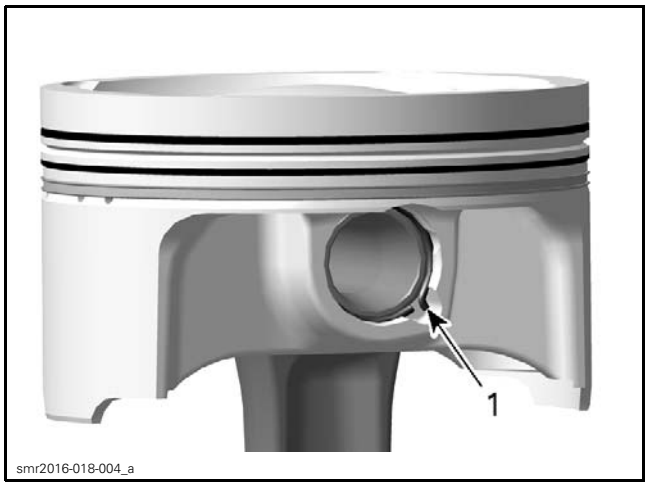
3.5 Insert the end of the handle into the piston pin, then push to engage the circlip in the piston groove.



TYPICAL
1. *Sleeve with piston circlip inside*
2. *Assembly jig from piston clip installer*

NOTICE If piston pin circlip installation fails, repeat step 3 by using a NEW circlip.

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

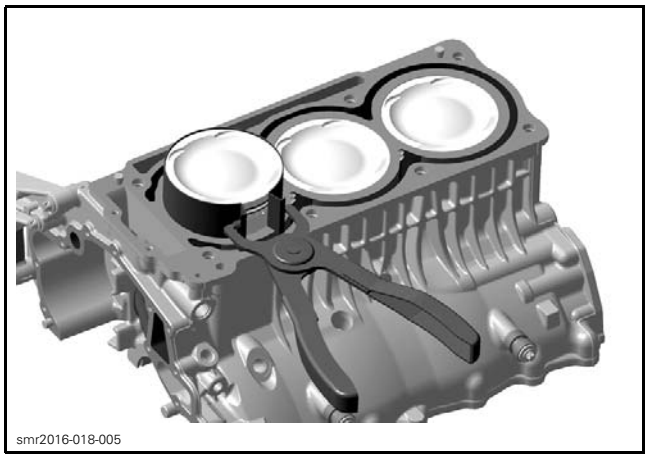


CORRECT POSITION OF THE PISTON CIRCLIP

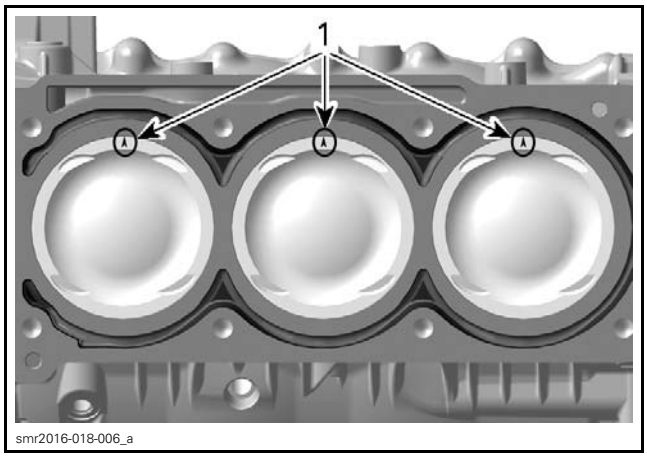
Installing the Piston and Connecting Rod

1. Use engine oil and lubricate:
   – Piston
   – Piston rings
   – Band of the piston ring compressor tool
   – Connecting rod bearings.
   – Cylinder bore
2. Slide piston into cylinder.

REQUIRED TOOL
Piston ring compressor pliers

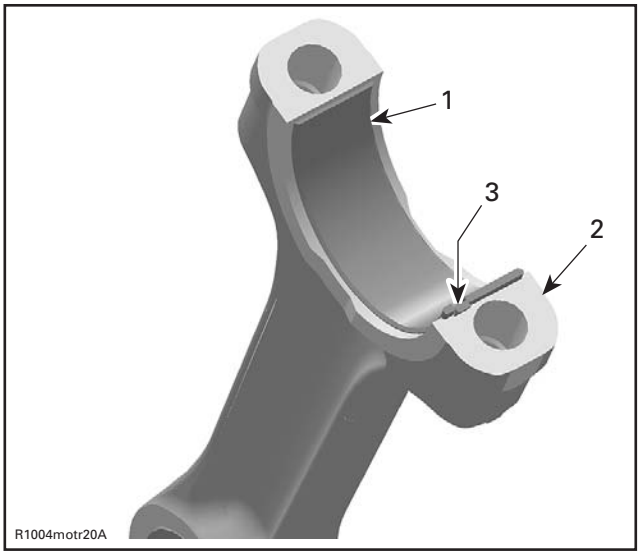


NOTICE Install piston with punched arrow toward exhaust side.



1. Arrows toward exhaust side

3. Correctly install bearings and carefully clean split surface on both sides (cracked area).



TYPICAL
1. Half bearing of connecting rod big end
2. Split surface of the connecting rod
3. Protrusion of bearing in line with connecting rod groove

4. Use compressed air to clean connecting rod threads.

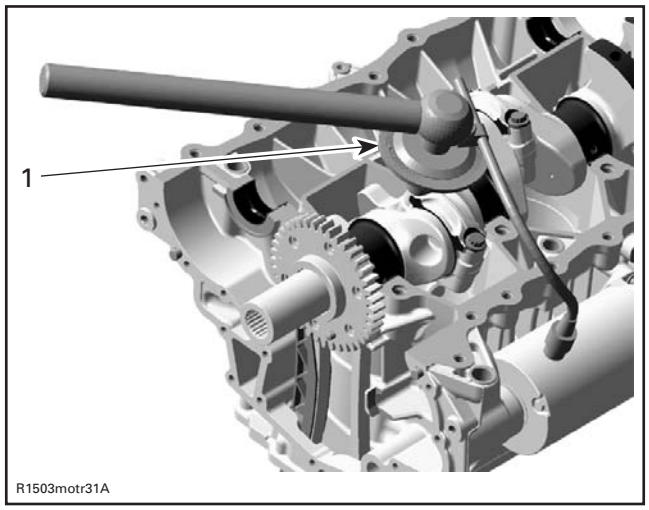
NOTICE Ensure that no debris fall inside the engine.

5. Tighten NEW connecting rod screws as per following procedure:

NOTICE This assembly uses stretch screws. Always use NEW screws and strictly adhere to the tightening procedure.

NOTICE All connecting rod screws must be torque FIRST according to step A before performing the step B.

TIGHTENING PROCEDURE		
Connecting rod screws	Step A	45 N•m ± 3 N•m (33 lbf•ft ± 2 lbf•ft)
	Step B	Additional 100° ± 5°



1. Angle torque wrench

PISTON RINGS

Removing the Piston Ring

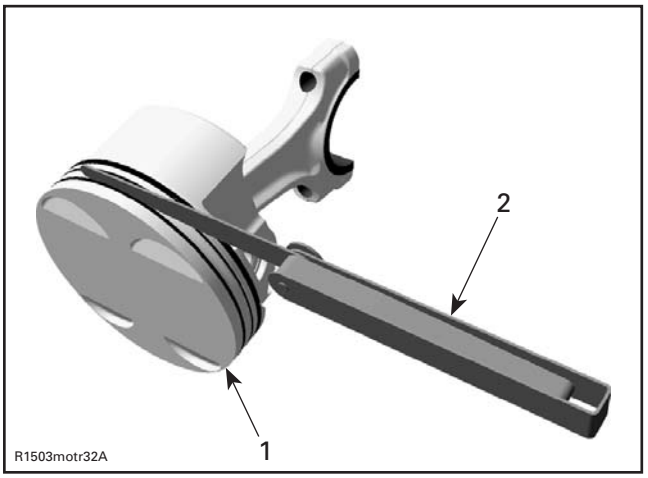
1. Remove the piston. Refer to the procedure in this subsection.
2. Remove the piston rings.

Inspecting the Piston Ring 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.

ENGINE TYPE	RING/PISTON GROOVE CLEARANCE	
RECTANGULAR		
100 130 170 230	NEW	0.010 mm to 0.060 mm (.0004 in to .0024 in)
300	NEW	0.025 mm to 0.070 mm (.001 in to .0028 in)
All	SERVICE LIMIT	0.150 mm (.0059 in)
TAPER-FACE		
All	NEW	0.015 mm to 0.060 mm (.0006 in to .0024 in)
	SERVICE LIMIT	0.150 mm (.0059 in)
OIL SCRAPER RING		
All	NEW	0.010 mm to 0.180 mm (.0004 in to .0071 in)
	SERVICE LIMIT	0.200 mm (.0079 in)



1. Piston
2. Filler gauge

Ring End Gap

1. Measure position for ring end gap in the area of 8 mm to 16 mm (.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.

2. Using a feeler gauge, check ring end gap. Replace ring if gap exceeds service limit.

ENGINE TYPE	RING END GAP SPECIFICATION	
	NEW	
100 130 170 230	RECTANGULAR	0.20 mm to 0.40 mm (.008 in to .016 in)
300		0.30 mm to 0.50 mm (.012 in to .02 in)

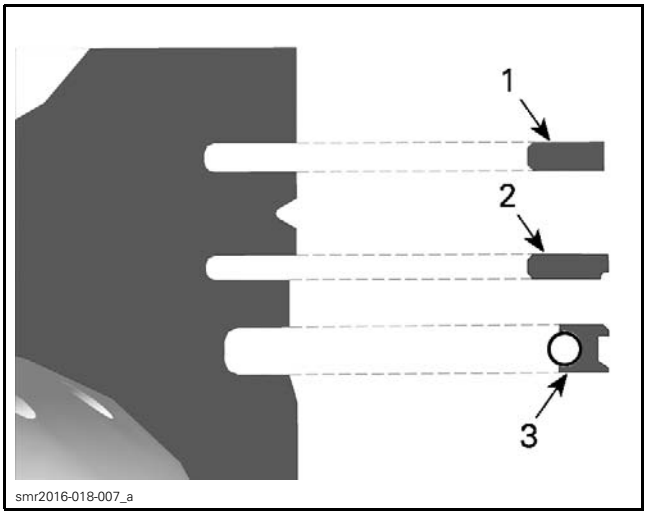
ENGINE TYPE	RING END GAP SPECIFICATION	
	NEW	
100 130 170 230	TAPER-FACE	0.70 mm to 0.95 mm (.028 in to .037 in)
300		0.35 mm to 0.55 mm (.014 in to .022 in)
All	OIL SCRAPER RING	0.20 mm to 0.70 mm (.008 in to .028 in)
	SERVICE LIMIT	
All	ALL	1.20 mm (.047 in)

Installing the Piston Ring

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

1. Install rings in the following order and layout:

PISTON RING INSTALLATION		
ORDER	RING	POSITION
FIRST STEP	Oil scraper ring	equal
SECOND STEP	Taper-face ring	Stamped "E" and "TOP" facing UP
THIRD STEP	Rectangular ring	Stamped "E" and "TOP" facing UP

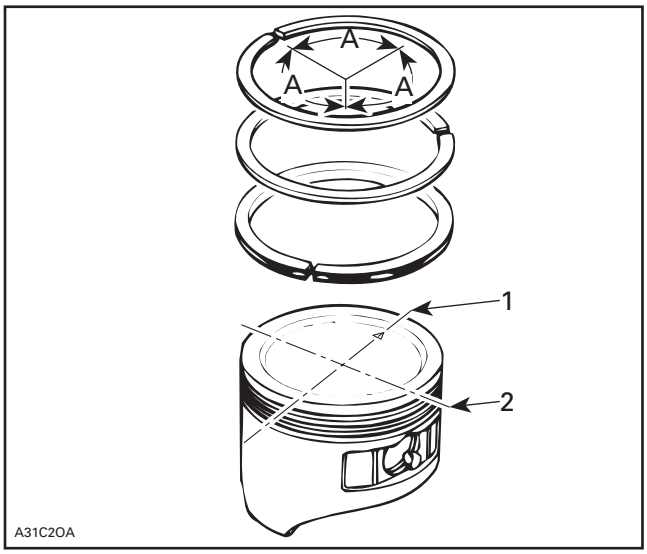


1. Rectangular ring
2. Taper-face ring
3. Oil scraper ring

NOTICE Ensure that top and second rings are not interchanged.

NOTE: Use a ring expander to prevent breakage during installation. The oil ring must be installed by hand.

2. Check that rings rotate smoothly after installation.
3. 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 trust side axis
2. DO NOT align ring gap with piston pin bore axis
A. 120°

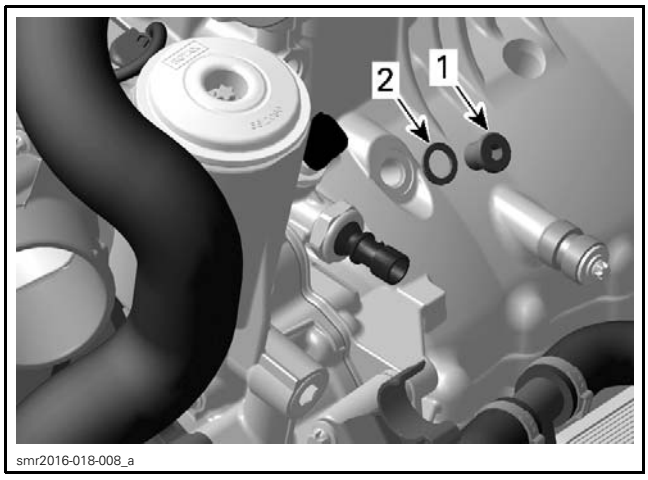
CRANKSHAFT

Crankshaft Locking Procedure

NOTICE The crankshaft must be locked at TDC for removal and installation of crankshaft, balancer shaft and camshaft.

NOTE: When the crankshaft is locked, the piston of cylinder 3 is at ignition TDC.

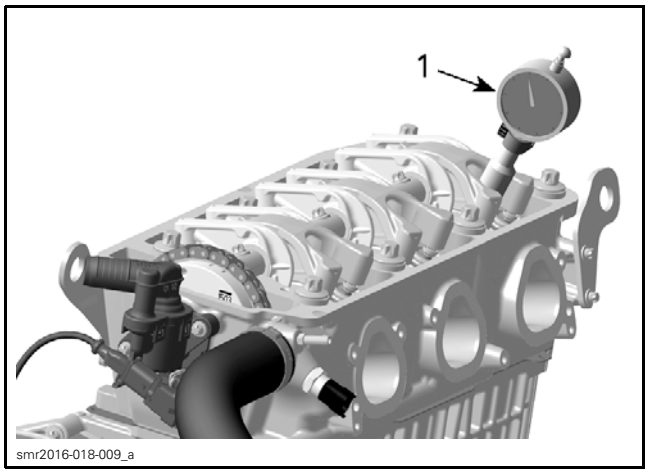
1. Remove:
   - Intake manifold (refer to *INTAKE MANIFOLD* subsection)
   - Spark plugs
   - Valve cover (refer to *CYLINDER HEAD* subsection)
   - Crankshaft access plug screw.



1. Crankshaft access plug screw
2. Gasket ring

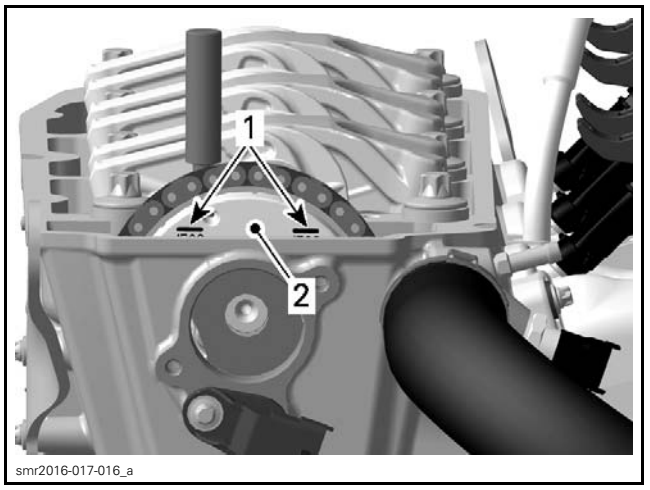
2. Turn engine counterclockwise.
3. Bring piston of cylinder 3 to ignition TDC, using a dial gauge or another similarly suitable tool.

NOTICE Do not scratch or damage piston and cylinder surface.



1. Dial gauge

NOTE: When the piston of cylinder 3 is at ignition TDC, the position lines on oil separator cover must be lined up as shown in the following illustration.



1. Position lines
2. Oil separator cover

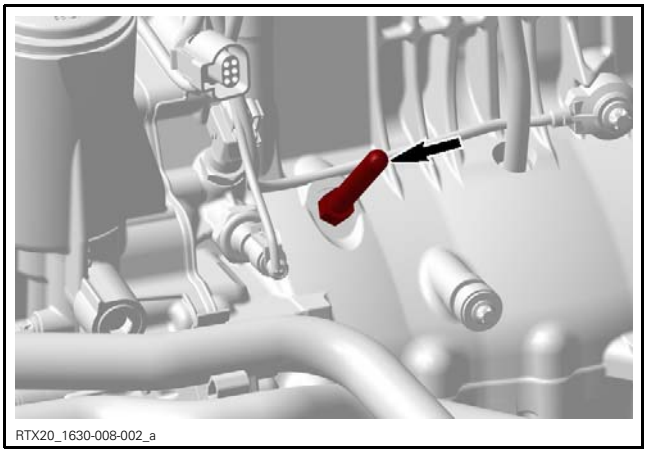
4. Use a small screwdriver to check if the groove in the crankshaft is aligned with the hole.
5. In this position, lock the crankshaft.

NOTICE If crankshaft is locked for input shaft removal (iDF only) use reinforced service tool as indicated.

REQUIRED TOOL	
CRANKSHAFT LOCKING TOOL (P/N 529 035 821)	
or alternatively use reinforced tool:	
CRANKSHAFT LOCKING TOOL (P/N 529 036 553)	

NOTICE Strictly adhere to the tightening torque. A hand tighten locking tool could cause damage to the cylinder block during the input shaft removal (iDF only).

TIGHTENING TORQUE	
Crankshaft locking tool	20 N•m ± 2 N•m (15 lbf•ft ± 1 lbf•ft)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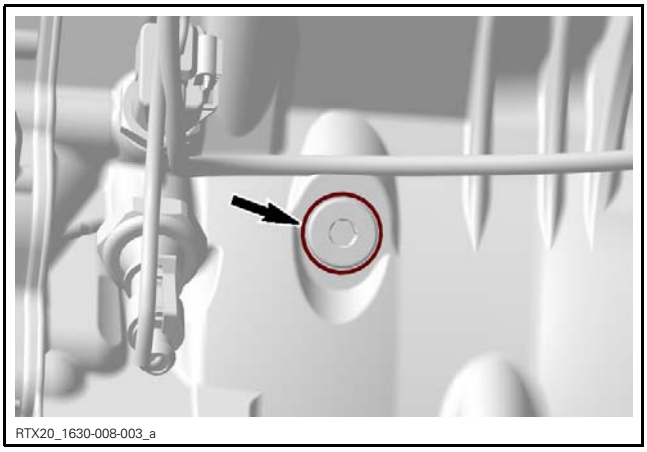
6. After removing the crankshaft locking tool install plug screw with a NEW gasket ring.

TIGHTENING TORQUE	
Plug screw	17 N•m ± 2 N•m (150 lbf•**in** ± 18 lbf•**in**)

7. Apply sealant around gasket ring as defined in the illustration.

NOTE: Gasket ring must be coated completely.

SERVICE PRODUCT
BLACK NEOPRENE PAINT (P/N 909570)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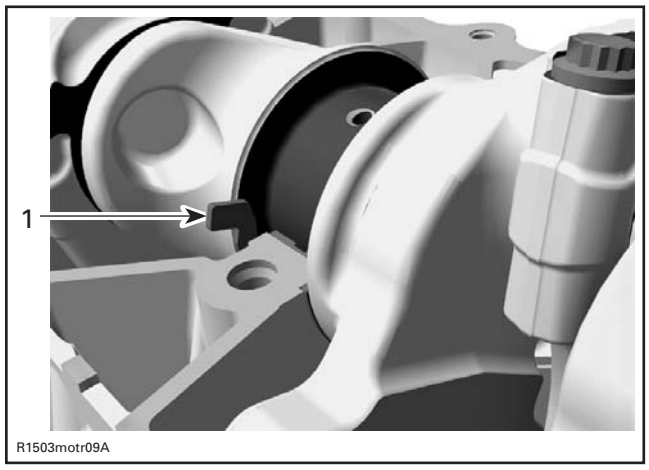
Removing the Crankshaft

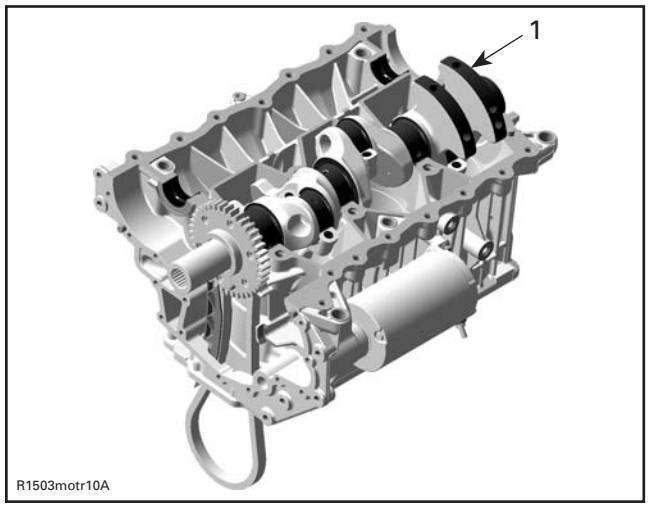
1. Disassemble the cylinder block as per procedure described in this subsection.
2. Remove the connecting rod screws. Refer to *PISTONS AND CONNECTING RODS* in this subsection.
3. Remove the thrust washers.



R1503motr09A

1. Thrust washer

4. Remove the crankshaft.



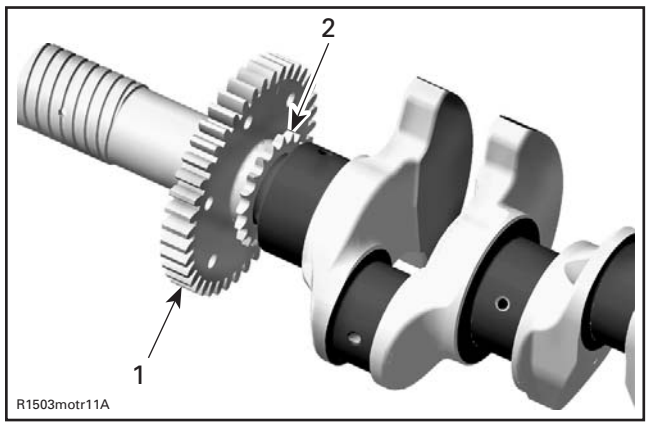
R1503motr10A

1. Crankshaft

Inspecting the Crankshaft

Inspecting the Crankshaft Gear

Replace crankshaft if the gears are worn or otherwise damaged.

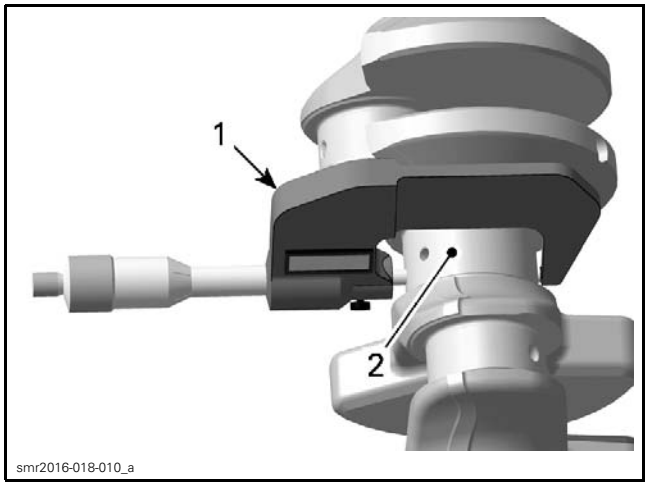


R1503motr11A

1. Balancer gear
2. Crankshaft timing gear

Crankshaft Radial Play

Measure all crankshaft journals. Compare to inside diameter of crankshaft bearings, refer to *CYLINDER BLOCK* in this subsection.



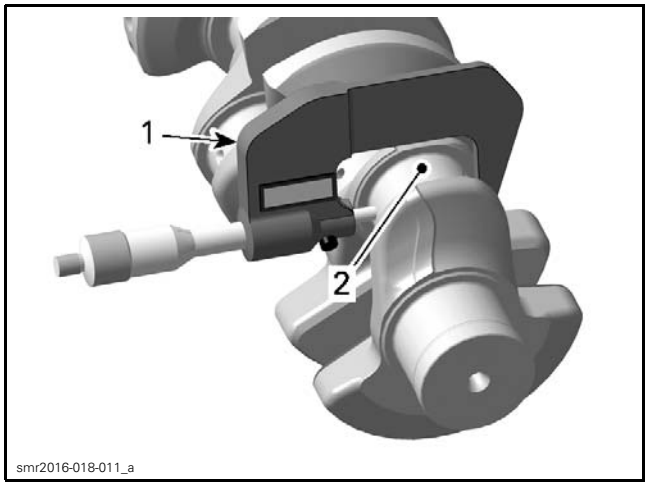
1. Micrometer
2. Crankshaft area for bearing

CRANKSHAFT JOURNAL DIAMETER	
New	49.991 mm to 50.010 mm (1.9681 in to 1.9689 in)
Service limit	49.950 mm (1.9665 in)

CRANKSHAFT JOURNAL RADIAL CLEARANCE	
Service limit	0.07 mm (.0028 in)

Crankshaft Pin

Measure all crankshaft pin diameters. Compare to inside diameter of connecting rod bearings, refer to *PISTONS AND CONNECTING RODS* in this subsection.



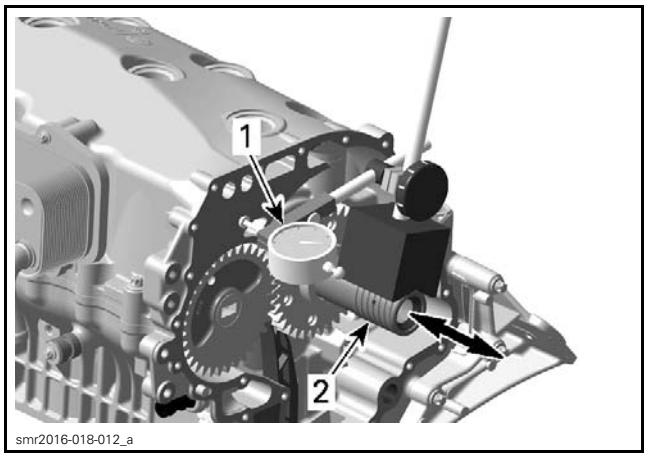
1. Micrometer
2. Crankshaft pin area for bearing

CRANKSHAFT PIN DIAMETER	
New	45.032 mm to 45.048 mm (1.7729 in to 1.7735 in)
Service limit	45.025 mm (1.7726 in)

CONNECTING ROD BIG END RADIAL PLAY	
Service limit	0.090 mm (.0035 in)

Crankshaft Axial Clearance

When assembling the cylinder-block, measure the crankshaft axial clearance.



1. Dial gauge
2. Crankshaft

CRANKSHAFT AXIAL CLEARANCE	
New	0.08 mm to 0.31 mm (.003 in to .012 in)
Service limit	0.35 mm (.014 in)

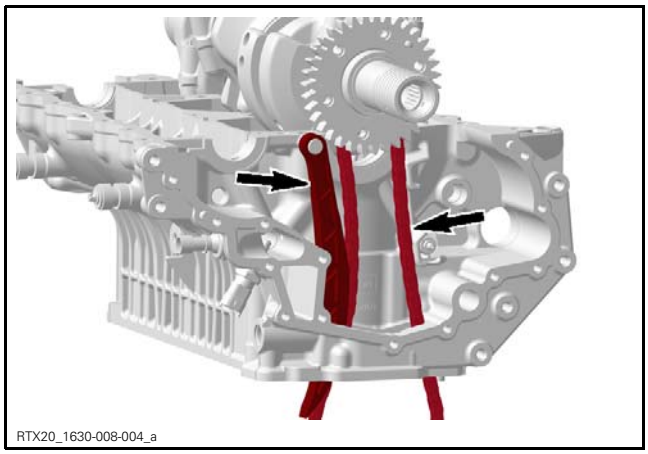
Installing the Crankshaft

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

NOTE: Be careful that connecting rods do not hit the cylinder block.

NOTICE **Before installing the crankshaft, ensure that:**
- **chain guide is already installed**
- **timing chain is installed on crankshaft timing gear.**

Those parts cannot be installed when the crankshaft is in place.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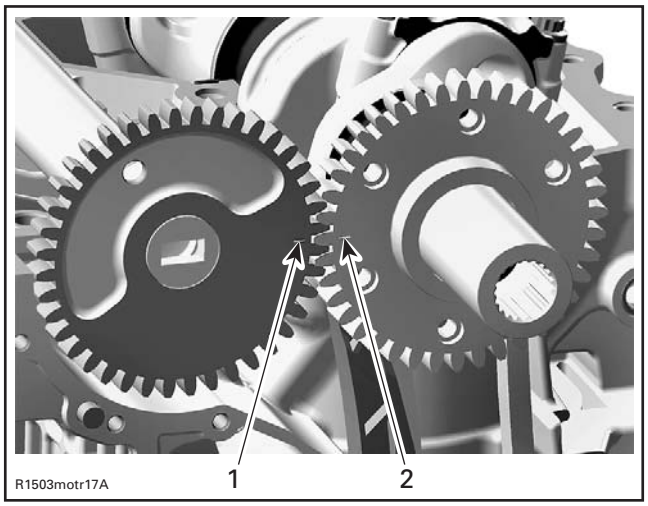
1. Install the crankshaft with the timing chain.

NOTICE Crankshaft and balancer shaft marks must be aligned.



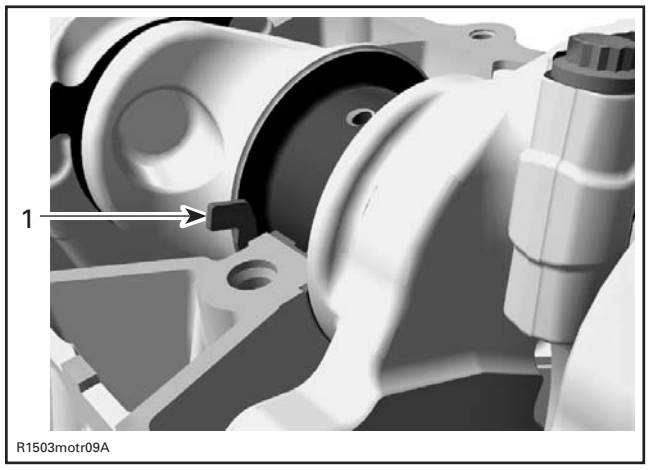
R1503motr17A

1. Mark on balancer shaft
2. Mark on crankshaft

2. Install connecting rod caps, refer to *PISTONS AND CONNECTING RODS* in this subsection.

NOTICE It is absolutely necessary to follow this procedure. Otherwise severe engine damage can occur.

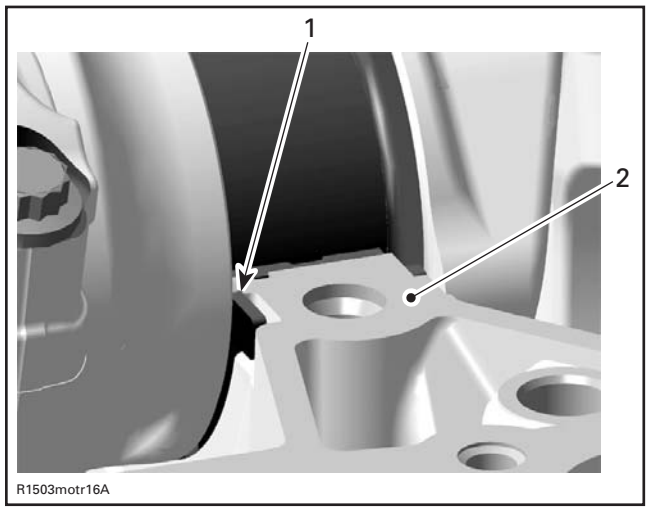
3. Insert thrust washers as soon as the crankshaft is in place as per following illustration.



R1503motr09A

THRUST WASHER INSERT DIRECTION
1. Thrust washer

NOTICE Thrust washers have to be flush with the cylinder block sealing surface.

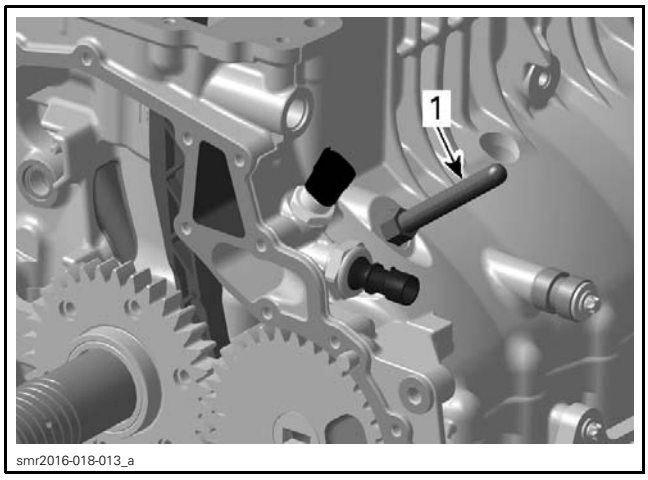


R1503motr16A

1. Thrust washer
2. Sealing surface

4. Install the cylinder block lower half. Refer to *CYLINDER BLOCK* in this subsection.
5. Lock the crankshaft at TDC before installing the camshaft and the rocker arms. Refer to *CYLINDER HEAD* subsection.

REQUIRED TOOL	
CRANKSHAFT LOCKING TOOL (P/N 529 035 821)	
or alternatively	
CRANKSHAFT LOCKING TOOL (P/N 529 036 553)	

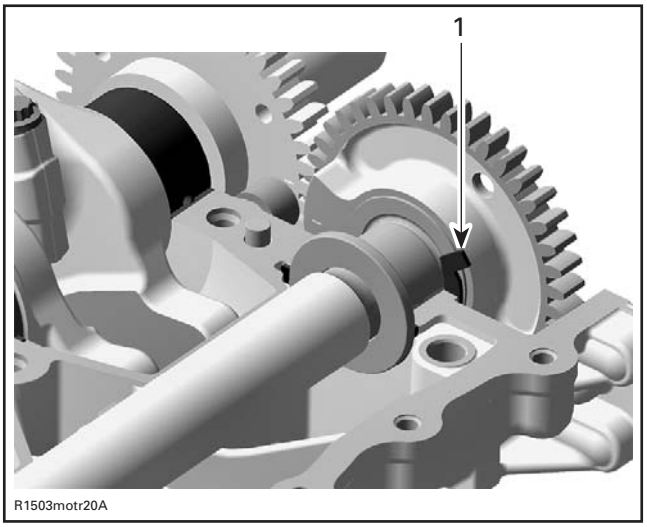


1. Crankshaft locking tool

BALANCER SHAFT

Removing the Balancer Shaft

1. Disassemble *CYLINDER BLOCK*, see procedure in this subsection.
2. Remove thrust washers.



1. Thrust washer

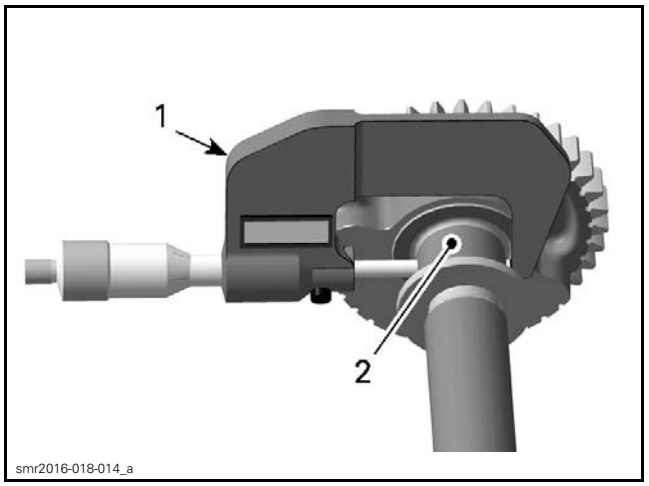
3. Remove balancer shaft.

Inspecting the Balancer Shaft

1. Check balancer shaft and replace if damaged.
2. If the gear on the balancer shaft is damaged, replace balancer shaft.
3. Check gear on the crankshaft at the same time and replace crankshaft if necessary (refer to *CRANKSHAFT* in this subsection).

Balancer Shaft Bearing Seat Play

Measure all balancer shaft bearing journals. Compare to inside diameter of balancer shaft bearings (see *INSPECTING THE CYLINDER BLOCK* in this subsection).



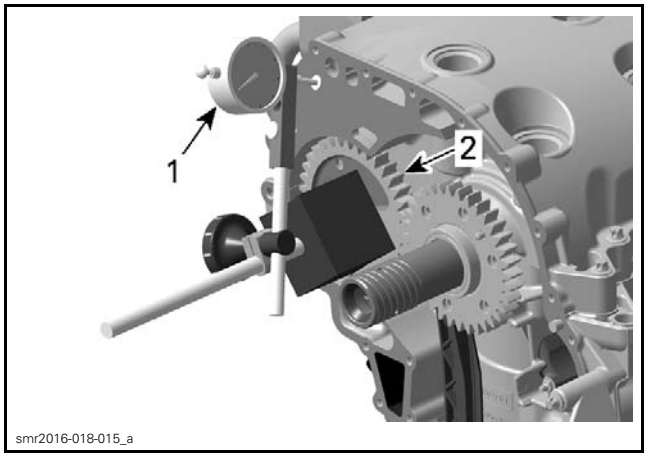
1. Micrometer
2. Balancer shaft area for bearing

BALANCER SHAFT JOURNAL DIAMETER	
New	31.984 mm to 32.000 mm (1.2592 in to 1.2598 in)
Service limit	31.950 mm (1.2579 in)

BALANCER SHAFT JOURNAL RADIAL CLEARANCE	
Service limit	0.070 mm (.0028 in)

Balancer Shaft Axial Clearance

When assembling the cylinder-block, measure the balance shaft axial play.



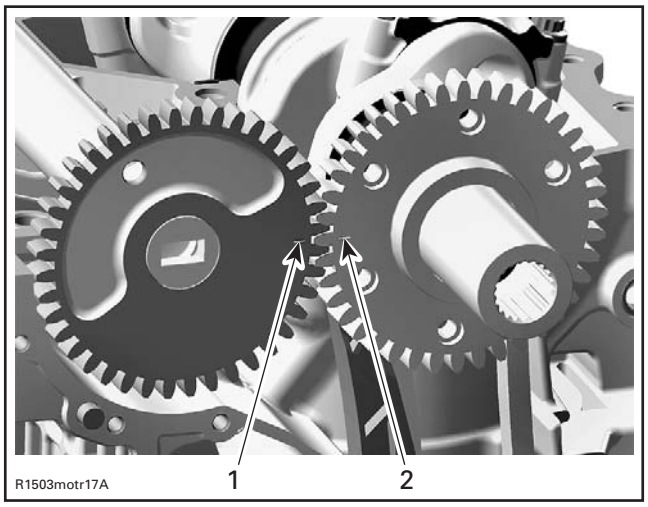
1. Dial gauge
2. Balancer shaft

BALANCER SHAFT AXIAL CLEARANCE	
New	0.02 mm to 0.25 mm (.001 in to .01 in)
Service limit	0.35 mm (.014 in)

Installing the Balancer Shaft

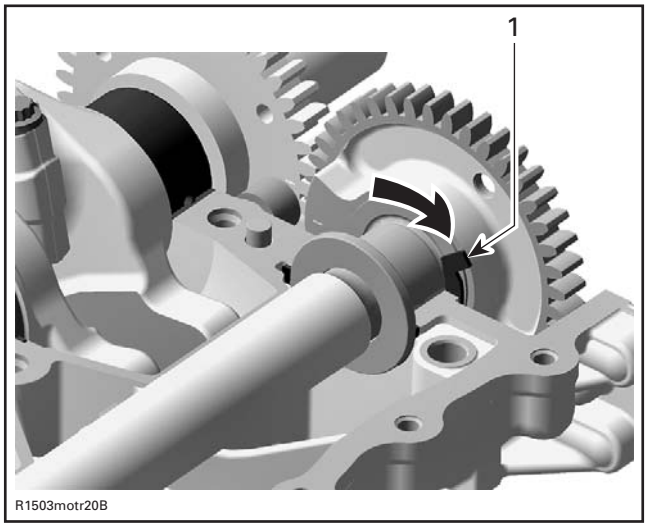
The installation is the reverse of the removal procedure. However, pay attention to following.

NOTICE Balancer shaft and crankshaft marks have to be aligned.



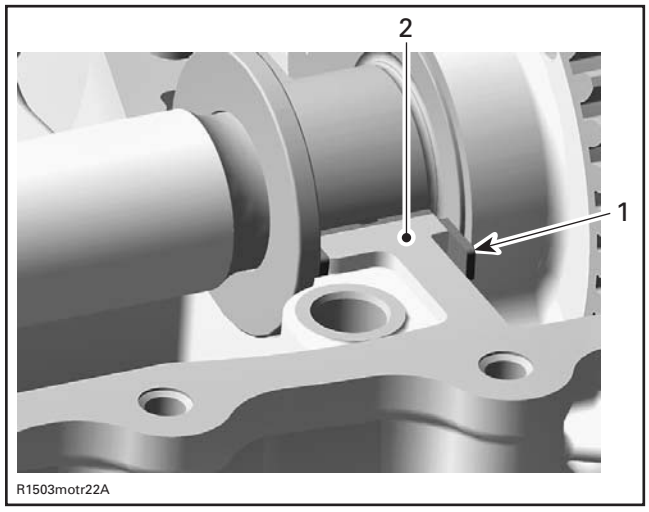
1. Mark on balancer shaft
2. Mark on crankshaft

1. Install thrust washers in place as per following illustration.



THRUST WASHER INSERT DIRECTION
1. Thrust washer

NOTICE Thrust washers must be flush with the cylinder block sealing surface.



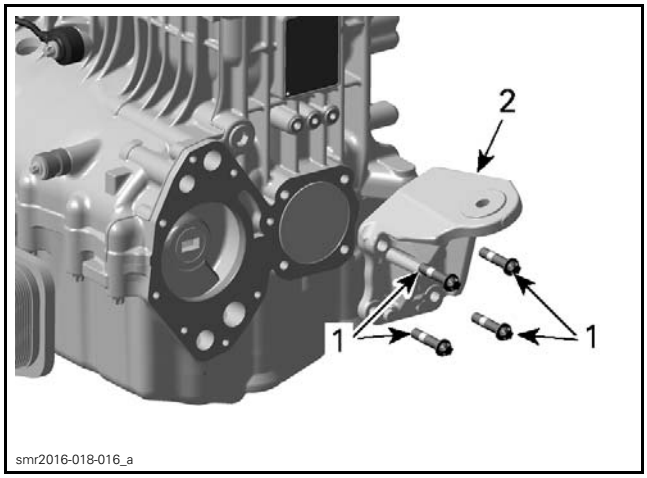
1. Thrust washer
2. Sealing surface

2. Install the cylinder block lower half. Refer to *CYLINDER BLOCK* in this subsection.
3. Reassemble the engine in accordance with the proper assembly procedures.

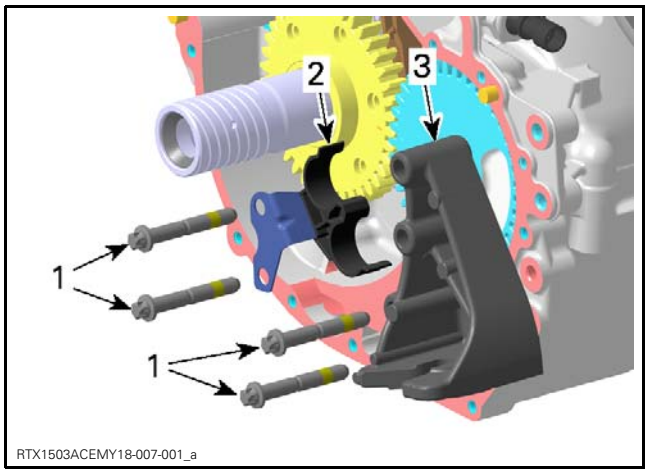
CYLINDER BLOCK

Disassembling the Cylinder Block

1. Refer to *PTO HOUSING, MAGNETO AND STARTER* subsection and remove:
   – PTO housing
   – Starter gear
   – Starter drive.
2. Refer to *LUBRICATION SYSTEM* subsection and remove oil suction pump.
3. Remove the engine mounting brackets.



1. Retaining screws
2. Engine mounting bracket

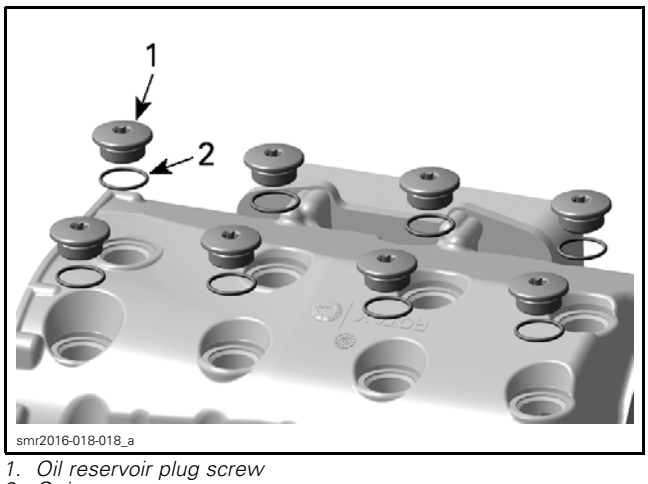


TYPICAL
1. *Retaining screws*
2. *Hose bracket*
3. *Engine mounting bracket*

4. Refer to *CYLINDER HEAD* subsection and remove cylinder head.

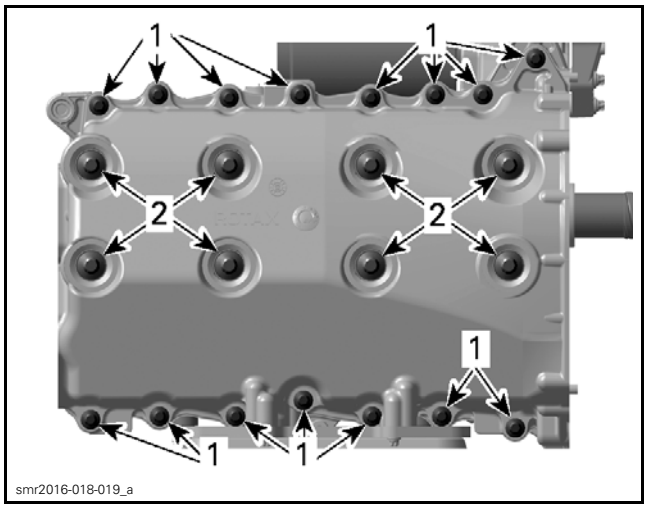
NOTE: Before splitting the cylinder block, measure crankshaft axial play. Refer to *CRANKSHAFT* in this subsection.

5. Remove the oil reservoir plug screws with O-rings.



1. *Oil reservoir plug screw*
2. *O-ring*

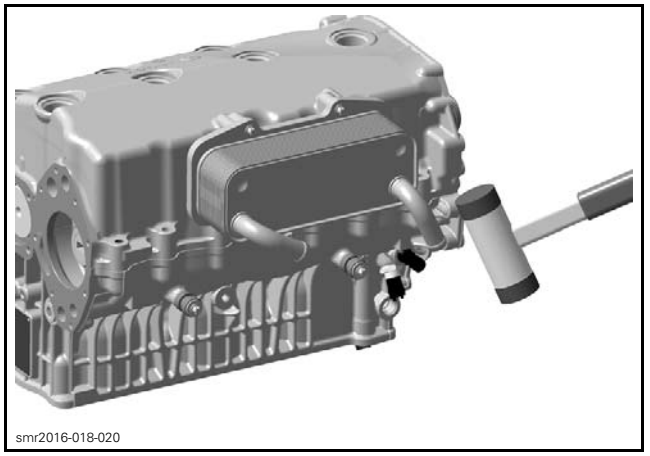
6. Remove cylinder block screws:
   1. Start removing the M8 screws.
   2. Then remove the M10 screws.



1. *M8 screws*
2. *M10 screws*

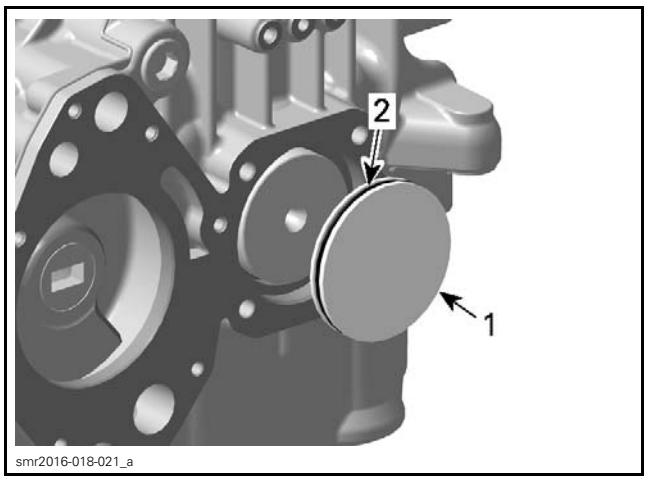
7. Carefully remove the cylinder block lower half by using a soft hammer.

NOTE: Take care not to damage the sealing surfaces of the cylinder block halves.



TYPICAL

8. Remove the crankshaft cover with O-ring.

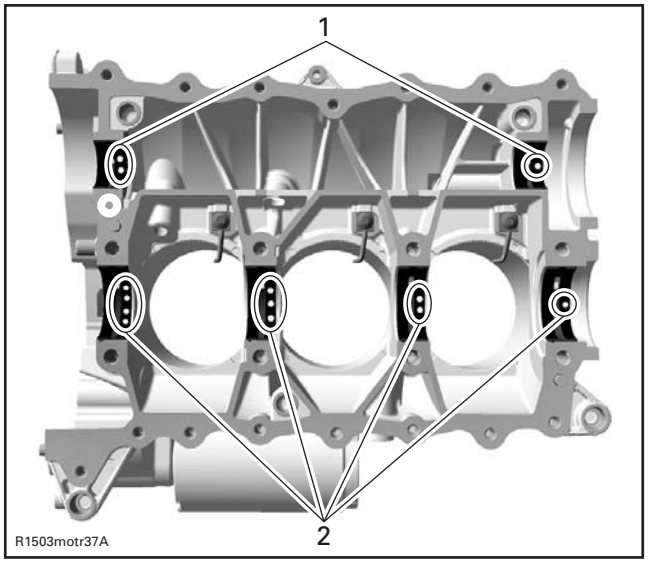


1. *Crankshaft cover*
2. *O-ring*

9. Refer to procedures in this subsection and remove:
   – Balancer shaft
   – Crankshaft
   – Piston with connecting rod.

Removing the Plain Bearings

When the plain bearings of crankshaft and balancer shaft need to be removed from the cylinder block, mark them to identify the correct position at installation. See the following illustration for an example:



1. Marks on balancer shaft bearings
2. Marks on crankshaft bearings

Cleaning the Cylinder Block

1. Clean cylinder block using a part cleaner, then use compressed air to dry it.
2. Blow out the oil orifices using compressed air and make sure they are not clogged.
3. Clean all metal components in a solvent.
4. Clean mating surfaces using gasket remover and a brass brush.
5. Brush a first pass in one direction then make the final brushing perpendicularly (90°) to the first pass (cross hatch).

SERVICE PRODUCT
LOCTITE CHISEL (GASKET REMOVER) (P/N 413 708 500)

NOTICE Do not wipe with rags. Use a new clean hand towel only.

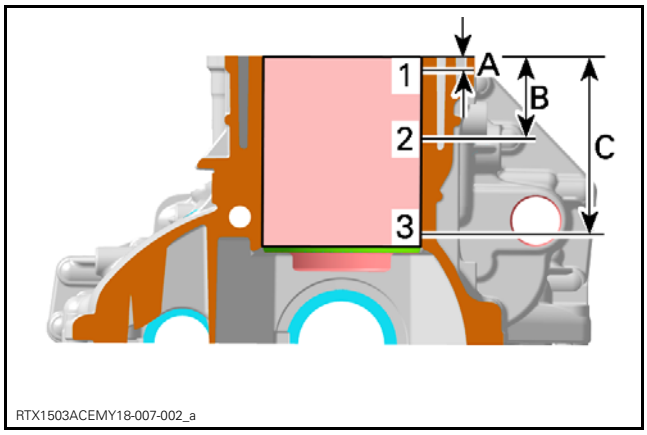
Inspecting the Cylinder Block

Cylinder Block and Cylinder Bores

1. Check cylinder block for cracks or other damage.
2. Check cylinder block mating surfaces for flatness using a straight edge.
3. Check cylinder bores for cracks, scoring and wear ridges on the top and bottom of the cylinder.
4. Replace cylinder block if necessary.

Cylinder Taper

1. Measure cylinder bore at 3 recommended positions. See the following illustration.



TYPICAL
1. First measuring diameter
2. Second measuring diameter
3. Third measuring diameter

A. 5 mm (.2 in)
B. 62 mm (2.44 in)
C. 115 mm (4.53 in)

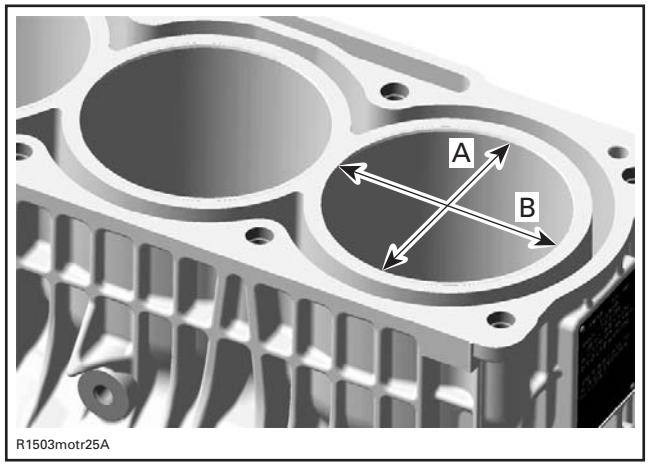
CYLINDER TAPER IN DIAMETER	
New	0.036 mm (.0014 in)
Service limit	0.100 mm (.0039 in)

2. If a cylinder bore is out of specification, replace the cylinder block assembly.

Cylinder Out of Round

Measure cylinder diameter in piston axis direction from top of cylinder. Take an other measurement 90° from first one and compare.

NOTE: Take the same measuring points as described in *CYLINDER TAPER*.

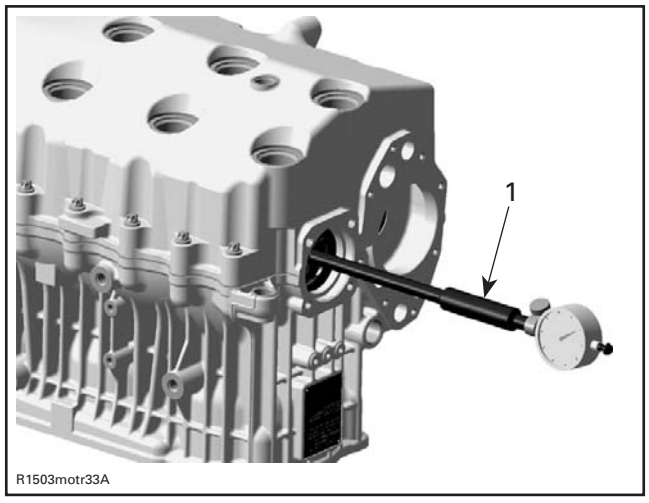


A. Perpendicular to crankshaft axis
B. Parallel to crankshaft axis

CYLINDER OUT OF ROUND	
New maximum	0.008 mm (.0003 in)
Service limit	0.020 mm (.0008 in)

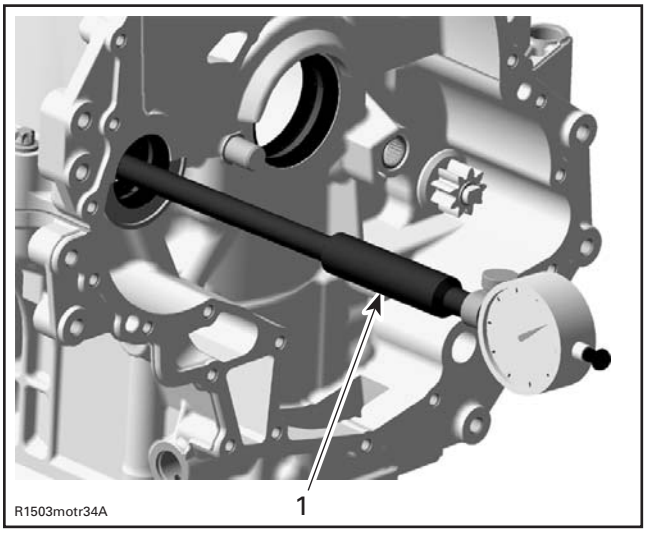
Bearings

1. Measure the plain bearing inside diameter and compare with crankshaft bearing journal diameter. Refer to *CRANKSHAFT* in this subsection). Proceed as follows:
   - Use the **OLD** plain bearings and put both cylinder block halves together.
   - Tighten screws as described in *ASSEMBLING THE CYLINDER BLOCK*.
   - Measure the inside diameter of the crankshaft plain bearings using a bore gauge.



ENGINE UPSIDE DOWN
1. Bore gauge

CRANKSHAFT BEARING INSIDE DIAMETER	
Service limit	50.10 mm (1.9724 in)



ENGINE UPSIDE DOWN
1. Bore gauge

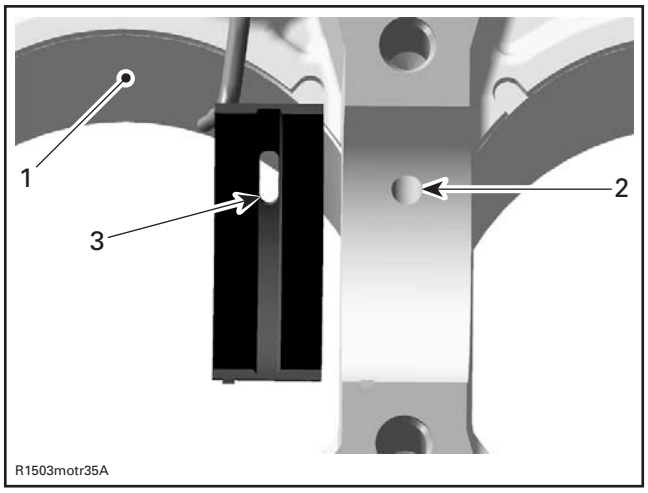
BALANCER SHAFT BEARING INSIDE DIAMETER	
Service limit	32.11 mm (1.2642 in)

2. Replace plain bearings if they are out of specifications.

Assembling the Cylinder Block

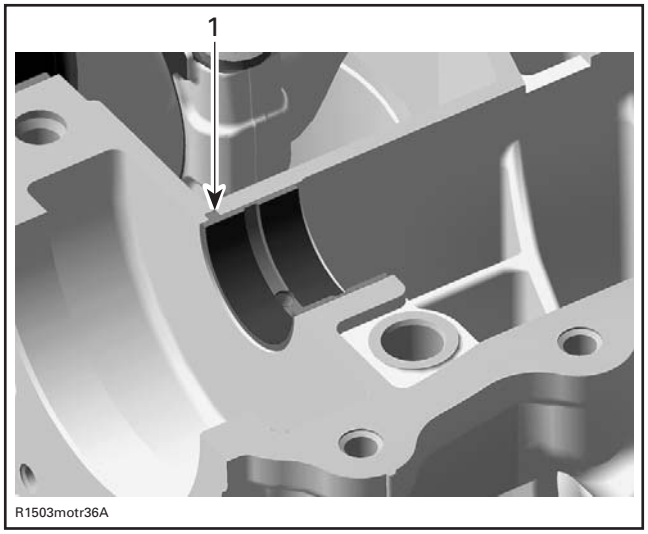
The assembly is the reverse of the disassembly procedure. However, pay attention to the following.

1. Install the following components:
   - Piston oil nozzles. Refer to *LUBRICATION SYSTEM* subsection
   - Oil cooler. Refer to *LUBRICATION SYSTEM* subsection
   - Supercharger oil spray nozzle. Refer to *LUBRICATION SYSTEM* subsection
   - Electric starter. Refer to *PTO HOUSING, MAGNETO AND STARTER* subsection
   - Knock sensor. Refer to procedure in this subsection
   - Chain tensioner guide.
2. If **OLD** bearings will be used again, reinstall them at the same position as they were before.
3. Correctly install bearings. Top crankshaft bearing halves have a bore which has to be placed in the upper cylinder block.



1. Cylinder block upper half
2. Oil bore in cylinder block
3. Oil bore in bearing

4. Bearings have to be flush with the cylinder block split surface and their protrusions have to fit in the notched areas in the cylinder block seat.



1. Bearing protrusion in cylinder block notch

5. Apply engine oil on all plain bearings.
6. For proper installation of pistons, refer to *PISTONS AND CONNECTING RODS* in this subsection.

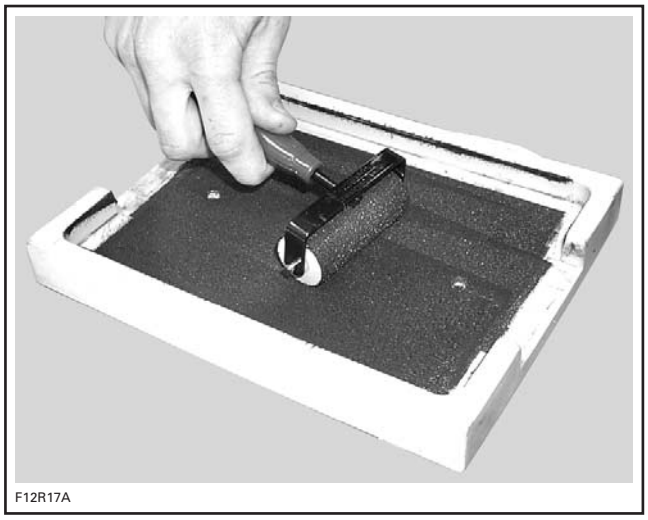
NOTICE Before installing the crankshaft, ensure that:
– chain guide is already installed
– timing chain is installed on crankshaft timing gear.
Those parts cannot be installed after as the crankshaft is in place.

7. IMPORTANT: When beginning the application of the crankcase sealant, the assembly and the first torquing should be done within 10 minutes. It is suggested to have all you need on hand to save time.
8. Apply sealant on mating surfaces.

SERVICE PRODUCT
LOCTITE 5910 (P/N 293 800 081)

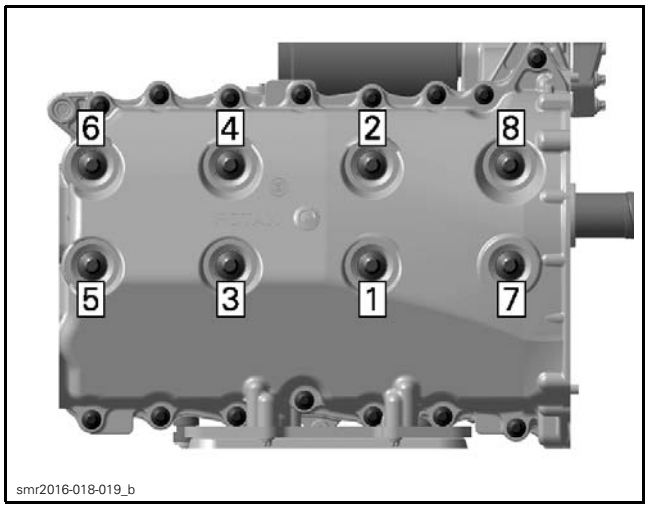
REQUIRED TOOL
Plexiglas plate
Soft rubber roller

9. Apply some sealant on the plate and get a thin uniform coat (spread as necessary).
10. Then apply the sealant on supercharger housing sealing surface.



NOTE: If you do not use the roller method, you may use your finger to uniformly distribute this sealant.

11. Do not apply in excess as it will spread out inside crankcase.
12. Tighten M10 cylinder block screws as per following sequence.

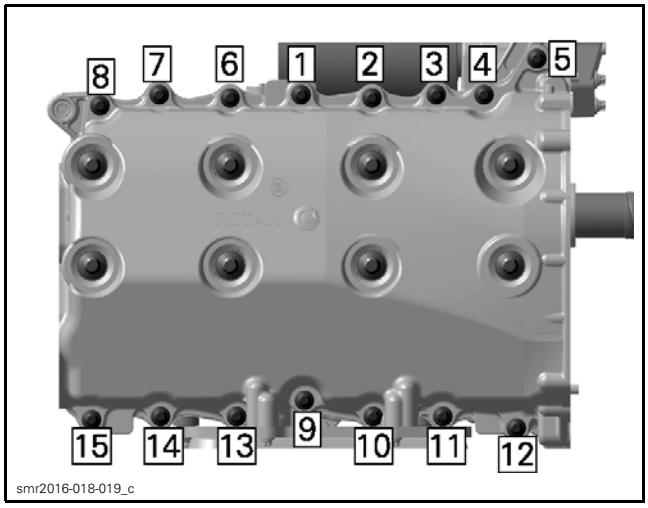


M10 SCREWS TIGHTENING SEQUENCE

NOTICE All M10 cylinder block screws must be torque FIRST according to step A before performing to step B.

TIGHTENING PROCEDURE		
M10 cylinder block screws	Step A	40 N•m ± 3 N•m (30 lbf•ft ± 2 lbf•ft)
	Step B	55 N•m ± 4 N•m (41 lbf•ft ± 3 lbf•ft)

13. Tighten M8 cylinder block screws as per following sequence.

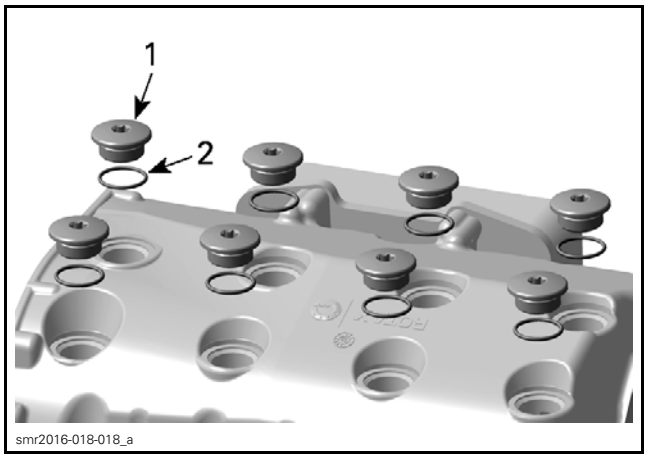


M8 SCREWS TIGHTENING SEQUENCE

TIGHTENING TORQUE	
M8 cylinder block screws	30 N•m ± 3 N•m (22 lbf•ft ± 2 lbf•ft) + LOCTITE 243 (BLUE) (P/N 293 800 060)

NOTE: Check axial clearance of balancer shaft and crankshaft before continuing the assembly. Refer to *CRANKSHAFT* and *BALANCER SHAFT* in this subsection for the procedure.

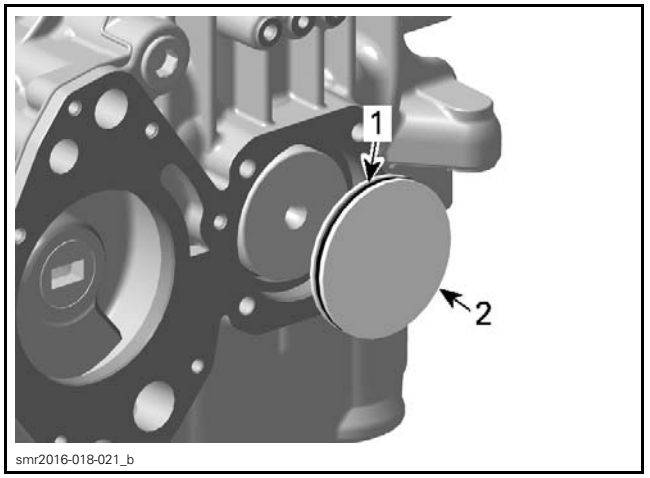
14. Install oil reservoir plug screws with O-rings.



1. *Oil reservoir plug screw*
2. *O-ring*

TIGHTENING TORQUE	
Oil reservoir plug screw	23 N•m ± 3 N•m (17 lbf•ft ± 2 lbf•ft) + LOCTITE 243 (BLUE) (P/N 293 800 060)

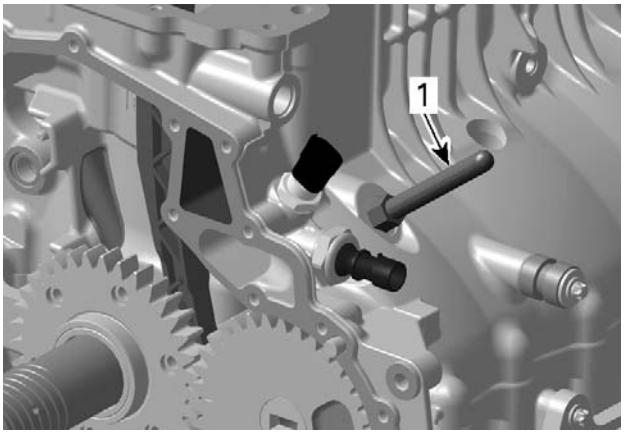
15. Apply engine oil on the O-ring and press in crankshaft cover.



1. *O-ring*
2. *Crankshaft cover*

16. Position the crankshaft at TDC before installing the camshaft and the rocker arms. Refer to *CYLINDER HEAD* subsection.

REQUIRED TOOL
CRANKSHAFT LOCKING TOOL (P/N 529 035 821) 
or alternatively
CRANKSHAFT LOCKING TOOL (P/N 529 036 553) 



1. Crankshaft locking tool

17. Reassemble the engine in accordance with the proper assembly procedures.

SUPERCHARGER

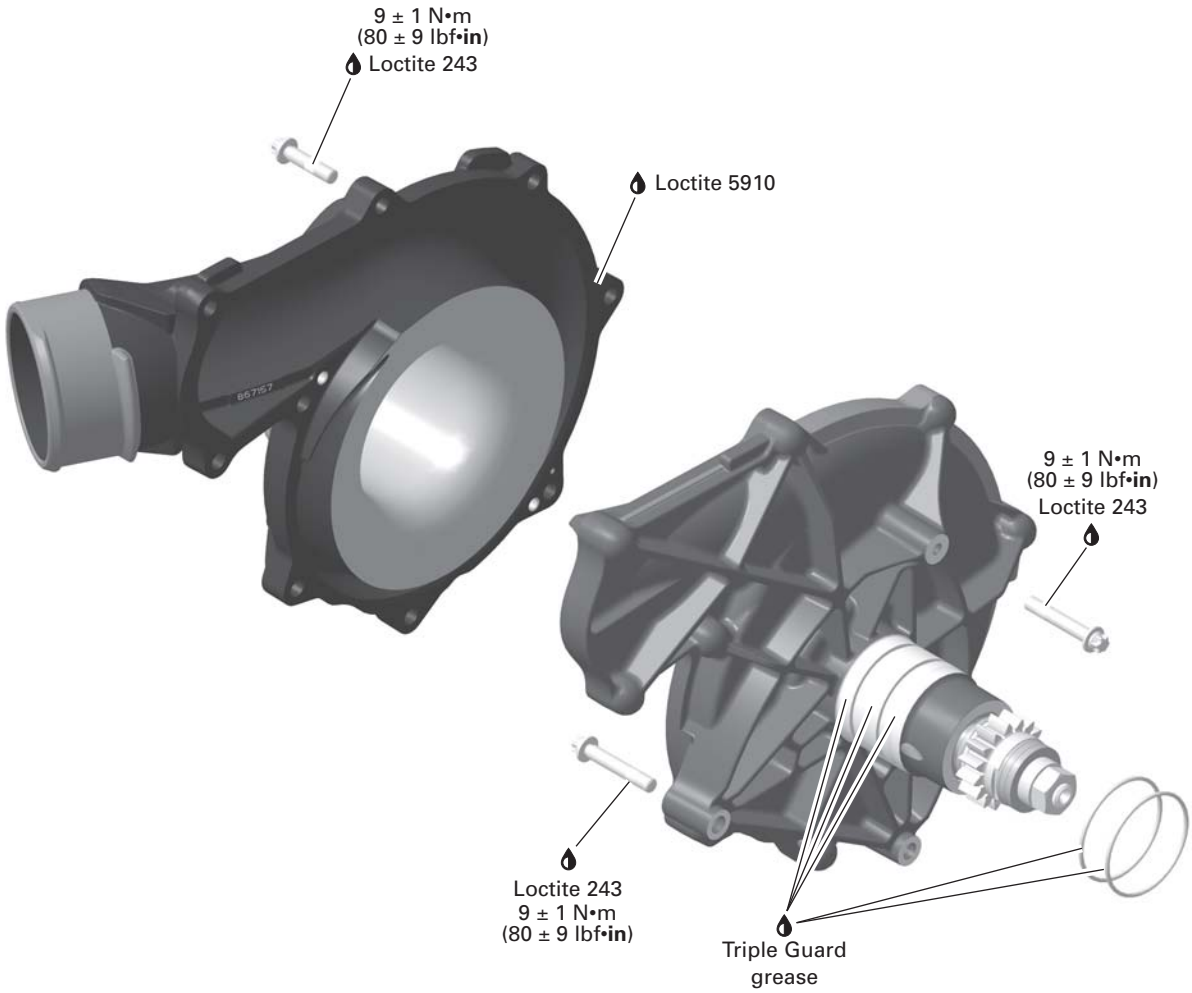
SERVICE TOOLS

Description	Part Number	Page
CAMSHAFT LOCKING TOOL	529 035 839	152
SUPERCHARGER GEAR HOLDER	529 036 025	153
SUPERCHARGER GEAR HOLDER	529 036 364	153
SUPERCHARGER SEPARATOR TOOL	529 036 397	156
SUPPORT PLATE	529 035 947	153, 155–156
TORX ADAPTER	529 035 938	155, 159

SERVICE PRODUCTS

Description	Part Number	Page
LOCTITE 243 (BLUE)	293 800 060	158–159
LOCTITE 5910	293 800 081	157
LOCTITE CHISEL (GASKET REMOVER)	413 708 500	157

230 Engines



NEW = Component must be replaced when removed.

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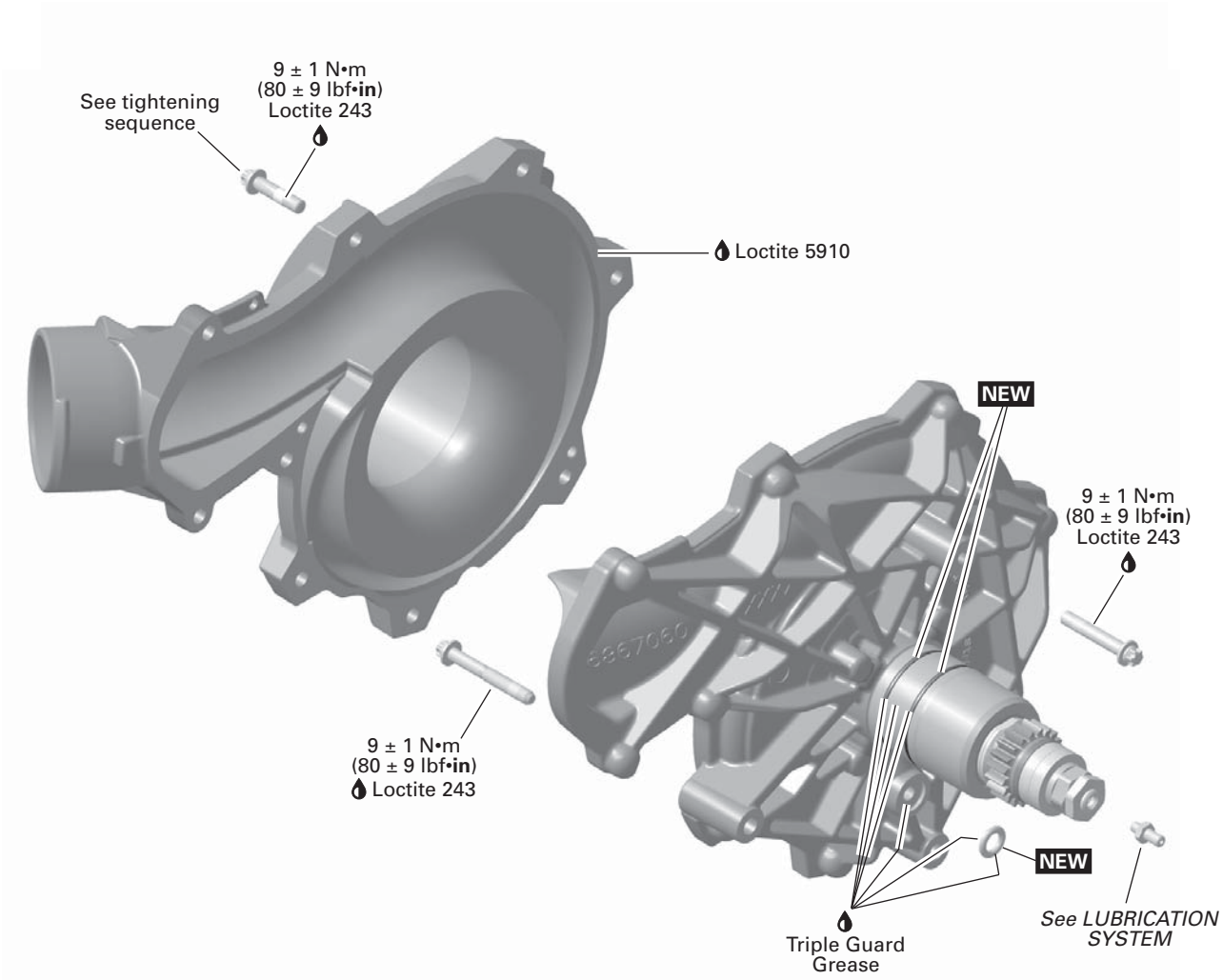
300 Engines



NEW = Component must be replaced when removed.

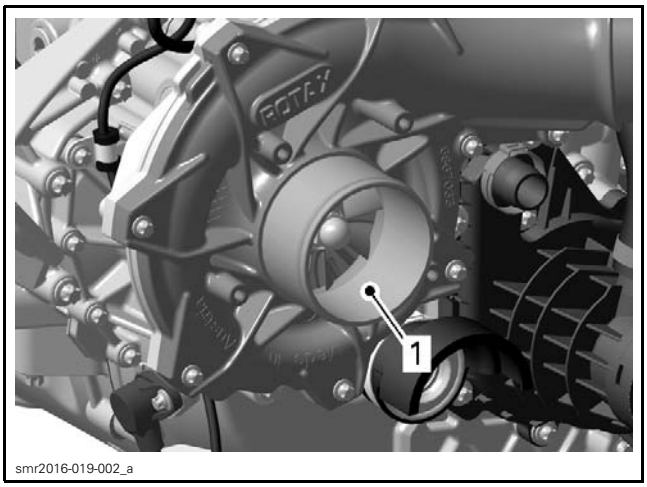
smr2016-019-001_b

INSPECTION

SUPERCHARGER INLET CLEANLINESS

NOTE: A lower than usual maximum RPM at full throttle might be caused by a dirty supercharger inlet.

1. Remove supercharger air inlet hose.
2. Visually inspect supercharger inlet side for oil, salt or any other deposits.



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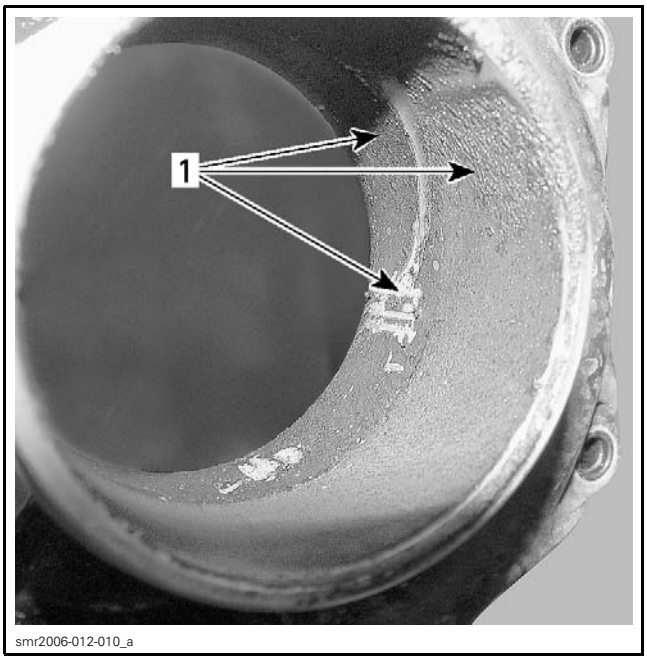
1. Supercharger inlet



smr2006-012-010_a

1. Dirt here

3. If dirt is found, proceed as follows.
4. Remove supercharger.
5. Separate supercharger housing.
6. Clean internal housing and impeller using a brass brush and cleaning solvent to get rid of oil deposits.
7. Blow dry with compressed air.

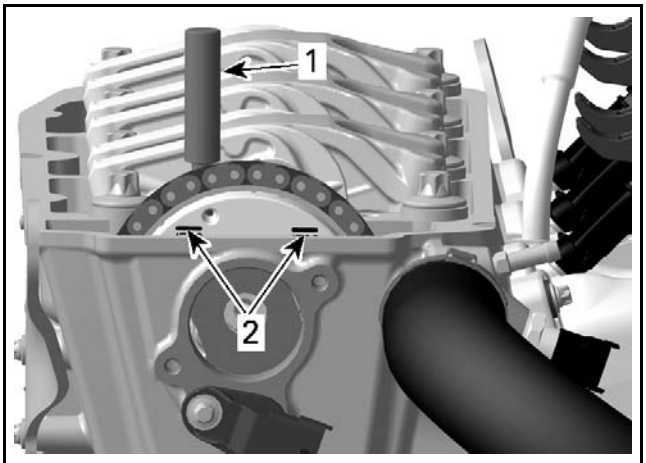
NOTICE **Do not let impeller spin when using compressed air.**

8. Complete usual assembly procedures as described in this subsection.

SUPERCHARGER CLUTCH SLIPPING MOMENT (ON ENGINE)

1. Remove the supercharger air inlet hose.
2. Remove:
   - Ignition coils and spark plugs. Refer to *IGNITION COILS AND SPARK PLUGS* subsection
   - Valve cover. Refer to *CYLINDER HEAD* subsection.
3. Turn the engine by rotating the supercharger nut counterclockwise until the position lines on oil separator cover are lined up as shown in the following illustration.
4. Lock the camshaft.

REQUIRED TOOL	
CAMSHAFT LOCKING TOOL (P/N 529 035 839)	



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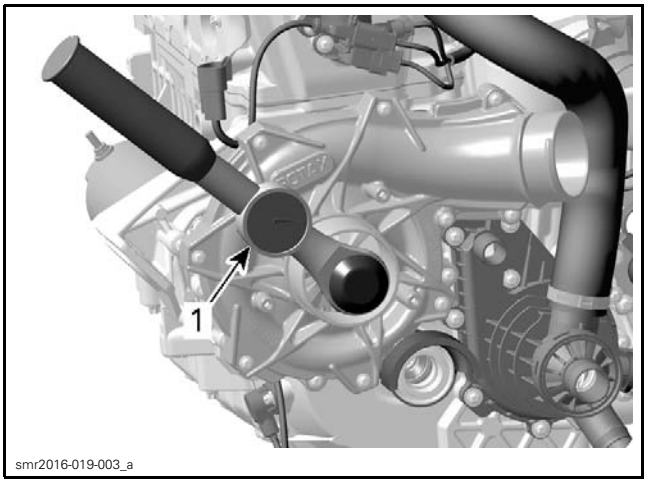
1. Camshaft locking tool
2. Position lines

5. Check slipping moment counterclockwise.

REQUIRED TOOL
Torque wrench with actual torque viewer
A mirror is useful to see the viewer



1. Torque wrench

NOTE: Before checking the supercharger slipping moment turn the clutch for a minimum of 3 complete revolutions. This will dissipate grease or oil on the friction shims for a precise reading.

6. Supercharger should start to turn at a torque within the specified values.

ENGINE TYPE	SLIPPING MOMENT (NEW SUPERCHARGER)
230	9 N•m to 14 N•m (80 lbf•**in** to 124 lbf•**in**)
300	14 N•m to 17 N•m (124 lbf•**in** to 150 lbf•**in**)

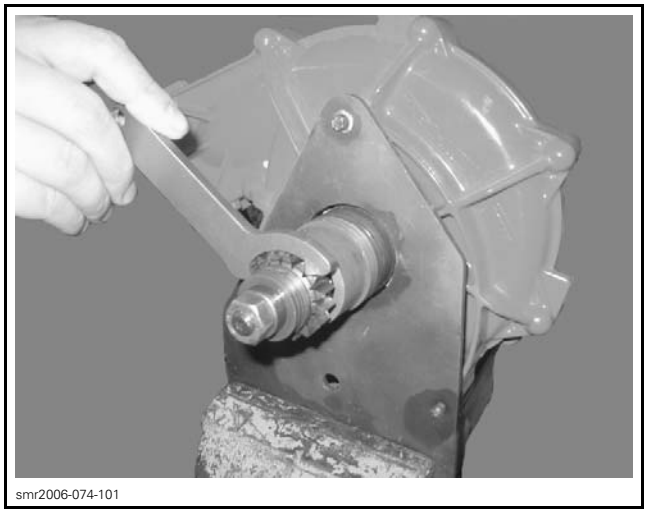
ENGINE TYPE	SLIPPING MOMENT (BREAK-IN SUPERCHARGER)
230	8 N•m to 12 N•m (71 lbf•**in** to 106 lbf•**in**)
300	Minimum 11 N•m (97 lbf•**in**)

7. If the torque is not within specifications, remove supercharger from the engine and repeat supercharger clutch slipping moment test on the bench.

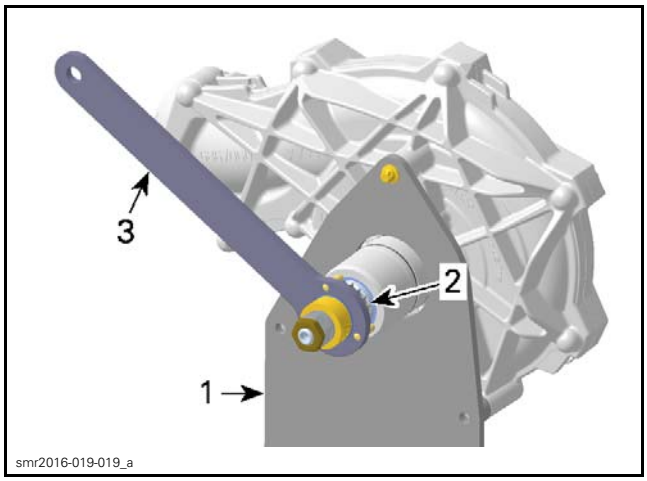
SUPERCHARGER CLUTCH SLIPPING MOMENT (BENCH TEST)

1. Mount the supercharger on the support plate.
2. Hold the supercharger gear.

ENGINE TYPE	REQUIRED TOOLS
All	SUPPORT PLATE (P/N 529 035 947) 
All	2x screw M6x25
230	SUPERCHARGER GEAR HOLDER (P/N 529 036 025) 
300	SUPERCHARGER GEAR HOLDER (P/N 529 036 364) 



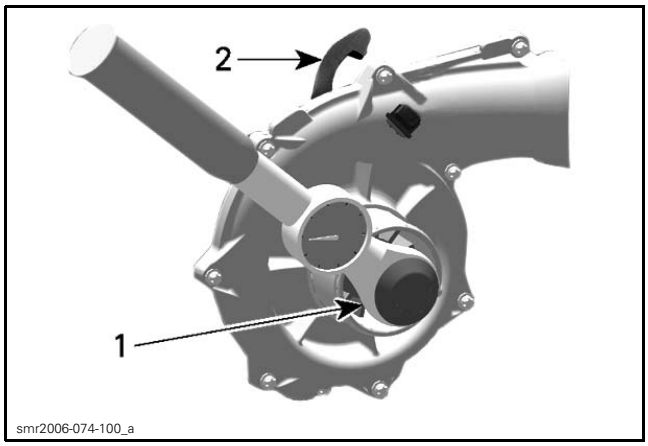
230 ENGINE



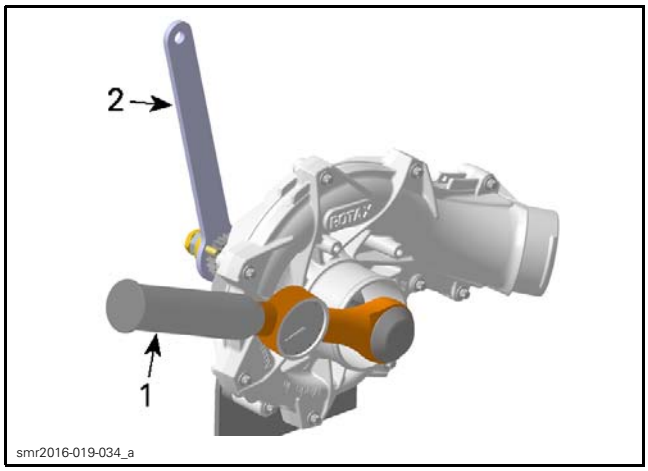
300 ENGINE
1. Support plate
2. Supercharger gear
3. Supercharger gear holder

3. Check slipping moment counterclockwise.

REQUIRED TOOL
Torque wrench with a viewer



230 ENGINE
1. *Torque wrench*
2. *Supercharger gear holder*



300 ENGINE
1. *Torque wrench*
2. *Supercharger gear holder*

NOTE: Before checking the supercharger slipping moment to turn the clutch for a minimum of 3 complete revolutions. This will dissipate grease or oil on the friction shims for a proper reading.

4. The supercharger should start to turn at a torque within the specified values.

ENGINE TYPE	SLIPPING MOMENT (NEW SUPERCHARGER)
230	9 N•m to 14 N•m (80 lbf•**in** to 124 lbf•**in**)
300	14 N•m to 17 N•m (124 lbf•**in** to 150 lbf•**in**)

ENGINE TYPE	SLIPPING MOMENT (BREAK-IN SUPERCHARGER)
230	8 N•m to 12 N•m (71 lbf•**in** to 106 lbf•**in**)
300	Minimum 11 N•m (97 lbf•**in**)

5. If the torque is not within specification, replace supercharger assembly.

TROUBLESHOOTING

The following is provided to help in diagnosing the probable source of troubles. It is a guideline and it should not be assumed to list all possible problems.

Always check for fault codes. If a fault code is detected, service the fault code first. Refer to *DIAGNOSTIC AND FAULT CODES* subsection.

ENGINE WILL NOT START (ENGINE DOES NOT TURN OVER)

1. Supercharger seized or obstructed
   - *Inspect and replace supercharger assembly if necessary.*
   - *Inspect supercharger oil spray nozzle, refer to LUBRICATION SYSTEM subsection.*

ENGINE LACKS ACCELERATION OR POWER (DOES NOT REACH MAXIMUM RPM)

1. Supercharger inlet is dirty
   - *Check and clean supercharger inlet.*
   - *Check engine oil. Siphon excess of oil.*
2. Supercharger slipping clutch defective
   - *Check slipping clutch moment.*
   - *Replace supercharger assembly if out of specification.*
3. Check intercooler for oil contamination.
   - *Clean intercooler.*

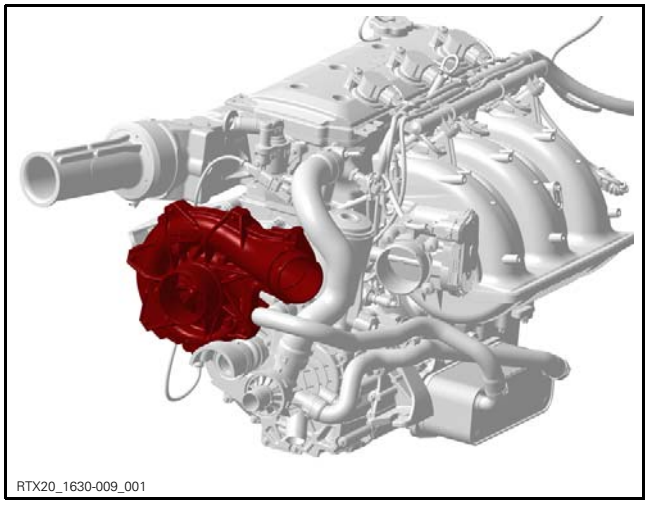
PROCEDURES

SUPERCHARGER OIL SPRAY NOZZLE

Refer to *LUBRICATION SYSTEM* subsection.

SUPERCHARGER

Supercharger Location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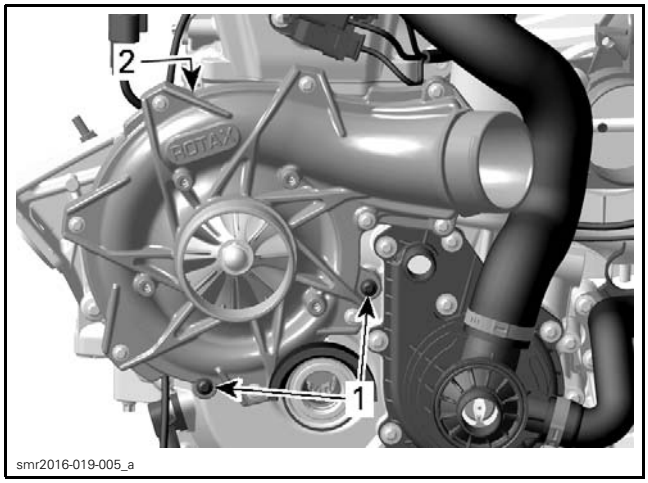
Removing the Supercharger

1. Remove the muffler. Refer to Exhaust System.
2. Remove the jet pump. Refer to *JET PUMP* subsection.

NOTE: Removing the jet pump allows the drive shaft to drop just enough so that the floating ring clears the supercharger.

3. Remove the retaining screws.



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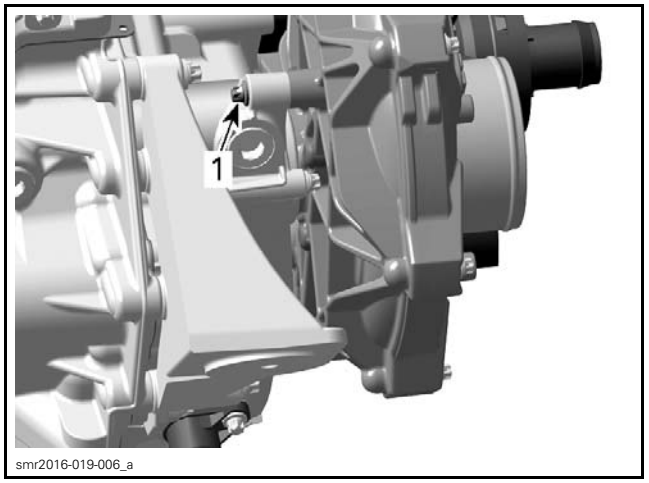
1. *Supercharger retaining screws*
2. *Upper supercharger retaining screw (hidden behind the supercharger)*

NOTE: Use the following tool to remove the upper retaining screw.

REQUIRED TOOL	
TORX ADAPTER (P/N 529 035 938)	



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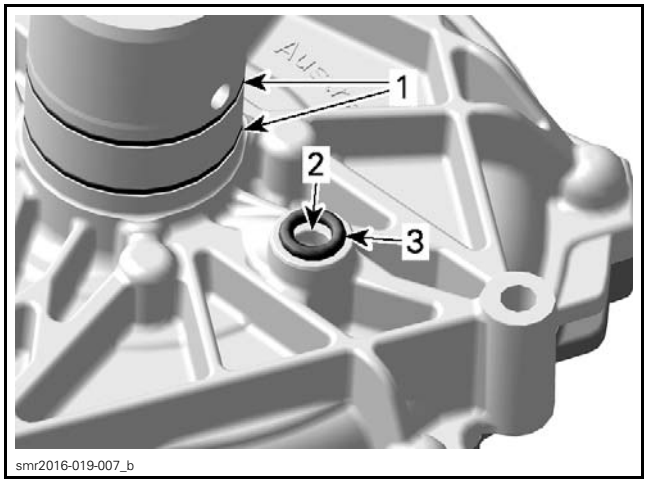
1. *Upper retaining screw*

4. Remove the supercharger from the engine.
5. Discard the O-rings.



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1. *O-rings*
2. *O-ring (300 only)*
3. *Oil return bore (300 only)*

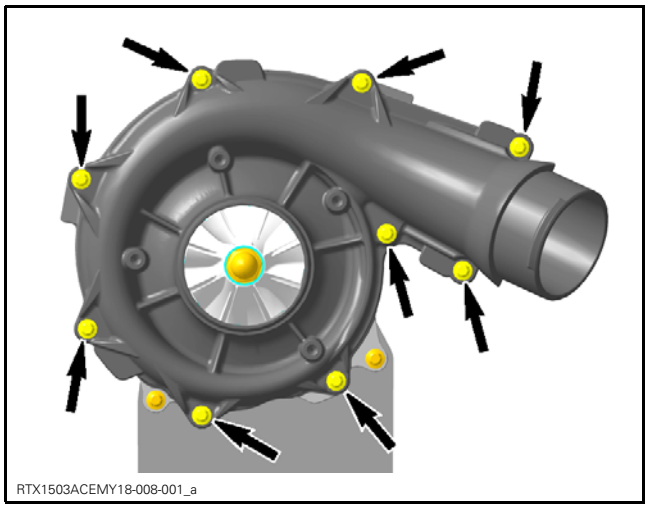
Disassembling the Supercharger (230 Engines)

NOTICE **Be scrupulous when working on supercharger parts. Supercharger rotation reaches 45 000 RPM. Any modification, improper handling or damage on the parts, may result in damage of the supercharger. Strictly follow the described procedures.**

1. Secure the supercharger on its support plate.

REQUIRED TOOL	
SUPPORT PLATE (P/N 529 035 947)	

2. Remove the supercharger housing screws.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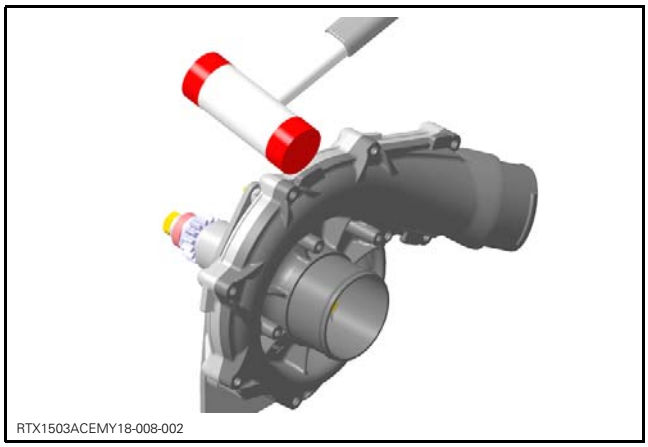
3. Separate the supercharger housing.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PLASTIC HAMMER

NOTICE All components of the supercharger are balanced together to obtain an optimal performance and a smooth operation. Consequently it is not possible to repair the supercharger.

Disassembling the Supercharger (300 Engines)

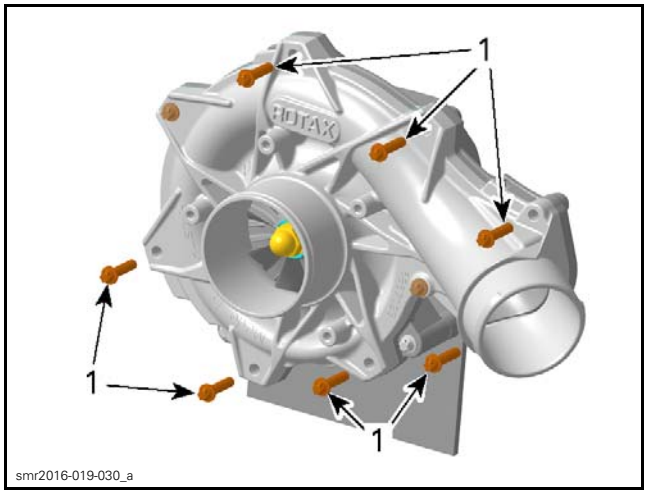
NOTE: Handle the supercharger with care. If the supercharger is hitting any obstacle this may cause high risk of pre-damaging the hybrid ball bearings.

NOTICE Be scrupulous when working on supercharger parts. Supercharger rotation reaches 46800 RPM. Any modification, improper handling or damage on the parts, may result in damage of the supercharger. Strictly follow the described procedures.

1. Secure the supercharger on its support plate.

REQUIRED TOOL	
SUPPORT PLATE (P/N 529 035 947)	
2x screw M6x25	

2. Remove supercharger housing screws (7x).



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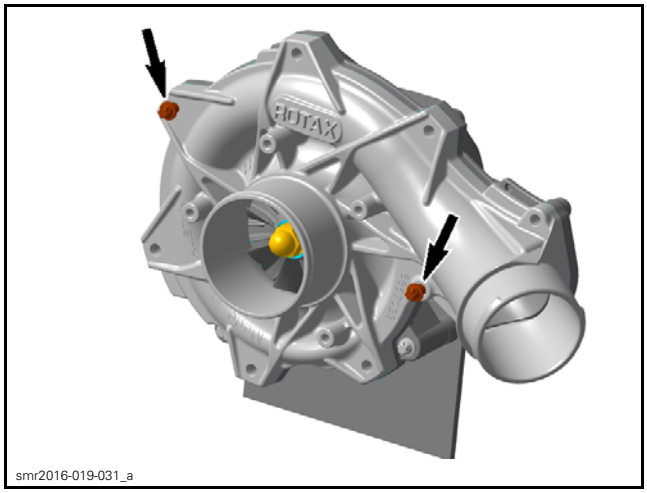
1. Supercharger housing screws (7x)

3. Loosen the 2 remaining screws but do not remove them completely.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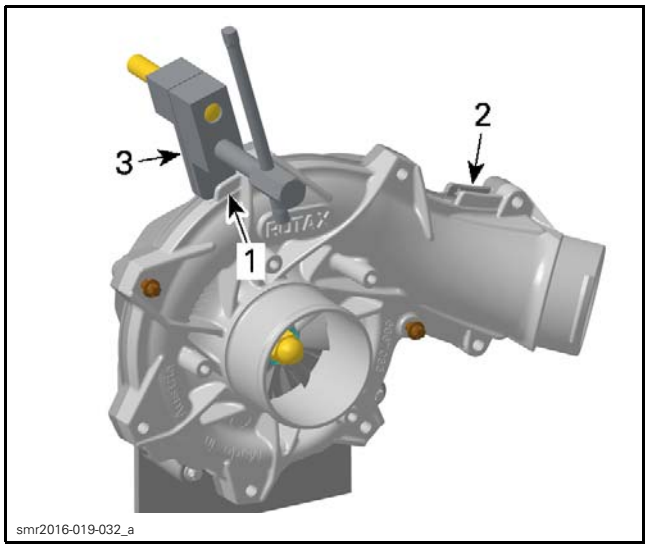
4. Separate supercharger housing.

REQUIRED TOOL
SUPERCHARGER SEPARATOR TOOL (P/N 529 036 397)

4.1 Place the supercharger separator at position **no. 1**.

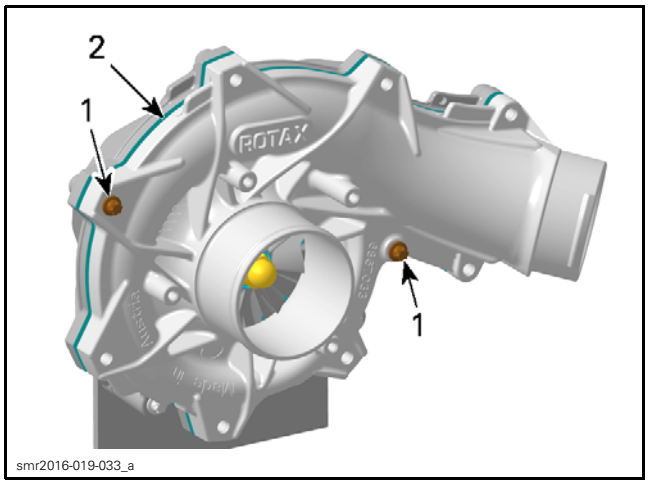


1. *Separator position* no. 1
2. *Separator position* no. 2
3. *Supercharger separator*

4.2 Turn the lever clockwise until the housing half (intake side) is falling apart.

4.3 If required place the supercharger separator at position **no. 2**.

4.4 Remove the remaining screws (2 x) and withdraw housing half (intake side).



1. *Screws (2 x)*
2. *Housing half (intake side)*

NOTICE To grant the optimal performance and smooth operation the supercharger assembly is balanced. Consequently it is not possible to perform any repairs on the supercharger assembly.

Assembling the Supercharger

1. Clean supercharger housing halves using a part cleaner, then use compressed air to dry it. Take care that deposits do not get into the bearing area.

NOTICE Do not let impeller spin when using compressed air.

2. Clean supercharger housing mating surfaces.

NOTICE Never grind or polish the mounting surface of the supercharger. Abrasive dust may cause severe supercharger damage.

3. Brush in one direction then make the final brushing perpendicularly (90°) to the first pass.

SERVICE PRODUCT
LOCTITE CHISEL (GASKET REMOVER) (P/N 413 708 500)

REQUIRED TOOL
Brass brush

4. Apply supercharger housing sealant:

SERVICE PRODUCT
LOCTITE 5910 (P/N 293 800 081)

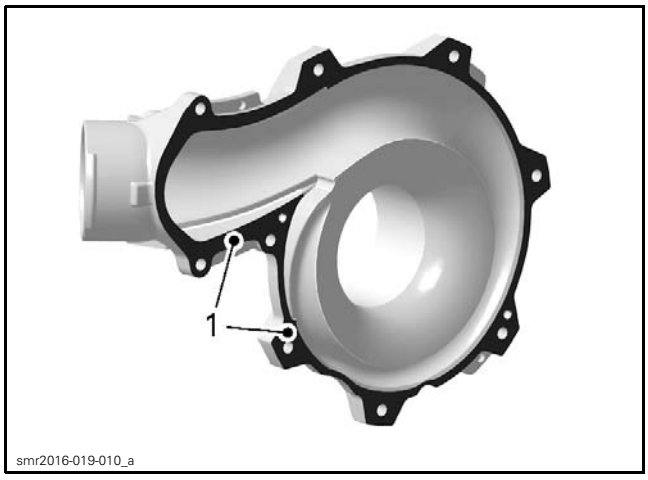
NOTICE When beginning the application of the supercharger housing sealant, the assembly and the first torquing should be done within 10 minutes. It is suggested to have all you need on hand to save time.

REQUIRED TOOL
Plexiglas plate
Soft rubber roller

4.1 Apply some sealant on the plate and get a thin uniform coat (spread as necessary).

4.2 Then apply the sealant on supercharger housing sealing surface.

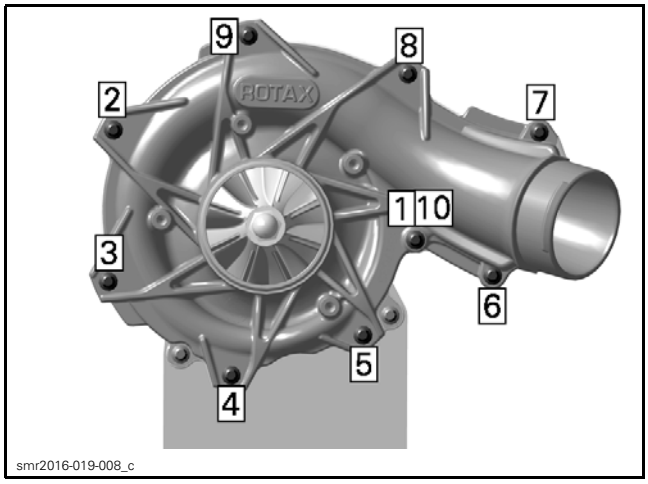
NOTE: Ensure not to apply too much sealant, as it will spread out inside supercharger housing.



HOUSING HALF (INTAKE SIDE)
1. Apply Loctite 5910 on sealing surface

5. Assemble supercharger housing halves.
6. Tighten supercharger housing screws according to the following sequence.

TIGHTENING TORQUE	
Supercharger housing screws	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)



TIGHTENING SEQUENCE

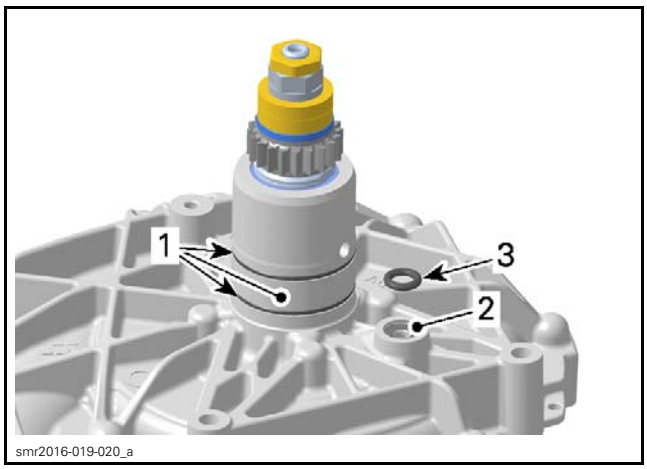
Installing the Supercharger

NOTE: Handle the supercharger with care. If the supercharger is hitting any obstacle this may cause high risk of pre-damaging the ball bearings.

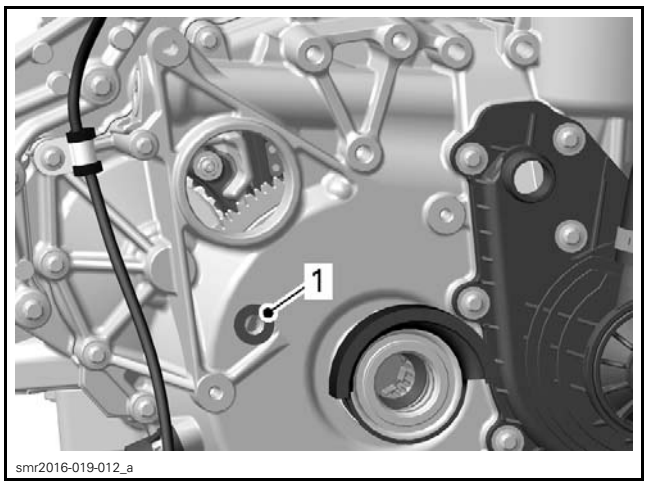
1. Grease:
   – Mounting surface of the supercharger with O-rings.
   – Sealing surface of oil return bore on supercharger housing (300 only)
   – O-ring (300 only)
   – Sealing surface of oil return bore on PTO housing (300 only).

SERVICE PRODUCT
(P/N 508298)

2. Install **NEW** O-rings.



LUBRICATE
1. Mounting surface with O-rings
2. Oil return bore sealing surface (300 only)
3. O-ring (300 only)



LUBRICATE (300 ONLY)
1. Oil return bore sealing surface

3. Install supercharger on PTO housing.

NOTICE **Never use a hammer when installing the supercharger. Do not tap the impeller shaft at any time.**

4. Turn the impeller while installing the supercharger to engage the supercharger drive gear.

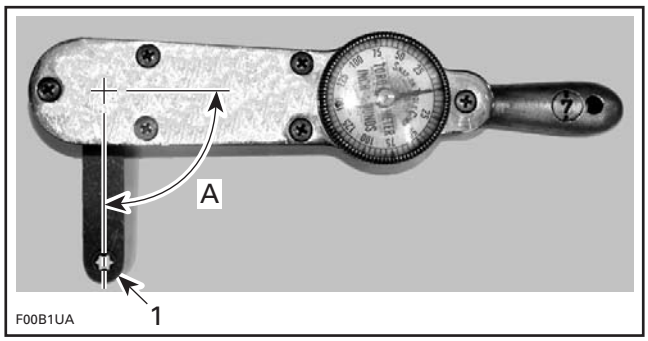
⚠ CAUTION **Impeller has sharp edges. Wear safety gloves when turning the supercharger at the impeller.**

5. Tighten supercharger retaining screws to specifications.

TIGHTENING TORQUE	
Supercharger retaining screws	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)

NOTE: For the upper retaining screw the following tool must be used mounted 90° to torque wrench.

REQUIRED TOOL	
TORX ADAPTER (P/N 529 035 938)	



1. Torx adapter perpendicular to torque wrench
A. 90°

NOTICE Not installing the tool as shown will change the torque applied to the screw.

ELECTRONIC CONTROL MODULE (ECM)

SERVICE TOOLS

SERVICE PRODUCTS

GENERAL

The following tools are required to test most of the electrical parts.

REQUIRED TOOLS	
FLUKE 115 MULTIMETER (P/N 529 035 868)	
ECM ADAPTER TOOL (P/N 529 036 166)	

SYSTEM DESCRIPTION

The electronic fuel injection system (EFI) is comprised of various sensors used for detecting ongoing operating conditions of the engine and watercraft, and includes all the actuators that perform the required adjustment to the engine.

This system also introduces torque management functions.

Electrical System

ECM (Engine Control Module)

From input signals (e.g. throttle lever, iBR lever), the ECM acknowledges driver demands and converts them to an engine torque requirement through calculation of several variables. Then, the ECM controls the iTC (intelligent Throttle Control), the injection system and the ignition system to meet the torque requirement.

The ECM manages the engine torque requirements and controls engine operation to ensure it is delivering optimum performance, fuel economy and meeting emission regulations. The ECM also controls idle speed and limits maximum engine speed.

Since the ECM manages several torque requirements at the same time including contradictory demands (such as the throttle lever and the iBR lever being fully pulled in at the same time), it must prioritize the most important requirement according to predefined conditions and apply the proper action.

TROUBLESHOOTING

DIAGNOSTIC TIPS

Electrical Related Problems

Electrical Connections

Pay particular attention to ensure that terminals and pins are not out of their connectors, corroded, or out of shape.

When probing terminals, pay attention not to deform the terminals as this could cause a loose or intermittent connection that would be difficult to troubleshoot.

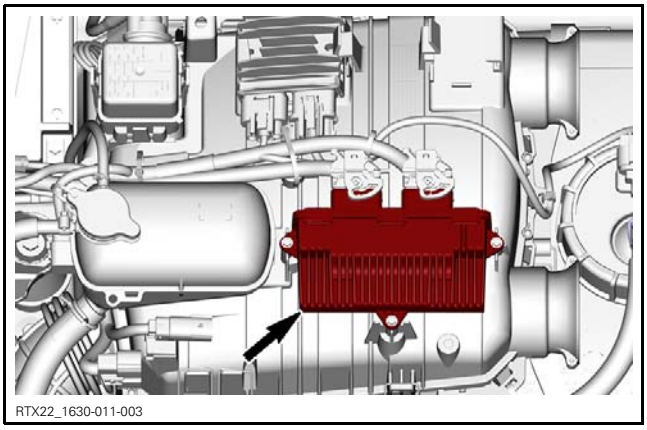
PROCEDURES

ENGINE CONTROL MODULE (ECM)

ECM Location

Configuration 1

The ECM is located on the air intake silencer.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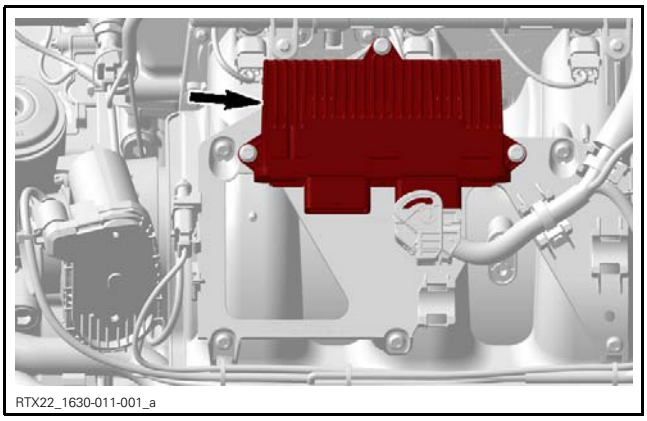
Configuration 2

The ECM is located on the intake manifold.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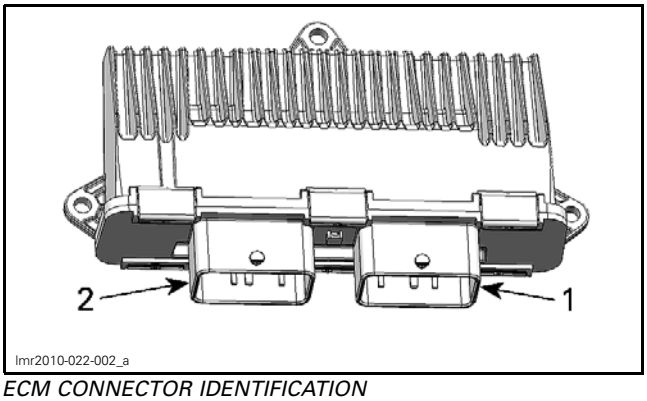
ECM Connector Identification

There are 2 connectors connected to the ECM.

– Engine harness connected to ECM-A
– Vehicle system control harness connected to ECM-B.



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ECM CONNECTOR IDENTIFICATION
1. Connector A
2. Connector B

The ECM connectors have 48 pins.

NOTE: For connector information, cleaning and probing, refer to *WIRING HARNESS AND CONNECTORS* subsection.

ECM Power Circuit Validation

1. Make sure the D.E.S.S. key is not installed on the D.E.S.S. post.
2. Press the START button.

QUICK INDICATION THAT ECM IS POWERED (assuming the observed component is working)
Information center turns on.
Fuel pump turns on for approximately 5 seconds.

NOTE: Since the tether cord is not installed, the information center will turn off a few seconds after the self-test, but the ECM and electrical system will stay powered for approximately 3 minutes longer.

3. If the ECM does not turn on, check the following:
   – ECM, Start/Stop and Fuel Pump fuses
   – Battery voltage. Refer to *CHARGING SYSTEM*
   – Relay and wiring. Refer to *POWER DISTRIBUTION AND GROUNDS*
   – ECM power supply wires and ground wires. See following procedure.

ECM Wake Up Logic

With Tether Cord Installed

When the START button is pressed to start engine:

– ECM pin B-D1 receives current from battery via the START switch. ECM is woken up.
– ECM pin B-H2 provides a ground to the relay coil in fuse box.
– The relay contacts close and provides main 12 Vdc power to the ECM at pin B-M4.
– The relay also powers the other components in the electrical system.
– ECM pin B-E4 monitors for a tether cord installed on the engine cut-off switch.
– When a tether cord is installed, the magnet in the tether cord cap closes the reed switches in the engine cut-off switch and the ECM pin B-F2 provides a ground. This tells the ECM the tether cord is installed.
– ECM pin B-B2 reads the D.E.S.S. key in the tether cap and determines if it is valid. If so, the engine can be started.

Without a Tether Cord Installed

When the START button is pressed:

– The information center turns on, goes through the self-test function, displays applicable messages and turns off a few seconds later.
– The engine cannot be cranked.
– The ECM stays powered up until it removes the ground to the relay coil after 3 minutes (pin B-H2).
– Relay contacts open and power to the ECM is removed.
– Power is also removed on all other electrical systems except the GPS supply to the information center.

ECM Shut Down Logic

When the engine is stopped by using the STOP button or by removing the tether cord from the engine cut-off switch, the following occurs:

– ECM stops the engine.
– After 5 seconds, the information center turns off.
– After 60 seconds, ECM (pin B-H2) removes the ground to the relay coil.
– Relay contacts open and power to the ECM is removed.
– Power is also removed on all other electrical systems except the GPS supply to the information center.

Testing ECM Power Supply

1. Press the START button to wake up the ECM.

NOTE: Do not install the tether cord.

2. Set the multimeter to Vdc.
3. Probe ECM fuse (F11).

NOTE: This will validate the fuse at the same time.

ECM POWER SUPPLY TEST		
FUSE BOX TERMINAL	BATTERY	SPECIFICATION
E1	Negative (-) post	Battery voltage
E2		

4. If battery voltage is measured at E1 but not at E2, replace the fuse.
5. If voltage is not measured at E2, check the wiring and connections between the relay output and F11 output. Refer to *WIRING DIAGRAM*.
6. If voltage is as per specification, continue with *TESTING CONTINUITY OF ECM POWER CIRCUIT*.

Testing Continuity of ECM Power Circuit

1. Wait for electrical power to go off (approximately 3 minutes).
2. Disconnect ECM-B connector from ECM and install it on the ECM adaptor tool.
3. Set the multimeter to Ω.
4. Probe terminals as per following table.

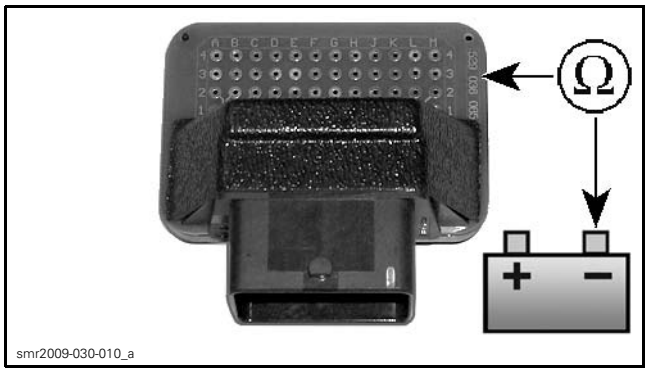
ECM POWER CIRCUIT CONTINUITY TEST		
FUSE BOX TERMINAL	ECM ADAPTER PIN	SPECIFICATION
E1	B-M4	Close to 0 Ω

5. If an open circuit is measured, repair or replace wiring and connectors.
6. If the ECM power circuit tests good, the problem may be one of the following:
   – Start switch circuit open to ECM. Refer to *STARTING SYSTEM* subsection.
   – ECM not providing a ground to relay in fuse box, refer to *POWER DISTRIBUTION AND GROUNDS* subsection.
   – ECM ground wire open circuit. Refer to *TESTING CONTINUITY OF ECM GROUND CIRCUITS* in this subsection.
   – ECM internal problem.

Testing Continuity of ECM Ground Circuits

1. With the "B" connector still connected to the ECM adaptor tool.
2. Set the multimeter to Ω.
3. Probe adapter terminals as per following table.

ECM GROUND CIRCUITS CONTINUITY TEST		
ECM ADAPTER PIN	BATTERY	SPECIFICATION
B-L1	Negative (-) post	Close to 0 Ω
B-M2		
B-M3		



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4. If any measurement is out of specification refer to *POWER DISTRIBUTION AND GROUNDS* subsection and check the following:
   – Wiring and connections
   – Engine ground
   – Battery ground.
5. If everything tests good and ECM does not power up, try a new ECM. Refer to *REPLACING THE ECM*.

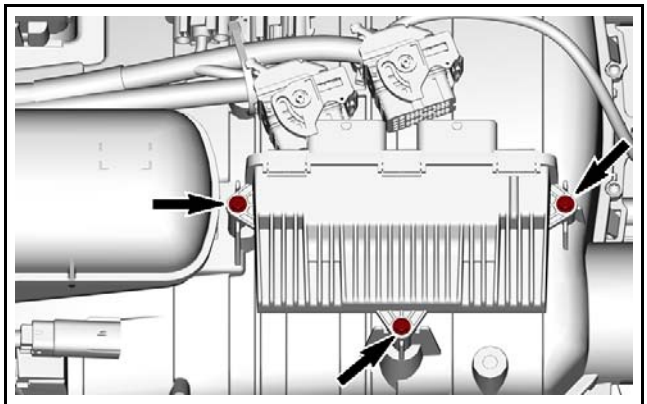
Removing the ECM

NOTE: If a new ECM is to be installed, first read the procedures in *REPLACING THE ECM* in this subsection.

1. Disconnect battery cables.

NOTICE **Always disconnect the BLACK negative (–) battery cable first, then disconnect RED positive (+) cable.**

2. Disconnect both ECM connectors from ECM.
3. Unscrew all ECM retaining screws and remove the ECM.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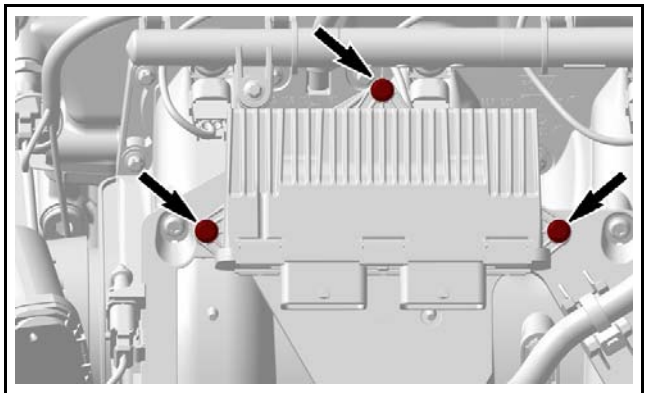
CONFIGURATION 1 - MOUNTED ON THE AIR INTAKE SILENCER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CONFIGURATION 2 - MOUNTED ON THE INTAKE MANIFOLD

Installing the ECM

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

1. Install ECM.

Configuration 1 - Mounted on the Air Intake Silencer

TIGHTENING TORQUE	
ECM retaining screws	2.5 N•m ± 0.5 N•m (22 lbf•**in** ± 4 lbf•**in**)

Configuration 2 - Mounted on the Intake Manifold

TIGHTENING TORQUE	
ECM retaining screws	5.5 N•m ± 0.6 N•m (49 lbf•**in** ± 5 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)

2. Reconnect ECM connectors.
3. Reconnect battery cables.

NOTICE Always reconnect the RED positive (+) battery cable first, then reconnect BLACK negative (–) cable.

4. If a new ECM is installed, refer to *REPLACING THE ECM* in this subsection.

Replacing the ECM

ECM Data Entry for ECM Replacement

ELECTRONIC FUEL INJECTION (EFI)

SERVICE TOOLS

SERVICE PRODUCTS

GENERAL

⚠ WARNING

Always disconnect battery prior to working on the fuel system.

⚠ WARNING

Fuel vapors are flammable and explosive under certain conditions. Ensure work area is well ventilated. Do not smoke or allow open flames or sparks in the vicinity.

Use the BRP diagnostic software (BUDS2) to release the fuel pressure in the system prior to disconnecting a fuel line. Refer to *FUEL TANK AND FUEL PUMP* subsection.

The following tools are required to test most of the electrical parts.

REQUIRED TOOL	
FLUKE 115 MULTIMETER (P/N 529 035 868)	
ECM ADAPTER TOOL (P/N 529 036 166)	

Cover the fuel line connection with an absorbent shop rag before disconnecting them. Slowly disconnect the fuel hose to minimize spilling.

⚠ WARNING

Fuel lines remain under pressure at all times. Do not allow fuel to spill on hot engine parts and/or on electrical connectors. Proceed with care when removing or installing high pressure test equipment, or disconnecting fuel line connections. Wipe off any fuel spillage in the bilge. Never use a hose pincher on high pressure hoses.

When the repair is completed, ensure the hose from the fuel rail to the fuel pump is properly connected and secured in its support. Test for fuel leaks as described in *FUEL TANK AND FUEL PUMP* subsection.

⚠ WARNING

Always perform the fuel system high pressure leak test if any component has been removed or disconnected.

⚠ WARNING

If a gasoline leak and/or odor is present, do not start the engine. Repair the leak.

SYSTEM DESCRIPTION

The electronic fuel injection system (EFI) is comprised of various sensors used for detecting ongoing operating conditions of the engine and watercraft, and includes all the actuators that perform the required adjustment to the engine.

This system also introduces torque management functions.

Electrical System

EFI Sensors

The ECM reads the inputs from the sensors which it compares to predetermined parameters stored in the ECM, makes computations, and activates the outputs accordingly (injectors, ignition coils etc.).

Signals from sensors are used by the ECM to determine the injection and ignition parameters (referenced to fuel and ignition maps) as required to maintain the optimum air-fuel ratio.

Air Induction

Throttle Body

A 60 mm throttle body is mounted on the intake manifold.

Air for combustion is drawn in by the engine (100, 130 and 170 engines) or by a mechanically-driven supercharger (230 and 300 engines). The air flows through the throttle body and is controlled by a throttle plate.

Fitted on the throttle body, an electronic throttle actuator (ETA) allows the ECM to electronically control the throttle plate opening which regulates the amount of air that enters the engine, and therefore engine speed.

There is no idle air control valve (IACV).

Fuel System

Fuel Rail

A single fuel rail is mounted on the intake manifold. The fuel rail ensures that enough fuel can be delivered to the fuel injectors throughout the engine operating range.

The fuel rail is fed by the fuel pump. The fuel pressure applied to the fuel rail is regulated by the fuel pressure regulator located in the fuel pump module.

Fuel Injectors

One injector per cylinder is used to inject fuel into the intake ports of the cylinder head.

Fuel Pump

An electric fuel pump with an integrated pressure regulator is used. Refer to *FUEL TANK AND FUEL PUMP* subsection.

ADJUSTMENT

IDLE SPEED

Idle speed is not adjustable. The ECM controls the idle speed of the engine through the iTC system by controlling throttle plate opening using the ETA (electronic throttle actuator).

Idle speed can be monitored in BUDS2.

CLOSED THROTTLE RESET

General Information

This operation performs a reset of the TPS values of the throttle body in the ECM.

Closed throttle reset must be carried out only when:

– Replacing the throttle body.
– Replacing the ECM.

Closed Throttle Reset Procedure

1. Connect the vehicle to the BRP diagnostic software (BUDS2).
2. Press the START button to wake up the ECM.
3. Install the tether cord on the engine cut-off switch.
4. In BUDS2, go to:
   – **Settings** page
   – **ECM** button
   – **Settings** tab
   – **Initializations - Reset TPS**
5. Follow instructions displayed on screen.
6. Start engine and make sure it operates normally through its full engine RPM range.
7. Check for fault codes using BUDS2. If a fault code related to the throttle actuator appears, clear it, then carry out another **Closed Throttle** reset procedure. To clear faults, refer to *DIAGNOSTIC AND FAULT CODES* subsection.

TROUBLESHOOTING

DIAGNOSTIC TIPS

Engine problems are not necessarily related to the fuel injection system.

It is important to ensure that the engine/propulsion system, fuel delivery and electrical systems are functioning normally.

It is a good practice to check for fault codes using the BRP diagnostic software (BUDS2) as a first troubleshooting step.

After a problem has been solved, be sure to clear the fault(s) in the ECM using the BRP diagnostic. software.

⚠ WARNING

All electrical actuators and electronic modules are powered as soon as the START button is pressed. Always disconnect the battery prior to disconnecting any electrical or electronic parts.

Never use a battery charger to temporarily substitute the battery as it may cause the ECM to function erratically, or not at all.

Check related-circuit fuse solidity and condition with an ohmmeter. A visual inspection could lead to a false diagnosis.

Electrical Related Problems

It is important to check the following in the electrical system:

– Battery voltage
– Fuses
– Ground connections
– Wiring and connectors.

Ensure that all electronic components are genuine OEM. Any modification to the wiring harness may lead to poor system operation or generate fault codes.

Electrical Connections

Pay particular attention to ensure that terminals and pins are not out of their connectors, corroded, or out of shape.

When probing terminals, pay attention not to deform the terminals as this could cause a loose or intermittent connection that would be difficult to troubleshoot.

PROCEDURES

FUEL RAIL

Fuel Rail Location

Fuel rail is located above intake manifold.

Removing the Fuel Rail

Fuel Rail Hose Disconnection

1. Release fuel pressure. Refer to *FUEL PUMP* in *FUEL TANK AND FUEL PUMP* subsection.
2. Place an absorbent shop rag under the fuel supply hose fitting at the fuel rail to catch any fuel leakage.
3. Disconnect fuel hose from fuel rail.

REQUIRED TOOL	
FUEL HOSE DISCONNECT TOOL (P/N 529 036 037)	

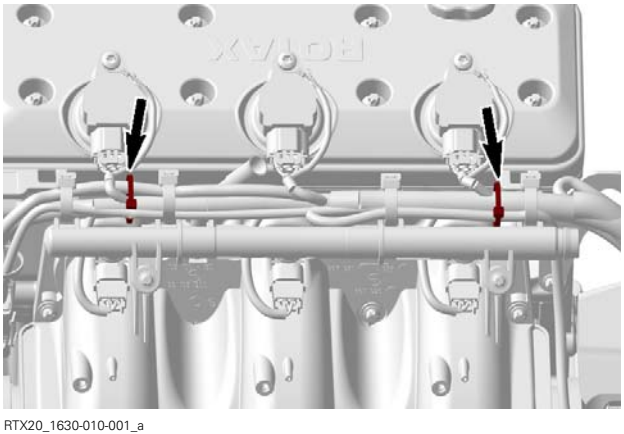
lmr2006-008-010

NOTE: It may be necessary to rotate fuel hose fitting to align the tool ends with the openings of the locking mechanism.

Removing the Fuel Rail

1. Install locking ties around wiring harness to maintain wiring position for installation.

NOTE: Do not secure the stator cable to the harness.



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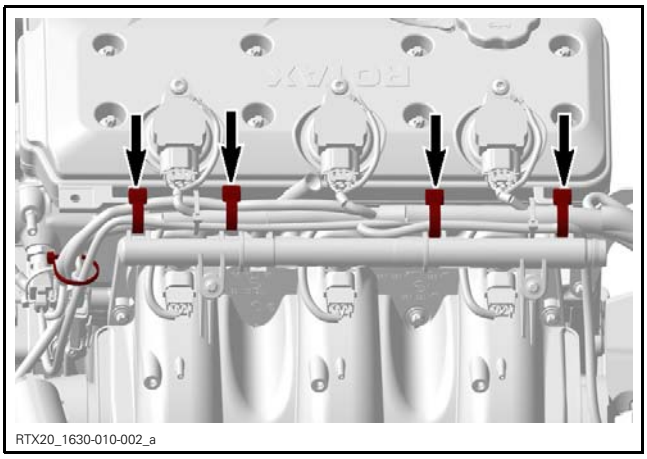
2. Cut locking ties retaining engine harness to fuel rail.



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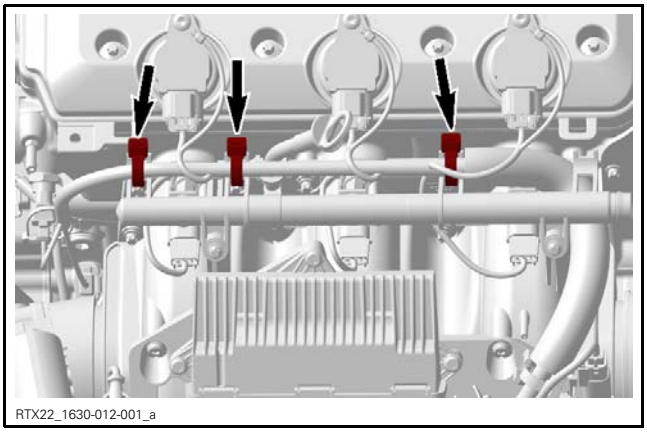
WITH ECM MOUNTED ON THE AIR INTAKE SILENCER



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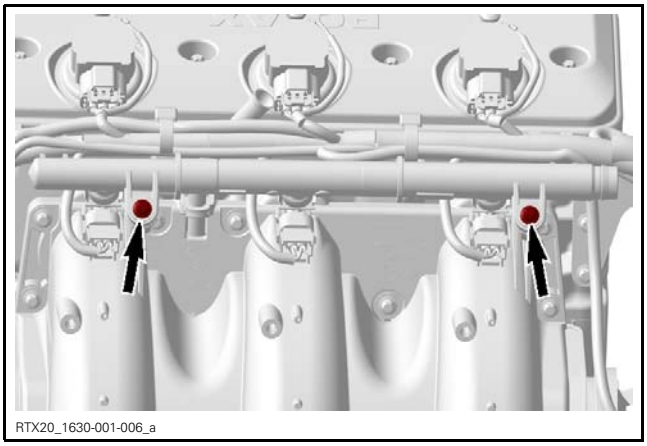
WITH ECM MOUNTED ON THE INTAKE MANIFOLD

3. Remove screws retaining the fuel rail.



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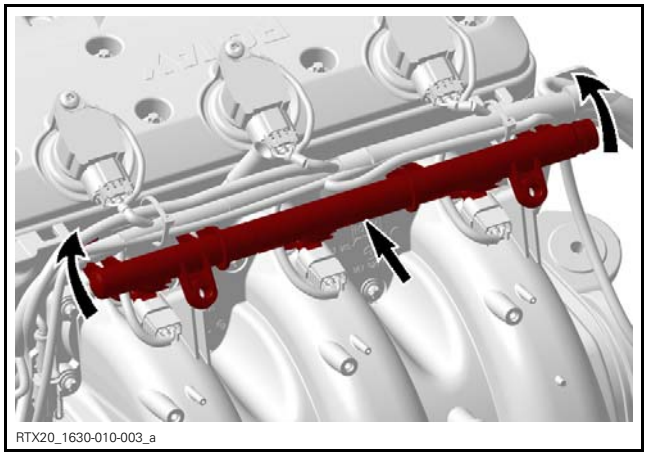
TYPICAL

4. Gently pull fuel rail side to side (wiggle).



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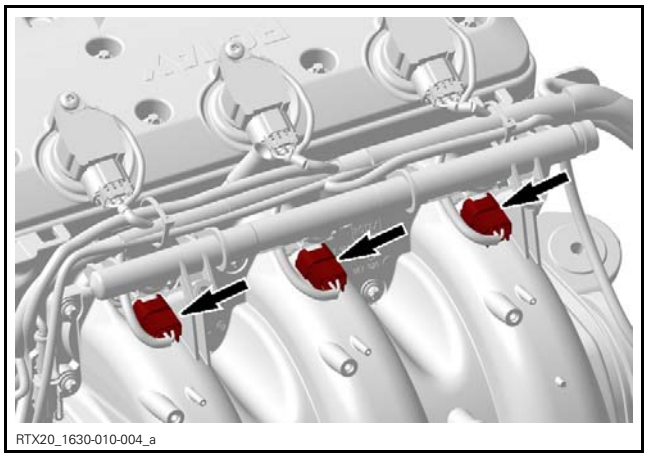
TYPICAL

5. Disconnect all injector connectors.



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TYPICAL

6. Pull fuel rail out with fuel injectors.

Installing the Fuel Rail

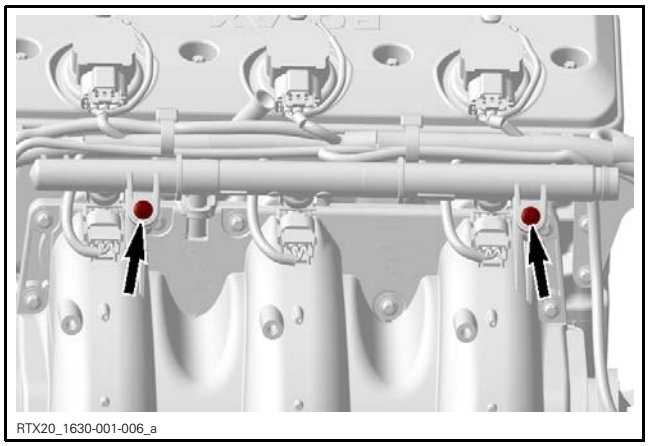
The installation is the reverse of the removal procedure. However, pay attention to the following.

1. Install fuel rail with injectors.
2. Lubricate O-rings of fuel injectors.

SERVICE PRODUCT
Engine oil

3. Tighten fuel rail retaining screws to specification.

TIGHTENING TORQUE	
Fuel rail retaining screws	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)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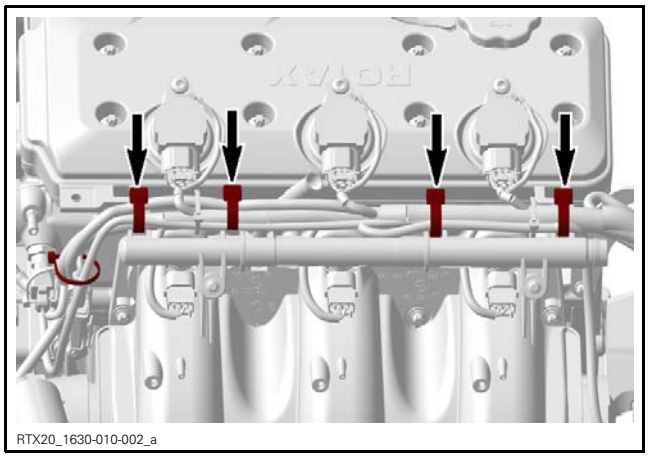
4. Properly install NEW locking ties to secure engine harness to fuel rail.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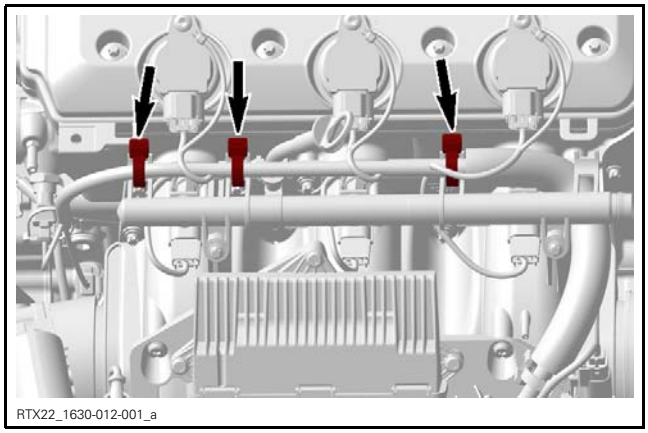
WITH ECM MOUNTED ON THE AIR INTAKE SILENCER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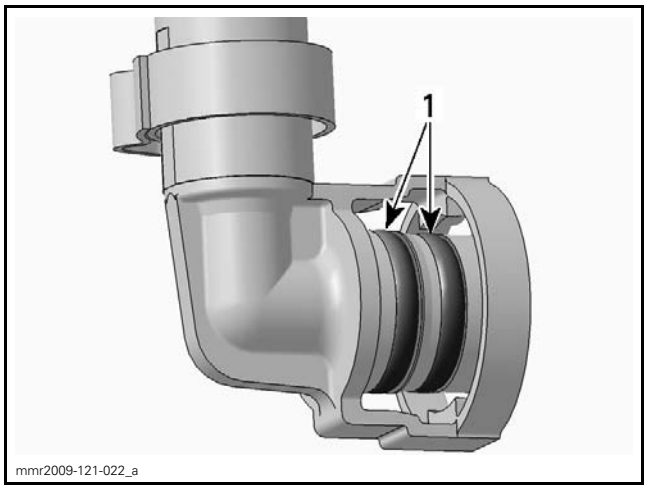
WITH ECM MOUNTED ON THE INTAKE MANIFOLD

Fuel Rail Hose Connection

1. Apply engine oil on O-rings of fitting.



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1. Apply oil on O-rings

2. Connect fuel hose to fuel rail.

IMPORTANT: Push fuel hose fitting on fuel rail until you hear a "click". Try pulling fuel hose off fuel rail to ensure fitting is properly locked.

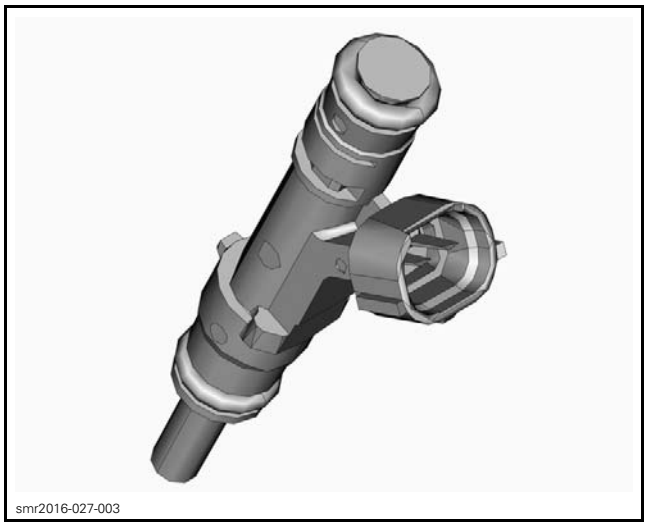
3. Pressurize the fuel system and check for a fuel leak. Refer to *FUEL TANK AND FUEL PUMP* subsection.

⚠ WARNING

Failure to pressurize the fuel system may result in severe injury or a life threatening situation should a leak occur.

4. Reinstall all remaining removed parts.

FUEL INJECTOR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Testing the Fuel Injector Operation with BUDS2(Dynamic)

1. Connect the vehicle to the BRP diagnostic software (BUDS2).

2. Start engine.

NOTICE If watercraft is out of water, exhaust system must be cooled using the flush kit. Never run engine more than 2 minutes.

3. In BUDS2, go to :
   – Functions page
   – ECM button
   – Functions tab
   – IO Controls - Activate Fuel Injectors.
4. Select the injector and click on the ACTIVATE button.
5. If the engine RPM drops when clicking on a cylinder, the injector and the ignition of this cylinder are functioning normally.
6. If the engine RPM does not drop when clicking on a cylinder, this cylinder is not functioning properly. Check the following:
   – Fuel injector operation. Refer to *TESTING THE FUEL INJECTOR OPERATION* in this subsection.
   – Spark plug and ignition coil. Refer to *IGNITION COILS AND SPARK PLUGS* subsection.
   – Engine condition.

Testing the Fuel Injector Operation with BUDS2 (Static)

NOTICE After fuel injector activation using BUDS2, always crank engine in drowned mode to ventilate engine and prevent a potential backfire due to fuel accumulation in the engine.

1. Connect the vehicle to the BRP diagnostic software (BUDS2).
2. Press the START button to wake up the ECM.
3. Install the tether cord on the engine cut-off switch.
4. In BUDS2, go to :
   – Functions page
   – ECM button
   – Functions tab
   – IO Controls - Activate Fuel Injectors.
5. Select the injector and click on the ACTIVATE button.
6. Listen to the injector.
7. If you can hear the injector, it validates its operation. Carry out *TESTING THE FUEL INJECTOR BALANCE*.
8. If you do not hear the injector, carry out *TESTING THE INJECTOR INPUT VOLTAGE*.

Testing the Fuel Injector Balance with BUDS2

NOTICE After fuel injector activation using BUDS2, always crank engine in drowned mode to ventilate engine and prevent a potential backfire due to fuel accumulation in engine.

1. Install a fuel pressure gauge as described in *FUEL TANK AND FUEL PUMP* subsection.
2. Connect the vehicle to the BRP diagnostic software (BUDS2).
3. Press the START button to wake up the ECM.
4. Install tether cord on engine cut-off switch.
5. In BUDS2, go to :
   – Functions page
   – ECM button
   – Functions tab
   – IO Controls - Activate Fuel Pump.
6. Fuel pressure must be within specification. Refer to *FUEL TANK AND FUEL PUMP* subsection. Re-activate fuel pump as necessary.
7. In BUDS2, activate the fuel injector no. 1.
8. Record the fuel pressure drop for injector no. 1.
9. In BUDS2, activate fuel pump.
10. Repeat the procedure for fuel injectors no. 2 and no. 3 and record the pressure drop for each injector.
11. The maximum fuel pressure drop between injectors should not exceed the following specification:

MAXIMUM FUEL PRESSURE DROP ALLOWED BETWEEN FUEL INJECTORS
10 kPa (1.5 PSI)

12. If pressure drop of any fuel injector is greater than the specification, replace that injector then repeat the test.
13. Using the valve on the fuel pressure gauge, release the pressure in the system (if so equipped).
14. Remove fuel pressure gauge and reinstall removed parts.

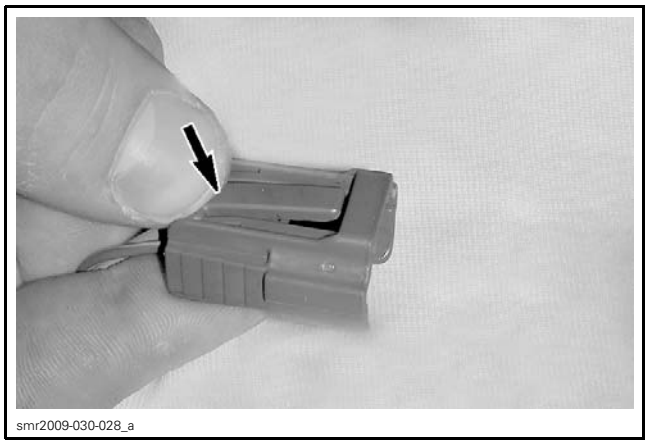
Testing the Fuel Injector Input Voltage

With ECM Mounted on the Intake Manifold

1. Remove ECM from its support.

All Engines

2. Disconnect fuel injector connectors.
   2.1 Push against tab underneath connector as illustrated to unlock it.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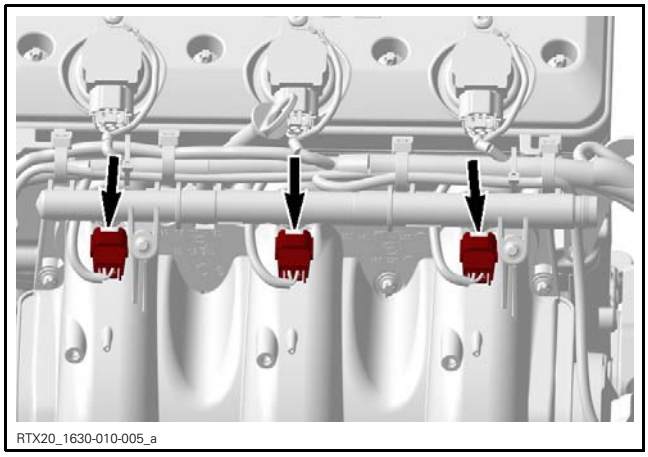
PUSH HERE TO UNLOCK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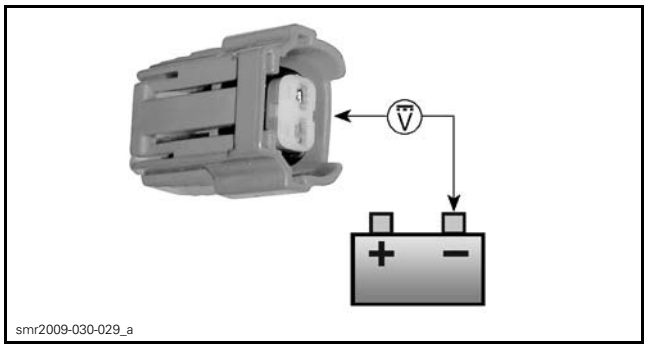
3. Press the START button to wake up the ECM.
4. Install tether cord on engine cut-off switch.
5. Set the multimeter to Vdc.
6. Read input voltage to the applicable injector as per following table.

FUEL INJECTOR INPUT VOLTAGE TEST		
INJECTOR CONNECTOR PIN	BATTERY	SPECIFICATION
2	Negative (-) post	Battery voltage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7. If battery voltage is measured, carry out *TESTING THE INJECTOR CONTROL CIRCUIT*.
8. If battery voltage is not measured, check continuity between fuse box and injector as follows.

Testing the Continuity of Injector Power Circuit

1. Remove cover of fuse box. Refer to *POWER DISTRIBUTION* subsection.
2. Set the multimeter to Ω.
3. Read resistance of the applicable injector circuit as per following table.

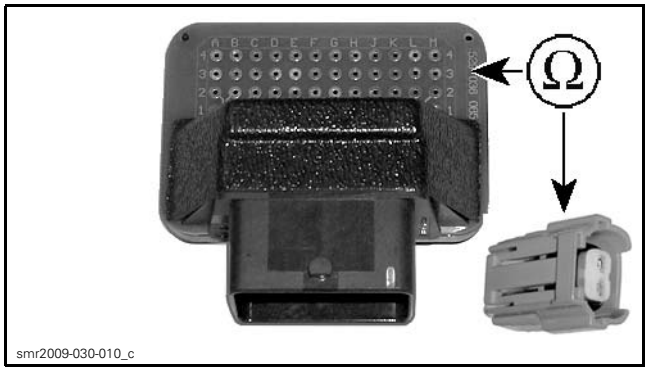
INJECTOR POWER CIRCUIT CONTINUITY TEST		
INJECTOR CONNECTOR PIN	FUSE BOX TERMINAL	SPECIFICATION
2	B1	Close to 0 Ω

4. If continuity is good, the fuse, wiring and connectors are functional.
5. If continuity is not obtained, first check the fuse and replace as required.
6. If fuse is good, repair/ replace wiring and connectors from fuse box to injector. Refer to *WIRING DIAGRAM* subsection.

Testing the Fuel Injector Control Circuit

1. Disconnect ECM-A connector from the ECM and install it on the ECM adapter tool.
2. Set the multimeter to Ω.
3. Disconnect the required injector connector.
4. Read resistance as per following table.

INJECTOR CONTROL CIRCUIT CONTINUITY TEST		
INJECTOR CONNECTOR PIN	ECM ADAPTER PIN	SPECIFICATION
1 (inj 1)	A-B3	Close to 0 Ω
1 (inj 2)	A-K1	
1 (inj 3)	A-J1	

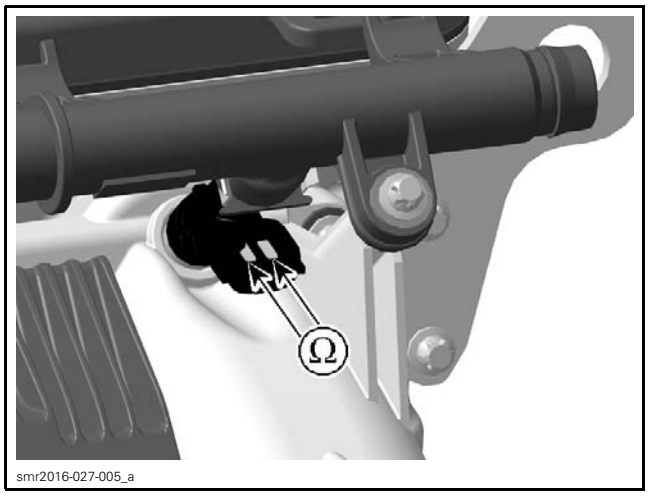


5. If control circuit is at fault, repair or replace wiring and connectors.
6. If control circuit and all tests applicable to the injector are good, try a new ECM. Refer to *ECM* in this subsection.

Testing the Fuel Injector Resistance

1. Remove injector connector.
2. Check resistance value between injector pins as per followings table.

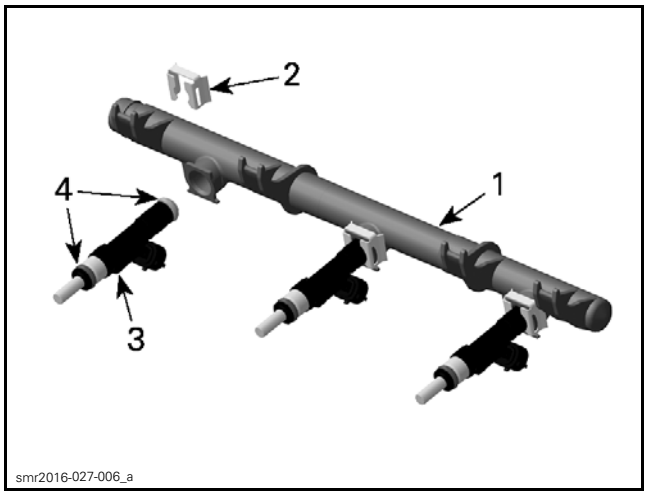
INJECTOR RESISTANCE TEST		
INJECTOR PIN		SPECIFICATION
1	2	11.4 - 12.6 Ω



3. If readings are not as specified, replace injector.
4. If readings are as specified, repair or replace wiring and connectors from ECM to injector.

Removing the Fuel Injector

1. Remove fuel rail. Refer to *FUEL RAIL* in this subsection.
2. Remove the injector clip.



FUEL RAIL ASSEMBLY
1. *Fuel rail*
2. *Injector clip*
3. *Fuel injector*
4. *O-rings*

3. Pull the fuel injector out of the fuel rail.

Installing the Fuel Injector

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

FUEL INJECTOR IDENTIFICATION	
Injector color code	YELLOW/GREEN

1. If you reinstall a used injector replace O-rings with **NEW** ones.
2. Apply a thin film of engine oil to O-rings.
3. Insert the fuel injector in the fuel rail.
4. Secure injector to fuel rail with a retaining clip.
5. Install fuel rail on engine. Refer to *FUEL RAIL* in this subsection.
6. Pressurize the fuel system and check for a fuel leak. Refer to *FUEL TANK AND FUEL PUMP* subsection.

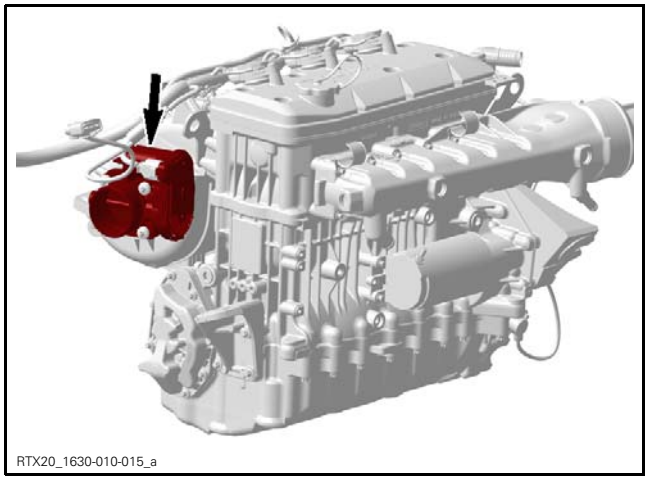
⚠ WARNING

Always carry out a fuel system high pressure leak test after working on the fuel system.

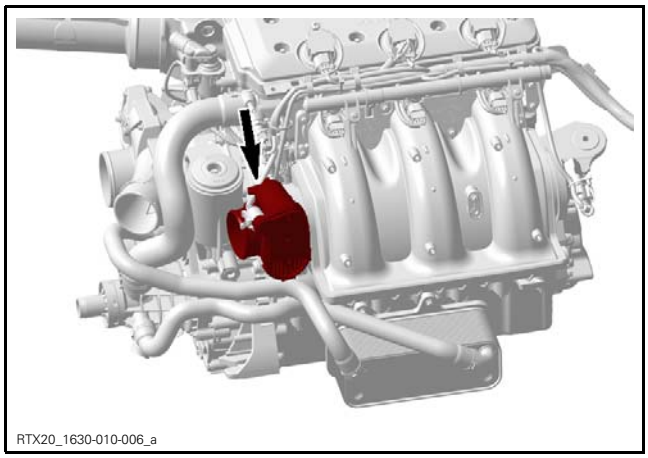
7. Reinstall all remaining removed parts, refer to applicable subsections.

THROTTLE BODY

Throttle Body Location

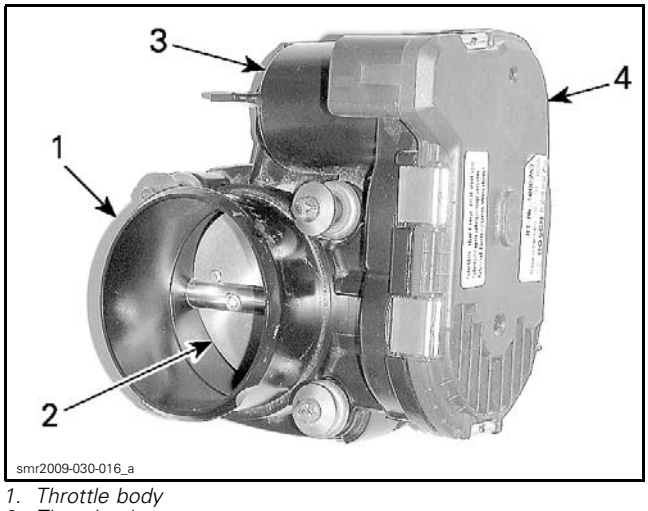


ENGINES WITH THROTTLE BODY MOUNTED FRONTWARD



ENGINES WITH THROTTLE BODY MOUNTED REARWARD

Throttle Body Description



1. *Throttle body*
2. *Throttle plate*
3. *Throttle actuator (electric motor inside)*
4. *Throttle position sensor (TPS) (inside)*

Electronic Throttle Actuator (ETA)

The electronic throttle actuator (ETA) is a DC motor on the throttle body that regulates the throttle plate via a drive gear. Pulse width modulation (PWM) is used to control the motor.

Throttle Plate Operating Positions

Two torsional springs are connected to the throttle plate. A main spring and another one in a plunger mechanism.

When there is no power to the throttle actuator (ETA), the plunger mechanism maintains the throttle plate at a rest position. This also serves as the limp home position.

When the throttle plate is opened by the ETA as commanded by the ECM, it acts against the main spring. If the ETA failed, the return spring would bring the throttle plate back to the limp home position.

ECM	ENGINE	THROTTLE BODY
OFF	Stopped	Throttle actuator: Off. Throttle plate: Rest position, maintained opened at approximately 8° (1). This is also the limp home position.
ON	Not started	Throttle actuator: On. Throttle plate: Moves from the rest position to approximately 14°. It then moves back to the rest position. This is the diagnostic mode where the rest position, actuator opening force to overcome the return springs and the motor return rate are monitored. If any of these parameters are out of range, a fault code is initiated.
ON	Started. Normal operation at idle	Throttle actuator: On. Throttle plate: Moves from the rest position to idle position (approximately 1-3°) according to ECM injection and ignition maps. Throttle plate is opened and closed as necessary to control the idle speed.
ON	Started. Normal operation at various RPM	Throttle actuator: On. Throttle plate: Opens and closes according to ECM torque management priorities.
(1) Degree values are given from the fully closed position.		

Throttle-Body Faults and Effects

NOTE: Among other things, a weak or broken spring and a sticky throttle plate (carbon build-up, dried salt water etc) are validated by the throttle body diagnostic mode.

FAULT	EFFECT
Partial failure of TAS sensor (one internal sensor only)	Limp home mode. Engine speed limited to idle. ECM will use the remaining TAS sensor. Fault code set and beeper activated to emit warning signals. Check engine light is turned ON. Driveability could be reset by releasing and reapplying the throttle.
Complete failure of TAS sensor (both internal sensors)	Limp home mode. Engine speed limited to 2500 RPM. Fault code set and beeper activated to emit warning signals. Check engine light is turned ON.
Any throttle body failure	Limp home mode. Engine speed limited to 2500 RPM. Engine speed can still be increased up to 3200 RPM using the throttle lever. Fault code set and beeper activated to emit warning signals. Check engine light is turned ON.
NOTE: When one of these faults is active, iBR will continue to monitor their input signals. ince the ECM cannot control the throttle body, the iBR may produce a fault since the ECM does not react to its specific torque requests. It all depends on the circumstances when the iBR is applied. (vehicle and engine speed will be a factor).	

Lubricating the Throttle Body

No lubrication is required.

Testing the ETA

Testing the Throttle Body Actuator (ETA) with BUDS2

1. Connect the vehicle to the BRP diagnostic software (BUDS2).
2. Press the START button to wake up the ECM.
3. In BUDS2, go to:
   - **Measurements** page
   - **ECM** button
   - **ECM - Basic** tab
   - **TAS (%DK)**
4. Slowly depress the throttle lever from the idle to WOT. The ETA should go from 0% to 100%.
5. If result is out of specification, carry out a *CLOSED THROTTLE RESET*. Refer to *ADJUSTMENT* in this subsection.

NOTE: The ETA is reset at the same time as the TPS.

6. After the reset, test ETA again.
7. If the result is still out of specification, check wire continuity between ECM and throttle body before assuming the ETA is at fault.

Inspecting the ETA

Always check for corroded terminals or damaged wiring when diagnosing throttle body problems.

Testing the ETA (Dynamic)

1. Remove the parts required to access the throttle body.
2. Remove the air inlet hose from the throttle body.
3. Observe the throttle plate with the engine stopped.

NOTE: The throttle plate should be in the rest position (slightly opened).

⚠ WARNING

Keep your fingers out of the throttle plate area while the ECM turns on. The throttle actuator will cycle. This could cause serious finger injuries as throttle plate quickly moves.

4. As you observe the throttle plate, have someone press the START button to wake up the ECM.

NOTE: The throttle plate should cycle quickly from the rest position to a partially open position (approximately 14°), then back to the rest position.

5. Install the tether cord on the engine cut-off switch.

NOTE: The throttle plate should cycle again.

6. As you observe the throttle plate, have someone gradually and evenly pull in the throttle lever, then release it in the same way.

The throttle plate should open then close according to throttle lever position. However, the movement of the throttle plate may not be linear with the displacement of the throttle lever.

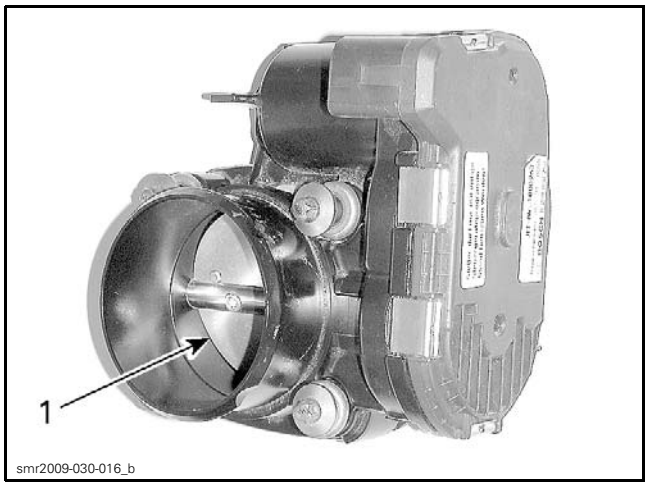
7. If any test failed, proceed with the *TESTING THE THROTTLE BODY (STATIC)*.

Testing the ETA (Static)

⚠ WARNING

First ensure the ECM is off. Do not move the throttle plate using your fingers. Otherwise, if the START button is pressed the ECM turn on and quickly cycle the throttle plate which could cause serious finger injury.

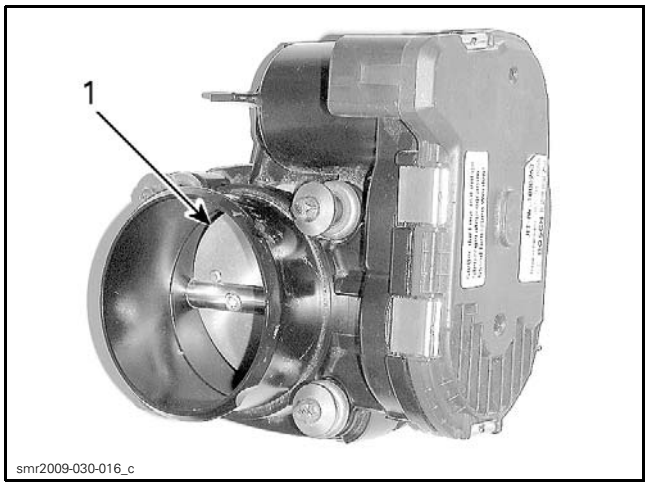
1. Using a blunt tool, push in on the throttle plate and ensure it opens smoothly within the throttle body.



1. Push here to open

NOTE: The throttle plate must open fully and return freely to the rest position (slightly opened) when released.

2. Push throttle plate closed as indicated in following illustration. It must close completely and return freely to the rest position (slightly opened) when released.



1. Push here to close

3. If the throttle plate does not move smoothly or does not return freely to the rest position, the problem is mechanical. Check for salt accumulation on throttle plate shaft. It may also be an actuator or gear problem. Replace throttle body as necessary.
4. If the throttle plate does not return properly after a proper cleaning, replace the throttle body.
5. If throttle plate operates normally, the problem is electrical. Check throttle actuator (ETA) wiring continuity, throttle position sensor (TPS) and throttle accelerator sensor (TAS).

Cleaning the Throttle Body

1. Remove the parts required to access the throttle body.
2. Check throttle body cleanliness using a flashlight. Fully open throttle plate and verify:
   - Throttle body bore
   - Throttle plate edge.
3. Look for:
   - Dirt
   - Oily surfaces
   - Carbon and salt deposits on throttle plate and the surrounding bore.
4. Clean as necessary.

NOTICE **Only use an appropriate throttle body cleaner that will not damage O-rings and EFI sensors. Refer to product manufacturer's instruction.**

5. **Before** beginning the throttle body cleaning:
   - Remove the tether cord cap.
   - Disconnect the battery.
   - Remove the ECM fuse (F11).
6. To avoid getting dirt into engine, spray cleaner on a clean rag (outside the bilge) then rub rag against throttle plate and bore. A toothbrush works well too.

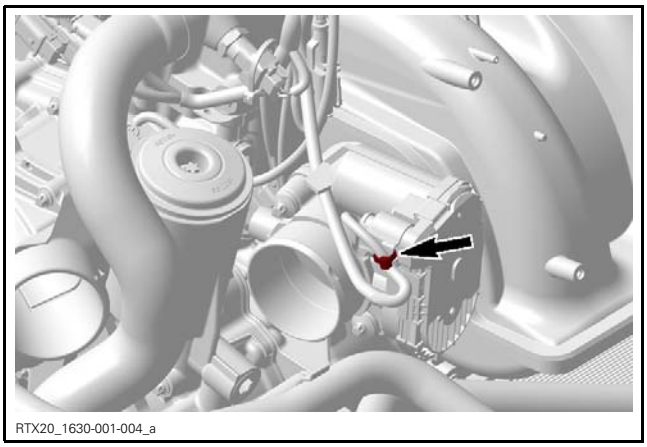
⚠ WARNING

First ensure ECM is off. Otherwise, if ECM should suddenly turn off, it would quickly close the throttle plate which could cause serious finger injury.

7. Manually open throttle and hold fully open to reach all surfaces.
8. To remove residual dirt, spray cleaner on throttle plate and on bore.
9. Reinstall removed parts.

Removing the Throttle Body

1. Disconnect inlet hose from throttle body.
2. Cut locking tie.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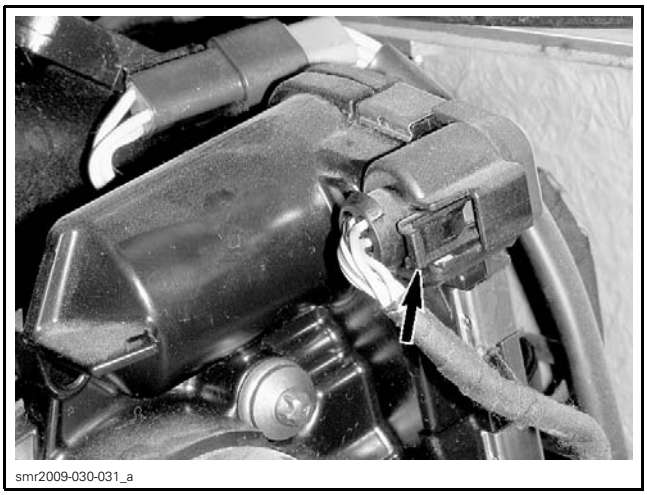
TYPICAL

3. Disconnect throttle body connector.

To remove connector from throttle body, press connector locking tab illustrated.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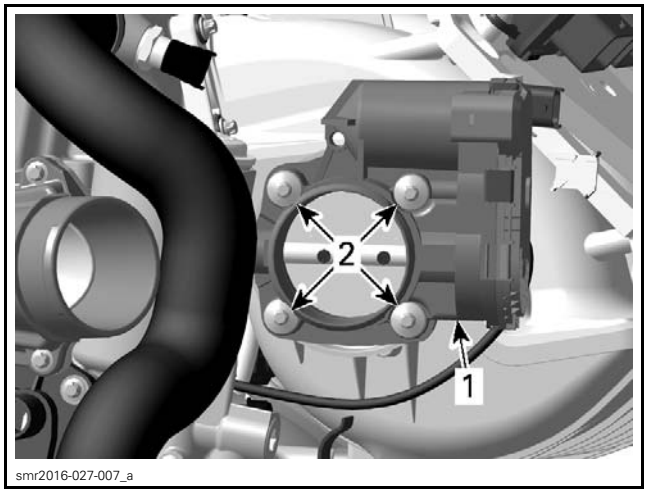
TYPICAL - PRESS HERE TO UNLOCK

4. Remove retaining screws from throttle body.



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TYPICAL
1. Throttle body
2. Retaining screws

5. Pull throttle body off intake manifold.

Installing the Throttle Body

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

1. Tighten retaining screws in a criss-cross sequence.

TIGHTENING TORQUE	
Throttle body retaining screws	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**)

2. Perform the **Closed Throttle** reset. Refer to procedure in *ADJUSTMENTS* in this subsection.

TPS (THROTTLE POSITION SENSOR)

General

NOTE: The TPS is part of the throttle body.

The throttle position sensor (TPS) is a double potentiometer that sends signals to the ECM that are proportional to the throttle plate angle. The TPS is located inside the throttle body.

Testing the TPS Wear

1. With the engine turned off, slowly pull in throttle lever and pay attention for smooth operation without physical stops.
2. Connect the vehicle to the BRP diagnostic software (BUDS2).
3. Press the START button to wake up the ECM.
4. Install the tether cord on the engine cut-off switch.

5. In BUDS2, go to:
   – **Measurements** page
   – **ECM** button
   – **ECM - Basic** tab
   – **Throttle Opening (%DK)**
6. Slowly and regularly depress the throttle lever.
7. Observe the **Throttle Opening**value.

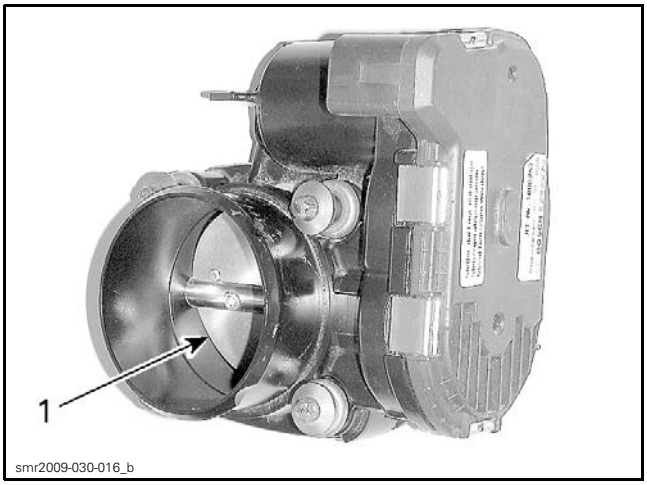
NOTE: The value should move gradually and regularly as you move the throttle lever. If the value "sticks", bounces or suddenly drops, it may indicate a worn TPS that needs to be replaced. An initial slight delay after the throttle lever is pulled and before the value starts to change is normal.

If the value behavior is not as expected, proceed with the following steps.

8. Manually move the throttle plate in throttle body using a blunt tool (without sharp tip).

⚠ WARNING

Do not move throttle plate with your fingers. Otherwise, if ECM should turn off, it would quickly close the throttle plate which could cause serious finger injury.



1. Push here

9. Check the value again.

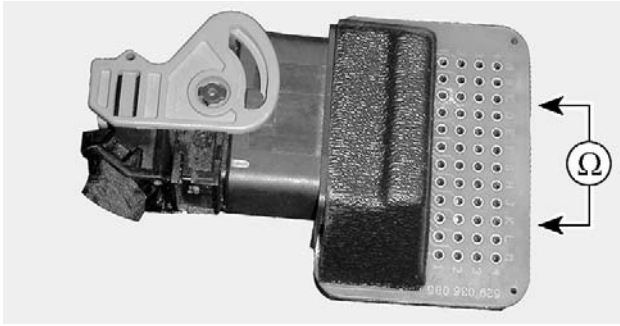
– If the value changes as expected, check the throttle accelerator sensor (TAS). Refer to *INTELLIGENT THROTTLE CONTROL (ITC)* subsection.
– If the value does not change as expected, perform *TESTING THE TPS RESISTANCE* in this subsection.

Testing the TPS Resistance

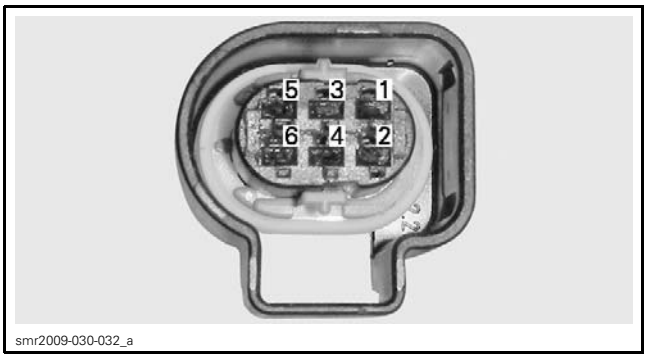
1. Remove the parts required to access the throttle body.
2. Ensure the throttle body connector is properly connected.
3. Disconnect the ECM-A connector from the ECM and install it on the ECM adapter tool.
4. Set the multimeter to Ω.
5. Probe circuit as per following table while using a finger to manually move throttle plate.

ECM ADAPTER		FULLY CLOSED THROTTLE PLATE (1)		FULLY OPEN THROTTLE PLATE	
		RESISTANCE (Ω)			
PIN		MIN.	MAX.	MIN.	MAX.
A-A2	A-K4	875	1625	875	1625
A-A2	A-K3	954	1934	228	585
A-A2	A-F3	254	634	980	1983
A-K3	A-K4	228	585	954	1934
A-K3	A-F3	1385	2315	1385	2315
A-K4	A-F3	980	1983	254	634

(1) To obtain the fully closed position, it is necessary to push against the throttle plate in the throttle body with a finger and hold it in this position for the measurement.



6. If any resistance value is incorrect, check wire continuity between ECM and throttle body before assuming the TPS is at fault. Refer to *WIRING DIAGRAM* subsection.



TPS CONNECTOR PIN-OUT

7. If the TPS resistance values are correct, try a new ECM. Refer to *ENGINE CONTROL MODULE* in this subsection.

IGNITION COILS AND SPARK PLUGS

SERVICE TOOLS

Description	Part Number	Page
ECM ADAPTER TOOL	529 036 166	184

SERVICE PRODUCTS

Description	Part Number	Page
LOCTITE 243 (BLUE)	293 800 060	186

GENERAL

⚠ WARNING

Torque wrench tightening specifications must be strictly adhered to.
Locking devices when removed (e.g.: locking tabs, elastic stop nuts, self-locking fasteners, cotter pins, etc.) must be replaced.

Hoses, cables or locking ties removed during a procedure must be reinstalled as per factory standards.

⚠ WARNING

Never check for engine ignition spark from an open coil and/or spark plug as spark may cause potential fuel vapors to ignite. Always use an approved spark tester.

SYSTEM DESCRIPTION

The engine control module (ECM) controls the ignition system, as well as many other engine related functions.

The battery supplies power to the primary side of the ignition coils through a relay while the ECM completes the circuit to each coil primary winding by switching it to ground at the appropriate moment.

The ignition system is a digital inductive type system.

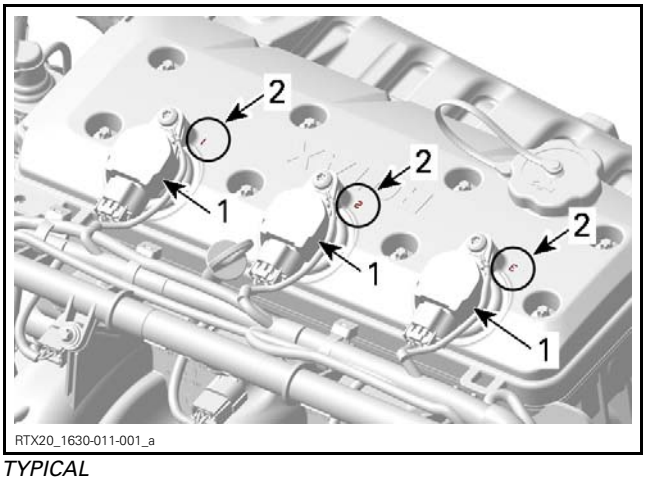
Ignition system parameters such as ignition timing, dwell time and firing order are controlled by the ECM in order to meet engine operational requirements.

Direct ignition coils (stick coils) are used for each cylinder.

Three separate ignition coils receive power from one fuse.

When a ground signal is provided by the ECM to an ignition coil primary winding, a high voltage is induced in the coil secondary winding that is used to produce a spark at the spark plug electrode.

Cylinder 1 is located on the PTO side of the engine. Each cylinder is identified by a number on the valve cover.



TYPICAL
1. *Ignition coils*
2. *Cylinder identification number on valve cover*

Ignition Timing

Ignition timing is not adjustable.

The ECM is programmed with ignition maps that it uses along with data received from a variety of sensors to establish optimum ignition timing under all engine operating conditions.

The firing of each spark plug is independent of the others.

Engine RPM Limiter

The ECM will limit the maximum engine speed by cutting off ignition spark and fuel at a predetermined engine RPM.

Watercraft

RPM LIMITER	
130	8040 RPM
170 230 300	8450 RPM

Pontoon

RPM LIMITER	
100	7400 RPM
170	8200 RPM
230	8450 RPM

Boat

RPM LIMITER	
130	8050 RPM
170 230	8400 RPM
300	8450 RPM

Knock Sensor

A knock sensor is mounted on the cylinder block behind the intake manifold. It detects specific vibrations that would typically be generated by engine detonation.

If detonation occurs, the knock sensor detects it and the ECM goes into a specific operating mode whereby it temporarily retards the ignition advance until detonation stops.

The ECM is able to identify in which cylinder the knocking occurs and modifies the ignition advance on that cylinder only.

Refer to the *CYLINDER BLOCK* subsection for testing and replacement procedures.

TROUBLESHOOTING

It is good practice to check for fault codes using the BRP diagnostic software (BUDS2) as a first troubleshooting step. Refer to *DIAGNOSTIC AND FAULT CODES* subsection.

Refer to *POWER DISTRIBUTION AND GROUNDS* for fuses and relay information.

Always refer to the *WIRING DIAGRAM* when troubleshooting an electrical circuit.

TESTING THE IGNITION SYSTEM

1. Ensure fuse F2 is powered and in good condition.
2. If the fuse is burnt, test for a short circuit or faulty component on that fuse circuit before replacing the fuse.

⚠ WARNING

Due to the possibility of flammable vapors accumulating in the bilge, you should always test for a short circuit which may produce a spark and ignite the vapors before replacing a burnt fuse.

3. If there is no active fault code, start diagnostic by *TESTING THE IGNITION COIL USING BUDS2*.
4. If a primary winding of an ignition coil or a circuit is at fault, a fault code will be set. Refer to *DIAGNOSTIC AND FAULT CODES* subsection.

DIAGNOSTIC GUIDELINES

The following is provided to help in diagnosing the probable cause of a problem. It is a guideline and should not be assumed to list all possible causes.

ENGINE WILL NOT START (ENGINE TURNS OVER)

1. Fouled or defective spark plug
   - *Check spark plug condition. Replace if necessary.*
2. Defective CPS
   - *Test CPS, refer to PTO HOUSING, MAGNETO AND STARTER subsection.*
3. Defective trigger wheel
   - *Check. Refer to PTO HOUSING, MAGNETO AND STARTER subsection.*
4. Defective ignition circuit
   - *Check fuses, ignition coils, wiring and connectors.*

ENGINE HARD TO START

1. Faulty, fouled or worn out spark plug
   - *Check spark plug condition. Replace if necessary.*
2. Drowned engine
   - *Check engine temperature value using BUDS2. If the temperature read is lower than the ambient temperature, CTS sensor may be defective or have a bad connection. Therefore, the ECM would erroneously set the engine in cold start mode and it could flood the spark plugs.*

ENGINE MISFIRES, RUNS IRREGULARLY

1. Fouled, defective, worn spark plugs
   - *Check spark plug condition. Replace if necessary.*
2. Defective T.O.P.S. sensor (if applicable)
   - *Test T.O.P.S. Refer to LUBRICATION SYSTEM subsection.*
3. Damaged trigger wheel/loose CPS
   - *Check. Refer to PTO HOUSING, MAGNETO AND STARTER subsection.*
4. Defective ignition circuit
   - *Check fuses, ignition coils, wiring and connectors.*
5. Poor engine grounds
   - *Check ground condition, refer to POWER DISTRIBUTION AND GROUNDS subsection.*

ENGINE CONTINUALLY BACKFIRES

1. Fouled, defective spark plugs
   - *Check spark plug condition. Replace if necessary.*
2. Damaged trigger wheel/defective or loose CPS
   - *Check, refer to PTO HOUSING, MAGNETO AND STARTER subsection.*

ENGINE DETONATION OR PINGING

1. Faulty or disconnected knock sensor
   - *Check, refer to CYLINDER BLOCK subsection.*

ENGINE LACKS ACCELERATION OR POWER

1. Weak spark
   - *Check spark plugs, coils, wiring and connections.*

ENGINE WILL NOT STOP WHEN REMOVING KEY FROM ENGINE CUT-OFF SWITCH

1. Defective engine cut-off switch
   - *Check engine cut-off switch. Replace if necessary.*

PROCEDURES

IGNITION COILS

⚠ WARNING

Never check for engine ignition spark from an open coil and/or spark plug in the engine compartment as a spark may cause fuel vapors which may have accumulated in the bilge to ignite.

Testing the Ignition Coil Using BUDS2

1. Connect the vehicle to the BRP diagnostic software (BUDS2).
2. In BUDS2, go to:
   – **Functions** page
   – **ECM** button
   – **Activate Ignition Coils**
3. Select the ignition coils to be tested and clicking on the ACTIVATE button.

You should hear the spark occurring. If in doubt, use a sealed **vapor proof** spark tester or an inductive spark tester as available from tool suppliers, to prevent a spark from occurring in the bilge.

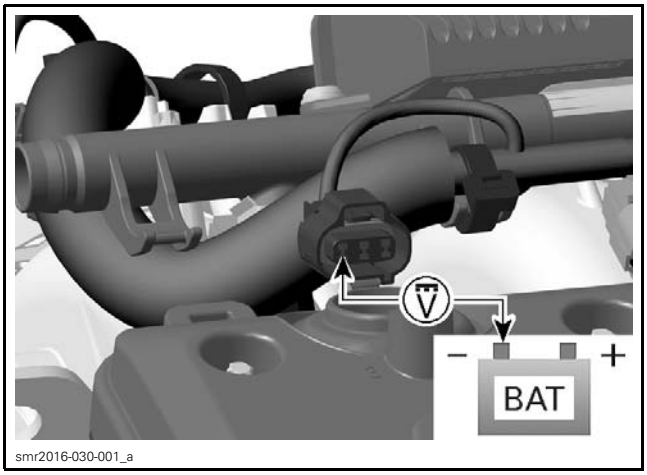
4. If there is no ignition at one or more coils, carry out *TESTING THE IGNITION COIL INPUT VOLTAGE*.
5. If spark is weak, try a new spark plug. If spark is still weak, try a new ignition coil.

NOTE: The voltage required to produce a spark in the combustion chamber is higher when the engine is running.

Testing the Ignition Coil Input Voltage

1. Make sure fuse F2 is good before testing.
2. Disconnect the applicable ignition coil connector.
3. Remove tether cord from the engine cut-off switch.
4. Press the START button to activate the ECM.
5. Measure voltage within 3 minutes after depressing START/STOP button.
6. Set multimeter to Vdc.

IGNITION COIL INPUT VOLTAGE TEST		
IGN COIL CONNECTOR PIN	BATTERY	SPECIFICATION
VIOLET/BLUE wire (ign coil no. 1)	Negative post (-)	Battery voltage
VIOLET/GREEN wire (ign coil no. 2)		
VIOLET/ORANGE wire (ign coil no. 3)		



IGNITION COIL INPUT VOLTAGE TEST

7. If test succeeds, carry out *TESTING THE IGNITION COIL RESISTANCE*.
8. If test fails, carry out *TESTING THE IGNITION COIL POWER CIRCUIT CONTINUITY*.

Testing the Ignition Coil Power Circuit Continuity

1. Remove fuse F2.
2. Read resistance of the desired ignition coil circuit.
3. Set multimeter to Ω.

IGNITION COIL POWER CIRCUIT CONTINUITY TEST		
IGN COIL WIRE	FUSE BOX	SPECIFICATION
VT/BU wire (ign coil no. 1)	B1	Close to 0 Ω
VT/GN wire (ign coil no. 2)		
VT/OR wire (ign coil no. 3)		

4. If test fails at any ignition coil, repair or replace wiring or terminals from fuse box to the applicable ignition coil.

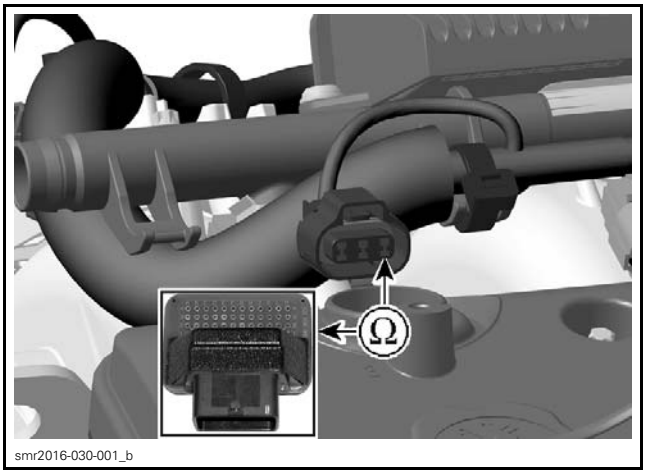
Testing the Ignition Coil Control Circuit Continuity

1. Disconnect the ECM-A connector. Refer to *WIRING HARNESS AND CONNECTOR* subsection.
2. Connect ECM connector to the adapter.

REQUIRED TOOL	
ECM ADAPTER TOOL (P/N 529 036 166)	

3. Disconnect ignition coil connector.
4. Test for continuity of circuit as per following table.

IGNITION COIL CONTROL CIRCUIT CONTINUITY TEST		
IGN COIL WIRE	ECM ADAPTER PIN	SPECIFICATION
BN/BK wire (ign coil no. 1)	A-M4	Close to 0 Ω
BN/OR wire (ign coil no. 2)	A-M2	
BN/YE wire (ign coil no. 3)	A-M1	

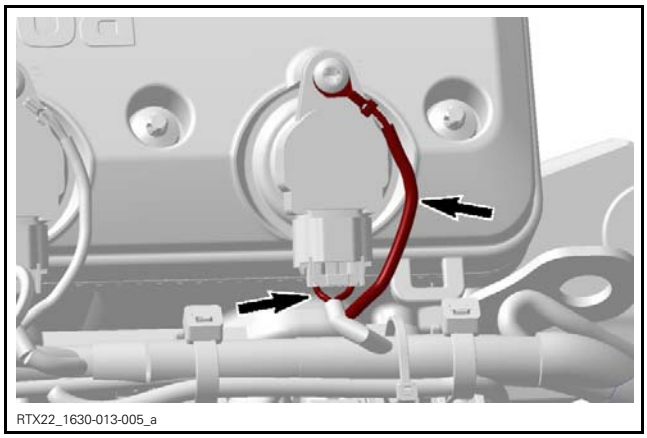


IGNITION COIL CONTROL CIRCUIT TEST

5. If test fails, repair the connector or replace the engine wiring harness.

Testing the Ignition Coil Ground Circuit Continuity

Ignition Coils with External Ground Cable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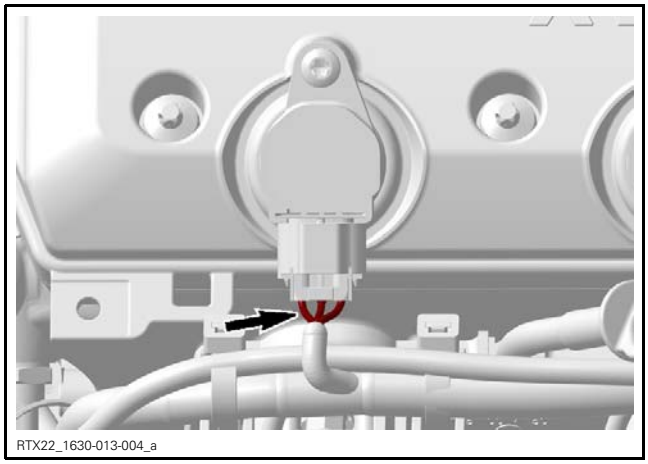
1. Disconnect ignition coil connector.
2. Test for continuity of circuit as per following table.

IGNITION COIL GROUND CIRCUIT CONTINUITY TEST		
IGN COIL WIRE	WIRING HARNESS	SPECIFICATION
External wire (ign coil no. 1)	Ground connector	Close to 0 Ω
External wire (ign coil no. 2)		
External wire (ign coil no. 3)		

3. If test fails, repair the connector or replace the engine wiring harness.

Ignition Coils with 3 Connected Pins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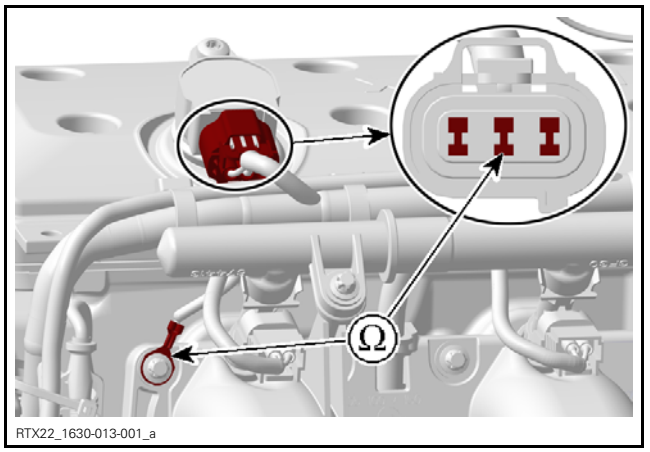
1. Disconnect ignition coil connector.
2. Test for continuity of circuit as per following table.

IGNITION COIL GROUND CIRCUIT CONTINUITY TEST		
IGN COIL WIRE	WIRING HARNESS	SPECIFICATION
BKI wire (ign coil no. 1)	Ground connector	Close to 0 Ω
BK wire (ign coil no. 2)		
BK wire (ign coil no. 3)		



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3. If test fails, repair the connector or replace the engine wiring harness.

Testing the Ignition Coil Resistance

An ignition coil with a good resistance measurement can still be faulty. Current leakage can occur at high voltage levels which is not detectable with an ohmmeter. Replacing the ignition coil may be necessary as a test.

Primary Winding

1. Remove ignition coil. Refer to *REMOVING THE IGNITION COIL* in this subsection.
2. Perform a visual inspection of the ignition coils. Check for corrosion, bent pins, loose or burnt contacts, and cracked or torn insulator.
3. Using a multimeter, measure the resistance of the primary winding.

IGNITION COIL RESISTANCE TEST		
IGNITION COIL PIN		SPECIFICATION @ 20°C (68°F)
1	3	0.8 - 0.97 Ω
1	2	Open Loop (OL)
2	3	

4. If test fails, replace ignition coil.
5. If test succeeds, carry out *TESTING THE IGNITION COIL CONTROL CIRCUIT CONTINUITY*.

Secondary Winding

The secondary winding on this type of ignition coil cannot be tested.

Removing the Ignition Coil

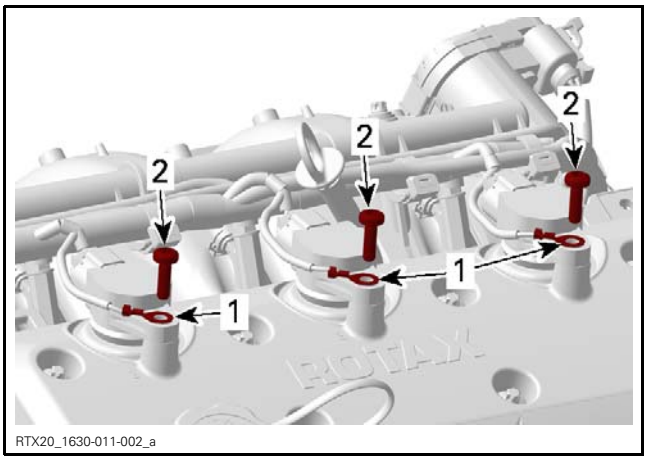
1. Disconnect ignition coil connector.

NOTICE Do not pry on ignition coil using any tool.

2. Remove ignition coil retaining screw.
3. Remove ignition coil from spark plug by rotating coil side to side as you pull up.

Installing the Ignition Coil

1. Install ignition coil on spark plug.
2. Align the retaining screw hole of the ignition coil with the threaded hole on the valve cover.
3. Push the ignition coil all the way down until it rests on the valve cover.
4. If applicable, place GND connector on ignition coil.
5. Install and tighten retaining screw.



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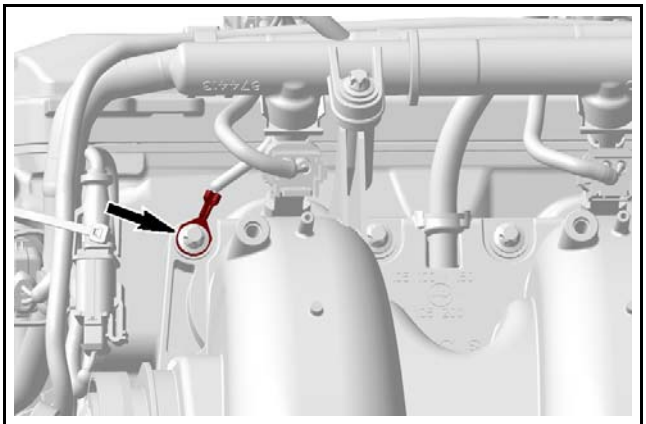
1. GND connector (if applicable)
2. Retaining screw

TIGHTENING TORQUE	
Ignition coil retaining screw	9 N•m ± 1 N•m (80 lbf•**in** ± 9 lbf•**in**)

6. Reconnect ignition coil connector.
7. If applicable, reinstall ground connector to the intake manifold.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TIGHTENING TORQUE	
Intake manifold screw	11 N•m ± 1 N•m (97 lbf•**in** ± 9 lbf•**in**) + LOCTITE 243 (BLUE) (P/N 293 800 060)

SPARK PLUGS

Removing the Spark Plug

1. Remove ignition coil. Refer to *REMOVING THE IGNITION COIL* in this subsection.

⚠ WARNING

Never remove an ignition coil from a spark plug without disconnecting it from the wiring harness. Flammable vapors may be present in the bilge. Should the tether cord be installed on the engine cut-off switch, a spark could be generated at the spark plug end of the coil possibly resulting in an explosion.

2. Using an appropriate spark plug socket with retention spring, release the torque applied and unscrew the spark plug.
3. Clean the spark plug and cylinder head with pressurized air.

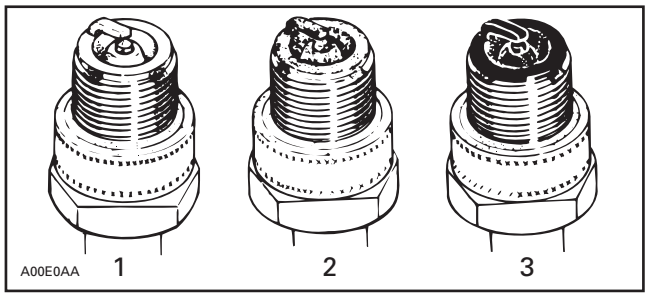
Troubleshooting a Fouled Spark Plug

Fouling of the spark plug is indicated by irregular running or misfiring of the engine, decreased engine speed due to misfiring, reduced performance, and increased fuel consumption.

Other possible causes are: use of an incorrect or bad fuel, defective ignition system, incorrect spark plug gap, loss of compression, or lubricating oil entering the combustion chamber.

The plug face of a fouled spark plug has either a wet or dry black carbon deposit. Such coatings form a conductive connection between the center electrode and the ground electrode.

Spark Plug Analysis



TYPICAL
1. *Overheated (light gray, white)*
2. *Normal (light brown, brown)*
3. *Fouled (black, wet or dry, dark deposits, gray, melted coating)*

The plug face reveals the condition of the engine, operating condition, method of driving and fuel mixture. For this reason it is advisable to inspect the spark plug at prescribed intervals, examining the plug face (i.e. the part of the plug projecting into the combustion chamber).

Installing the Spark Plug

1. Prior to installation, ensure the contact surfaces of the cylinder head and spark plug are free of grime.
2. Check electrode gap as specified.

NOTICE Do not adjust gap on this type of spark plug. The adjustment could weaken the negative electrode which may lead to electrode breakage and severe engine damage.

REQUIRED TOOL
Wire feeler gauge

ELECTRODE GAP	
NOT adjustable	
100 130 170 230	0.8 mm to 0.9 mm (.031 in to .035 in)
300	0.7 mm to 0.8 mm (.028 in to .031 in)

3. Hand screw spark plug into cylinder head.
4. Then tighten the spark plug clockwise to specification using an appropriate spark plug socket.

TIGHTENING TORQUE	
Spark plug	18 N•m ± 2 N•m (159 lbf•**in** ± 18 lbf•**in**)

5. Install ignition coil. Refer to *INSTALLING THE IGNITION COIL* in this subsection.
6. Complete the installation in the reverse order of the removal.

ENGINE

ENGINE			
Engine type			ROTAX® 1630 ACE™ HO, 4-stroke, Single Over Head Camshaft (SOHC)
Declared Power	Boats	130	106kW @ 7300 RPM
		170 with catalyst	124 kW @ 8000 RPM
		170 without catalyst	126 kW @ 8000 RPM
		230	169kW @ 8000 RPM
		300	217 kW @ 8000 RPM
	Pontoon	100	72kW @ 6300 RPM
		170	122kW @ 7250 RPM
		230	169kW @ 8000 RPM
	Watercraft	130	100kW @ 6500 RPM
		170	125 kW @ 8000 RPM
		230	169 kW @ 8000 RPM
		300	217 kW @ 8000 RPM
Induction		100 130 170	Naturally-Aspirated
		230 300	Supercharged intercooled
Number of cylinders			3
Number of valves			12 valves with hydraulic lifters (no adjustment)
Bore			100 mm (3.9 in)
Stroke			69.2 mm (2.7 in)
Displacement			1 630.5 cm^3 (99.5 in^3)
Compression ratio		100 130 170	11:1
		230	8.3:1
		300	8.4:1
Intake valve opening		100 130 170	2° BTDC
		230	2° ATDC
		300	0° BTDC

ENGINE			
Intake valve closing		100 130 170	55° ABDC
		230	42° ABDC
		300	50° ABDC
Exhaust valve opening		100 130 170	52° BBDC
		230	48° BBDC
		300	50° BBDC
Exhaust valve closing		100 130 170	3° ATDC
		230	8° BTDC
		300	0° ATDC
Valve stem diameter	Intake	New	5.961 mm to 5.975 mm (.2347 in to .2352 in)
		Service limit	5.930 mm (.2335 in)
	Exhaust	New	5.946 mm to 5.960 mm (.2341 in to .2346 in)
		Service limit	5.930 mm (.2335 in)
Valve guide diameter		New	5.994 mm to 6.018 mm (.236 in to .2369 in)
		Service limit	6.060 mm (.2386 in)
Valve spring free length	Inner	New	41.02 mm (1.615 in)
		Service limit	38.80 mm (1.528 in)
	Outer	New	45.45 mm (1.789 in)
		Service limit	43.00 mm (1.693 in)
Valve seat contact width	Intake	New	1.05 mm to 1.35 mm (.041 in to .053 in)
		Service limit	1.60 mm (.063 in)
	Exhaust	New	1.25 mm to 1.55 mm (.049 in to .061 in)
		Service limit	1.80 mm (.071 in)
Rocker arm inner diameter		New	20.007 mm to 20.020 mm (.7877 in to .7882 in)
		Service limit	20.050 mm (.7894 in)
Rocker arm shaft diameter		New	19.980 mm to 19.993 mm (.7866 in to .7871 in)
		Service limit	19.970 mm (.7862 in)
Cylinder head maximum warpage		Service limit	0.100 mm (.004 in)
Piston ring type		1st	Upper compression ring, rectangular
		2nd	Lower compression ring, tapered face
		3rd	Oil scraper ring

ENGINE				
Ring end gap	Rectangular	New	100 130 170 230	0.20 mm to 0.40 mm (.008 in to .016 in)
		New	300	0.30 mm to 0.50 mm (.012 in to .02 in)
	Taper-face	New	100 130 170 230	0.70 mm to 0.95 mm (.028 in to .037 in)
		New	300	0.35 mm to 0.55 mm (.014 in to .022 in)
	Oil scraper ring	New	All	0.20 mm to 0.70 mm (.008 in to .028 in)
	All	Service limit	All	1.20 mm (.047 in)
Ring/piston groove clearance	Rectangular	New	100 130 170 230	0.010 mm to 0.060 mm (.0004 in to .0024 in)
		New	300	0.025 mm to 0.070 mm (.001 in to .0028 in)
		Service limit	All	0.150 mm (.0059 in)
	Taper-face	New	All	0.015 mm to 0.060 mm (.0006 in to .0024 in)
		Service limit	All	0.150 mm (.0059 in)
	Oil scraper ring	New	All	0.010 mm to 0.180 mm (.0004 in to .0071 in)
		Service limit	All	0.200 mm (.0079 in)
Piston measurement		New	100 130 170 230	99.951 mm to 99.969 mm (3.9351 in to 3.9358 in)
		Service limit		99.900 mm (3.9331 in)
		New	300	99.931 mm to 99.949 mm (3.9343 in to 3.935 in)
		Service limit		99.900 mm (3.9331 in)
Piston/cylinder wall clearance		New	100 130 170 230	0.024 mm to 0.056 mm (.0009 in to .0022 in)
		Service limit		0.100 mm (.0039 in)
		New	300	0.044 mm to 0.076 mm (.0017 in to .003 in)
		Service limit		0.100 mm (.0039 in)
Cylinder taper		New Maximum		0.036 mm (.0014 in)
		Service limit		0.100 mm (.0039 in)
Cylinder out of round		New Maximum		0.008 mm (.0003 in)
		Service limit		0.020 mm (.0008 in)

ENGINE				
Camshaft bearing journal diameter	Front	New		24.909 mm to 24.940 mm (.9807 in to .9819 in)
		Service limit		24.880 mm (.9795 in)
	PTO and center	New		39.892 mm to 39.905 mm (1.5706 in to 1.5711 in)
		Service limit		39.880 mm (1.5701 in)
Camshaft bearing inner diameter	Front	New		25.000 mm to 25.013 mm (.9843 in to .9848 in)
		Service limit		25.050 mm (.9862 in)
	PTO and center	New		40.000 mm to 40.020 mm (1.5748 in to 1.5756 in)
		Service limit		40.050 mm (1.5768 in)
Cam lobe height	Intake	New	100 130 170	31.710 mm to 31.910 mm (1.2484 in to 1.2563 in)
		Service limit		31.660 mm (1.2465 in)
		New	230	30.513 mm to 30.713 mm (1.2013 in to 1.2092 in)
		Service limit		30.460 mm (1.1992 in)
		New	300	31.540 mm to 31.740 mm (1.2417 in to 1.2496 in)
		Service limit		31.500 mm (1.2402 in)
	Exhaust	New	100 130 170	31.720 mm to 31.920 mm (1.2488 in to 1.2567 in)
		Service limit		31.670 mm (1.2469 in)
		New	230	30.630 mm to 30.830 mm (1.2059 in to 1.2138 in)
		Service limit		30.580 mm (1.2039 in)
		New	300	31.430 mm to 31.630 mm (1.2374 in to 1.2453 in)
		Service limit		31.380 mm (1.2354 in)
Crankshaft deflection		Maximum		0.08 mm (.003 in)
Crankshaft axial clearance		New		0.08 mm to 0.31 mm (.003 in to .012 in)
		Service limit		0.35 mm (.014 in)
Crankshaft bearing journal diameter		New		49.991 mm to 50.010 mm (1.9681 in to 1.9689 in)
		Service limit		49.950 mm (1.9665 in)
Crankshaft radial clearance		Service limit		0.07 mm (.0028 in)
Crankshaft bearing inside diameter		Service limit		50.10 mm (1.9724 in)
Crankshaft pin diameter		New		45.032 mm to 45.048 mm (1.7729 in to 1.7735 in)
		Service limit		45.025 mm (1.7726 in)
Connecting rod big end diameter		Service limit		45.080 mm (1.7748 in)

ENGINE			
Connecting rod big end radial play	Service limit		0.090 mm (.0035 in)
Connecting rod big end axial play	New		0.100 mm to 0.452 mm (.004 in to .018 in)
	Service limit		0.500 mm (.02 in)
Connecting rod small end diameter	New		22.01 mm to 22.02 mm (.8665 in to .8669 in)
	Service limit		22.07 mm (.8689 in)
Connecting rod small end radial play	Service limit		0.080 mm (.003 in)
Piston pin diameter	New		21.996 mm to 22.000 mm (.866 in to .8661 in)
	Service limit		21.990 mm (.8657 in)
Balance shaft journal diameter	New		31.984 mm to 32.000 mm (1.2592 in to 1.2598 in)
	Service limit		31.950 mm (1.2579 in)
Balance shaft radial clearance	Service limit		0.070 mm (.0028 in)
Balance shaft bearing inside diameter	Service limit		32.11 mm (1.2642 in)
Balance shaft axial clearance	New		0.02 mm to 0.25 mm (.001 in to .01 in)
	Service limit		0.35 mm (.014 in)
Supercharger clutch slipping moment	New supercharger	230	9 N•m to 14 N•m (80 lbf•**in** to 124 lbf•**in**)
	Break-in supercharger		8 N•m to 12 N•m (71 lbf•**in** to 106 lbf•**in**)
	New supercharger	300	14 N•m to 17 N•m (124 lbf•**in** to 150 lbf•**in**)
	Break-in supercharger		Minimum 11 N•m (97 lbf•**in**)

INTELLIGENT DEBRIS FREE PUMP SYSTEM (IDF)		
Spacer outer diameter	New	21.896 mm to 21.980 mm (.862 in to .8654 in)
	Service limit	21.790 mm (.8579 in)
Shift fork claw thickness (shift gear)	New	3.79 mm to 3.91 mm (.149 in to .154 in)
	Service limit	3.70 mm (.146 in)
Shift fork claw thickness (output shaft)	New	3.94 mm to 4.06 mm (.155 in to .16 in)
	Service limit	3.80 mm (.15 in)
Shift fork engagement groove width - output shaft	New	4.10 mm to 4.20 mm (.161 in to .165 in)
	Service limit	4.30 mm (.169 in)

AIR INTAKE SYSTEM	
Intake spark arrester	Tubular, wire screen, integrated in the intake manifold

LUBRICATION SYSTEM			
Lubrication	Oil type		XPS 4-stroke synthetic blend oil) (P/N 293 600 121) or a 10W40 **mineral** engine oil compatible with wet clutches (JASO MA certified oils)
	Capacity		3 L (3.2 qt (U.S. liq.)) oil change w/filter 5 L (5.3 qt (U.S. liq.))total
	Type		Dry sump (2 oil pumps). Replaceable oil filter. Water-cooled oil cooler
Oil pressure	Idle (cold)		400 kPa - 600 kPa (58 PSI - 87 PSI)
	Idle (at 80°C (176°F))		Min. 150 kPa (22 PSI)
	4000 - 8000 (at 100°C (212°F))		350 kPa - 500 kPa (51 PSI - 73 PSI)
Oil pressure regulator outer compression spring free length	New		60.0 mm (2.362 in)
	Service limit		57.0 mm (2.244 in)
Oil temperature sensor	Limp home mode activation	100 130 170	Above 115°C (239°F)
		230	Above 120°C (248°F)
		300 Boat	Above 95°C (203°F)
		300 Watercraft	Above 97°C (207°F)
Oil pump radial clearance	Service limit		0.25 mm (.0098 in)
Oil pump axial clearance	Service limit		0.1 mm (.004 in)

COOLING SYSTEM		
Type		Closed loop cooling system
Coolant		Ethylene-glycol / distilled water mix (50%/50%). Use premix coolant from BRP (Long life antifreeze) or a coolant specially formulated for aluminum engines
Cooling system capacity		5.5 L (5.8 qt (U.S. liq.)) total
Thermostat opening temperature		80°C (176°F)
Monitoring beeper setting	100 130 170 230	Above 102°C (216°F)
	300 Boat	Above 98°C (208°F)
	300 Watercraft	Above 97°C (207°F)
Radiator cap opening pressure		90 kPa (13 PSI)

EXHAUST SYSTEM			
Type			D-Sea-Bel sound reduction system. Water cooled/water injected (open loop). Direct flow from jet pump
Water injection in muffler		Pontoon without catalyst All Watercraft	4 x 3.5 mm (.138 in) on exhaust manifold

FUEL SYSTEM			
Fuel injection type			Multipoint fuel injection with iTC (intelligent Throttle Control). Single throttle body (60 mm) with an actuator
Fuel pressure			386 kPa to 414 kPa (56 PSI to 60 PSI)
Fuel injector	Quantity		3
Idle speed		100 130 170	1820 ± 50 RPM (not adjustable)
		230 Boat	1820 ± 50 RPM (not adjustable)
		230 Pontoon and Watercraft	1750 ± 50 RPM (not adjustable)
		300	1700 ± 50 RPM (not adjustable)

ELECTRICAL SYSTEM			
Magneto generator output		Pontoon Watercraft except FishPro TROPHY 170	14V 420W @ 6000 RPM
		Boats Watercraft FishPro TROPHY 170	14V 650W @ 6000 RPM
Stator			0.1 to 1.0 Ω
Ignition system type			IDI (Inductive Discharge Ignition)
Ignition timing			Variable (electronically controlled)
Spark plug	Make and type	100 130 170 230	NGK DCPR8E
		300	NGK KR9E-G
	Gap	100 130 170 230	0.8 mm to 0.9 mm (.031 in to .035 in)
		300	0.7 mm to 0.8 mm (.028 in to .031 in)

ELECTRICAL SYSTEM			
Ignition coil	Primary		0.80 to 0.97 Ω
	Secondary		N.A.
Engine speed limiter setting	Boats	130	8050 RPM
		170 230	8400 RPM
		300	8450 RPM
	Pontoon	100	7400 RPM
		170	8200 RPM
		230	8450 RPM
	Watercraft	130	8040 RPM
		170 230 300	8450 RPM