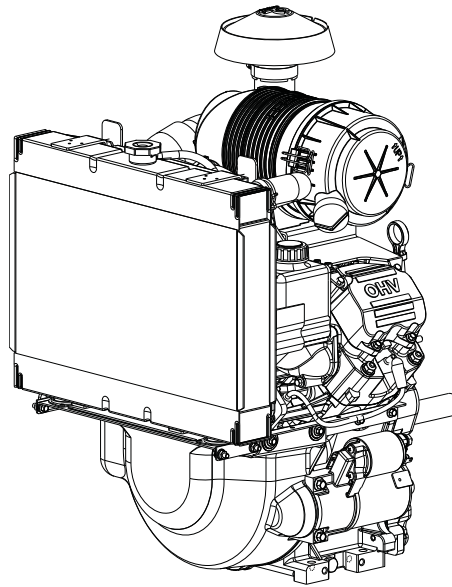


# KOHLER® Aegis

LH630, LH640, LH685, LH690, LH750, LH755

## Service Manual



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**IMPORTANT:** Read all safety precautions and instructions carefully before operating equipment. Refer to operating instruction of equipment that this engine powers.

Ensure engine is stopped and level before performing any maintenance or service.

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# Safety


## SAFETY PRECAUTIONS


**⚠ WARNING:** A hazard that could result in death, serious injury, or substantial property damage.


**⚠ CAUTION:** A hazard that could result in minor personal injury or property damage.


NOTE: is used to notify people of important installation, operation, or maintenance information.


	<b>⚠ WARNING</b>
	Explosive Fuel can cause fires and severe burns. Do not fill fuel tank while engine is hot or running.
Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent.	


	<b>⚠ WARNING</b>
	Rotating Parts can cause severe injury. Stay away while engine is in operation.
Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate engine with covers, shrouds, or guards removed.	


	<b>⚠ WARNING</b>
	Carbon Monoxide can cause severe nausea, fainting or death. Avoid inhaling exhaust fumes.
Engine exhaust gases contain poisonous carbon monoxide. Carbon monoxide is odorless, colorless, and can cause death if inhaled.	


	<b>⚠ WARNING</b>
	Accidental Starts can cause severe injury or death. Disconnect and ground spark plug lead(s) before servicing.
Before working on engine or equipment, disable engine as follows: 1) Disconnect spark plug lead(s). 2) Disconnect negative (-) battery cable from battery.	

	<b>⚠ WARNING</b>
	Hot Parts can cause severe burns. Do not touch engine while operating or just after stopping.
Never operate engine with heat shields or guards removed.	




	<b>⚠ WARNING</b>
	Cleaning Solvents can cause severe injury or death. Use only in well ventilated areas away from ignition sources.
Carburetor cleaners and solvents are extremely flammable. Follow cleaner manufacturer's warnings and instructions on its proper and safe use. Never use gasoline as a cleaning agent.	

	<b>⚠ CAUTION</b>
	Electrical Shock can cause injury. Do not touch wires while engine is running.

	<b>⚠ CAUTION</b>
	Damaging Crankshaft and Flywheel Can Cause Personal Injury!
Using improper procedures can lead to broken fragments. Broken fragments could be thrown from engine. Always observe and use precautions and procedures when installing flywheel.	

	<b>⚠ WARNING</b>
	Hot liquid can cause severe burns. Do not loosen radiator cap while engine is operating or warm to touch.
Liquid coolant can get extremely hot from operation. Turning radiator cap when engine is hot can allow steam and scalding liquid to blow out and burn you severely. Shut off machine. Only remove radiator cap when cool enough to touch with bare hands. Slowly loosen cap to first stop to relieve pressure before removing completely.	

## MAINTENANCE INSTRUCTIONS

  	<b>⚠ WARNING</b>	Before working on engine or equipment, disable engine as follows: 1) Disconnect spark plug lead(s). 2) Disconnect negative (-) battery cable from battery.
	Accidental Starts can cause severe injury or death. Disconnect and ground spark plug lead(s) before servicing.	

Normal maintenance, replacement or repair of emission control devices and systems may be performed by any repair establishment or individual; however, warranty repairs must be performed by a Kohler authorized dealer.

## MAINTENANCE SCHEDULE

Every 200 Hours<sup>1</sup>

<ul style="list-style-type: none"> <li>Change oil and oil filter.</li> </ul>	Lubrication System
--	--------------------

Every 200 Hours

<ul style="list-style-type: none"> <li>Replace fuel filter.</li> </ul>
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Every 250 Hours<sup>1</sup>

<ul style="list-style-type: none"> <li>Replace air cleaner element and check inner element.</li> </ul>	Air Cleaner/Intake
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Every 500 Hours<sup>1</sup>

<ul style="list-style-type: none"> <li>Replace air cleaner inner element.</li> </ul>	Air Cleaner/Intake
--	--------------------

Every 500 Hours

<ul style="list-style-type: none"> <li>Replace spark plugs and set gap.</li> </ul>	Electrical System
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Every 1000 Hours

<ul style="list-style-type: none"> <li>Change engine coolant.</li> </ul>	Cooling System
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<sup>1</sup> Perform these procedures more frequently under severe, dusty, dirty conditions.

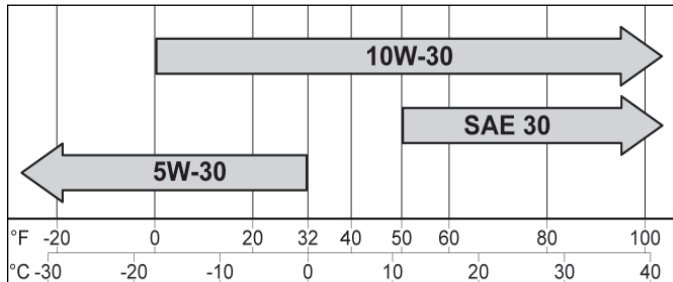
## REPAIRS/SERVICE PARTS

Kohler genuine service parts can be purchased from Kohler authorized dealers. Find your local Kohler Engines dealer at [KohlerEngines.com](http://KohlerEngines.com) or call 1-800-544-2444 (U.S.A. and Canada).


# Maintenance

## OIL RECOMMENDATIONS

We recommend use of Kohler oils for best performance. Other high-quality detergent oils (including synthetic) of API (American Petroleum Institute) service class SJ or higher are acceptable. Select viscosity based on air temperature at time of operation as shown in table below.



## FUEL RECOMMENDATIONS

	<b>⚠ WARNING</b>
	Explosive Fuel can cause fires and severe burns. Do not fill fuel tank while engine is hot or running.
Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent.	

NOTE: E15, E20 and E85 are NOT approved and should NOT be used; effects of old, stale or contaminated fuel are not warrantable.

Fuel must meet these requirements:

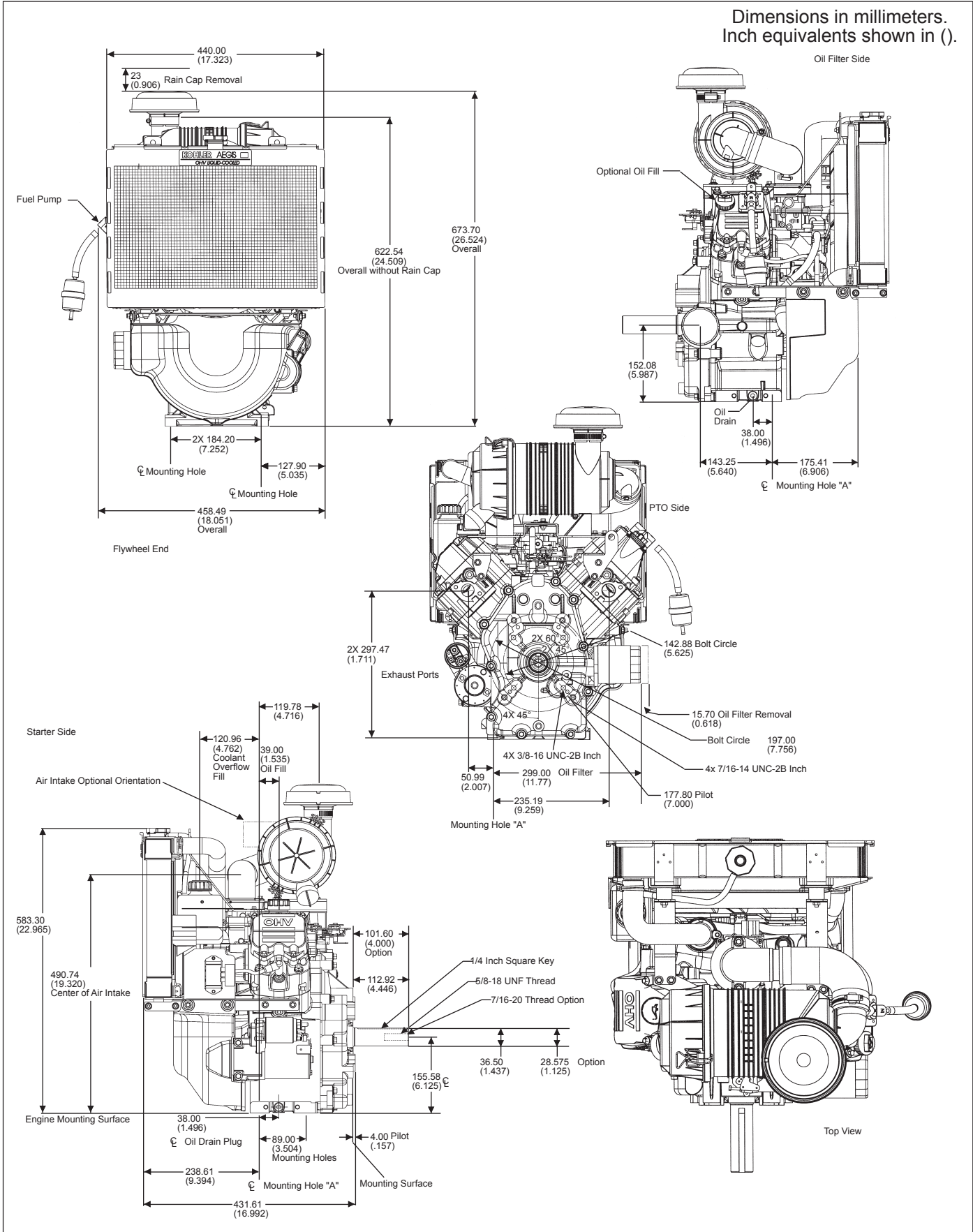
- Clean, fresh, unleaded gasoline.
- Octane rating of 87 (R+M)/2 or higher.
- Research Octane Number (RON) 90 octane minimum.
- Gasoline up to 10% ethyl alcohol, 90% unleaded is acceptable.
- Methyl Tertiary Butyl Ether (MTBE) and unleaded gasoline blend (max 15% MTBE by volume) are approved.
- Do not add oil to gasoline.
- Do not overfill fuel tank.
- Do not use gasoline older than 30 days.

## STORAGE

If engine will be out of service for 2 months or more follow procedure below.

1. Add Kohler PRO Series fuel treatment or equivalent to fuel tank. Run engine 2-3 minutes to get stabilized fuel into fuel system (failures due to untreated fuel are not warrantable).
2. Change oil while engine is still warm from operation. Remove spark plug(s) and pour about 1 oz. of engine oil into cylinder(s). Replace spark plug(s) and crank engine slowly to distribute oil.
3. Disconnect negative (-) battery cable.
4. Store engine in a clean, dry place.

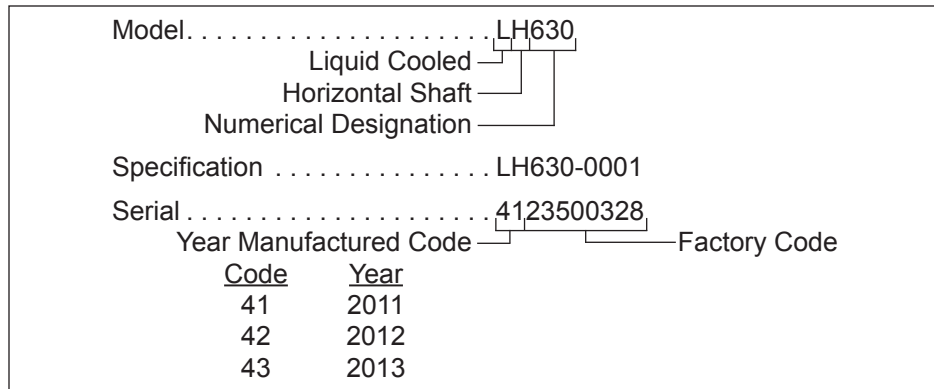
Engine Dimensions



# Specifications

## ENGINE IDENTIFICATION NUMBERS

Kohler engine identification numbers (model, specification and serial) should be referenced for efficient repair, ordering correct parts, and engine replacement.



## GENERAL SPECIFICATIONS<sup>3,6</sup>

	LH630	LH640	LH685	LH690	LH750	LH755
Bore	77 mm (3.03 in.)		80 mm (3.15 in.)		83 mm (3.3 in.)	
Stroke	67 mm (2.64 in.)				69 mm (2.7 in.)	
Displacement	624 cc (38.1 cu. in.)		674 cc (41.1 cu. in.)		747 cc (45.6 cu. in.)	
Oil Capacity (refill)	1.6-1.8 L (1.7-1.9 U.S. qt.)					
Maximum Angle of Operation (@ full oil level) <sup>4</sup>	20°					

## TORQUE SPECIFICATIONS<sup>3,5</sup>

	LH630	LH640	LH685	LH690	LH750	LH755
<b>Carburetor and Intake Manifold</b>						
Intake Manifold Fastener (torque in 2 increments)	first to 7.4 N·m (66 in. lb.) finally to 9.9 N·m (88 in. lb.)					
Thermostat Housing Mounting Fastener	6.2-7.3 N·m (55-65 in. lb.)					
Carburetor Mounting Fastener	9.9 N·m (88 in. lb.)					
<b>Closure Plate</b>						
Closure Plate Fastener	24.4 N·m (216 in. lb.)					
<b>Connecting Rod</b>						
Cap Fastener (torque in increments)	11.3 N·m (100 in. lb.)					
<b>Crankcase</b>						
Breather Cover Fastener	10.7 N·m (95 in. lb.) into new hole 7.3 N·m (65 in. lb.) into used hole					
Oil Drain Plug	13.6 N·m (10 ft . lb.)					
<b>Cylinder Head</b>						
Cylinder Head Fastener (torque in 2 increments)	first to 16.9 N·m (150 in. lb.) finally to 33.9 N·m (300 in. lb.)					
Rocker Pivot Fastener	11.3 N·m (100 in. lb.)					

<sup>3</sup> Values are in Metric units. Values in parentheses are English equivalents.

<sup>4</sup> Exceeding maximum angle of operation may cause engine damage from insufficient lubrication.

<sup>5</sup> Lubricate threads with engine oil prior to assembly.

<sup>6</sup> Any and all horsepower (hp) references by Kohler are Certified Power Ratings and per SAE J1940 & J1995 hp standards. Details on Certified Power Ratings can be found at KohlerEngines.com.

## TORQUE SPECIFICATIONS<sup>3,5</sup>

LH630 LH640 LH685 LH690 LH750 LH755

### Electric Starter

Starter Thru Bolt	5.6-9.0 N·m (49-79 in. lb.)
Starter Mounting Screw	15.3 N·m (135 in. lb.)
Starter Brush Holder Fastener	2.5-3.3 N·m (22-29 in. lb.)
Starter Solenoid Fastener	4.0-6.0 N·m (35-53 in. lb.)
Starter Solenoid Positive (+) Brush Lead Retaining Nut	8.0-11.0 N·m (71-97 in. lb.)

### Fan/Flywheel

Rear Fan Shaft to Mounting Bracket Nut	15.8 N·m (140 in. lb.)
Front Fan Assembly to Fan Shaft Nut	15.8 N·m (140 in. lb.)
Fan/Pulley/Hub Assembly Fastener	6.8 N·m (60 in. lb.)
Flywheel Retaining Screw	66.4 N·m (49 ft. lb.)
Lower Flywheel Cover Mounting Screw	into hex or weld nuts 9.9 N·m (88 in. lb.) into Timmerman clips/nuts 2.2-2.8 N·m (20-25 in. lb.)
Lower Pulley Mounting Screw	24.3 N·m (215 in. lb.)

### Governor

Governor Lever Nut	6.8 N·m (60 in. lb.)
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### Ignition

Spark Plug	27 N·m (20 ft. lb.)
Ignition Module Fastener	6.2 N·m (55 in. lb.) into new hole 4.0 N·m (35 in. lb.) into used hole
Rectifier-Regulator Fastener	4.0 N·m (35 in. lb.)

### Muffler

Muffler Retaining Nuts	24.4 N·m (216 in. lb.)
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### Speed Control

Speed Control Bracket Assembly Fastener	10.7 N·m (95 in. lb.) into new holes 7.3 N·m (65 in. lb.) into used holes
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### Stator

Stator Mounting Screw	6.2 N·m (55 in. lb.)
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### Valve Cover/Rocker Arms

Valve Cover Fastener	6.2 N·m (55 in. lb.)
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### Water Pump

Mounting Screw	9.9 N·m (88 in. lb.)
Pulley Mounting Screw	9.9 N·m (88 in. lb.)

## CLEARANCE SPECIFICATIONS<sup>3</sup>

LH630 LH640 LH685 LH690 LH750 LH755

### Camshaft

End Play (with shim)	0.076/0.127 mm (0.0030/0.0050 in.)
Running Clearance	0.025/0.063 mm (0.0010/0.0025 in.)
Bore I.D. New Max. Wear Limit	20.000/20.025 mm (0.7874/0.7884 in.) 20.038 mm (0.7889 in.)
Camshaft Bearing Surface O.D. New Max. Wear Limit	19.962/19.975 mm (0.7859/0.7864 in.) 19.959 mm (0.7858 in.)

<sup>3</sup> Values are in Metric units. Values in parentheses are English equivalents.

<sup>5</sup> Lubricate threads with engine oil prior to assembly.

# Specifications

## CLEARANCE SPECIFICATIONS<sup>3</sup>

LH630 LH640 LH685 LH690 LH750 LH755

### Connecting Rod

Connecting Rod-to-Crankpin Running Clearance New Max. Wear Limit	0.043/0.068 mm (0.0016/0.0026 in.) 0.083 mm (0.0032 in.)
Connecting Rod-to-Crankpin Side Clearance	0.26/0.63 mm (0.0102/0.0248 in.)
Connecting Rod-to-Piston Pin Running Clearance	0.015/0.028 mm (0.0006/0.0011 in.)

### Crankcase

Governor Cross Shaft Bore I.D. New Max. Wear Limit	8.025/8.075 mm (0.3159/0.3179 in.) 8.088 mm (0.3184 in.)
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### Crankshaft

End Play (free)	0.070/0.590 mm (0.0028/0.0230 in.)
Crankshaft Sleeve Bearing I.D. (crankcase) New Max. Wear Limit	40.974/40.987 mm (1.6131/1.6136 in.) 41.000 mm (1.6141 in.)
Crankshaft Bore (in closure plate) New Max. Wear Limit	40.974/41.000 mm (1.6131/1.6141 in.) 41.038 mm (1.6156 in.)
Crankshaft Bore (in closure plate)-to-Crankshaft Running Clearance New	0.039/0.087 mm (0.0015/0.0034 in.)
Main Bearing Journals O.D. - New O.D. - Max. Wear Limit Max. Taper Max. Out-of-Round	40.913/40.935 mm (1.6107/1.6116 in.) 40.84 mm (1.608 in.) 0.022 mm (0.0009 in.) 0.025 mm (0.0010 in.)
Crankshaft to Sleeve Bearing (crankcase) Running Clearance New	0.039/0.074 mm (0.0015/0.0029 in.)
Connecting Rod Journal O.D. - New O.D. - Max. Wear Limit Max. Taper Max. Out-of-Round	35.955/35.973 mm (1.4156/1.4163 in.) 35.94 mm (1.415 in.) 0.018 mm (0.0007 in.) 0.025 mm (0.0010 in.)
Crankshaft T.I.R. PTO End, Crank in Engine Entire Crank, in V-Blocks	0.15 mm (0.0059 in.) 0.10 mm (0.0039 in.)

### Cylinder Bore

Cylinder Bore I.D. New	77.000/77.025 mm (3.0315/3.0325 in.)	80.000/80.025 mm (3.1496/3.1506 in.)	83.006/83.031 mm (3.2679/3.2689 in.)
Max. Wear Limit	77.063 mm (3.0340 in.)	80.065 mm (3.1522 in.)	83.069 mm (3.2704 in.)
Max. Taper Max. Out-of-Round	0.12 mm (0.0047 in.) 0.05 mm (0.0020 in.)		

### Cylinder Head

Max. Out-of-Flatness	0.076 mm (0.003 in.)
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<sup>3</sup> Values are in Metric units. Values in parentheses are English equivalents.



## CLEARANCE SPECIFICATIONS<sup>3</sup>

**LH630   LH640   LH685   LH690   LH750   LH755**


### Governor

Governor Cross Shaft to Crankcase Running Clearance	0.025/0.126 mm (0.0009/0.0049 in.)
Governor Cross Shaft O.D. New Max. Wear Limit	7.949/8.000 mm (0.3129/0.3149 in.) 7.936 mm (0.3124 in.)
Governor Gear Shaft O.D. New Max. Wear Limit	5.990/6.000 mm (0.2358/0.2362 in.) 5.977 mm (0.2353 in.)
Governor Gear Shaft -to-Governor Gear Running Clearance	0.090/0.160 mm (0.0035/0.0063 in.)

### Ignition

Spark Plug Gap	0.76 mm (0.030 in.)
Ignition Module Air Gap	0.203/0.305 mm (0.008/0.012 in.)

### Piston, Piston Rings, and Piston Pin

Piston Style A 			
Piston-to-Piston Pin	0.006/0.018 mm (0.0002/0.0007 in.)		
Piston Pin Bore I.D. New Max. Wear Limit	17.006/17.013 mm (0.6695/0.6698 in.) 17.025 mm (0.6703 in.)		
Piston Pin O.D. New Max. Wear Limit	16.995/17.000 mm (0.6691/0.6693 in.) 16.994 mm (0.6691 in.)		
Top Compression Ring-to-Groove Side Clearance	0.040/0.086 mm (0.0016/0.0034 in.)	0.050/0.096 mm (0.0020/0.0038 in.)	0.014/0.041 mm (0.0005/0.0016 in.)
Middle Compression Ring-to-Groove Side Clearance	0.040/0.086 mm (0.0016/0.0034 in.)	0.030/0.076 mm (0.0012/0.0030 in.)	0.012/0.039 mm (0.0004/0.0015 in.)
Oil Control Ring-to-Groove Side Clearance	0.046/0.196 mm (0.0018/0.0077 in.)	0.046/0.196 mm (0.0018/0.0077 in.)	0.026/0.176 mm (0.0010/0.0070 in.)
Top and Middle Compression Ring End Gap New Bore Top Ring	0.180/0.380 mm (0.0071/0.0150 in.)	0.180/0.430 mm (0.0071/0.0169 in.)	0.250/0.56 mm (0.0098/0.022 in.)
Middle Ring	0.250/0.450 mm (0.0098/0.0177 in.)	0.250/0.460 mm (0.0098/0.0181 in.)	----
Used Bore (Max.)	0.77 mm (0.030 in.)	0.80 mm (0.0315 in.)	0.94 mm (0.037 in.)
Piston Thrust Face O.D. <sup>7</sup> New	76.968/76.986 mm (3.0302/3.0309 in.)	79.963/79.981 mm (3.1481/3.1488 in.)	82.973/82.991 mm (3.2666/3.2673 in.)
Max. Wear Limit	76.840 mm (3.0252 in.)	79.831 mm (3.1430 in.)	82.841 mm (3.3136 in.)
Piston Thrust Face-to-Cylinder Bore <sup>7</sup> Running Clearance	0.014/0.057 mm (0.0005/0.0022 in.)	0.019/0.062 mm (0.0007/0.0024 in.)	0.015/0.058 mm (0.005/0.0022 in.)

<sup>3</sup> Values are in Metric units. Values in parentheses are English equivalents.


<sup>7</sup> Measure 6 mm (0.2362 in.) above bottom of piston skirt at right angles to piston pin.

# Specifications

## CLEARANCE SPECIFICATIONS<sup>3</sup>

LH630 LH640 LH685 LH690 LH750 LH755

Piston, Piston Rings, and Piston Pin (continued)

Piston Style B 			
Piston-to-Piston Pin		0.006/0.017 mm (0.0002/0.0007 in.)	
Piston Pin Bore I.D.		17.006/17.012 mm (0.6695/0.6698 in.)	
New		17.025 mm (0.6703 in.)	
Max. Wear Limit			
Piston Pin O.D.		16.995/17.000 mm (0.6691/0.6693 in.)	
New		16.994 mm (0.6691 in.)	
Max. Wear Limit			
Top Compression Ring-to-Groove Side Clearance		0.030/0.070 mm (0.001/0.0026 in.)	
Middle Compression Ring-to-Groove Side Clearance		0.030/0.070 mm (0.001/0.0026 in.)	
Oil Control Ring-to-Groove Side Clearance		0.060/0.190 mm (0.0022/0.0073 in.)	
Top Compression Ring End Gap			
New Bore		0.100/0.279 mm (0.0039/0.0110 in.)	0.189/0.277 mm (0.0074/0.0109 in.)
Used Bore (Max.)		0.490 mm (0.0192 in.)	0.531 mm (0.0209 in.)
Middle Compression Ring End Gap			
New Bore		1.400/1.679 mm (0.0551/0.0661 in.)	1.519/1.797 mm (0.0598/0.0708 in.)
Used Bore (Max.)		1.941 mm (0.0764 in.)	2.051 mm (0.0808 in.)
Piston Thrust Face O.D.			
New		79.966 mm (3.1483 in.) <sup>8</sup>	82.978 mm (3.2668 in.) <sup>7</sup>
Max. Wear Limit		79.821 mm (3.1426 in.) <sup>8</sup>	82.833 mm (3.2611 in.) <sup>7</sup>
Piston Thrust Face-to-Cylinder Bore Running Clearance		0.025/0.068 mm (0.0010/ 0.0027 in.) <sup>8</sup>	0.019/0.062 mm (0.0007/ 0.0024 in.) <sup>7</sup>

### Valves and Valve Lifters




Hydraulic Valve Lifter to Crankcase Running Clearance		0.0124/0.0501 mm (0.0005/0.0020 in.)	
Intake Valve Stem-to-Valve Guide Running Clearance		0.038/0.076 mm (0.0015/0.0030 in.)	
Exhaust Valve Stem-to-Valve Guide Running Clearance		0.050/0.088 mm (0.0020/0.0035 in.)	
Intake Valve Guide I.D.		7.038/7.058 mm (0.2771/0.2779 in.)	
New		7.134 mm (0.2809 in.)	
Max. Wear Limit			
Intake Valve Stem Diameter		6.982/7.000 mm (0.2749/0.2756 in.)	
New			
Exhaust Valve Guide I.D.		7.038/7.058 mm (0.2771/0.2779 in.)	
New		7.159 mm (0.2819 in.)	
Max. Wear Limit			
Exhaust Valve Stem Diameter		6.970/6.988 mm (0.2744/0.2751 in.)	
New			
Valve Guide Reamer Size		7.048 mm (0.2775 in.)	
Standard		7.298 mm (0.2873 in.)	
0.25 mm O.S.			
Intake Valve Lift		8.88 mm (0.3496 in.)	
Exhaust Valve Lift		8.88 mm (0.3496 in.)	
Nominal Valve Seat Angle		45°	

<sup>3</sup> Values are in Metric units. Values in parentheses are English equivalents.






<sup>7</sup> Measure 6 mm (0.2362 in.) above bottom of piston skirt at right angles to piston pin.

<sup>8</sup> Measure 13 mm (0.5118 in.) above bottom of piston skirt at right angles to piston pin.

## GENERAL TORQUE VALUES

English Fastener Torque Recommendations for Standard Applications				
Bolts, Screws, Nuts and Fasteners Assembled Into Cast Iron or Steel				Grade 2 or 5 Fasteners Into Aluminum
Size	 Grade 2	 Grade 5	 Grade 8	
<b>Tightening Torque: N·m (in. lb.) ± 20%</b>				
8-32	2.3 (20)	2.8 (25)	—	2.3 (20)
10-24	3.6 (32)	4.5 (40)	—	3.6 (32)
10-32	3.6 (32)	4.5 (40)	—	—
1/4-20	7.9 (70)	13.0 (115)	18.7 (165)	7.9 (70)
1/4-28	9.6 (85)	15.8 (140)	22.6 (200)	—
5/16-18	17.0 (150)	28.3 (250)	39.6 (350)	17.0 (150)
5/16-24	18.7 (165)	30.5 (270)	—	—
3/8-16	29.4 (260)	—	—	—
3/8-24	33.9 (300)	—	—	—

Tightening Torque: N·m (ft. lb.) ± 20%				
5/16-24	—	—	40.7 (30)	—
3/8-16	—	47.5 (35)	67.8 (50)	—
3/8-24	—	54.2 (40)	81.4 (60)	—
7/16-14	47.5 (35)	74.6 (55)	108.5 (80)	—
7/16-20	61.0 (45)	101.7 (75)	142.5 (105)	—
1/2-13	67.8 (50)	108.5 (80)	155.9 (115)	—
1/2-20	94.9 (70)	142.4 (105)	223.7 (165)	—
9/16-12	101.7 (75)	169.5 (125)	237.3 (175)	—
9/16-18	135.6 (100)	223.7 (165)	311.9 (230)	—
5/8-11	149.5 (110)	244.1 (180)	352.6 (260)	—
5/8-18	189.8 (140)	311.9 (230)	447.5 (330)	—
3/4-10	199.3 (147)	332.2 (245)	474.6 (350)	—
3/4-16	271.2 (200)	440.7 (325)	637.3 (470)	—

Metric Fastener Torque Recommendations for Standard Applications						
Size	Property Class					Noncritical Fasteners Into Aluminum
						
<b>Tightening Torque: N·m (in. lb.) ± 10%</b>						
M4	1.2 (11)	1.7 (15)	2.9 (26)	4.1 (36)	5.0 (44)	2.0 (18)
M5	2.5 (22)	3.2 (28)	5.8 (51)	8.1 (72)	9.7 (86)	4.0 (35)
M6	4.3 (38)	5.7 (50)	9.9 (88)	14.0 (124)	16.5 (146)	6.8 (60)
M8	10.5 (93)	13.6 (120)	24.4 (216)	33.9 (300)	40.7 (360)	17.0 (150)
<b>Tightening Torque: N·m (ft. lb.) ± 10%</b>						
M10	21.7 (16)	27.1 (20)	47.5 (35)	66.4 (49)	81.4 (60)	33.9 (25)
M12	36.6 (27)	47.5 (35)	82.7 (61)	116.6 (86)	139.7 (103)	61.0 (45)
M14	58.3 (43)	76.4 (56)	131.5 (97)	184.4 (136)	219.7 (162)	94.9 (70)

Torque Conversions	
N·m = in. lb. x 0.113	in. lb. = N·m x 8.85
N·m = ft. lb. x 1.356	ft. lb. = N·m x 0.737

## Tools and Aids

Certain quality tools are designed to help you perform specific disassembly, repair, and reassembly procedures. By using these tools, you can properly service engines easier, faster, and safer! In addition, you'll increase your service capabilities and customer satisfaction by decreasing engine downtime.

Here is a list of tools and their source.

### SEPARATE TOOL SUPPLIERS

Kohler Tools  
Contact your local Kohler source of supply.

SE Tools  
415 Howard St.  
Lapeer, MI 48446  
Phone 810-664-2981  
Toll Free 800-664-2981  
Fax 810-664-8181

Design Technology Inc.  
768 Burr Oak Drive  
Westmont, IL 60559  
Phone 630-920-1300  
Fax 630-920-0011

### TOOLS

Description	Source/Part No.
<b>Alcohol Content Tester</b> For testing alcohol content (%) in reformulated/oxygenated fuels.	Kohler 25 455 11-S
<b>Camshaft Endplay Plate</b> For checking camshaft endplay.	SE Tools KLR-82405
<b>Camshaft Seal Protector (Aegis)</b> For protecting seal during camshaft installation.	SE Tools KLR-82417
<b>Cylinder Leakdown Tester</b> For checking combustion retention and if cylinder, piston, rings, or valves are worn. Individual component available: Adapter 12 mm x 14 mm (Required for leakdown test on XT-6 engines)	Kohler 25 761 05-S Design Technology Inc. DTI-731-03
<b>Dealer Tool Kit (Domestic)</b> Complete kit of Kohler required tools. Components of 25 761 39-S Ignition System Tester Cylinder Leakdown Tester Oil Pressure Test Kit Rectifier-Regulator Tester (120 V AC/60Hz)	Kohler 25 761 39-S  Kohler 25 455 01-S Kohler 25 761 05-S Kohler 25 761 06-S Kohler 25 761 20-S
<b>Dealer Tool Kit (International)</b> Complete kit of Kohler required tools. Components of 25 761 42-S Ignition System Tester Cylinder Leakdown Tester Oil Pressure Test Kit Rectifier-Regulator Tester (240 V AC/50Hz)	Kohler 25 761 42-S  Kohler 25 455 01-S Kohler 25 761 05-S Kohler 25 761 06-S Kohler 25 761 41-S
<b>Digital Vacuum/Pressure Tester</b> For checking crankcase vacuum. Individual component available: Rubber Adapter Plug	Design Technology Inc. DTI-721-01 Design Technology Inc. DTI-721-10
<b>Electronic Fuel Injection (EFI) Diagnostic Software</b> For Laptop or Desktop PC.	Kohler 25 761 23-S
<b>EFI Service Kit</b> For troubleshooting and setting up an EFI engine. Components of 24 761 01-S Fuel Pressure Tester Noid Light 90° Adapter In-line "T" Fitting Code Plug, Red Wire Code Plug, Blue Wire Shrader Valve Adapter Hose	Kohler 24 761 01-S  Design Technology Inc. DTI-019 DTI-021 DTI-023 DTI-035 DTI-027 DTI-029 DTI-037
<b>Flywheel Holding Tool (CS)</b> For holding flywheel of CS series engines.	SE Tools KLR-82407
<b>Flywheel Puller</b> For properly removing flywheel from engine.	SE Tools KLR-82408
<b>Flywheel Strap Wrench</b> For holding flywheel during removal.	SE Tools KLR-82409

### TOOLS

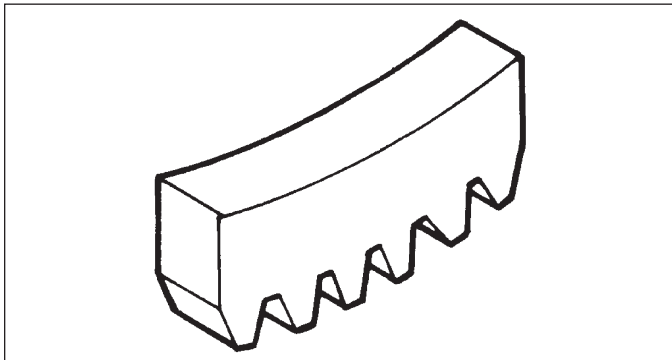
Description	Source/Part No.
<b>Hydraulic Valve Lifter Tool</b> For removing and installing hydraulic lifters.	Kohler 25 761 38-S
<b>Ignition System Tester</b> For testing output on all systems, including CD.	Kohler 25 455 01-S
<b>Inductive Tachometer (Digital)</b> For checking operating speed (RPM) of an engine.	Design Technology Inc. DTI-110
<b>Offset Wrench (K and M Series)</b> For removing and reinstalling cylinder barrel retaining nuts.	Kohler 52 455 04-S
<b>Oil Pressure Test Kit</b> For testing/verifying oil pressure on pressure lubricated engines.	Kohler 25 761 06-S
<b>Radiator Tester</b> For pressure testing radiator and cap on Aegis liquid-cooled engines.	Kohler 25 455 10-S
<b>Rectifier-Regulator Tester (120 volt current)</b> <b>Rectifier-Regulator Tester (240 volt current)</b> For testing rectifier-regulators. Components of 25 761 20-S and 25 761 41-S CS-PRO Regulator Test Harness Special Regulator Test Harness with Diode	Kohler 25 761 20-S Kohler 25 761 41-S  Design Technology Inc. DTI-031 DTI-033
<b>Spark Advance Module (SAM) Tester</b> For testing SAM (ASAM and DSAM) on engines with SMART-SPARK™.	Kohler 25 761 40-S
<b>Starter Servicing Kit (All Starters)</b> For removing and reinstalling drive retaining rings and brushes. Individual component available: Starter Brush Holding Tool (Solenoid Shift)	SE Tools KLR-82411  SE Tools KLR-82416
<b>Triad/OHC Timing Tool Set</b> For holding cam gears and crankshaft in timed position while installing timing belt.	Kohler 28 761 01-S
<b>Valve Guide Reamer (K and M Series)</b> For properly sizing valve guides after installation.	Design Technology Inc. DTI-K828
<b>Valve Guide Reamer O.S. (Command Series)</b> For reaming worn valve guides to accept replacement oversize valves. Can be used in low-speed drill press or with handle below for hand reaming.	Kohler 25 455 12-S
<b>Reamer Handle</b> For hand reaming using Kohler 25 455 12-S reamer.	Design Technology Inc. DTI-K830
<b>Valve Guide Service Kit (Courage, Aegis, Command, OHC)</b> For servicing worn valve guides.	SE Tools KLR-82415

### AIDS

Description	Source/Part No.
<b>Camshaft Lubricant (Valspar ZZ613)</b>	Kohler 25 357 14-S
<b>Dielectric Grease (GE/Novaguard G661)</b>	Kohler 25 357 11-S
<b>Dielectric Grease</b>	Loctite® 51360
<b>Kohler Electric Starter Drive Lubricant (Inertia Drive)</b>	Kohler 52 357 01-S
<b>Kohler Electric Starter Drive Lubricant (Solenoid Shift)</b>	Kohler 52 357 02-S
<b>RTV Silicone Sealant</b> Loctite® 5900® Heavy Body in 4 oz. aerosol dispenser. Only oxime-based, oil resistant RTV sealants, such as those listed, are approved for use. Loctite® Nos. 5900® or 5910® are recommended for best sealing characteristics.	Kohler 25 597 07-S Loctite® 5910® Loctite® Ultra Black 598™ Loctite® Ultra Blue 587™ Loctite® Ultra Copper 5920™
<b>Spline Drive Lubricant</b>	Kohler 25 357 12-S

## Tools and Aids

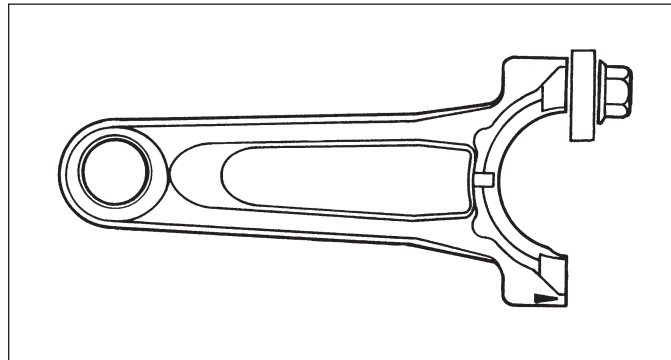
### FLYWHEEL HOLDING TOOL



A flywheel holding tool can be made out of an old junk flywheel ring gear and used in place of a strap wrench.

1. Using an abrasive cut-off wheel, cut out a six tooth segment of ring gear as shown.
2. Grind off any burrs or sharp edges.
3. Invert segment and place it between ignition bosses on crankcase so tool teeth engage flywheel ring gear teeth. Bosses will lock tool and flywheel in position for loosening, tightening, or removing with a puller.

### ROCKER ARM/CRANKSHAFT TOOL



A spanner wrench to lift rocker arms or turn crankshaft may be made out of an old junk connecting rod.

1. Find a used connecting rod from a 10 HP or larger engine. Remove and discard rod cap.
2. Remove studs of a Posi-Lock rod or grind off aligning steps of a Command rod, so joint surface is flat.
3. Find a 1 in. long capscrew with correct thread size to match threads in connecting rod.
4. Use a flat washer with correct I.D. to slip on capscrew and approximately 1 in. O.D. Assemble capscrew and washer to joint surface of rod.

## TROUBLESHOOTING GUIDE

When troubles occur, be sure to check simple causes which, at first, may seem too obvious to be considered. For example, a starting problem could be caused by an empty fuel tank.

Some general common causes of engine troubles are listed below and vary by engine specification. Use these to locate causing factors.

### Engine Cranks But Will Not Start

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- Battery connected backwards.
- Blown fuse.
- Carburetor solenoid malfunction.
- Choke not closing.
- Clogged fuel line or fuel filter.
- Diode in wiring harness failed in open circuit mode.
- DSAI or DSAM malfunction.
- Empty fuel tank.
- Faulty electronic control unit.
- Faulty ignition coil(s).
- Faulty spark plug(s).
- Fuel pump malfunction-vacuum hose clogged or leaking.
- Fuel shut-off valve closed.
- Ignition module(s) faulty or improperly gapped.
- Insufficient voltage to electronic control unit.
- Interlock switch is engaged or faulty.
- Key switch or kill switch in OFF position.
- Low oil level.
- Quality of fuel (dirt, water, stale, mixture).
- SMART-SPARK™ malfunction.
- Spark plug lead(s) disconnected.

### Engine Starts But Does Not Keep Running

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- Faulty carburetor.
- Faulty cylinder head gasket.
- Faulty or misadjusted choke or throttle controls.
- Fuel pump malfunction-vacuum hose clogged or leaking.
- Intake system leak.
- Loose wires or connections that intermittently ground ignition kill circuit.
- Quality of fuel (dirt, water, stale, mixture).
- Restricted fuel tank cap vent.

### Engine Starts Hard

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- Clogged fuel line or fuel filter.
- Engine overheated.
- Faulty ACR mechanism.
- Faulty or misadjusted choke or throttle controls.
- Faulty spark plug(s).
- Flywheel key sheared.
- Fuel pump malfunction-vacuum hose clogged or leaking.
- Interlock switch is engaged or faulty.
- Loose wires or connections that intermittently ground ignition kill circuit.
- Low compression.
- Quality of fuel (dirt, water, stale, mixture).
- Weak spark.

### Engine Will Not Crank

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- Battery is discharged.
- Faulty electric starter or solenoid.
- Faulty key switch or ignition switch.
- Interlock switch is engaged or faulty.
- Loose wires or connections that intermittently ground ignition kill circuit.
- Pawls not engaging in drive cup.
- Seized internal engine components.

### Engine Runs But Misses

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- Carburetor adjusted incorrectly.
- Engine overheated.
- Faulty spark plug(s).
- Ignition module(s) faulty or improperly gapped.
- Incorrect crankshaft position sensor air gap.
- Interlock switch is engaged or faulty.
- Loose wires or connections that intermittently ground ignition kill circuit.
- Quality of fuel (dirt, water, stale, mixture).
- Spark plug lead(s) disconnected.
- Spark plug lead boot loose on plug.
- Spark plug lead loose.

### Engine Will Not Idle

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- Engine overheated.
- Faulty spark plug(s).
- Idle fuel adjusting needle(s) improperly set.
- Idle speed adjusting screw improperly set.
- Inadequate fuel supply.
- Low compression.
- Quality of fuel (dirt, water, stale, mixture).
- Restricted fuel tank cap vent.

### Engine Overheats

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- Cooling fan broken.
- Excessive engine load.
- Fan belt failed/off.
- Faulty carburetor.
- High crankcase oil level.
- Lean fuel mixture.
- Low cooling system fluid level.
- Low crankcase oil level.
- Radiator, and/or cooling system components clogged, restricted, or leaking.
- Water pump belt failed/broken.
- Water pump malfunction.

### Engine Knocks

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- Excessive engine load.
- Hydraulic lifter malfunction.
- Incorrect oil viscosity/type.
- Internal wear or damage.
- Low crankcase oil level.
- Quality of fuel (dirt, water, stale, mixture).

# Troubleshooting

## Engine Loses Power

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- Dirty air cleaner element.
- Engine overheated.
- Excessive engine load.
- Restricted exhaust.
- Faulty spark plug(s).
- High crankcase oil level.
- Incorrect governor setting.
- Low battery.
- Low compression.
- Low crankcase oil level.
- Quality of fuel (dirt, water, stale, mixture).

## Engine Uses Excessive Amount of Oil

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- Loose or improperly torqued fasteners.
- Blown head gasket/overheated.
- Breather reed broken.
- Clogged, broken, or inoperative crankcase breather.
- Crankcase overfilled.
- Incorrect oil viscosity/type.
- Worn cylinder bore.
- Worn or broken piston rings.
- Worn valve stems/valve guides.

## Oil Leaks from Oil Seals, Gaskets

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- Breather reed broken.
- Clogged, broken, or inoperative crankcase breather.
- Loose or improperly torqued fasteners.
- Piston blow by, or leaky valves.
- Restricted exhaust.

## EXTERNAL ENGINE INSPECTION


NOTE: It is good practice to drain oil at a location away from workbench. Be sure to allow ample time for complete drainage.

Before cleaning or disassembling engine, make a thorough inspection of its external appearance and condition. This inspection can give clues to what might be found inside engines (and cause) when it is disassembled.

- Check for buildup of dirt and debris on crankcase, cooling fins, grass screen, and other external surfaces. Dirt or debris on these areas can cause overheating.
- Check for obvious fuel and oil leaks, and damaged components. Excessive oil leakage can indicate a clogged or inoperative breather, worn or damaged seals or gaskets, or loose fasteners.
- Check air cleaner cover and base for damage or indications of improper fit and seal.
- Check air cleaner element. Look for holes, tears, cracked or damaged sealing surfaces, or other damage that could allow unfiltered air into engine. A dirty or clogged element could indicate insufficient or improper maintenance.
- Check carburetor throat for dirt. Dirt in throat is further indication that air cleaner was not functioning properly.
- Check if oil level is within operating range on dipstick. If it is above, sniff for gasoline odor.
- Check condition of oil. Drain oil into a container; it should flow freely. Check for metal chips and other foreign particles.

Sludge is a natural by-product of combustion; a small accumulation is normal. Excessive sludge formation could indicate over rich fuel settings, weak ignition, overextended oil change interval or wrong weight or type of oil was used.

## CLEANING ENGINE


	<b>⚠ WARNING</b>
	Cleaning Solvents can cause severe injury or death. Use only in well ventilated areas away from ignition sources.
Carburetor cleaners and solvents are extremely flammable. Follow cleaner manufacturer's warnings and instructions on its proper and safe use. Never use gasoline as a cleaning agent.	


After inspecting external condition of engine, clean engine thoroughly before disassembly. Clean individual components as engine is disassembled. Only clean parts can be accurately inspected and gauged for wear or damage. There are many commercially available cleaners that will quickly remove grease, oil, and grime from engine parts. When such a cleaner is used, follow manufacturer's instructions and safety precautions carefully.

Make sure all traces of cleaner are removed before engine is reassembled and placed into operation. Even small amounts of these cleaners can quickly break down lubricating properties of engine oil.



## CRANKCASE VACUUM TEST

	<b>⚠ WARNING</b>
	Carbon Monoxide can cause severe nausea, fainting or death. Avoid inhaling exhaust fumes.
Engine exhaust gases contain poisonous carbon monoxide. Carbon monoxide is odorless, colorless, and can cause death if inhaled.	

	<b>⚠ WARNING</b>
	Rotating Parts can cause severe injury. Stay away while engine is in operation.
Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate engine with covers, shrouds, or guards removed.	

A partial vacuum should be present in crankcase when engine is operating. Pressure in crankcase (normally caused by a clogged or improperly assembled breather) can cause oil to be forced out at oil seals, gaskets, or other available spots.

Crankcase vacuum is best measured with either a water manometer or a vacuum gauge. Complete instructions are provided in kits.

To test crankcase vacuum with manometer:

1. Insert rubber stopper into oil fill hole. Be sure pinch clamp is installed on hose and use tapered adapters to connect hose between stopper and one manometer tube. Leave other tube open to atmosphere. Check that water level in manometer is at 0 line. Make sure pinch clamp is closed.
2. Start engine and run no-load high speed.
3. Open clamp and note water level in tube.  
Level in engine side should be a minimum of 10.2 cm (4 in.) above level in open side.  
If level in engine side is less than specified (low/no vacuum), or level in engine side is lower than level in open side (pressure), check for conditions in table below.
4. Close pinch clamp before stopping engine.

To test crankcase vacuum with vacuum/pressure gauge:

1. Remove dipstick or oil fill plug/cap.
2. Install adapter into oil fill/dipstick tube opening, upside down over end of a small diameter dipstick tube, or directly into engine if a tube is not used. Insert barbed gauge fitting into hole in stopper.
3. Run engine and observe gauge reading.  
Analog tester—needle movement to left of 0 is a vacuum, and movement to right indicates a pressure.  
Digital tester—depress test button on top of tester.  
Crankcase vacuum should be a minimum of 10.2 cm (4 in.) of water. If reading is below specification, or if pressure is present, check table below for possible causes and conclusions.

Condition	Conclusion
Crankcase breather clogged or inoperative.	NOTE: If breather is integral part of valve cover and cannot be serviced separately, replace valve cover and recheck pressure. Disassemble breather, clean parts thoroughly, check sealing surfaces for flatness, reassemble, and recheck pressure.
Seals and/or gaskets leaking. Loose or improperly torque fasteners.	Replace all worn or damaged seals and gaskets. Make sure all fasteners are tightened securely. Use appropriate torque valves and sequences when necessary.
Piston blow by or leaky valves (confirm by inspecting components).	Recondition piston, rings, cylinder bore, valves and valves guides.
Restricted exhaust.	Check exhaust screen/spark arrestor (if equipped). Clean or replace as needed. Repair or replace any other damaged/restricted muffler or exhaust system parts.

# Troubleshooting

## COMPRESSION TEST

For Command Twins:

A compression test is best performed on a warm engine. Clean any dirt or debris away from base of spark plug(s) before removing them. Be sure choke is off, and throttle is wide open during test. Compression should be at least 160 psi and should not vary more than 15% between cylinders.

All other models:

These engines are equipped with an automatic compression release (ACR) mechanism. It is difficult to obtain an accurate compression reading because of ACR mechanism. As an alternative, use cylinder leakdown test described below.

## CYLINDER LEAKDOWN TEST

A cylinder leakdown test can be a valuable alternative to a compression test. By pressurizing combustion chamber from an external air source you can determine if valves or rings are leaking, and how badly.

Cylinder leakdown tester is a relatively simple, inexpensive leakdown tester for small engines. This tester includes a quick-connect for attaching adapter hose and a holding tool.

1. Run engine for 3-5 minutes to warm it up.
2. Remove spark plug(s) and air filter from engine.
3. Rotate crankshaft until piston (of cylinder being tested) is at top dead center (TDC) of compression stroke. Hold engine in this position while testing. Holding tool supplied with tester can be used if PTO end of crankshaft is accessible. Lock holding tool onto crankshaft. Install a 3/8 in. breaker bar into hole/slot of holding tool, so it is perpendicular to both holding tool and crankshaft PTO.

If flywheel end is more accessible, use a breaker bar and socket on flywheel nut/screw to hold it in position. An assistant may be needed to hold breaker bar during testing. If engine is mounted in a piece of equipment, it may be possible to hold it by clamping or wedging a driven component. Just be certain that engine cannot rotate off of TDC in either direction.

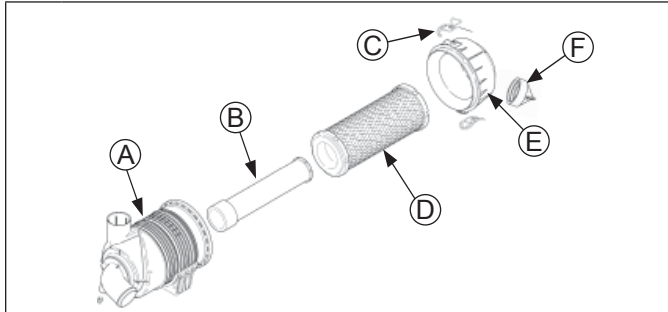
4. Install adapter into spark plug hole, but do not attach it to tester at this time.
5. Turn regulator knob completely counterclockwise.
6. Connect an air source of at least 50 psi to tester.
7. Turn regulator knob clockwise (increase direction) until gauge needle is in yellow set area at low end of scale.
8. Connect tester quick-connect to adapter hose. While firmly holding engine at TDC, gradually open tester valve. Note gauge reading and listen for escaping air at combustion air intake, exhaust outlet, and crankcase breather.

Condition	Conclusion
Air escaping from crankcase breather.	Ring or cylinder worn.
Air escaping from exhaust system.	Defective exhaust valve/improper seating.
Air escaping from intake.	Defective intake valve/improper seating.
Gauge reading in low (green) zone.	Piston rings and cylinder in good condition.
Gauge reading in moderate (yellow) zone.	Engine is still usable, but there is some wear present. Customer should start planning for overhaul or replacement.
Gauge reading in high (red) zone.	Rings and/or cylinder have considerable wear. Engine should be reconditioned or replaced.

## AIR CLEANER

These systems are CARB/EPA certified and components should not be altered or modified in any way.

### Heavy-Duty Air Cleaner Components



<b>A</b>	Air Cleaner Housing	<b>B</b>	Inner Element
<b>C</b>	Retaining Clip	<b>D</b>	Element
<b>E</b>	End Cap	<b>F</b>	Dust Ejector Valve

NOTE: Operating engine with loose or damaged air cleaner components could cause premature wear and failure. Replace all bent or damaged components.

NOTE: Paper element cannot be blown out with compressed air.

1. Unhook retaining clips and remove end cap(s).
2. Check and clean inlet screen (if equipped).
3. Pull air cleaner element out of housing and replace. Check condition of inner element; replace when dirty.
4. Check all parts for wear, cracks, or damage, and that ejector area is clean.
5. Install new element(s).
6. Reinstall end cap(s) with dust ejector valve/screen down; secure with retaining clips.

## BREATHER TUBE

Ensure both ends of breather tube are properly connected.

## AIR COOLING

	<b>WARNING</b>
	<p>Hot Parts can cause severe burns. Do not touch engine while operating or just after stopping.</p>
<p>Never operate engine with heat shields or guards removed.</p>	

Proper cooling is essential. To prevent over heating, clean screens, cooling fins, and other external surfaces of engine. Avoid spraying water at wiring harness or any electrical components. Refer to Maintenance Schedule.

# Fuel System

Typical carbureted fuel system and related components include following:

- Fuel tank.
- In-line fuel filter.
- Fuel pump.
- Carburetor.
- Fuel lines.

Fuel from tank is moved through in-line filter and fuel lines by fuel pump. Fuel then enters carburetor float bowl and is drawn into carburetor body and mixed with air.

This fuel-air mixture is then burned in engine combustion chamber.

## FUEL RECOMMENDATIONS

Refer to Maintenance.

## FUEL LINE

Low permeation fuel line must be installed on carbureted Kohler Co. engines to maintain EPA and CARB regulatory compliance.

## FUEL SYSTEM TESTS

When engine starts hard or turns over but will not start, fuel system might be causing problems. Test fuel system by performing following tests.

1. Check for fuel in combustion chamber.
  - a. Disconnect and ground spark plug leads.
  - b. Close choke on carburetor.
  - c. Crank engine several times.
  - d. Remove spark plug and check for fuel at tip.
2. Check for fuel flow from tank to fuel pump.
  - a. Remove fuel line from inlet fitting of fuel pump.
  - b. Hold line below bottom of tank. Open shut-off valve (if equipped) and observe flow.
3. Check operation of fuel pump.
  - a. Remove fuel line from inlet fitting of carburetor.
  - b. Crank engine several times and observe flow.

## FUEL PUMP

These engines use either a mechanical fuel pump, or optional remote-mounted electric fuel pump assembly. Operation of mechanical fuel pump occurs by direct lever/pump actuation off rocker arm movement. Pumping action causes diaphragm on inside of pump to pull fuel in on its downward stroke and to push it into carburetor on its upward stroke, internal check valves prevent fuel from going backward through pump.



## Fuel Pump Replacement

Mechanical fuel pump is an integral part of valve cover assembly and not serviced separately.

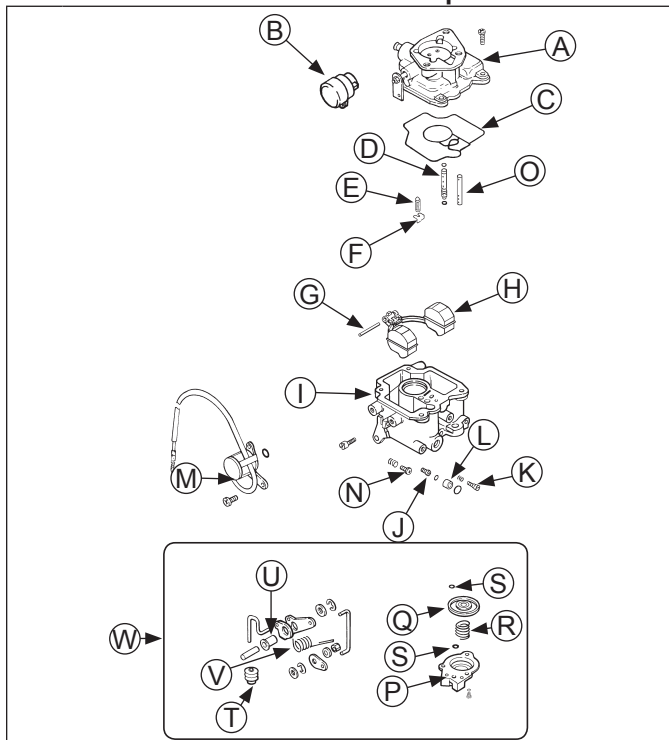
1. Disconnect fuel lines from inlet and outlet fittings. Note orientation.
2. Follow procedure for replacing valve cover. Refer to Disassembly and Reassembly.
3. Reconnect fuel lines to inlet and outlet fittings and secure with clamps.

Condition	Conclusion
Fuel at tip of spark plug.	Fuel is reaching combustion chamber.
No fuel at tip of spark plug.	Check fuel flow from fuel tank (step 2).
Fuel flows from fuel line.	Check for faulty fuel pump (step 3). If fuel pump is working, check for faulty carburetor. Refer to Carburetor.
No fuel flow from fuel line.	Check fuel tank cap vent, fuel pickup screen, in-line filter, shut-off valve, and fuel line. Correct any observed problem and reconnect line.
Fuel line condition.	Check for a clogged fuel line. If fuel line is unobstructed, check for overfilled crankcase and/or oil in pulse line. If checks don't reveal cause of problem, replace pump.

## CARBURETOR

	 <b>WARNING</b>
	<p>Explosive Fuel can cause fires and severe burns.</p> <p>Do not fill fuel tank while engine is hot or running.</p>
<p>Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent.</p>	

### Keihin One-Barrel Carburetor Components



<b>A</b>	Carburetor Upper Body (Choke)	<b>B</b>	Self-relieving Choke
<b>C</b>	Body Gasket (Formed Rubber)	<b>D</b>	Slow Speed Jet
<b>E</b>	Inlet Needle Valve	<b>F</b>	Clip
<b>G</b>	Float Pin	<b>H</b>	Float Assembly
<b>I</b>	Carburetor Lower Body (Throttle)	<b>J</b>	Main Jet
<b>K</b>	Idle Fuel Adjusting Needle	<b>L</b>	Solenoid Seat
<b>M</b>	Fuel Shut-off Solenoid	<b>N</b>	Idle Speed Adjusting Screw
<b>O</b>	Jet (Accelerator Pump Carburetor only)	<b>P</b>	Accelerator Pump Cover
<b>Q</b>	Diaphragm	<b>R</b>	Diaphragm Spring
<b>S</b>	O-ring	<b>T</b>	Rubber Boot
<b>U</b>	Bushing	<b>V</b>	Return Spring
<b>W</b>	Accelerator Pump		

Engines in this series are equipped with emission compliant fixed main jet carburetors, manufactured by Keihin. All have self-relieving chokes for efficient operation. Depending on specifications and application involved, most will also contain a fuel shut-off solenoid and an accelerator pump.

### Troubleshooting Checklist

When engine starts hard, runs rough, or stalls at low idle speed, check these areas before adjusting or disassembling carburetor.

1. Make sure fuel tank is filled with clean, fresh gasoline.
2. Make sure fuel tank cap vent is not blocked and is operating properly.
3. Make sure fuel is reaching carburetor. This includes checking fuel shut-off valve, fuel tank filter screen, in-line fuel filter, fuel lines and fuel pump for restrictions or faulty components as necessary.
4. Make sure air cleaner base and carburetor are securely fastened to engine using gaskets in good condition.
5. Make sure air cleaner element (including precleaner if equipped) is clean and all air cleaner components are fastened securely.
6. Make sure ignition system, governor system, exhaust system, and throttle and choke controls are operating properly.

# Fuel System

## Troubleshooting-Carburetor Related Causes

Condition	Possible Cause	Conclusion
Engine starts hard, runs rough, or stalls at idle speed.	Low idle fuel mixture (some models)/ speed improperly adjusted.	Adjust low idle speed tab, then adjust low idle fuel needle.
Engine runs rich (indicated by black, sooty exhaust smoke, misfiring, loss of speed and power, governor hunting, or excessive throttle opening).	Clogged air cleaner.	Clean or replace air cleaner.
	Choke partially closed during operation.	Check choke lever/linkage to ensure choke is operating properly.
	Low idle fuel mixture is improperly adjusted.	Adjust low idle fuel needle (some models).
	Float level is set too high.	Adjust float according to steps outlined in repair kit installation instructions.
	Dirt under fuel inlet needle.	Remove needle; clean needle and seat and blow with compressed air.
	Bowl vent or air bleeds plugged.	Remove low idle fuel adjusting needle. Clean vent, ports, and air bleeds. Blow out all passages with compressed air.
	Leaky, cracked, or damaged float.	Submerge float to check for leaks.
Engine runs lean (indicated by misfiring, loss of speed and power, governor hunting, or excessive throttle opening).	Low idle fuel mixture is improperly adjusted.	Adjust low idle fuel needle (some models).
	Float level is set too low.	Adjust float according to steps outlined in repair kit installation instructions.
	Idle holes plugged; dirt in fuel delivery channels.	Remove low idle fuel adjusting needle. Clean main fuel jet and all passages; blow out with compressed air.
Fuel leaks from carburetor.	Float level set too high.	Adjust float according to steps outlined in repair kit installation instructions.
	Dirt under fuel inlet needle.	Remove needle; clean needle and seat and blow with compressed air.
	Bowl vents plugged.	Blow out with compressed air.
	Carburetor bowl gasket leaks.	Replace gasket.

## Fuel Shut-off Solenoid

Most carburetors are equipped with a fuel shut-off solenoid. Solenoid is attached to fuel bowl. Solenoid has a spring-loaded pin that retracts when 12 volts is applied to lead, allowing fuel flow to main jet. When current is removed, pin extends blocking fuel flow.

Below is a simple test, performed with engine off, that can determine if solenoid is functioning properly:

1. Shut off fuel and remove solenoid from carburetor. When solenoid is loosened and removed, gas will leak out of carburetor. Have a container ready to catch fuel.
2. Wipe tip of solenoid with a shop towel or blow with compressed air to remove any remaining fuel. Take solenoid to a location with good ventilation and no fuel vapors present. You will also need a 12 volt power source that can be switched on and off.
3. Be sure power source is switched OFF. Connect positive power source lead to red lead of solenoid. Connect negative power source lead to solenoid body.
4. Turn power source ON and observe pin in center of solenoid. Pin should retract with power ON and return to its original position with power OFF. Test several times to verify operation.

## Carburetor Circuits

### Float

Fuel level in bowl is maintained by float and fuel inlet needle. Buoyant force of float stops fuel flow when engine is at rest. When fuel is being consumed, float will drop and fuel pressure will push inlet needle away from seat, allowing more fuel to enter bowl. When demand ceases, buoyant force of float will again overcome fuel pressure, rising to predetermined setting and stop flow.

## Slow and Mid-Range

At low speeds engine operates only on slow circuit. As a metered amount of air is drawn through slow air bleed jets, fuel is drawn through main jet and further metered through slow jet. Air and fuel are mixed in body of slow jet and exit to idle progression (transfer port) chamber. From idle progression chamber, air fuel mixture is metered through idle port passage. At low idle air/fuel mixture is controlled by setting of idle fuel adjusting screws. This mixture is then mixed with main body of air and delivered to engine. As throttle plate opening increases, greater amounts of air/fuel mixture are drawn in through fixed and metered idle progression holes. As throttle plate opens further, vacuum signal becomes great enough at venturi so main circuit begins to work.

## Main (high-speed)

At high speeds/loads engine operates on main circuit. As a metered amount of air is drawn through air jet, fuel is drawn through main jet. Air and fuel are mixed in main nozzles then enters main body of airflow where further mixing of fuel and air occurs. This mixture is then delivered to combustion chamber. Carburetor has a fixed main circuit; no adjustment is possible.

## Carburetor Adjustments

NOTE: Carburetor adjustments should be made only after engine has warmed up.

Carburetor is designed to deliver correct fuel-to-air mixture to engine under all operating conditions. Main fuel jet is calibrated at factory and is not adjustable. Idle fuel adjusting needles are also set at factory and normally do not need adjustment.

## Low Idle Speed (RPM) Adjustment

NOTE: Actual low idle speed depends on application. Refer to equipment manufacturer's recommendations. Low idle speed for basic engines is 1200 RPM.

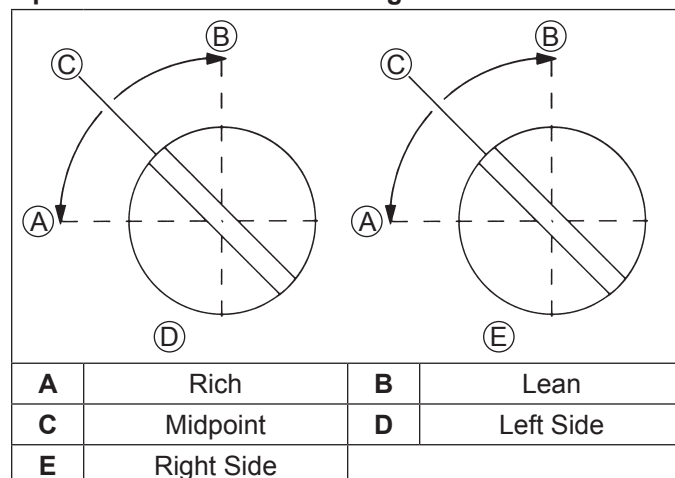
Place throttle control into idle or slow position. Turn low idle speed adjusting screw in or out to obtain allow idle speed of 1200 RPM ( $\pm 75$  RPM).

## Governed Idle Speed Adjustment (If equipped)

1. Hold governor lever away from carburetor so throttle lever is against idle speed (RPM) adjustment screw of carburetor. Start engine and allow to warm up, then adjust screw to set approximately 1200 RPM. Check speed using a tachometer. Turn adjustment screw (inner) clockwise (in) to increase or counterclockwise (out) to decrease speed.
2. Release governor lever and check that throttle lever is in idle position. Turn governed idle adjustment screw to obtain equipment manufacturer's recommended idle speed (1500-1800 RPM). Some engines have a bendable tab that is used to set this speed. A pliers should be used to bend this tab to achieve recommended speed. Governed idle speed (RPM) is typically 300 RPM (approximate) higher than low idle speed.
3. Move throttle lever to wide-open/full throttle position and hold in this position. Turn high speed screw to obtain intended high speed no-load RPM. Governed idle speed must be set before making this adjustment.

## Low Idle Fuel Adjustment

### Optimum Low Idle Fuel Setting



NOTE: Engines will have fixed low idle or limiter caps on idle fuel adjusting needles. Step 2 can only be performed within limits allowed by cap. Do not attempt to remove limiter caps.


1. Place throttle control into idle or slow position. Adjust low idle speed to 1200 RPM. Follow Low Idle Speed (RPM) Adjustment.
2. Low idle fuel needle(s) setting: place throttle into idle or slow position.
  - a. Turn 1 low idle fuel adjusting needle out (counterclockwise) from preliminary setting until engine speed decreases (rich). Note position of needle. Now turn adjusting needle in (clockwise). Engine speed may increase, then it will decrease as needle is turned in (lean). Note position of needle. Set adjusting needle midway between rich and lean settings.
  - b. Repeat procedure on other low idle adjustment needle (two-barrel carburetor only).
3. Recheck/adjust Low Idle Speed (RPM) to specified setting.

## High Speed (RPM) Adjustment

1. With engine running, move throttle control to fast.
2. Turn inner adjustment screw outward to decrease, or inward to increase RPM speed. Courage singles require loosening screws on speed control bracket and sliding towards carburetor to lower and away from carburetor to increase speed.

# Fuel System

## Carburetor Servicing

	<b>⚠ WARNING</b>
	Explosive Fuel can cause fires and severe burns. Do not fill fuel tank while engine is hot or running.
Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent.	

NOTE: Main and slow jets are fixed and size specific and can be removed if required. Fixed jets for high altitudes are available.

- Inspect carburetor body for cracks, holes, and other wear or damage.
  - Inspect float for cracks, holes, and missing or damaged float tabs. Check float hinge and shaft for wear or damage.
  - Inspect fuel inlet needle and seat for wear or damage.
  - Inspect spring loaded choke plate to make sure it moves freely on shaft.
1. Perform removal procedures for appropriate air cleaner and carburetor outlined in Disassembly.
  2. Clean exterior surfaces of dirt or foreign material before disassembling carburetor. Remove bowl retaining screws, or solenoid assembly on most single cylinder engines, and carefully separate fuel bowl from carburetor. Do not damage fuel bowl O-rings. Transfer any remaining fuel into an approved container. Save all parts. Fuel can also be drained prior to bowl removal by loosening/removing bowl drain screw.
  3. Remove float pin (some carburetors may have a screw which requires removal), and inlet needle. Seat for inlet needle is not serviceable and should not be removed.
  4. Clean carburetor bowl and inlet seat areas as required.
  5. Carefully remove main jets from carburetor. For two-barrel carburetors, note and mark jets by location for proper reassembly. Main jets may be size/side specific. After main jets are removed, on some carburetors, main nozzles can be removed through bottom of main towers. Note orientation/direction of nozzles. End with 2 raised shoulders should be out/down adjacent to main jets. Save parts for cleaning and reuse.
  6. Position of slow jet varies and is removable only on some styles of carburetors. See correct illustration for corresponding style of carburetor showing location. (On two-barrel carburetors, slow jets may be sized to specific side. Mark or tag jets for proper reassembly. Note small O-ring on bottom of each jet.) Save parts for cleaning and reuse unless a jet kit is also being installed. Clean slow jets using compressed air. Do not use wire or carburetor cleaner.

Carburetor is now disassembled for appropriate cleaning and installation of parts in overhaul kit. See instructions provided with repair kits for more detailed information.

## High Altitude Operation

Engines may require a high altitude carburetor kit to ensure correct engine operation at altitudes above 1219 meters (4000 ft.). To obtain high altitude kit information or to find a Kohler authorized dealer visit [KohlerEngines.com](http://KohlerEngines.com) or call 1-800-544-2444 (U.S. and Canada).

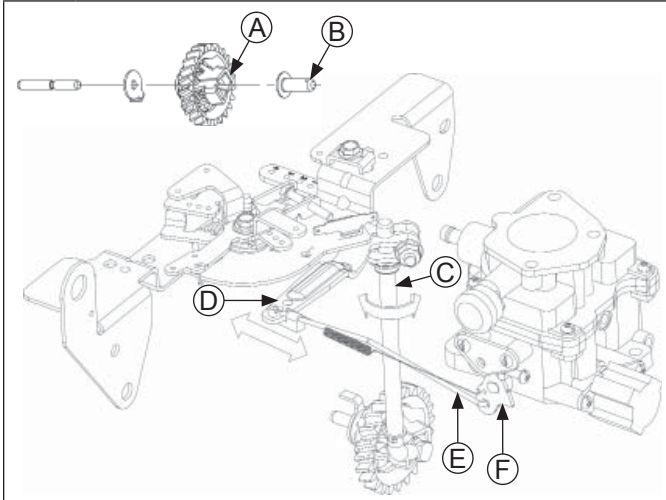
This engine should be operated in its original configuration below 1219 meters (4000 ft.) as damage may occur if high altitude carburetor kit is installed and operated below 1219 meters (4000 ft.).



## GOVERNOR

Engine is equipped with a centrifugal flyweight mechanical governor. It is designed to hold engine speed constant under changing load conditions. Governor gear/flyweight mechanism is mounted inside closure plate and is driven off gear on camshaft.

### Governor Components



<b>A</b>	Flyweight	<b>B</b>	Regulating Pin
<b>C</b>	Cross shaft	<b>D</b>	Governor Lever
<b>E</b>	Throttle Linkage	<b>F</b>	Throttle Lever

- Centrifugal force acting on rotating governor gear assembly causes flyweights to move outward as speed increases. Governor spring tension moves them inward as speed decreases.
- As flyweights move outward, they cause regulating pin to move outward.
- Regulating pin contacts tab on cross shaft causing shaft to rotate.
- One end of cross shaft protrudes through crankcase. Rotating action of cross shaft is transmitted to throttle lever of carburetor through external linkage.
- When engine is at rest, and throttle is in fast position, tension of governor spring holds throttle plate open. When engine is operating, governor gear assembly is rotating. Force applied by regulating pin, against cross shaft, tends to close throttle plate. Governor spring tension and force applied by regulating pin balance each other during operation, to maintain engine speed.
- When load is applied and engine speed and governor gear speed decreases, governor spring tension moves governor arm to open throttle plate wider. This allows more fuel into engine, increasing engine speed. As speed reaches governed setting, governor spring tension and force applied by regulating pin will again offset each other to hold a steady engine speed.

### Governor Adjustments

**NOTE:** Do not tamper with governor setting. Overspeed is hazardous and could cause personal injury.

#### Initial Adjustment Procedure

Make this adjustment whenever governor lever is loosened or removed from cross shaft.

1. Make sure throttle linkage is connected to governor lever and throttle lever on carburetor.
2. Loosen hex nut holding governor lever to cross shaft.
3. Move governor lever towards carburetor as far as it will move (wide open throttle) and hold in position.
4. Insert a nail into hole on cross shaft and rotate shaft counterclockwise as far as it will turn, then torque hex nut to 6.8 N·m (60 in. lb.).

#### Sensitivity Adjustment

Governor sensitivity is adjusted by repositioning governor spring in holes on governor lever. If speed surging occurs with a change in engine load, governor is set too sensitive. If a big drop in speed occurs when normal load is applied, governor should be set for greater sensitivity.

1. To increase sensitivity, move spring closer to governor cross shaft.
2. To decrease sensitivity, move spring away from governor cross shaft.

#### High Speed RPM Adjustment

**NOTE:** When throttle and choke control cables are routed side-by-side, especially under a single clamp, there must be a small gap between cables to prevent internal binding. After high-speed setting has been complete, check that there is gap of at least 0.5 mm (0.020 in.) between control cables.

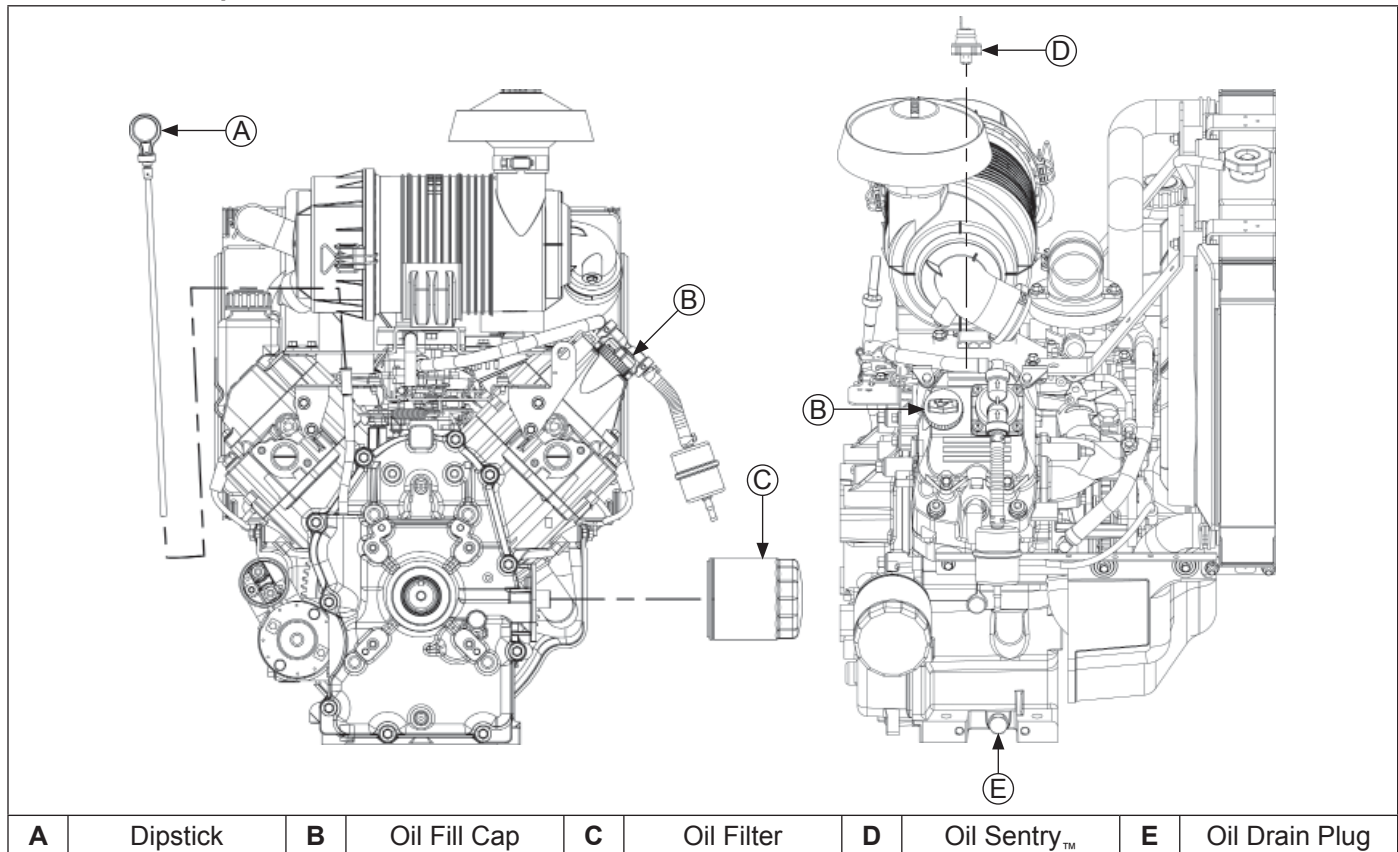
1. With engine running, move throttle control to fast. Use a tachometer to check RPM speed.
2. Loosen lock nut on high speed adjusting screw. Turn screw outward to decrease, or inward to increase RPM speed. Check RPM with a tachometer.
3. When desired RPM speed is obtained, retighten lock nut.

# Lubrication System

This engine uses a full pressure lubrication system. This system delivers oil under pressure to crankshaft, camshaft and connecting rod bearing surfaces. In addition to lubricating bearing surfaces, lubrication system supplies oil to hydraulic valve lifters.

A high-efficiency gerotor pump is located in closure plate. Oil pump maintains high oil flow and oil pressure, even at low speeds and high operating temperatures. A pressure relief valve in closure plate limits maximum pressure of system.

## Lubrication Components



### OIL RECOMMENDATIONS

Refer to Maintenance.

#### CHECK OIL LEVEL

**NOTE:** To prevent extensive engine wear or damage, never run engine with oil level below or above operating range indicator on dipstick.

Ensure engine is cool. Clean oil fill/dipstick areas of any debris.

1. Remove dipstick; wipe oil off.
2. Reinsert dipstick into tube; press completely down.
3. Remove dipstick; check oil level. Level should be at top of indicator on dipstick.
4. If oil is low on indicator, add oil up to top of indicator mark.
5. Reinstall and secure dipstick.

### CHANGE OIL AND FILTER

Change oil while engine is warm.

1. Clean area around oil fill cap/dipstick, drain plug/oil drain valve. Remove drain plug and oil fill cap/dipstick. Allow oil to drain completely.
2. Clean area around oil filter. Place a container under filter to catch any oil and remove filter. Wipe off mounting surface. Reinstall drain plug. Torque to 13.6 N·m (10 ft. lb.).
3. Place new filter in shallow pan with open end up. Fill with new oil until oil reaches bottom of threads. Allow 2 minutes for oil to be absorbed by filter material.
4. Apply a thin film of clean oil to rubber gasket on new filter.
5. Refer to instructions on oil filter for proper installation.
6. Fill crankcase with new oil. Level should be at top of indicator on dipstick.
7. Reinstall oil fill cap/dipstick and tighten securely.
8. Start engine; check for oil leaks. Stop engine; correct leaks. Recheck oil level.

9. Dispose of used oil and filter in accordance with local ordinances.

## **OIL SENTRY™ (if equipped)**

This switch is designed to prevent engine from starting in a low oil or no oil condition. Oil Sentry™ may not shut down a running engine before damage occurs. In some applications this switch may activate a warning signal. Read your equipment manuals for more information.

Oil Sentry™ pressure switch is installed in breather cover. On engines not equipped with Oil Sentry™ installation hole is sealed with a 1/8-27 N.P.T.F. pipe plug.

## **Installation**

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1. Apply pipe sealant with Teflon® (Loctite® PST® 592™ Thread Sealant or equivalent) to threads of switch.
2. Install switch into tapped hole in closure plate.
3. Torque switch to 4.5 N·m (40 in. lb.).

## **Testing**

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Compressed air, a pressure regulator, pressure gauge, and a continuity tester are required to test switch.

1. Connect continuity tester across blade terminal and metal case of switch. With 0 psi pressure applied to switch, tester should indicate continuity (switch closed).
2. Gradually increase pressure to switch. As pressure increases through range of 3-5 psi tester should indicate a change to no continuity (switch open). Switch should remain open as pressure is increased to 90 psi maximum.
3. Gradually decrease pressure through range of 3-5 psi. Tester should indicate a change to continuity (switch closed) down to 0 psi.
4. Replace switch if it does not operate as specified.

# Electrical System

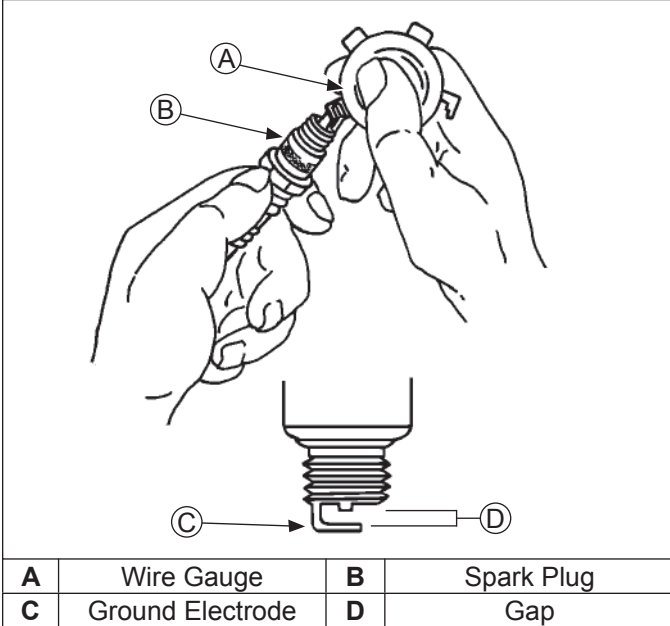
## SPARK PLUGS



### ⚠ CAUTION

Electrical Shock can cause injury.  
Do not touch wires while engine is running.

### Spark Plug Component and Details



<b>A</b>	Wire Gauge	<b>B</b>	Spark Plug
<b>C</b>	Ground Electrode	<b>D</b>	Gap

**NOTE:** Do not clean spark plug in a machine using abrasive grit. Some grit could remain in spark plug and enter engine causing extensive wear and damage.

Engine misfire or starting problems are often caused by a spark plug that has improper gap or is in poor condition.

Engine is equipped with following spark plugs:

Gap	0.76 mm (0.03 in.)
Thread Size	14 mm
Reach	19.1 mm (3/4 in.)
Hex Size	15.9 mm (5/8 in.)

Refer to Maintenance for Repairs/Service Parts.

### Service

Clean out spark plug recess. Remove plug and replace.

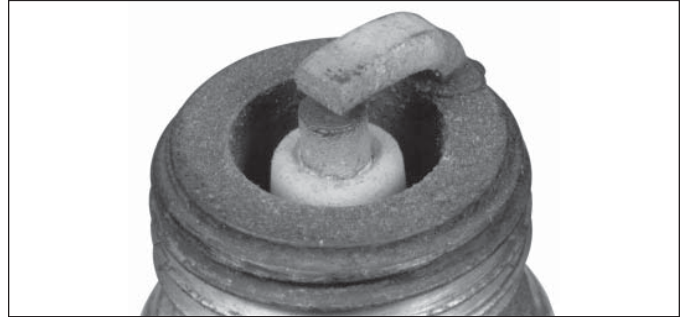
1. Check gap using wire feeler gauge. Adjust gap to 0.76 mm (0.03 in.).
2. Install plug into cylinder head.
3. Torque plug to 27 N·m (20 ft. lb.).

### Inspection

Inspect each spark plug as it is removed from cylinder head. Deposits on tip are an indication of general condition of piston rings, valves, and carburetor.

Normal and fouled plugs are shown in following photos:

### Normal



Plug taken from an engine operating under normal conditions will have light tan or gray colored deposits. If center electrode is not worn, plug can be set to proper gap and reused.

### Worn



On a worn plug, center electrode will be rounded and gap will be greater than specified gap. Replace a worn spark plug immediately.

### Wet Fouled



A wet plug is caused by excess fuel or oil in combustion chamber. Excess fuel could be caused by a restricted air cleaner, a carburetor problem, or operating engine with too much choke. Oil in combustion chamber is usually caused by a restricted air cleaner, a breather problem, worn piston rings, or valve guides.

## Carbon Fouled



Soft, sooty, black deposits indicate incomplete combustion caused by a restricted air cleaner, over rich carburetion, weak ignition, or poor compression.

## Overheated



Chalky, white deposits indicate very high combustion temperatures. This condition is usually accompanied by excessive gap erosion. Lean carburetor settings, an intake air leak, or incorrect spark timing are normal causes for high combustion temperatures.

## BATTERY

A 12-volt battery with 400 cold cranking amps (cca) is generally recommended for starting in all conditions. A smaller capacity battery is often sufficient if an application is started only in warmer temperatures. Refer to following table for minimum capacities based on anticipated ambient temperatures. Actual cold cranking requirement depends on engine size, application, and starting temperatures. Cranking requirements increase as temperatures decrease and battery capacity shrinks. Refer to equipment's operating instructions for specific battery requirements.

### Battery Size Recommendations

Temperature	Battery Required
Above 32°F (0°C)	200 cca minimum
0°F to 32°F (-18°C to 0°C)	250 cca minimum
-5°F to 0°F (-21°C to -18°C)	300 cca minimum
-10°F (-23°C) or below	400 cca minimum

If battery charge is insufficient to turn over engine, recharge battery.

### Battery Maintenance

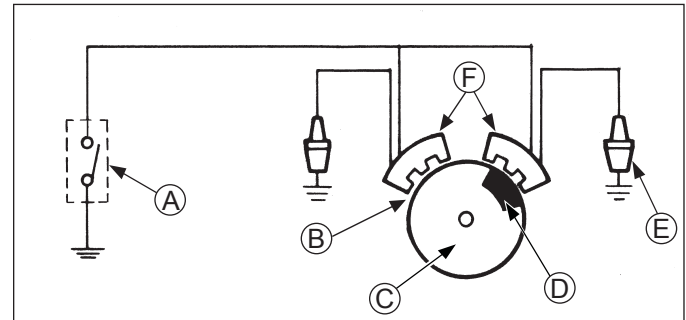
Regular maintenance is necessary to prolong battery life.

### Battery Test

To test battery, follow manufacturer's instructions.

## ELECTRONIC IGNITION SYSTEMS

### Ignition System Components



A	Kill Switch/ Off Position of Key Switch	B	Air Gap
C	Flywheel	D	Magnet
E	Spark Plug	F	Ignition Modules

These engines are equipped with a capacitive discharge (CD) coil.

This ignition system is designed to be trouble free for life of engine. Other than periodically checking/replacing spark plugs, no maintenance or timing adjustments are necessary or possible. Mechanical systems do occasionally fail or break down. Refer to Troubleshooting to determine root of a reported problem.

Reported ignition problems are most often due to poor connections. Before beginning test procedure, check all external wiring. Be certain all ignition-related wires are connected, including spark plug leads. Be certain all terminal connections fit snugly. Make sure ignition switch is in run position.

Ignition timing and spark remains constant regardless of engine speed. Timing of spark is controlled by location of flywheel magnet group as referenced to engine TDC. A typical fixed ignition system consists of:

- 1 magnet assembly which is permanently affixed to flywheel.
- 2 electronic capacitive-discharge ignition modules which mount on engine crankcase.
- 1 kill switch (or key switch) which grounds modules to stop engine.
- 2 spark plugs.



## Electrical System

<b>A</b>	Accessory (Yellow)	<b>B</b>	Battery (Red)	<b>C</b>	Starter (Blue/Red)	<b>D</b>	Run (Red)
<b>E</b>	Ignition Kill (White)	<b>F</b>	Key Switch Ground (Black)	<b>G</b>	Ground	<b>H</b>	Starter
<b>I</b>	Battery	<b>J</b>	Accessory	<b>K</b>	Key Switch	<b>L</b>	Ignition Kill
<b>M</b>	Run	<b>N</b>	Yellow	<b>O</b>	Connector	<b>P</b>	Starter Solenoid Stud
<b>Q</b>	Starter Solenoid Tang	<b>R</b>	Starter Assembly	<b>S</b>	Fuse	<b>T</b>	Red
<b>U</b>	Black	<b>V</b>	White	<b>W</b>	Carburetor	<b>X</b>	Intake Manifold Screw
<b>Y</b>	Ground (Black)	<b>Z</b>	Oil Sentry™ Light	<b>AA</b>	Carburetor Solenoid	<b>AB</b>	Regulator Rectifier (15 Amp)
<b>AC</b>	Regulator Connector	<b>AD</b>	AC	<b>AE</b>	B+	<b>AF</b>	Stator AC (White)
<b>AG</b>	Purple	<b>AH</b>	Regulator Rectifier (25 Amp)	<b>AI</b>	Blower Housing Safety Switch	<b>AJ</b>	Spark Plug(s)
<b>AK</b>	Ignition Module(s)	<b>AL</b>	Flywheel Stator Assembly	<b>AM</b>	Coolant Temp. Switch	<b>AN</b>	Oil Pressure Switch
<b>AO</b>	Orange	<b>AP</b>	Coolant Temp. Gauge	<b>AQ</b>	Coolant Temp. Over-heat Alarm	<b>AR</b>	Blue
<b>AS</b>	Accessory Terminal (+)						

### Electronic Ignition Systems Tests

#### Special Tools Required:

NOTE: Ignition tester must be used to test ignition on these engines. Use of any other tester can result in inaccurate findings. Battery on unit must be fully charged and properly connected before performing tests (a battery that is hooked up or charged backward will crank engine but it won't have spark). Be certain drive is in neutral and all external loads are disconnected.

- Hand tachometer.
- Ignition tester.
- Automotive timing light.
- Multi-meter (digital).

#### Specifications Required:

- 0.76 mm (0.03 in.).

#### Test Ignition Systems

NOTE: If engine starts or runs during testing, you may need to ground kill lead to shut it down. Because you have interrupted kill circuit, it may not stop using switch.

Isolate and verify trouble is within engine.

1. Locate connectors where wiring harnesses from engine and equipment are joined. Separate connectors and remove white kill lead from engine connector. Rejoin connectors and position or insulate kill lead terminal so it cannot touch ground. Try to start engine to verify whether reported problem is still present.

Condition	Possible Cause	Conclusion
Problem goes away.	Electrical System	Check key switch, wires, connections, safety interlocks, etc.
Problem persists.	Ignition or Electrical System	Leave kill lead isolated until all testing is completed.  Identify white kill lead of engine wiring harness connector. Establish a connection to a known good ground location. Engine should kill completely. If not or only one cylinder is affected, test ignition modules and white kill lead connection.

# Electrical System

## Test for Spark

NOTE: If 2 testers are available, testing can be performed simultaneously for both cylinders. However, if only 1 tester is available, 2 individual tests must be performed. Side not being tested must have spark plug lead connected or grounded. Do not crank engine or perform tests with 1 spark plug lead disconnected and not grounded, or permanent system damage may occur.

1. With engine stopped, disconnect 1 spark plug lead. Connect spark plug lead to post terminal of spark tester and attach tester clip to a good engine ground.
2. Crank engine over, establishing a minimum of 550-600 RPM, and observe tester(s) for spark.
3. Repeat spark test on opposite cylinder if cylinders are being tested individually.

Condition	Possible Cause	Conclusion
Both cylinders have good spark but engine runs poorly or existing plug condition is questionable.	Spark Plug(s)	Install new spark plug(s) and retest engine performance.
1 cylinder has good spark and other cylinder has no or intermittent spark.	Ignition	Test ignition modules and connections.
No spark at either cylinder.	Ignition Switch	Recheck position of ignition switch and shorted kill lead.

## BATTERY CHARGING SYSTEM

NOTE: Observe following guidelines to avoid damage to electrical system and components:

- Make sure battery polarity is correct. A negative (-) ground system is used.
- Disconnect rectifier-regulator plug and/or wiring harness plug before doing any electric welding on equipment powered by engine. Disconnect all other electrical accessories in common ground with engine.
- Prevent stator (AC) leads from touching or shorting while engine is running. This could damage stator.

NOTE: 20 amp charging systems use a 15 amp stator with a 25 amp rectifier-regulator.

Most engines are equipped with a 15, 20, or 25 amp regulated charging system.

### 15/20/25 Amp Regulated Charging System

#### Stator

Stator is mounted on crankcase behind flywheel. Follow procedures in Disassembly and Reassembly if stator replacement is necessary.

#### Rectifier-Regulator

NOTE: When installing rectifier-regulator, take note of terminal positions and install plug correctly.

NOTE: Disconnect all electrical connections attached to rectifier-regulator. Testing may be performed with rectifier-regulator mounted or loose. Repeat applicable test procedure 2 or 3 times to determine condition of part.

Rectifier-regulator is mounted on backing shroud assembly. To replace it, disconnect plug, remove mounting screws, and ground lead.

Testing rectifier-regulator may be performed as follows, using appropriate rectifier-regulator tester.

To test 20/25 amp rectifier-regulators:

1. Connect single lead adapter in between B+ (center) terminal of rectifier-regulator being tested and squared single end of tandem adapter lead.
2. Connect tester ground lead (with spring clamp) to body of rectifier-regulator.
3. Connect red lead and 1 black lead to terminals on open end of tandem adapter lead (connections are not location specific).
4. Connect remaining black lead from tester to 1 outer AC terminal on rectifier-regulator.

5. Plug tester into proper AC outlet/power for tester being used. Turn on power switch. POWER light should be illuminated and 1 of 4 status lights may be on as well. This does not represent condition of part.

6. Press TEST button until a click is heard and then release. Momentarily 1 of 4 lights will illuminate indicating partial condition of part.

To test 15 amp rectifier-regulators:

1. Connect tester ground lead (with spring clamp) to body of rectifier-regulator being tested.
2. Connect tester red lead to B+ terminal of rectifier-regulator and 2 black tester leads to 2 AC terminals.
3. Plug tester into proper AC outlet/power for tester being used. Turn on power switch. POWER light should be illuminated and 1 of 4 status lights may be on as well. This does not represent condition of part.
4. Press TEST button until a click is heard and then release. Momentarily 1 of 4 status lights will illuminate indicating condition of part.



Condition	Conclusion	
	20/25 amp	15 amp
OK (green) light comes on and stays steady.	Disconnect tester black lead attached to 1 AC terminal and reconnect it to other AC terminal. Repeat test. If OK (green) light comes on again, part is good and may be used.	Part is good and may be used.
NOTE: A flashing LOW light can also occur as a result of an inadequate ground lead connection. Make certain connection location is clean and clamp is secure.  Other lights come on.	Rectifier-regulator is faulty and should not be used.	

### 15/20/25 Amp Battery Charging Systems

NOTE: Always zero ohmmeter on each scale before testing to ensure accurate readings. Voltage tests should be made with engine running at 3600 RPM with no load. Battery must be good and fully charged.

When problems occur in keeping battery charged or battery charges at high rate, charging system or battery might be causing problems.

To test charging system for no charge to battery:

1. Insert an ammeter in B+ lead from rectifier-regulator. With engine running at 3600 RPM and B+ (at terminal on rectifier-regulator) to ground using a DC voltmeter.

If voltage is 13.8 volts or more, place a minimum load of 5 amps (turn on lights if 60 watts or more, or place a 2.5 ohm, 100 watt resistor across battery terminals) on battery to reduce voltage. Observe ammeter.

Condition	Conclusion
Charge rate increases when load is applied.	Charging system is OK and battery was fully charged.
Charge rate does not increase when load is applied.	Test stator and rectifier-regulator (steps 2 and 3).

2. Remove connector from rectifier-regulator. With engine running at 3600 RPM, measure AC voltage across stator leads using an AC voltmeter.

Condition	Conclusion
Voltage is 28 volts or more.	Stator is OK. Rectifier-regulator is faulty; replace.
Voltage is less than 28 volts.	Stator is faulty; replace. Test stator further using an ohmmeter (steps 3 and 4).

3. With engine stopped, measure resistance across stator leads using an ohmmeter.

Condition	Conclusion
Resistance is 0.064/0.2 ohms.	Stator is OK.
Resistance is 0 ohms.	Stator is shorted; replace.
Resistance is infinity ohms.	Stator is open; replace.

4. With engine stopped, measure resistance from each stator lead to ground using an ohmmeter.

Condition	Conclusion
Resistance is infinity ohms (no continuity).	Stator is OK (not shorted to ground).
Resistance (or continuity) measured.	Stator leads are shorted to ground; replace.

To test charging system for battery continuously charging at high rate:

1. With engine running at 3600 RPM, measure voltage from B+ lead to ground using a DC voltmeter.

Condition	Conclusion
Voltage is 14.7 volts or less.	Charging system is OK. Battery is unable to hold charge; service or replace.
Voltage is more than 14.7 volts.	Faulty rectifier-regulator; replace.

## Starter System

NOTE: Do not crank engine continuously for more than 10 seconds. Allow a 60 second cool down period between starting attempts. Failure to follow these guidelines can burn out starter motor.

NOTE: If engine develops sufficient speed to disengage starter but does not keep running (a false start), engine rotation must be allowed to come to a complete stop before attempting to restart engine. If starter is engaged while flywheel is rotating, starter pinion and flywheel ring gear may clash and damage starter.

NOTE: If starter does not crank engine, shut off starter immediately. Do not make further attempts to start engine until condition is corrected.

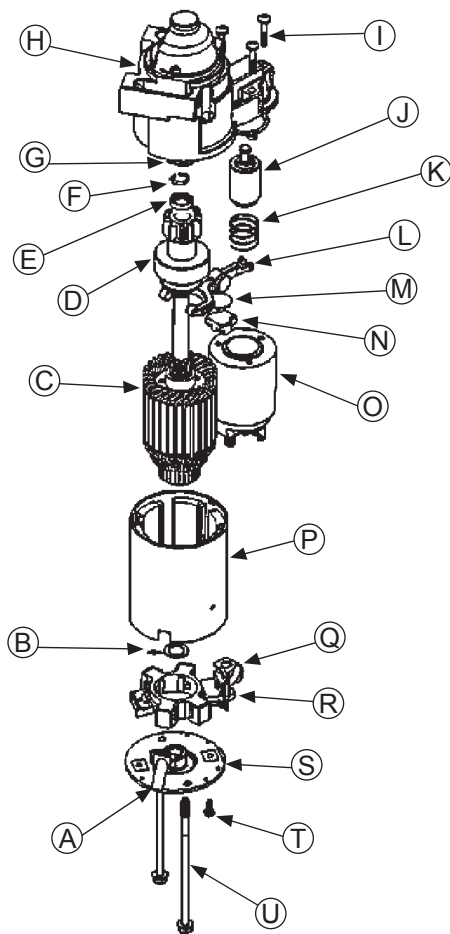
NOTE: Do not drop starter or strike starter frame. Doing so can damage starter.

Engines in this series use solenoid shift starters.

### Troubleshooting-Starting Difficulties

Condition	Possible Cause	Conclusion
Starter does not energize.	Battery	Check specific gravity of battery. If low, recharge or replace battery as necessary.
	Wiring	Clean corroded connections and tighten loose connections. Replace wires in poor condition and with frayed or broken insulation.
	Starter Switch or Solenoid	By-pass switch or solenoid with a jumper wire. If starter cranks normally, replace faulty components. Remove and perform individual solenoid test procedure.
Starter energizes but turns slowly.	Battery	Check specific gravity of battery. If low, recharge or replace battery as necessary.
	Brushes	Check for excessively dirty or worn brushes and commutator. Clean using a coarse cloth (not emery cloth). Replace brushes if excessively or unevenly worn.
	Transmission or Engine	Make sure clutch or transmission is disengaged or placed in neutral. This is especially important on equipment with hydrostatic drive. Transmission must be exactly in neutral to prevent resistance which could keep engine from starting. Check for seized engine components such as bearings, connecting rod, and piston.

## Solenoid Shift Starter Components



A	Tube	B	Washer
C	Armature	D	Drive
E	Stop	F	Retaining Ring
G	Collar	H	Drive End Cap
I	Screw	J	Plunger
K	Spring	L	Lever
M	Plate	N	Plug
O	Solenoid	P	Frame and Field
Q	Brush Holder	R	Nut
S	Commutator End Plate	T	Screw
U	Bolt		

When power is applied to starter electric solenoid moves drive pinion out onto drive shaft and into mesh with flywheel ring gear. When pinion reaches end of drive shaft it rotates flywheel and cranks engine.

When engine starts and start switch is released, starter solenoid is deactivated, drive lever moves back, and drive pinion moves out of mesh with ring gear into retracted position.

## Starter Disassembly

NOTE: Do not reuse old retainer.

NOTE: Do not soak armature or use solvent when cleaning. Wipe clean using a soft cloth, or use compressed air.

1. Remove hex nut and disconnect positive (+) brush lead/bracket from solenoid terminal.
2. Remove screws securing solenoid to starter.
3. Unhook plunger pin from drive lever. Remove gasket from recess in housing.
4. Remove thru (larger) bolts.
5. Remove commutator end plate assembly, containing brush holder, brushes, springs, and locking caps. Remove thrust washer from inside commutator end.
6. Remove frame from armature and drive end cap.
7. Remove drive lever pivot bushing and backing plate (if equipped) from end cap.
8. Take out drive lever and pull armature out of drive end cap.
9. Remove thrust washer from armature shaft.
10. Push stop collar down to expose retaining ring.
11. Remove retainer from armature shaft. Save stop collar.
12. Remove drive pinion assembly from armature.
13. Clean parts as required.

## Inspection

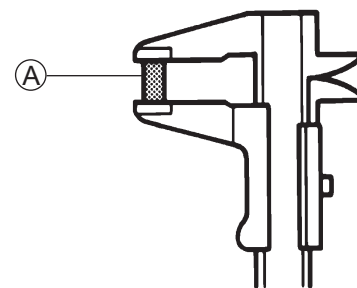
### Drive Pinion

Check and inspect following areas:

- Pinion teeth for abnormal wear or damage.
- Surface between pinion and clutch mechanism for nicks or irregularities which could cause seal damage.
- Check drive clutch by holding clutch housing and rotating pinion. Pinion should rotate in only 1 direction.

## Brushes and Springs

### Detail

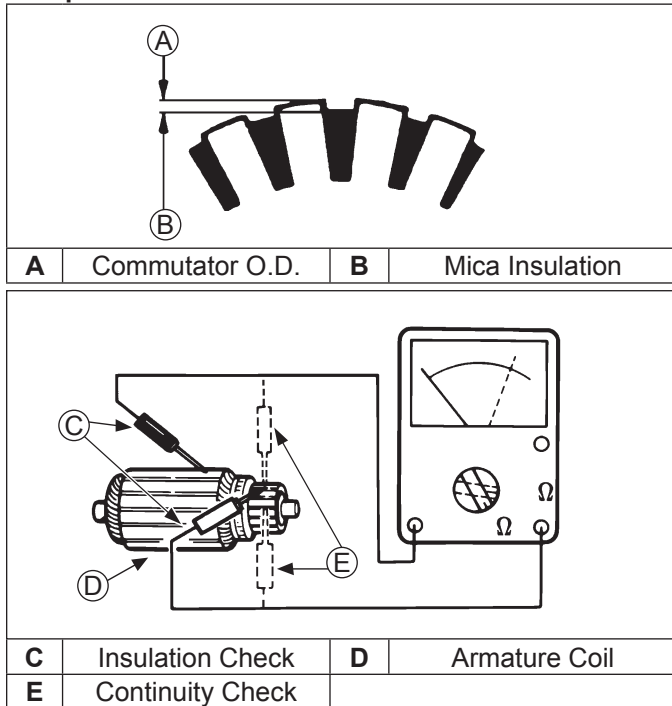


A Wear Limit Length

Inspect both springs and brushes for wear, fatigue, or damage. Measure length of each brush. Minimum length for each brush is 7.6 mm (0.300 in.). Replace brushes if they are worn, undersize, or condition is questionable.

# Starter System

## Armature Components and Details



1. Clean and inspect commutator (outer surface). Mica insulation must be lower than commutator bars (undercut) to ensure proper operation of commutator.
2. Use an ohmmeter set to Rx1 scale. Touch probes between 2 different segments of commutator, and check for continuity. Test all segments. Continuity must exist between all or armature is bad.
3. Check for continuity between armature coil segments and commutator segments. There should be no continuity. If continuity exists between any 2 armature is bad.
4. Check armature windings/insulation for shorting.

### Shift Fork

Check that shift fork is complete, and pivot and contact areas are not excessively worn, cracked, or broken.

### Brush Replacement

4 brushes and springs are serviced as a set. Use a new Kohler brush and spring kit if replacement is necessary.

1. Perform steps 1-5 in Starter Disassembly.
2. Remove screws securing brush holder assembly to end cap (plate). Note orientation for reassembly later. Discard old brush holder assembly.
3. Clean component parts as required.
4. New brushes and springs come preassembled in a brush holder with a protective sleeve that will also serve as an installation tool.
5. Perform steps 10-13 in Starter Reassembly sequence. If starter has been disassembled, installation must be done after armature, drive lever, and frame are installed.

## Starter Reassembly

NOTE: Always use a new retainer. Do not reuse old retainers that have been removed.

NOTE: Correctly installed, center pivot section of drive lever will be flush or below machined surface of housing.

1. Apply drive lubricant to armature shaft splines. Install drive pinion onto armature shaft.
2. Install and assemble stop collar/retainer assembly.
  - a. Install stop collar down onto armature shaft with counter bore (recess) up.
  - b. Install a new retainer in larger (rear) groove of armature shaft. Squeeze with a pliers to compress it in groove.
  - c. Slide stop collar up and lock it into place, so recess surrounds retainer in groove. If necessary, rotate pinion outward on armature splines against retainer to help seat collar around retainer.
3. Install offset thrust (stop) washer so smaller offset of washer faces retainer/collar.
4. Apply a small amount of oil to bearing in drive end cap, and install armature with drive pinion.
5. Lubricate fork end and center pivot of drive lever with drive lubricant. Position fork end into space between captured washer and rear of pinion.
6. Slide armature into drive end cap and at same time seat drive lever into housing.
7. Install rubber grommet into matching recess of drive end cap. Molded recesses in grommet should be out, matching and aligned with those in end cap.
8. Install frame, with small notch forward, onto armature and drive end cap. Align notch with corresponding section in rubber grommet. Install drain tube in rear cutout, if it was removed previously.
9. Install flat thrust washer onto commutator end of armature shaft.
10. Starter reassembly when replacing brushes/brush holder assembly:

- a. Hold starter assembly vertically on end housing, and carefully position assembled brush holder assembly, with supplied protective tube, against end of commutator/armature. Mounting screw holes in metal clips must be up/out. Slide brush holder assembly down into place around commutator, and install positive (+) brush lead grommet in cutout of frame. Protective tube may be saved and used for future servicing.

Starter reassembly when not replacing brushes/brush holder assembly:

- a. Carefully unhook retaining caps from brush assemblies. Do not lose springs.
- b. Position brushes back in their slots so they are flush with I.D. of brush holder assembly. Insert brush installation tool (with extension), or use tube described above from a prior brush installation, through brush holder assembly, so holes in metal mounting clips are up/out.

- c. Install brush springs and snap on retainer caps.
  - d. Hold starter assembly vertically on end housing, and carefully place tool (with extension) and assembled original brush holder assembly onto end of armature shaft. Slide brush holder assembly down into place around commutator, install positive (+) brush lead grommet in cutout of frame.
11. Install end cap onto armature and frame, aligning thin raised rib in end cap with corresponding slot in grommet of positive (+) brush lead.
  12. Install thru bolts and brush holder mounting screws. Torque bolts to 5.6-9.0 N·m (49-79 in. lb.) and brush holder mounting screws to 2.5-3.3 N·m (22-29 in. lb.).
  13. Hook plunger behind upper end of drive lever and install spring into solenoid. Insert mounting screws through holes in drive end cap. Use these to hold solenoid gasket in position, then mount solenoid. Torque screws to 4.0-6.0 N·m (35-53 in. lb.).
  14. Connect positive (+) brush lead/bracket to solenoid and secure with nut. Torque nut to 8-11 N·m (71-97 in. lb.). Do not overtighten.

## Solenoid Tests

NOTE: DO NOT leave 12 volt test leads connected to solenoid for any time over what is necessary for performing each of individual tests. Internal damage to solenoid may occur.

Disconnect all leads from solenoid including positive brush lead attached to lower stud terminal. Remove mounting hardware and separate solenoid from starter for testing.

To test solenoid pull-in coil/plunger:

Actuation

1. Use a 12 volt power supply and 2 test leads.
2. Connect 1 lead to flat spade S/start terminal on solenoid. Momentarily connect other lead to lower large post terminal.

When connection is made solenoid should energize (audible click) and plunger retract. Repeat test several times.

Continuity

1. Use an ohmmeter set to audible or Rx2K scale, and connect 2 ohmmeter leads to 2 large post terminals.
2. Perform solenoid pull-in coil/plunger actuation test and check for continuity. Ohmmeter should indicate continuity. Repeat test several times.

To test solenoid hold-in coil:

Function


1. Connect a 12 volt test lead to flat spade S/start terminal on solenoid and other lead to body or mounting surface of solenoid.
2. Manually push plunger IN and check if coil holds plunger retracted. Do not allow test leads to remain connected to solenoid for a prolonged period of time.

Continuity

1. Use an ohmmeter set to audible or Rx2K scale, and connect 2 ohmmeter leads to 2 large post terminals.
2. Perform preceding solenoid hold-in coil function test and check for continuity. Meter should indicate continuity. Repeat test several times.

Condition	Conclusion
Solenoid fails to activate.	Replace solenoid.
No continuity is indicated.	
Plunger fails to stay retracted.	

# Cooling System

	<b>⚠ WARNING</b>	Liquid coolant can get extremely hot from operation. Turning radiator cap when engine is hot can allow steam and scalding liquid to blow out and burn you severely. Shut off machine. Only remove radiator cap when cool enough to touch with bare hands. Slowly loosen cap to first stop to relieve pressure before removing completely.
	Hot liquid can cause severe burns. Do not loosen radiator cap while engine is operating or warm to touch.	

When it is necessary to open cooling system at radiator cap, shut off engine and remove filler cap only when cool enough to touch with bare hands. Slowly loosen cap to first stop to relieve pressure before removing completely.

This section covers operation and servicing of liquid cooling system.

## Cooling System Components

Cooling system consists of these following components:

- Radiator with removable screen
- Hoses
- Coolant Pump and Belt
- Thermostat
- Intake Manifold with Thermostat Housing
- Radiator Cap
- Cooling Fan, Belt, and Drive Pulleys
- Overflow Reservoir
- Crankcase and Heads with Integral Cooling Passages

## Operation

Engine coolant is pumped through cooling system by a pump, belt-driven off camshaft. Coolant coming out of pump is divided, and moves simultaneously through separate circuits within each head and corresponding sides of crankcase. As coolant moves through these passages, it absorbs heat from engine parts. After traveling through engine, coolant from two separate circuits merges and moves through intake manifold to lower side of thermostat. During warm-up, thermostat is closed, preventing circulation through radiator. Coolant circulates through engine only and is returned to pump via bypass hose. When engine heat brings coolant up to a temperature of 79.4°C (175°F), thermostat will begin to open, allowing coolant to circulate through upper hose to radiator. Thermostat is completely open at 90.5°C (195°F) allowing full coolant flow through radiator, where it is cooled. After getting cooled in radiator, coolant is drawn into pump through lower radiator hose and circulation starts all over again. A cooling fan, driven off flywheel by a belt, draws ambient air through radiator, to maintain cooling process.

Coolant will provide protection from -37°C (-34°F) to 108°C (226°F). For protection and use outside indicated temperature limits, follow antifreeze manufacturer's instructions on container, but do not exceed 70% antifreeze.

DO NOT use antifreeze with stop-leak additive(s), or put any other additives in cooling system.

## Cooling System Maintenance and Service

### Maintenance

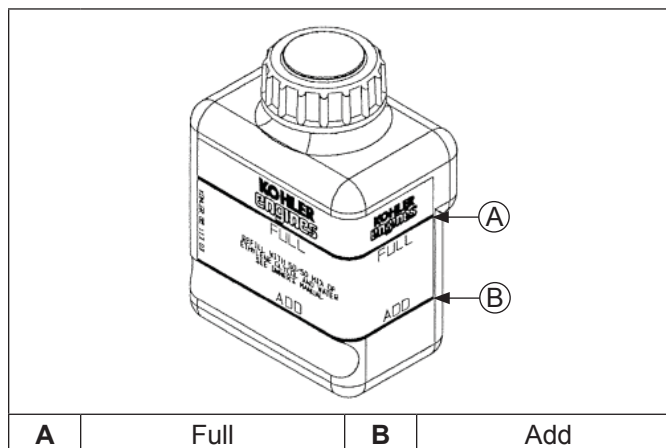
Maintaining correct coolant level, cleaning any debris accumulation from radiator surfaces, and insuring all parts are in proper operating condition, is critical to ensuring long life, proper system performance and preventing overheating. To ensure proper air circulation, make sure radiator, cooling fan, drive belt, pulleys, cooling fins, and external surfaces of engine are kept clean and in good condition at all times. Check coolant level and clean away any debris accumulation daily or before each use. Simultaneously inspect hoses and all system connections for signs of leakage. Make sure cooling fan is not cracked or missing any blades. Check that fan belt and two drive pulleys, are in good condition and proper belt tension is present.

### Service

Lift screen vertically to remove for cleaning/servicing. Clean screen and cooling fins of radiator with a soft brush or blow out using clean compressed air. To avoid damage to screen and cooling fins, do not use a high pressure washer to clean.

## Checking Coolant Level

### Overflow Reservoir Details



**NOTE:** Do not operate engine without coolant in system. Do not remove radiator cap when hot. Engine coolant is hot and under pressure and can cause severe burns. To prevent engine overheating and damage, do not exceed more than 70% antifreeze in cooling system.

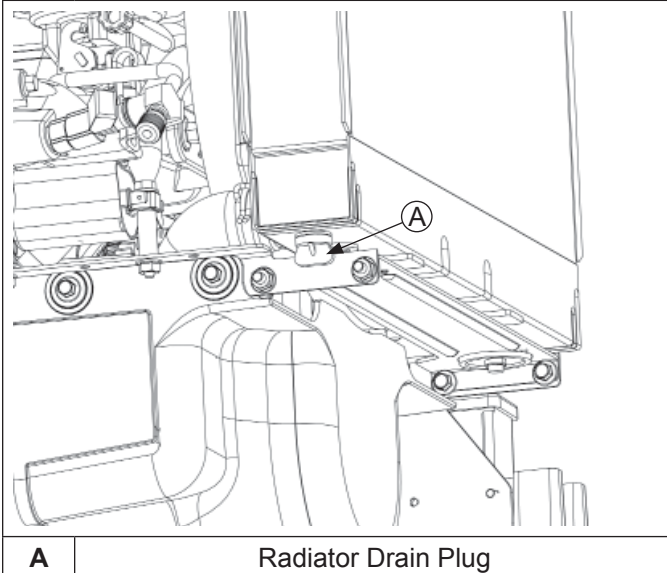
Coolant level should be checked at overflow reservoir, located behind radiator on fan shroud.

1. Check coolant level within overflow reservoir. Coolant level should be between FULL and ADD marks on reservoir. Do not operate engine with coolant level below ADD mark.

Add coolant to overflow reservoir as required, which is a 50/50 mixture of ethylene glycol and water (distilled or deionized water is recommended).

## Drain Cooling System

### Radiator Drain Plug Details



**A** Radiator Drain Plug

1. Ensure engine is cool. When radiator is cool to touch, slowly loosen radiator cap to first stop and allow any pressure to bleed off. Then loosen it fully and remove it.  
Loosen/remove radiator drain plug and allow coolant to drain.
2. If equipped, remove coolant drain plugs located on each side of engine block. Drain coolant into a suitable container. After coolant has drained completely, apply pipe sealant with Teflon® (Loctite® PST® 592™ or equivalent), to threads and reinstall plugs. Torque plugs to 36.7 N·m (325 in. lb.).
3. Remove overflow hose from reservoir. Unhook inboard retainer and slide reservoir out of supports. Pour out contents and wash or clean as required. Dispose of all old coolant in accordance with local ordinances.
4. Reinstall reservoir cap. Do not kink/pinch hose.
5. Flush cooling system.

### Flushing Cooling System

NOTE: To prevent engine damage, do not pour water into a hot engine. Do not operate engine without coolant.

With system properly drained:

1. Fill cooling system with clean water and a cooling system cleaner recommended for aluminum engines. Follow directions on container.
2. Reinstall and tighten radiator cap.
3. Start and run engine for five minutes, or until it reaches operating temperature. Stop engine and allow it to cool.

4. Drain cooling system.
5. Fill cooling system.

### Filling Cooling System

NOTE: To prevent engine damage, do not use antifreeze mixture greater than 70% ethylene glycol in cooling system. Do not use antifreeze with stop-leak additive(s) or mix/add other additives to cooling system. Use only ethylene glycol antifreeze.

Cooling system capacity is approximately 2 liters (2.18 qt.).

1. Check condition of cooling system hoses, clamps, and associated components. Replace as required.
2. Fill with 2.0 L (2.1 U.S. qt.) equal parts of ethylene glycol (anti-freeze) and water only. Distilled or deionized water is recommended, especially in areas where water contains a high mineral content. Propylene glycol based anti-freeze is not recommended.
3. Fill radiator with coolant mixture. Allow coolant to drain into lower areas. Fill overflow reservoir to a level between FULL and ADD marks. Reinstall radiator and reservoir caps.
4. Start and run engine for five minutes. Stop engine and allow to cool.
5. Recheck coolant level in reservoir. Coolant level should be between FULL and ADD marks. Add coolant to reservoir if required.

### Inspection

#### Cooling Fan Assembly, Belt, and Drive Pulleys

Cooling fan assembly, used to draw air through radiator, is attached to a hub and pulley assembly with sealed ball bearings. This assembly is belt driven off flywheel, via a lower split pulley, and requires very little service or maintenance. DO NOT operate engine without fan and properly functioning cooling system or engine damage will occur.

1. Inspect fan for any cracks, damaged/missing fan blades, and secure mounting.
2. Bearings in hub of pulley should rotate smoothly, without roughness, binding, or play/wobble.
3. V-groove of each pulley (upper and lower) should not be bent, nicked, or damaged. Pulley mounting areas and lower pulley shims should be free of any cracks or elongation.
4. Drive belt is designed and constructed for this system. Do not use a substitute belt. Check overall condition and replace belt if cracked, damaged, or proper tension cannot be established by repositioning of lower pulley shims. Use only Kohler Part No. 66 203 02-S belt if replacement is necessary.  
See a Kohler authorized dealer for any necessary service.

# Cooling System

## Checking Fan Belt and Tension

Fan belt and belt tension should be checked daily or before each use. Fan belt should not be cracked, damaged, or exhibit excessive wear. Proper tension is 12.7 mm (3/8 - 1/2 in.) belt deflection per side under 10 lbs. applied tension.

If belt is cracked, damaged, or is worn that relocation of pulley shims cannot establish proper belt tension, belt should be replaced. Use only Kohler Part No. 66 203 02-S belt. DO NOT use a substitute belt.

For a new belt, assemble lower pulley with all three shims between pulley halves. For a used/original belt being reinstalled, assemble with two or one shim(s) between pulley halves and remaining shim(s) on outside (front) of outer pulley half. Check belt tension as described above.

When proper tension is obtained, individually remove each capscrew of lower pulley, apply Loctite<sup>®</sup> 242<sup>®</sup> to threads, and reinstall. Torque each capscrew in a criss-cross sequence to 24.5 N·m (215 in. lb.).

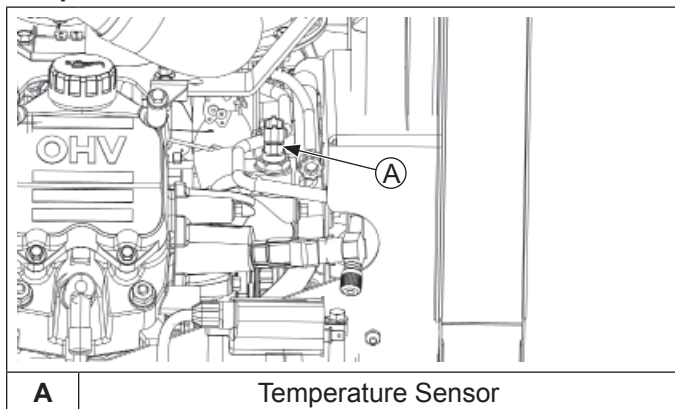
## Hoses and Tubes

Hoses and tubes are used to connect components within cooling system. To guard against coolant loss and hose failure, hoses, tubes and their connections should be checked regularly for leaks or damage. Loss of coolant can result in serious engine damage. Over time, engine vibration can affect hose/joint connections, and hoses themselves can be affected by heat and coolant. Swelling, hardening, and/or deterioration can occur depending on operating environment. Deterioration usually takes place more rapidly from inside, making outside inspections incomplete and not always dependable. Regular outside inspection and careful inside inspection whenever connections are opened, can minimize a possible in-service problem.

Use new clamps whenever a hose is replaced or a joint connection is opened. When making hose connections, a light coating of rubber lubricant will make assembly easier.

## Thermostat Testing and Servicing

### Temperature Sensor Details



Thermostat is mounted in intake manifold, beneath thermostat housing. It controls rapid warm-up and operating temperature of engine. If a problem is encountered which is thought to be fault of thermostat, it can be checked to determine its operating condition. Before removing and testing thermostat, make sure all other possible causes such as debris accumulation/obstruction, leaks, belt or fan failure, coolant level, and damaged components are eliminated as possible causes.

### To Test

Remove thermostat from system. Hang or suspend thermostat by its frame in a container of water, so thermostat does not touch bottom of container. Heat water and measure temperature (an oven thermometer can be used). Spring-loaded valve of thermostat should begin to open at 79.4°C (175°F), and can be completely open at 90°C (195°F). If valve opens at a temperature more than 10 degrees below specified opening or fails to open at a temperature 10 to 15 degrees above specified opening, thermostat should be replaced. If valve in thermostat can be moved or pushed off its seat with a slight effort when thermostat is cold, unit may be considered defective and should be replaced. Thermostat should be replaced if operation is found to be questionable or faulty.

### Installation

1. Thoroughly clean sealing surfaces of intake manifold and thermostat housing with an aerosol gasket remover. Make sure sealing surfaces are clean and free of nicks or damage. Make sure notch in intake manifold is clean.
2. Install a new thermostat into intake manifold, so larger spring end is down into well of intake manifold. Position a new thermostat gasket on intake manifold.
3. Install thermostat housing onto intake manifold.
4. Install and torque screws to 9.9 N·m (88 in. lb.).
5. Reconnect radiator hose and secure with hose clamp, if separated previously.

## High Temperature Sensor

A high temperature sensor may be mounted in intake manifold and is used to activate a warning light, audible alarm, or kill engine (depending on application), if safe operating temperature is exceeded. Sensor is a normally open switch which completes a circuit, when coolant temperature reaches rated temperature limit of switch. For these engines temperature sensor limit is 123.8°C (255°F).

If warning device activates, or engine kills, indicating an excessive operating temperature, check following:

1. Make sure fan belt is in good condition and properly tensioned.
2. Make sure cooling fan is properly secured, not broken, damaged, or missing blades.
3. Make sure all air intake and cooling surfaces are clean and free of debris accumulation.
4. After engine has sufficiently cooled, check coolant level in system to make sure it is not low, or improperly mixed.
5. Check cooling system for leaks.



6. Check thermostat, and pressure test radiator cap.
  7. Make sure water pump and drive belt are operational.
  8. Check and inspect wiring from sensor for shorting or damage.
- If none of those are found to be cause do following:
1. Drain coolant from system, so level is lower than installed position of temperature sensor.
  2. Remove and replace temperature sensor. Use pipe sealant with Teflon® on threads.
2. Remove dipstick and check appearance of oil in crankcase. Another method would be to remove an oil drain plug and drain a small amount of oil for inspection. A milky or an opaque color, similar to chocolate milk, indicates presence of engine coolant in oil. Check for a blown head gasket (step 3 below) or a possible crack or internal leakage from water jacket.
  3. Remove spark plugs. Apply 14-15 lbs. of pressure and listen/inspect for internal coolant leakage into cylinder/combustion chambers. This can denote a head gasket failure/leak. If required, further test by performing a Cylinder Leakdown Test as described in Troubleshooting.

## Cooling System Leakage Test

A pressure test of cooling system can be performed as a relatively simple means of determining whether cooling system may contain a leak. A pump/pressure type cooling system tester with appropriate 45 mm adapter may be used to check cooling system and radiator cap.

### Test Instructions

1. With engine cool, carefully remove radiator cap (see Pressure Radiator Cap). Make sure all parts of cap and adapter are clean. Install cap on corresponding adapter and make sure it is completely seated. Install adapter onto tester and lock in place.
2. Pressurize tester to 15 psi.
3. Observe indicated pressure. It should hold steady and not decrease or leak down.  
If leakage is detected, cap should be replaced. If tester pressure is increased to 16 psi, or above, cap should then bleed off this excess pressure.
4. Install and lock system adapter and tester onto neck of cooling system. Pressurize tester to 14-15 psi.
5. Observe system pressure on gauge.

### Gauge Needle Holds Steady

If gauge needle holds steady, there should be no serious leaks in system. It is however, recommended that all connections be checked for overall condition anyway, using a flashlight.

### Gauge Needle Drops Slowly

If gauge needle drops slowly it indicates presence of a small leak or seepage. Check all components and connections for signs of leakage. Check condition of radiator hoses. If they swell excessively while testing system, they may be weak and should be replaced.

### Gauge Needle Drops Quickly

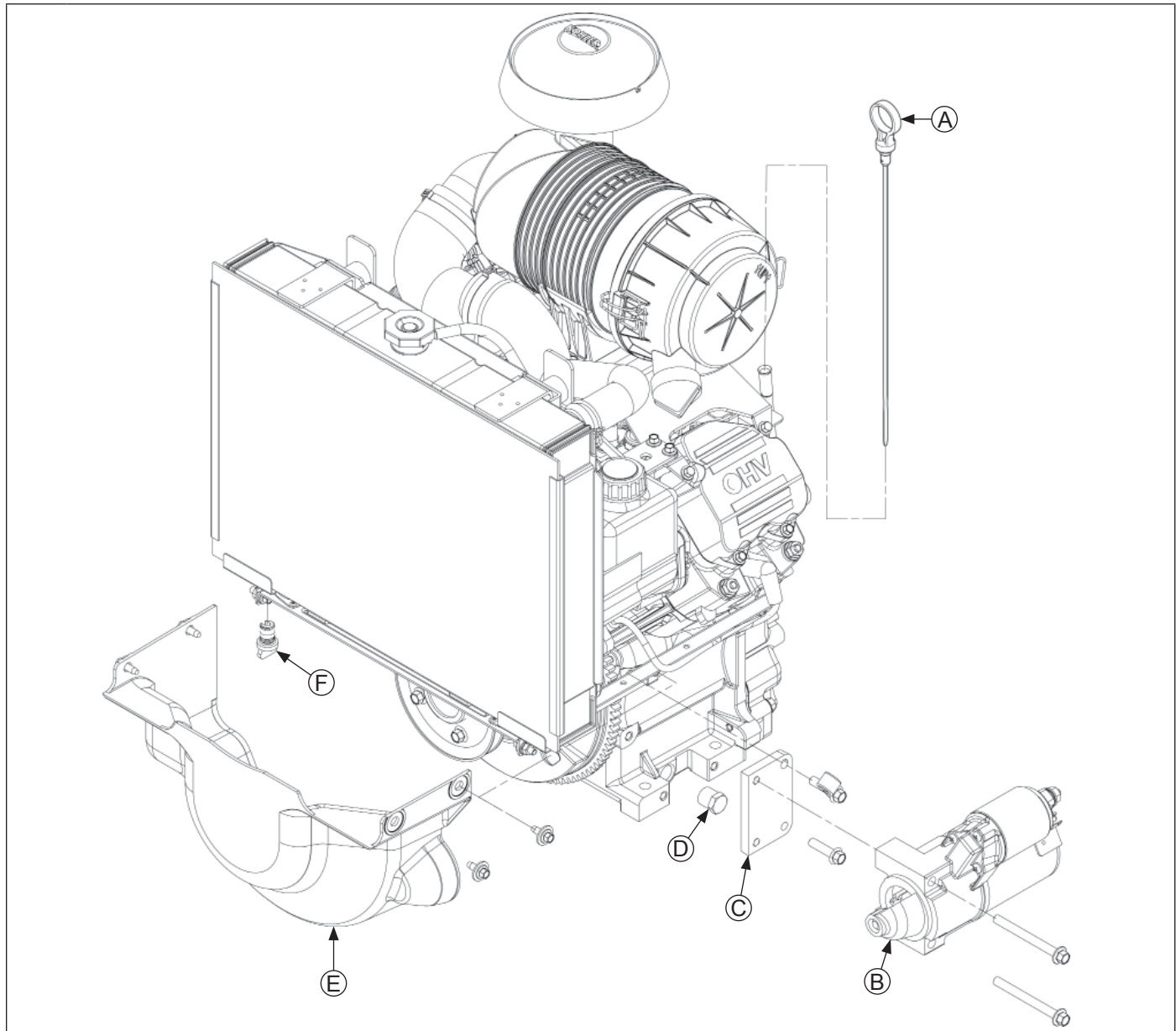
A steady drop or loss of pressure indicates serious leakage is occurring within system, which must be located and corrected before engine is returned to service.

If a pressure loss is noted:

1. With pressure on system, apply a soap/water solution and check all joint connections, hoses, and cooling system components for external leakage. Repair or replace as required.

# Disassembly/Inspection and Service

## External Engine Components



<b>A</b>	Dipstick	<b>B</b>	Electric Starter	<b>C</b>	Adapter Plate	<b>D</b>	Oil Drain Plug
<b>E</b>	Flywheel Cover	<b>F</b>	Radiator Drain Plug				

Clean all parts thoroughly as engine is disassembled. Only clean parts can be accurately inspected and gauged for wear or damage. There are many commercially available cleaners that will quickly remove grease, oil, and grime from engine parts. When such a cleaner is used, follow manufacturer's instructions and safety precautions carefully.

Make sure all traces of cleaner are removed before engine is reassembled and placed into operation. Even small amounts of these cleaners can quickly break down lubricating properties of engine oil.

### Disconnect Spark Plug Leads

**NOTE:** Pull on boot only, to prevent damage to spark plug lead.

1. Disconnect leads from spark plugs.
2. Shut off fuel supply.

### Remove Muffler

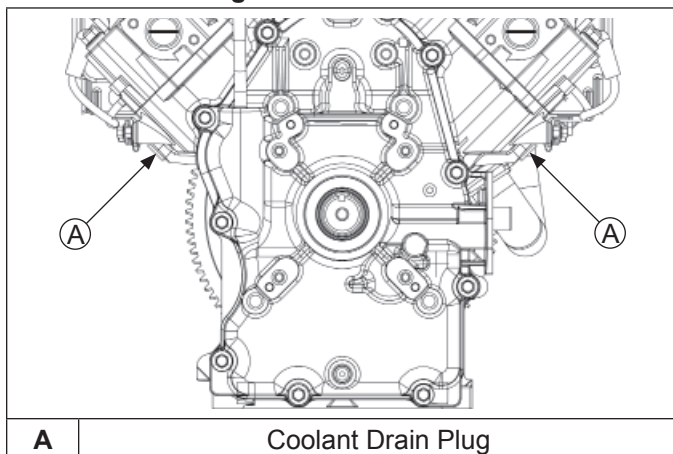
Remove exhaust system, muffler, and attaching hardware from engine.

## Remove Starter and Adapter Plate

1. Disconnect leads attached to starter solenoid terminals.
2. Remove screws securing starter to adapter plate.
3. Remove screws attaching adapter to crankcase. Note orientation of cutout. Upper screw may also secure a clamp for stator leads.

## Drain Coolant from Cooling System

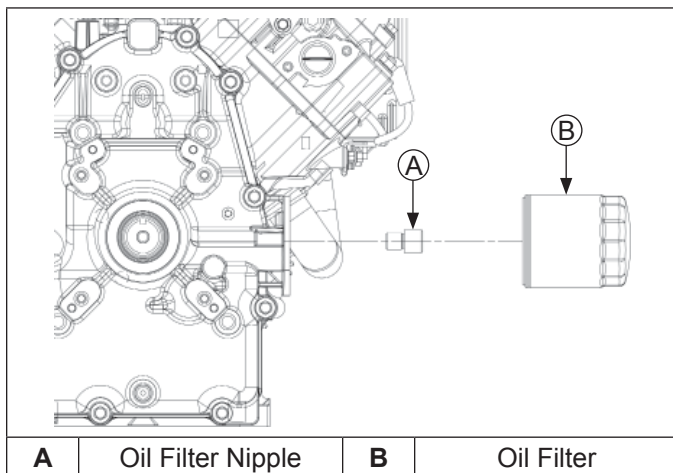
### Coolant Drain Plug Details



1. Loosen radiator cap, then loosen radiator drain plug and allow system to drain. Use a suitable container to catch coolant.
2. If equipped, remove coolant drain plugs on each side of block. Allow any remaining coolant to drain out. Dispose of coolant properly, according to local regulations.

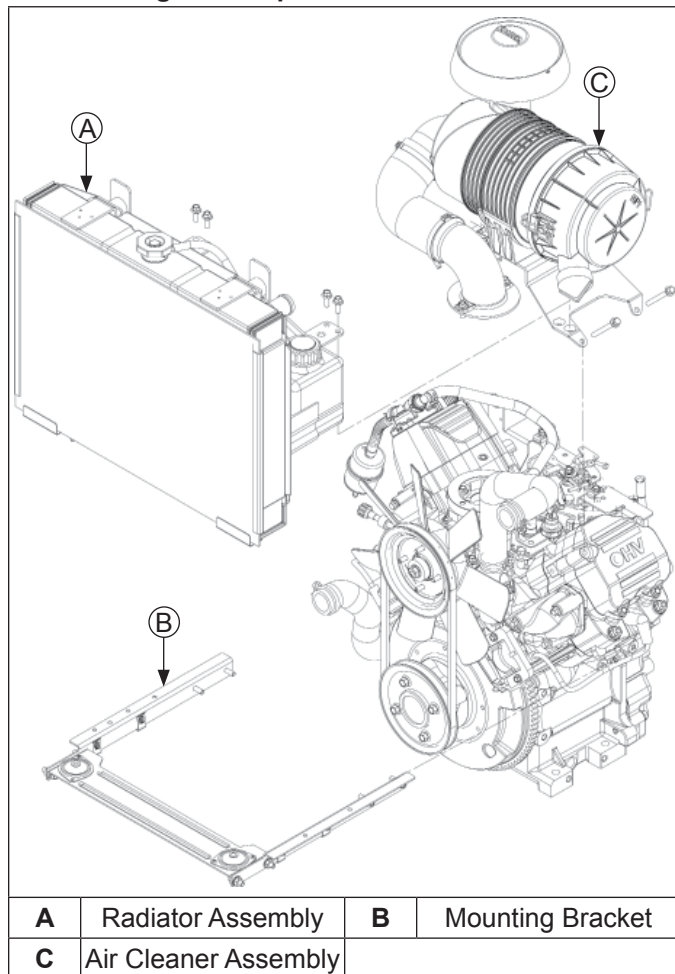
## Drain Oil from Crankcase and Remove Oil Filter

### Oil Filter Details



1. Remove oil fill cap and dipstick, and one or both drain plugs. Allow sufficient time for oil to drain out.
2. Remove and discard oil filter.

## External Engine Components



## Remove Flywheel Cover, Radiator Assembly, Mounting Brackets and Attached Components

NOTE: Do not allow cooling fins of radiator to contact fan blades.

1. Remove screws or nuts and flat washers (2 on each side) securing lower flywheel cover to LH and RH radiator support brackets. Mounting plate for rectifier-regulator will become detached when LH screws are removed. Do not lose small spacers located within holes of lower cover. Clips are used on some models instead of nuts.
2. If a pulse style fuel pump is used, disconnect fuel line from pump outlet, and disconnect pulse line from fuel pump fitting.
3. Disconnect upper radiator hose from radiator, and lower radiator hose from inlet of water pump.
4. Remove screws securing two upper radiator supports to air cleaner mounting bracket.
5. Carefully tilt (pull) radiator forward slightly to clear fan and lift complete assembly out of lower mounting bracket.
6. Disconnect connector plug from rectifier-regulator and remove mounting plate, with rectifier-regulator attached.

## Disassembly/Inspection and Service

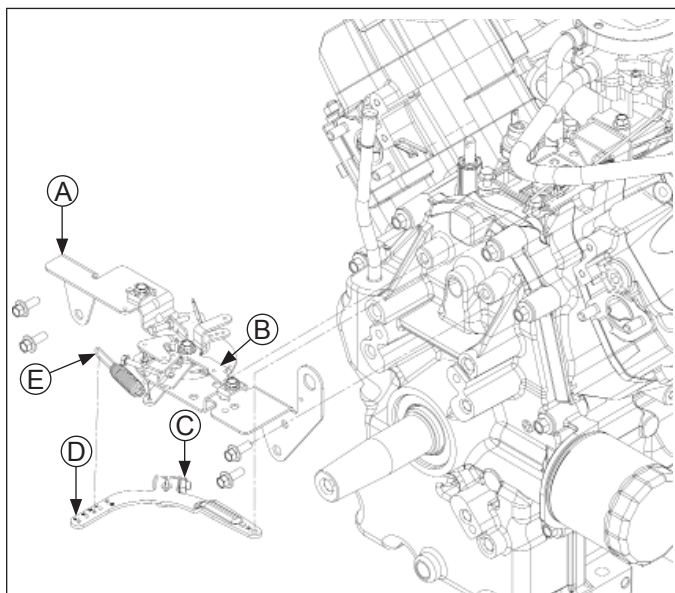
- Remove four screws securing LH and RH side mounting brackets to crankcase. Pull complete mount assembly forward to remove.
- Further disassembly for component servicing may be performed as required.

### Remove Air Cleaner Assembly

- Remove screws securing elbow adapter and gasket to carburetor.
- Remove upper valve cover mounting screws on each side, which also secure main mounting bracket for air cleaner.
- Lift air cleaner/mounting bracket assembly off engine.

### Remove Throttle and Choke Controls

#### Control Panel Details



<b>A</b>	Control Panel	<b>B</b>	Choke Lever
<b>C</b>	Governor Lever Nut	<b>D</b>	Governor Lever
<b>E</b>	Governor Spring		

- Remove screws securing main control bracket to cylinder heads.
- Mark hole location and disconnect governor spring from governor lever.
- Tilt main bracket and disconnect choke linkage from choke lever. Remove main control bracket.
- Unhook choke linkage from actuator lever on carburetor.

### Remove External Governor Controls

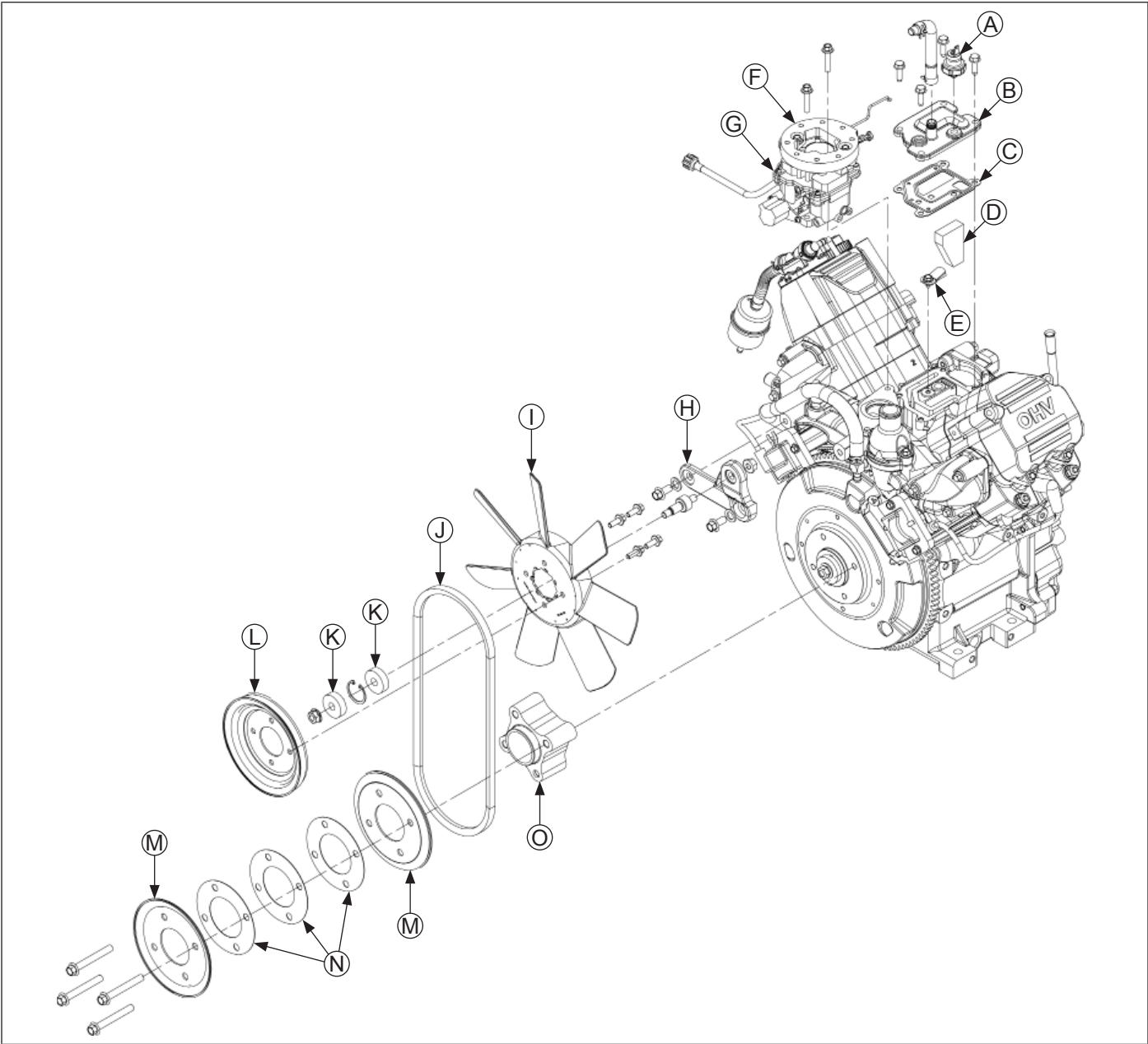
Loosen nut of governor lever mounting screw. Leave throttle linkage and spring connected to lever. Lift governor lever off governor shaft and lay assembly on top of crankcase, to be removed with carburetor.

### Remove Carburetor and Adapter

	<b>⚠ WARNING</b>
	<p>Explosive Fuel can cause fires and severe burns.</p> <p>Do not fill fuel tank while engine is hot or running.</p>
<p>Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent.</p>	

- Disconnect lead to fuel shut-off solenoid (if equipped). If a mechanical fuel pump is used, disconnect fuel line from carburetor inlet.
- Disconnect breather hose from adapter fitting on carburetor.
- Remove carburetor mounting screws. If a flexible tube and knob idle speed adjuster is used, open retaining clamp and unhook.
- Remove carburetor, throttle linkage and governor lever as an assembly.
- Remove carburetor gasket.
- Carburetor, adapter, throttle linkage, and governor lever may be separated for individual component servicing as required. If linkages are separated, reattach bushings to linkages to prevent them from being lost.

External Engine Components



<b>A</b>	Oil Sentry™	<b>B</b>	Breather Cover	<b>C</b>	Gasket	<b>D</b>	Fiber Filter
<b>E</b>	Breather Reed Assembly	<b>F</b>	Adapter Plate	<b>G</b>	Carburetor	<b>H</b>	Fan Mounting Bracket
<b>I</b>	Fan	<b>J</b>	Fan Belt	<b>K</b>	Bearing	<b>L</b>	Pulley
<b>M</b>	Pulley Half	<b>N</b>	Spacer Shims	<b>O</b>	Adapter		

# Disassembly/Inspection and Service

## Remove Oil Sentry™ (if equipped)

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Disconnect wire lead from Oil Sentry™ switch, and remove switch from breather cover.

## Remove Breather Cover

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1. Remove screws securing breather cover to crankcase.
2. Carefully pry under protruding edge of breather cover to separate and remove cover from gasket.  
Do not pry on sealing surfaces as it could cause damage resulting in leaks.
3. Remove breather gasket and fiber filter from breather chamber.
4. Remove screw, breather reed retainer and breather reed from breather chamber.

## Remove Lower Drive Pulley and Fan Belt

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1. Remove four screws attaching lower drive pulley assembly to pulley adapter and flywheel.
2. Remove pulley halves with spacer shims from adapter, and take fan belt off upper pulley/fan assembly. Note number of shims between pulley halves, and on front side of pulley, especially if same belt will be reinstalled.

## Remove Fan Assembly, Mounting Bracket, and Fan Shaft

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NOTE: Further disassembly of fan/hub and pulley assembly is not necessary unless a problem exists; see. If disassembly is performed, note assembly order and position of parts.

1. Remove front nut and washer securing fan assembly to fan shaft. Remove fan and pulley assembly from upper mounting bracket.
2. Remove screws and take off mounting bracket, with fan shaft attached.
3. Fan shaft may be removed from mounting bracket, by removing rear nut, if individual servicing of either part is required.

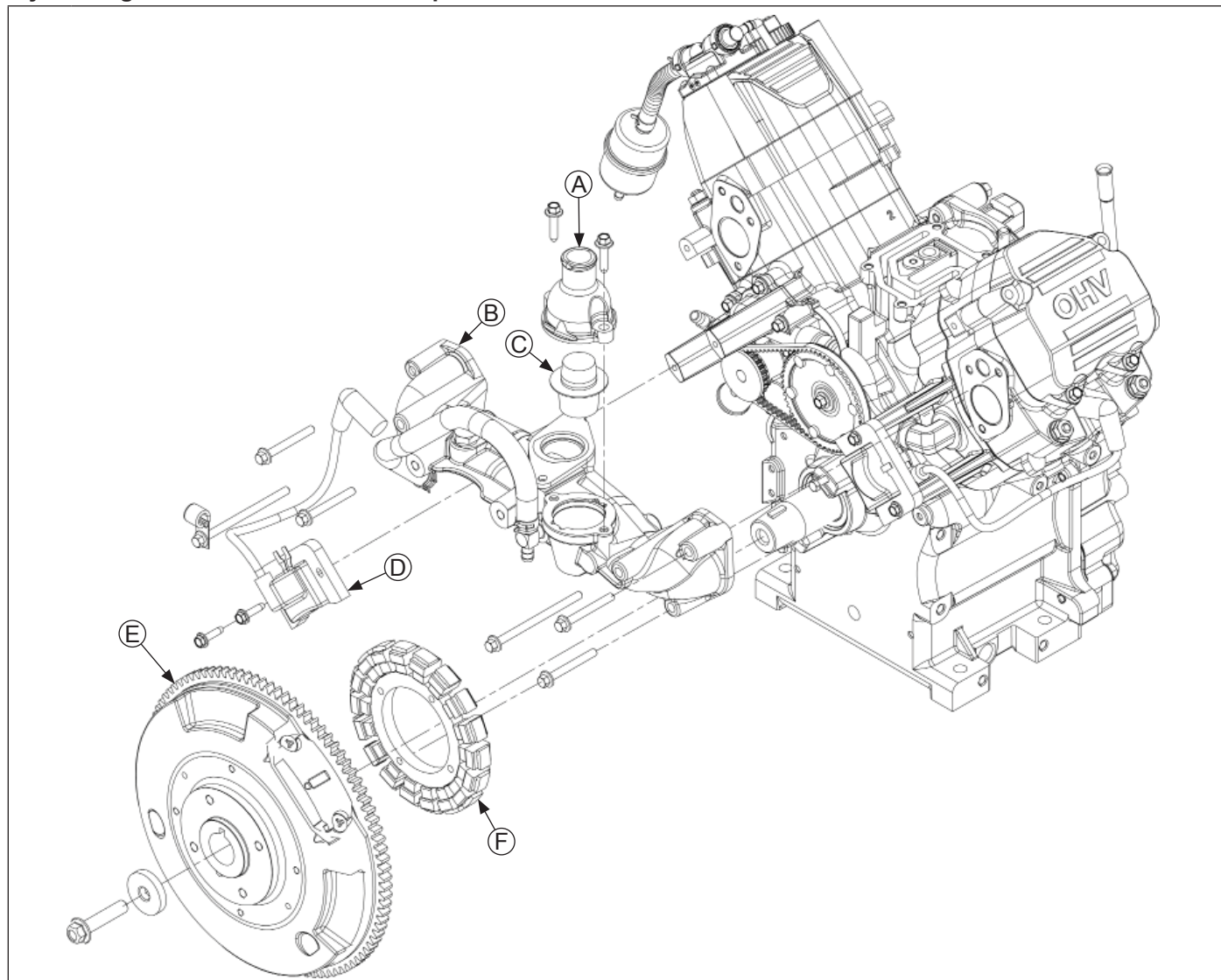
## Inspection and Service

Cooling fan assembly consists of a fan attached to a v-pulley and bearing carrier (hub), rotating on a dual ball-bearing fan shaft (arbor). Assembly is mounted with a bracket to intake manifold and driven via a split pulley off flywheel.

Inspect components carefully for signs of wear or damage.

1. Inspect fan to make sure blades are in good condition and free of any cracks, nicks, or damage. Area around fan mounting holes must also be free of any cracks or damage.
2. Fan and hub assembly, when mounted to center arbor shaft, must rotate smoothly without noticeable bearing play, wobble, or binding.
3. Check v-belt for excessive wear, cracking or damage. If proper belt tension cannot be obtained, or condition of belt is suspect; replace it with Kohler Part No. 66 203 02-S. Do not use a substitute belt.

## Flywheel/ignition/Intake Manifold Components



<b>A</b>	Thermostat Housing	<b>B</b>	Intake Manifold	<b>C</b>	Thermostat	<b>D</b>	Ignition Module
<b>E</b>	Flywheel	<b>F</b>	Stator				

### Remove Ignition Modules

1. Disconnect kill leads from ignition modules.
2. Rotate flywheel, so magnet is away from ignition modules.
3. Remove mounting screws and take off each ignition module.

### Remove Flywheel

**NOTE:** Always use a flywheel puller to remove flywheel from crankshaft. Do not strike crankshaft or flywheel, as these parts could become cracked or damaged.

1. Use a flywheel strap wrench or holding tool to hold flywheel. Remove screw and flat washer.
2. Use a puller to remove flywheel from crankshaft.
3. Remove woodruff key from crankshaft keyway.

### Inspection

Inspect flywheel for cracks, and flywheel keyway for damage. Replace flywheel if cracked. Replace flywheel, crankshaft, and key if flywheel key is sheared or keyway is damaged.

Inspect ring gear for cracks or damage. Kohler does not provide ring gears as a serviceable part. Replace flywheel if ring gear is damaged.

Check charging system magnets to be sure they are not loose or cracked.

### Remove Stator Assembly

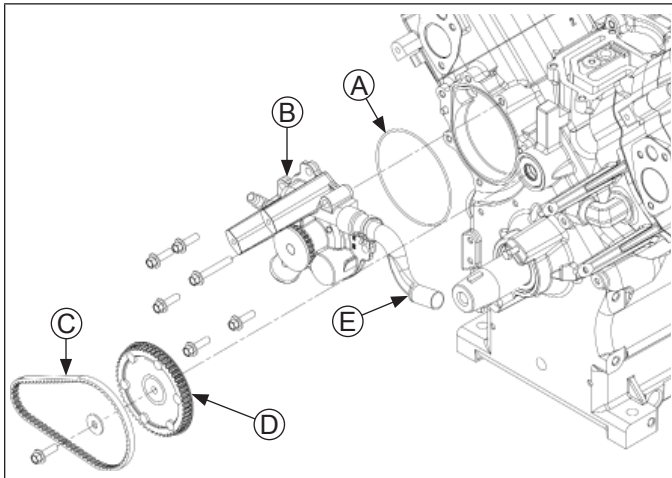
Remove mounting screws, and pull stator, with plug-in connector attached, from engine.

# Disassembly/Inspection and Service

## Remove Intake Manifold, Thermostat Housing, Bypass Hose and Wiring Harness

1. Disconnect by-pass hose from fitting on water pump.
2. Remove six mounting screws and carefully separate intake manifold from cylinder heads, with by-pass hose and wiring harness attached.
3. Remove intake manifold gaskets.
4. Further disassembly of intake manifold components may be performed as necessary. If thermostat is to be removed, loosen and remove screws securing thermostat housing to intake manifold. Separate housing and remove thermostat, discard old gasket.

## Water Pump Components



<b>A</b>	O-ring	<b>B</b>	Water Pump
<b>C</b>	Water Pump Belt	<b>D</b>	Camshaft Pulley
<b>E</b>	Transfer Tube		

## Remove Camshaft Pulley and Water Pump Belt

1. Remove screw and flat washer, securing cogged drive pulley to camshaft.
2. Carefully lift pulley off camshaft and remove belt from water pump pulley.
3. Remove camshaft key from keyway.

## Remove Water Pump and Transfer Tube

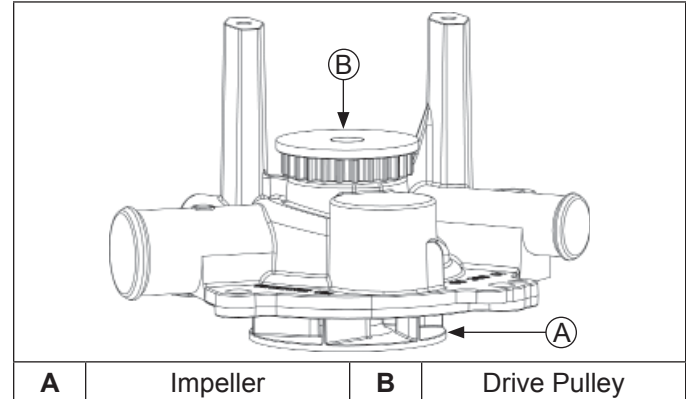
1. Loosen and unscrew hex cap section securing transfer tube to 90° fitting in crankcase. Support fitting with a wrench, when loosening hex cap section.
2. Remove screws securing water pump to crankcase.
3. Lift water pump up, and carefully work ferruled end of transfer tube out of fitting. Remove water pump with transfer tube and hose section attached. Remove and discard O-ring from within channel of pump housing.

4. Inspect and, if necessary, separate transfer tube and hose section from water pump. Remove hose clamps, noting their size differences and position of tangs.

**IMPORTANT:** 90° fitting in crankcase, which transfer tube is connected to, is sealed and installed at factory in a specific position. Do not loosen, remove, or alter mounted position of this fitting at any time. Contact factory service department for specific instructions if fitting is damaged, or its mounting is affected in any way.

## Inspection and Service

### Water Pump Details



Water/coolant pump consists of a sealed impeller assembly, which includes outer cover and a cogged drive pulley. When pump is mounted to crankcase, impeller fits into a cast recess, and cover seals against an O-ring outside perimeter of recess.

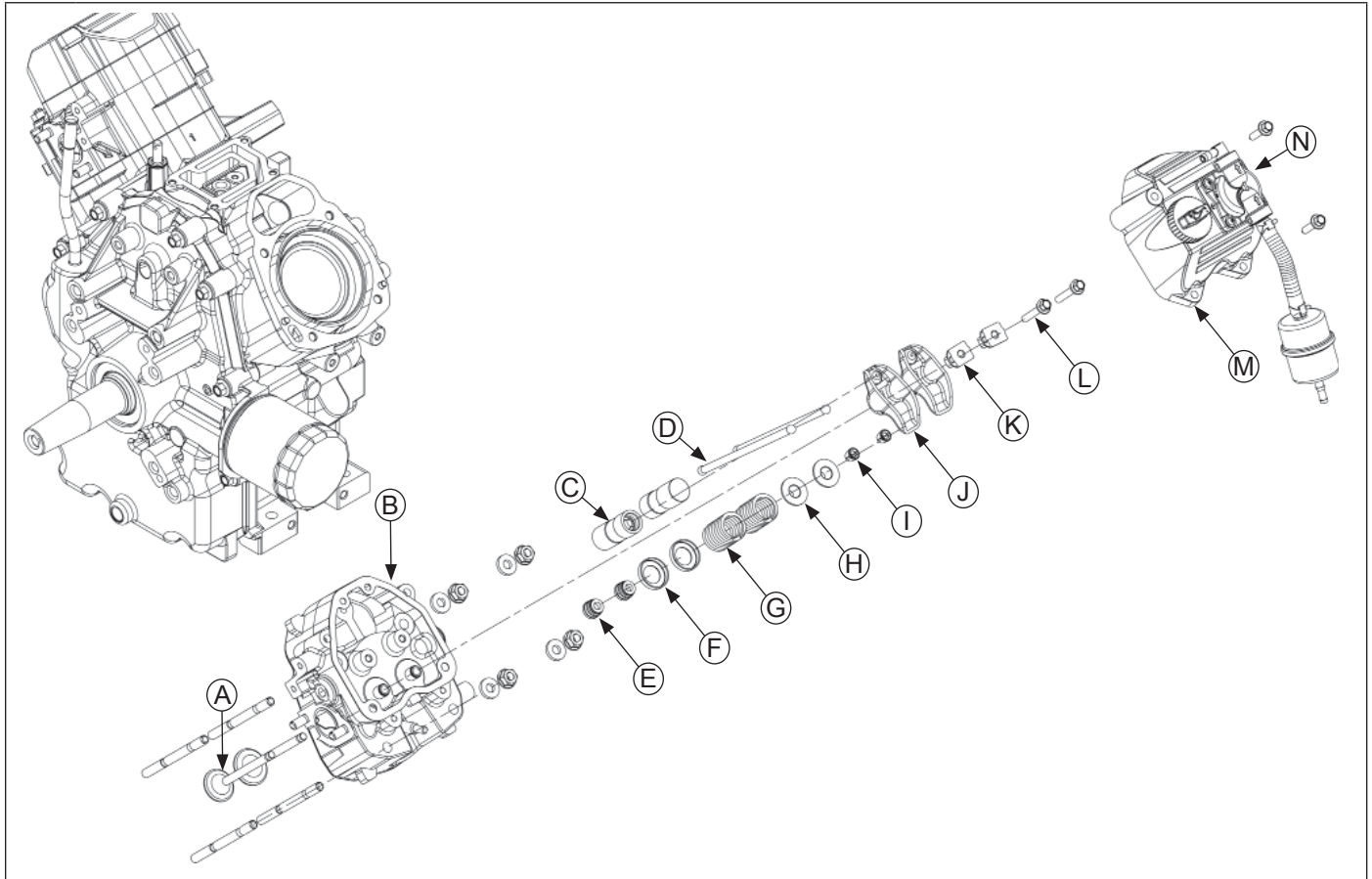
Impeller assembly is not serviceable, but it should be inspected for wear or damage.

1. Inspect impeller to make sure blades are in good condition and free of any cracks, nicks, or damage.
2. Impeller shaft should rotate smoothly, without binding or wobbling, and there should be no sign that coolant has leaked past shaft to outer surface of cover.
3. Check that drive pulley is not cracked or damaged in any way.

If your inspection causes you to doubt its reliability, water pump assembly should be replaced. Always use a new O-ring whenever water pump is removed. Do not reuse old O-ring or try to use RTV in its place.



## Cylinder Head Components



<b>A</b>	Valve	<b>B</b>	Head	<b>C</b>	Hydraulic Lifter	<b>D</b>	Push Rods
<b>E</b>	Valve Stem Seal	<b>F</b>	Valve Spring Cap	<b>G</b>	Spring	<b>H</b>	Valve Spring Retainers
<b>I</b>	Valve Spring Keepers	<b>J</b>	Rocker Arms	<b>K</b>	Rocker Arm Pivot	<b>L</b>	Rocker Arm Screw
<b>M</b>	Valve Cover	<b>N</b>	Fuel Pump				

### Remove Valve Covers

1. Remove screws from two lower valve cover mounting locations on each side.
2. Remove valve covers and valve cover gaskets. Note on which side oil fill or fuel pump is located, for correct reassembly later.

### Remove Spark Plugs

Remove spark plugs from cylinder heads using a spark plug socket.

### Remove Cylinder Heads and Valve Lifters

**NOTE:** It is not necessary to remove cylinder studs from crankcase unless replacement is intended. If studs are removed for any reason, discard old stud(s), do not reuse/reinstall. Use new studs and refer to assembly sequence for proper installation.

1. Rotate crankshaft of engine until valves of one cylinder are closed. Loosen rocker arm screws until rocker arms can be pivoted to free push rods.

2. Remove push rods and mark their location as either intake or exhaust, and cylinder 1 or 2. Push rods should always be reinstalled in their original position.
3. Repeat for opposite cylinder.
4. Remove nuts and washers from cylinder head studs. Carefully remove cylinder heads and head gaskets.
5. Remove hydraulic lifters using a hydraulic lifter removing tool (do not use a magnet). Mark them similar to push rods (intake or exhaust and cylinder 1 or 2). Hydraulic lifters should always be reinstalled in their original location.

### Hydraulic Lifters Inspection

Check base surface of hydraulic lifters for wear or damage. If lifters need to be replaced, apply a liberal coating of Kohler lubricant to base of each new lifter before it is installed.

### Bleeding Lifters

To prevent a possible bent push rod or broken rocker arm, it is important to bleed any excess oil out of lifters before they are installed.

1. Cut a 50-75 mm (2-3 in.) piece from end of an old push rod and chuck it in a drill press.

# Disassembly/Inspection and Service

2. Lay a rag or shop towel on table of drill press and place lifter, open end up, on towel.
3. Lower chucked push rod until it contacts plunger in lifter. Slowly pump plunger two or three times to force oil out of feed hole in side of lifter.

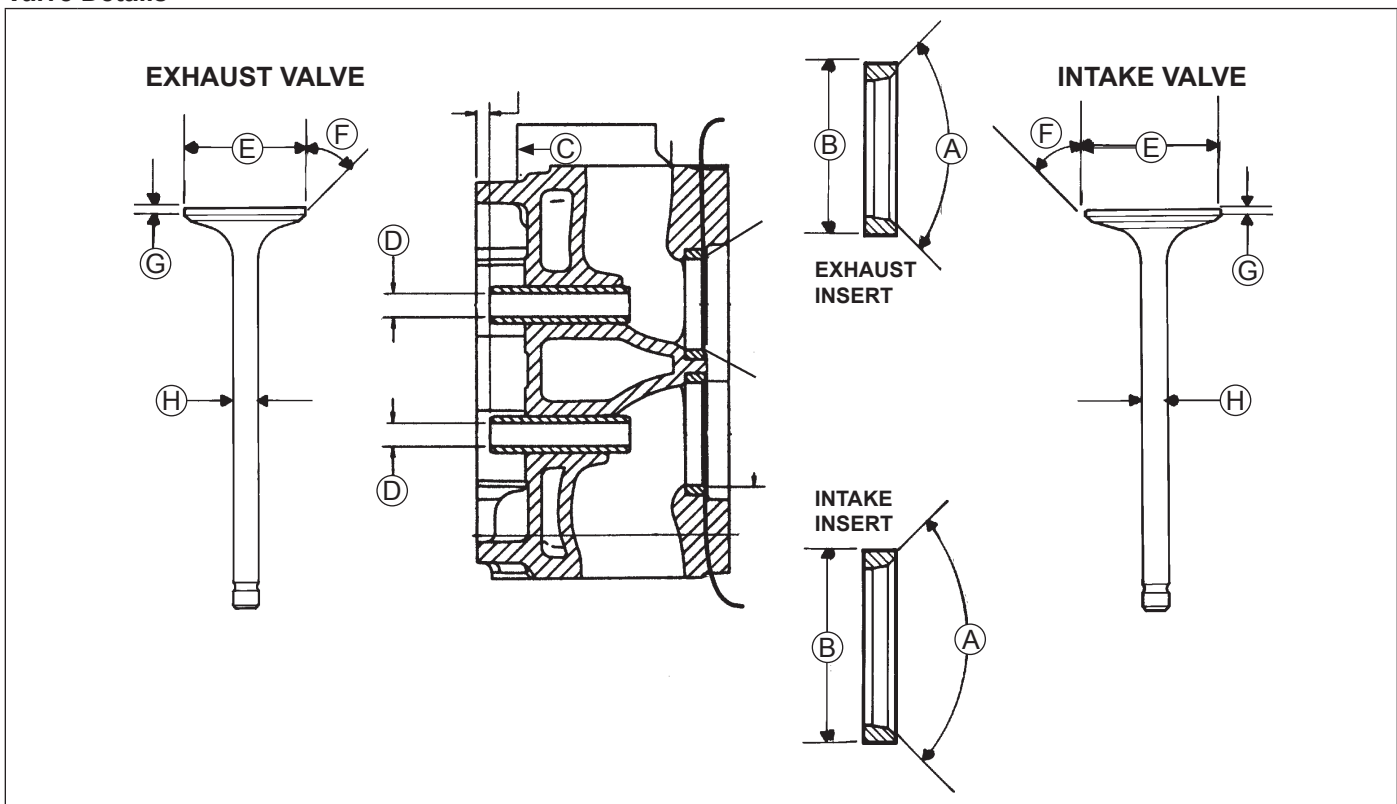
## Disassemble Cylinder Heads

NOTE: These engines use a valve stem seal on intake and exhaust valves. Serial No. 3422000010 and lower used a seal on intake side only. Always use new seals when valves are removed from cylinder head. Replace seals if they are deteriorated or damaged in any way. Never reuse an old seal.

1. Remove screws, rocker arms pivots and rocker arms from cylinder head(s).
2. Compress valve springs using a valve spring compressor and remove valve spring keepers. Remove compressor.
3. With keepers taken out following items can be removed.
  - Valve spring retainers.
  - Valve springs.
  - Valve spring caps.
  - Intake and exhaust valves.
  - Valve stem seals (intake valve only).
4. Repeat above procedure for other cylinder head. Do not interchange parts from 1 cylinder head to other.

## Inspection and Service

### Valve Details



Dimension		Intake	Exhaust
A	Seat Angle	89°	89°
B	Insert O.D.	36.987/37.013 mm (1.4562/1.4572 in.)	32.987/33.013 mm (1.2987/1.2997 in.)
C	Guide Depth	4 mm (0.1575 in.)	6.5 mm (0.2559 in.)
D	Guide I.D.	7.038/7.058 mm (0.2771/0.2779 in.)	7.038/7.058 mm (0.2771/0.2779 in.)
E	Valve Head Diameter	33.37/33.63 mm (1.3138/1.3240 in.)	29.37/29.63 mm (1.1563/1.1665 in.)
F	Valve Face Angle	45°	45°
G	Valve Margin (Min.)	1.5 mm (0.0591 in.)	1.5 mm (0.0591 in.)
H	Valve Stem Diameter	6.982/7.000 mm (0.2749/0.2756 in.)	6.970/6.988 mm (0.2744/0.2751 in.)

After cleaning, check flatness of cylinder head and corresponding top surface of crankcase, using a surface plate or piece of glass and feeler gauge. Maximum allowable out of flatness is 0.076 mm (0.003 in.).

Carefully inspect valve mechanism parts. Inspect valve springs and related hardware for excessive wear or distortion. Check valves and valve seat area or inserts for evidence of deep pitting, cracks, or distortion. Check clearance of valve stems in guides.

Hard starting or loss of power accompanied by high fuel consumption may be symptoms of faulty valves. Although these symptoms could also be attributed to worn rings, remove and check valves first. After removal, clean valve heads, faces, and stems with a power wire brush.

Then, carefully inspect each valve for defects such as a warped head, excessive corrosion, or a worn stem end. Replace valves found to be in bad condition.

### Valve Guides

If a valve guide is worn beyond specifications, it will not guide valve in a straight line. This may result in burnt valve faces or seats, loss of compression, and excessive oil consumption.

To check valve guide-to-valve stem clearance, thoroughly clean valve guide and, using a split-ball gauge, measure inside diameter of guide. Then, using an outside micrometer, measure diameter of valve stem at several points on stem where it moves in valve guide. Use largest stem diameter to calculate clearance by subtracting stem diameter from guide diameter. If intake clearance exceeds 0.038/0.076 mm (0.0015/0.0030 in.) or exhaust clearance exceeds 0.050/0.088 mm (0.0020/0.0035 in.), determine whether valve stem or guide is responsible for excessive clearance.

Maximum (I.D.) wear on intake valve guide is 7.134 mm (0.2809 in.) while 7.159 mm (0.2819 in.) is maximum allowed on exhaust guide. Guides are not removable but can be reamed 0.25 mm (0.010 in.) oversize. Valves with 0.25 mm oversize stems must then be used.

If guides are within limits but valve stems are worn beyond limits, install new valves.

### Valve Seat Inserts

Hardened steel alloy intake and exhaust valve seat inserts are press fitted into cylinder head. Inserts are not replaceable but can be reconditioned if not too badly pitted or distorted. If cracked or badly warped, cylinder head should be replaced.

Recondition valve seat inserts following instructions provided with valve seat cutter being used. Final cut should be made with an 89° cutter as specified for valve seat angle. Cutting proper 45° valve face angle as specified, and proper valve seat angle (44.5°, half of full 89° angle), will achieve desired 0.5° (1.0° full cut) interference angle where maximum pressure occurs on outside diameters of valve face and seat.

### Lapping Valves

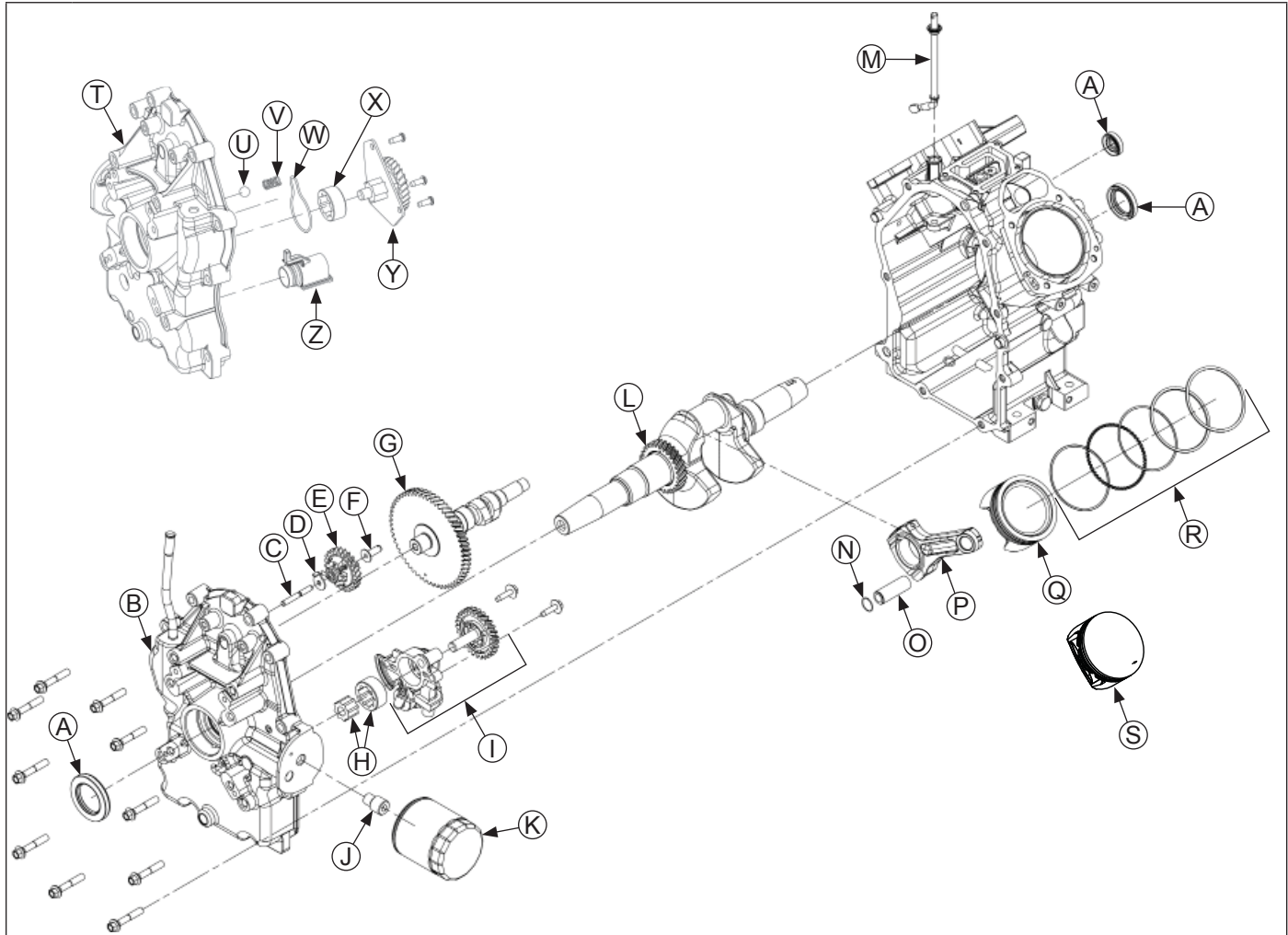
Reground or new valves must be lapped in, to provide proper fit. Use a hand valve grinder with a suction cup for final lapping. Lightly coat valve face with a fine grade of grinding compound, then rotate valve on its seat with grinder. Continue grinding until a smooth surface is obtained on seat and on valve face. Thoroughly clean cylinder head in soap and hot water to remove all traces of grinding compound. After drying cylinder head, apply a light coating of SAE 10 oil to prevent rusting.

### Intake Valve Stem Seal

These engines use valve stem seals on intake valves. Always use a new seal when valves are removed from cylinder head. Seals should also be replaced if deteriorated or damaged in any way. Never reuse an old seal.

# Disassembly/Inspection and Service

## Crankcase Components



<b>A</b>	Oil Seal	<b>B</b>	Closure Plate (Style A)	<b>C</b>	Governor Gear Shaft	<b>D</b>	Locking Tab Thrust Washer
<b>E</b>	Governor Gear	<b>F</b>	Regulating Pin	<b>G</b>	Camshaft	<b>H</b>	Gerotor Gears (Style A)
<b>I</b>	Oil Pump Assembly (Style A)	<b>J</b>	Nipple	<b>K</b>	Oil Filter	<b>L</b>	Crankshaft
<b>M</b>	Governor Cross Shaft	<b>N</b>	Piston Pin Retainer	<b>O</b>	Piston Pin	<b>P</b>	Connecting Rod
<b>Q</b>	Piston (Style B)	<b>R</b>	Piston Ring Set	<b>S</b>	Piston (Style A)	<b>T</b>	Closure Plate (Style B)
<b>U</b>	Ball (Style B)	<b>V</b>	Spring (Style B)	<b>W</b>	Oil Pump Cover O-ring (Style B)	<b>X</b>	Outer Gerotor Gear (Style B)
<b>Y</b>	Oil Pump Assembly (Style B)	<b>Z</b>	Oil Pick-Up (Style B)				

### Remove Closure Plate

1. Remove screws securing closure plate to crankcase.
2. Locate three splitting tabs, which are cast into perimeter of closure plate. Insert drive end of a 1/2" breaker bar between top splitting tab and crankcase. Hold handle horizontal and pull it toward you to break RTV seal. If necessary, pry at bottom splitting tabs also. Do not pry on sealing surfaces, as this could cause leaks. Note assembly and orientation of parts. Carefully pull closure plate from crankcase.

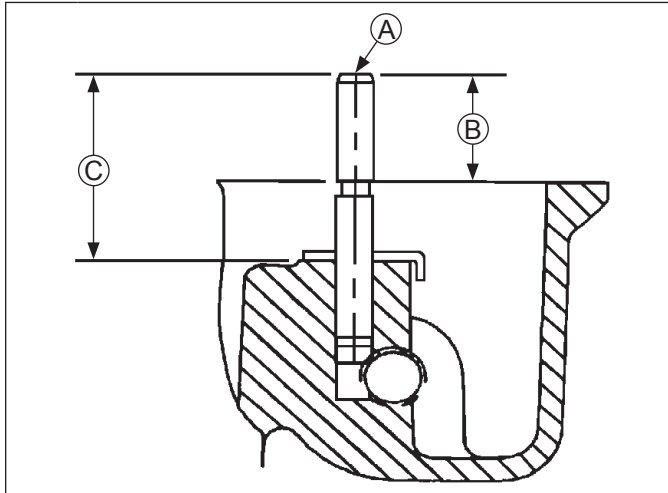
### Inspection

Inspect oil seal in closure plate and remove it if it is worn or damaged.

Inspect main bearing surface for wear or damage. Replace closure plate assembly if required.

## Governor Gear Assembly

### Governor Shaft Press Depth Details



<b>A</b>	Gear Shaft
<b>B</b>	19.40 mm (0.7638 in.)
<b>C</b>	34.0 mm (1.3386 in.) 33.5 mm (1.3189 in.)

Governor gear assembly is located inside closure plate. If service is required, refer to these procedures.

#### Inspection

Inspect governor gear teeth. Replace gear if it is worn, chipped, or if any teeth are missing. Inspect governor weights. They should move freely in governor gear.

#### Disassembly

**NOTE:** Governor gear is held onto shaft by small molded tabs in gear. When gear is removed from shaft, these tabs are destroyed and gear must be replaced. Therefore, remove gear only if absolutely necessary.

Governor gear must be replaced once it is removed from closure plate.

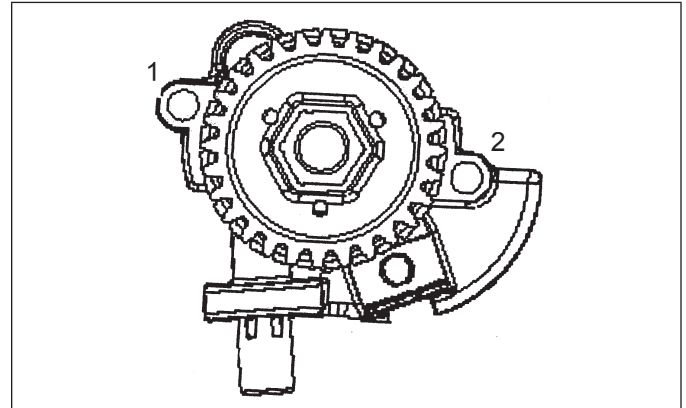
1. Remove regulating pin and governor gear assembly.
2. Remove locking tab thrust washer located under governor gear assembly.
3. Carefully inspect governor gear shaft and replace it only if it is damaged. After removing damaged shaft, press or lightly tap replacement shaft into closure plate to depth shown.

#### Reassembly

1. Install locking tab thrust washer on governor gear shaft with tab down.
2. Position regulating pin within governor gear/flyweight assembly and slide both onto governor shaft.

## Oil Pump Assembly (Style A)

### Oil Pump (Style A) Torque Sequence



Oil pump is mounted inside of closure plate. If service is required, continue with Disassembly, Inspection, and Reassembly.

#### Disassembly

1. Remove screws.
2. Remove oil pump assembly from closure plate.
3. Remove oil pump rotor.
4. Remove oil pickup by unhooking locking clip, and pulling it free from oil pump body.
5. If relief valve is similar to shown, drive out pin to remove oil pressure relief valve piston and spring. Refer to following inspection and reassembly procedures.

If relief valve is a one-piece style, staked to oil pump housing removal should not be attempted, nor is internal servicing possible. If a problem with relief valve is encountered, oil pump should be replaced.

#### Inspection

Inspect oil pump housing, gear, and rotors for nicks, burrs, wear, or any visible damage. If any parts are worn or damaged, replace oil pump.

Inspect oil pressure relief valve piston. It should be free of nicks or burrs.

Check spring for wear or distortion. Free length of spring should be approximately 47.4 mm (1.8 in.). Replace spring if it is distorted or worn.

#### Reassembly

1. Install pressure relief valve piston and spring.
2. Install oil pickup to oil pump body. Lubricate O-ring with oil and make sure it remains in groove as pickup is being installed.
3. Install rotor.
4. Install oil pump body to closure plate and secure with screws. Torque screws as follows:
  - a. Install fastener into screw location 1 and lightly tighten to position pump.
  - b. Install fastener into screw location 2 and fully torque to recommended value.
  - c. Torque fastener in screw location 1 to 10.7 N·m (95 in. lb.) into new holes, or 6.7 N·m (60 in. lb.) into used holes.

## Disassembly/Inspection and Service

- After torquing, rotate gear and check for freedom of movement. Make sure there is no binding. If binding occurs, loosen screws, reposition pump, retorque screws and recheck movement.

### Remove Oil Pump (Style B)

Oil pump is mounted inside closure plate. If service is required, continue with Disassembly, Inspection, and Reassembly.

#### Disassembly

- Remove screws.
- Lift oil pump assembly from closure plate. Remove outer gerotor gear from closure plate.
- Ensure ball and spring remain installed in pressure relief hole of closure plate. If ball and spring fall out of pressure relief hole, see reassembly for correct installation.
- Remove oil pump cover O-ring from groove in closure plate.

#### Inspection

Inspect oil pump housing, gear, and rotors for nicks, burrs, wear, or any visible damage. Inspect oil pump cover O-ring for cuts, nicks, or any visible damage. If any parts are worn or damaged, replace oil pump assembly and/or O-ring. Check oil pickup screen for damage or restriction, replace if necessary.

#### Reassembly

- Lubricate outer gerotor gear with oil. Install outer gerotor gear through shaft of oil pump, around inner gerotor gear. Matching molding dots on inner and outer gerotor gears is not necessary and will not affect oil pump efficiency.
- Reinstall ball, then spring into pressure relief hole in closure plate.
- Reinstall O-ring into groove in closure plate; make sure it is fully seated in groove.
- Install oil pump inserting center shaft into corresponding recess in closure plate. Apply consistent downward pressure to oil pump cover, compressing oil pressure relief spring and start screws. Secure oil pump by torquing screws (in no specific sequence) to 7.9 N·m (70 in. lb.).
- After torquing, rotate gear and check for freedom of movement. Make sure there is no binding. If binding occurs, loosen screws, reposition pump, retorque screws and recheck movement.

### Remove Camshaft

Remove camshaft and shims.

### Remove Connecting Rods with Pistons and Rings

NOTE: If a carbon ridge is present at top of either cylinder bore, use a ridge reamer tool to remove it before attempting to remove piston.

NOTE: Cylinders are numbered on crankcase. Use numbers to mark each end cap and connecting rod/piston assembly for reassembly later. Do not mix end caps and connecting rods.

- Remove screws securing closest connecting rod end cap. Remove end cap.
- Carefully remove connecting rod and piston assembly from cylinder bore.
- Repeat above procedure for other connecting rod and piston assembly.

### Connecting Rods

Offset, stepped-cap connecting rods are used in all these engines.

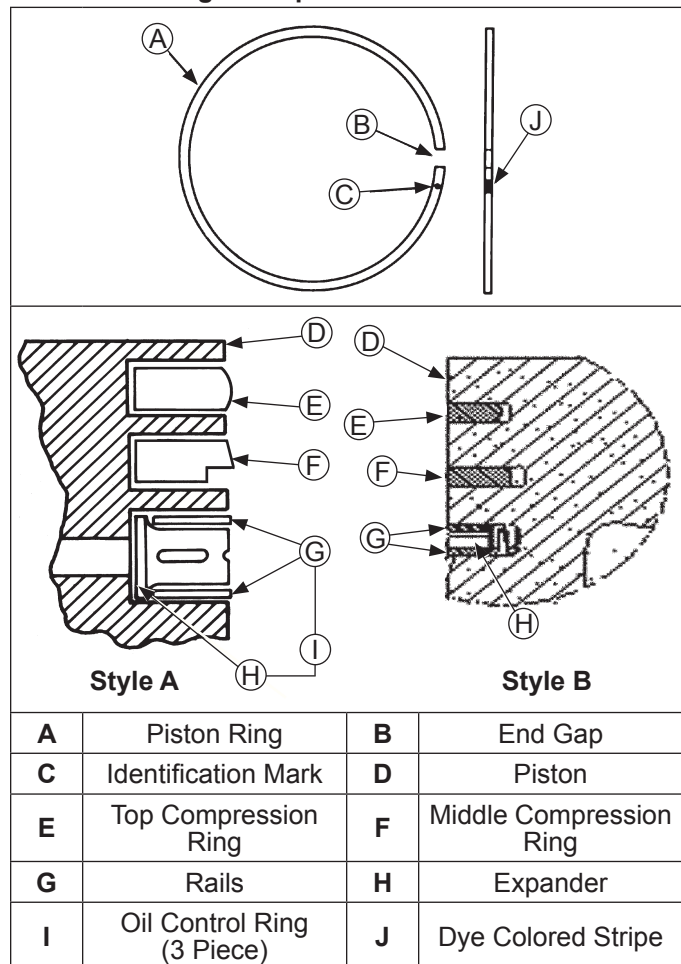
#### Inspection and Service

Check bearing area (big end) for excessive wear, score marks, running and side clearances. Replace rod and cap if scored or excessively worn.

Service replacement connecting rods are available in STD crankpin size and 0.25 mm (0.010 in.) undersize. An 0.25 mm (0.010 in.) undersized rod can be identified by a drilled hole located in lower end of rod shank. Always refer to appropriate parts information to ensure correct replacements are used.

### Inspection

#### Piston and Rings Components and Details



Scuffing and scoring of pistons and cylinder walls occurs when internal engine temperatures approach welding point of piston. Temperatures high enough to do this are created by friction, which is usually attributed to improper lubrication and/or overheating of engine.

Normally, very little wear takes place in piston boss-piston pin area. If original piston and connecting rod can be reused after new rings are installed, original pin can also be reused but new piston pin retainers are required. Piston pin is included as part of piston assembly – if pin boss in piston or pin are worn or damaged, a new piston assembly is required.

Ring failure is usually indicated by excessive oil consumption and blue exhaust smoke. When rings fail, oil is allowed to enter combustion chamber where it is burned along with fuel. High oil consumption can also occur when piston ring end gap is incorrect because ring cannot properly conform to cylinder wall under this condition. Oil control is also lost when ring gaps are not staggered during installation.

When cylinder temperatures get too high, lacquer and varnish collect on pistons causing rings to stick, which results in rapid wear. A worn ring usually takes on a shiny or bright appearance.

Scratches on rings and pistons are caused by abrasive material such as carbon, dirt, or pieces of hard metal.

Detonation damage occurs when a portion of fuel charge ignites spontaneously from heat and pressure shortly after ignition. This creates two flame fronts which meet and explode to create extreme hammering pressures on a specific area of piston. Detonation generally occurs from using low octane fuels.

Preignition or ignition of fuel charge before timed spark can cause damage similar to detonation. Preignition damage is often more severe than detonation damage. Preignition is caused by a hot spot in combustion chamber from sources such as glowing carbon deposits, blocked cooling fins, an improperly seated valve, or wrong spark plug(s).

Replacement pistons are available in STD bore size, and in 0.25 mm (0.010 in.), and 0.50 mm (0.020 in.) oversize. Replacement pistons include new piston ring sets and new piston pins.

Replacement ring sets are also available separately for STD, 0.25 mm (0.010 in.), and 0.50 mm (0.020 in.) oversize pistons. Always use new piston rings when installing pistons. Never use old rings.

Some important points to remember when servicing piston rings:

### Piston Style A

1. Cylinder bore must be de-glazed before service ring sets are used.
2. If cylinder bore does not need re-boring and if old piston is within wear limits and free of score or scuff marks, old piston may be reused.
3. Remove old rings and clean up grooves. Never reuse old rings.

4. Before installing new rings on piston, place top 2 rings, each in turn, in its running area in cylinder bore and check end gap. Top and middle compression ring end gap clearance is 0.25/0.56 mm (0.0100/0.0224 in.) for a new bore, or 0.94 mm (0.037 in.) for a used bore.
5. After installing new compression (top and middle) rings on piston, make sure top compression ring-to-groove side clearance is 0.025/0.048 mm (0.0010/0.0019 in.) and middle compression ring-to-groove side clearance 0.015/0.037 mm (0.0006/0.0015 in.). If side clearance is greater than specified, a new piston must be used.

### Piston Style B

1. Cylinder bore must be de-glazed before service ring sets are used.
2. If cylinder bore does not need re-boring and if old piston is within wear limits and free of score or scuff marks, old piston may be reused.
3. Remove old rings and clean up grooves. Never reuse old rings.
4. Before installing new rings on piston, place top 2 rings, each in turn, in its running area in cylinder bore and check end gap.

80 mm bore engines: Top compression ring end gap clearance is 0.100/0.279 mm (0.0039/0.0110 in.) for a new bore, or 0.490 mm (0.0192 in.) for a used bore. Middle compression ring end gap is 1.400/1.679 mm (0.0551/0.0661 in.) for a new bore, or 1.941 mm (0.0764 in.) for a used bore.

83 mm bore engines: Top compression ring end gap clearance is 0.189/0.277 mm (0.0074/0.0109 in.) for a new bore, or 0.531 mm (0.0209 in.) for a used bore. Middle compression ring end gap is 1.519/1.797 mm (0.0598/0.0708 in.) for a new bore, or 2.051 mm (0.0808 in.) for a used bore.

5. After installing new compression (top and middle) rings on piston, make sure top compression ring-to-groove side clearance and is 0.030/0.070 mm (0.0010/0.0026 in.) and middle compression ring-to-groove side clearance 0.030/0.070 mm (0.0010/0.0026 in.). If side clearance is greater than specified, a new piston must be used.

### Install New Piston Rings

NOTE: Rings must be installed correctly. Ring installation instructions are usually included with new ring sets. Follow instructions carefully. Use a piston ring expander to install rings. Install bottom (oil control) ring first and top compression ring last.

To install new piston rings, proceed as follows:

1. Oil control ring (bottom groove): Install expander and then rails. Make sure ends of expander are not overlapped.
2. Middle compression ring (center groove): Install center ring using a piston ring installation tool. Make sure identification mark is up or dye colored stripe (if contained) is to left of end gap.
3. Top compression ring (top groove): Install top ring using a piston ring expander. Make sure identification mark is up or dye colored stripe (if contained), left of end gap.

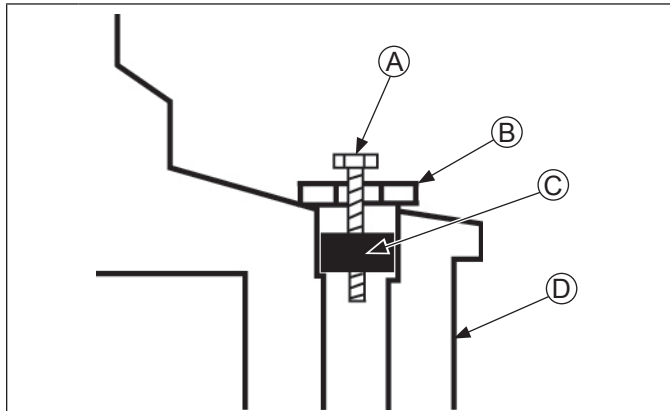
# Disassembly/Inspection and Service

## Remove Crankshaft

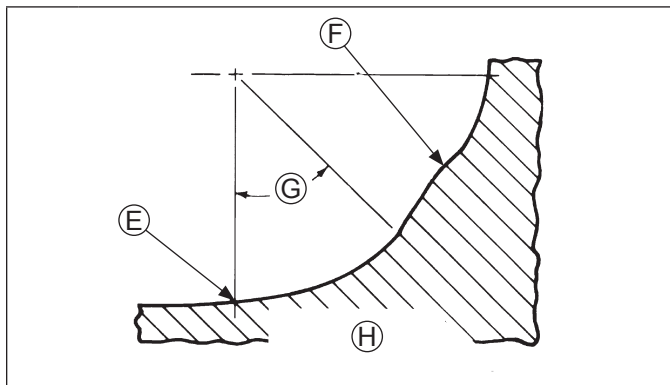
Carefully pull crankshaft from crankcase. Note thrust washer and shims if used.

## Inspection and Service

### Crankshaft Components and Details



<b>A</b>	Self-Tapping Screw	<b>B</b>	Flat Washer
<b>C</b>	Plug	<b>D</b>	Crankshaft



<b>E</b>	Fillet Must Blend Smoothly with Bearing Journal Surface
<b>F</b>	High Point from Fillet Intersections
<b>G</b>	45° Minimum
<b>H</b>	This Fillet Area Must Be Completely Smooth

Inspect gear teeth of crankshaft. If teeth are badly worn, chipped, or some are missing, replacement of crankshaft will be necessary.

Inspect crankshaft bearing surfaces for scoring, grooving, etc. Replaceable bearing is used in crankshaft bore of closure plate and/or crankcase. Do not replace bearing unless they show signs of damage or are out of running clearance 0.039/0.074 mm (0.0015/0.0029 in.). If crankshaft turns easily, without noise, and there is no evidence of scoring, grooving, etc., on races or bearing surfaces, bearing can be reused.

Inspect crankshaft keyways. If they are worn or chipped, replacement of crankshaft will be necessary.

Inspect crankpin for score marks or metallic pickup. Slight score marks can be cleaned with crocus cloth soaked in oil. If wear limits, as stated in Clearance

Specifications, are exceeded, it will be necessary to replace crankshaft or regrind crankpin to 0.25 mm (0.010 in.) undersize. If reground, a 0.25 mm (0.010 in.) undersize connecting rod (big end) must then be used to achieve proper running clearance. Measure crankpin for size, taper, and out-of-round.

Connecting rod journal can be ground 1 size under. When grinding a crankshaft, grinding stone deposits can get caught in oil passages, which could cause severe engine damage. Removing crankpin plug when crankshaft is ground provides easy access for removing any grinding deposits that may collect in oil passages. Use following procedure to remove and replace plug.

### Remove Crankshaft Plug

1. Drill a 3/16 in. hole through plug in crankshaft.
2. Thread a 3/4 in. or 1 in. long self-tapping screw with a flat washer into drilled hole. Flat washer must be large enough to seat against shoulder of plug bore.
3. Tighten self-tapping screw until it draws plug out of crankshaft.

### Install New Crankshaft Plug

Use 1 single cylinder camshaft pin, as a driver and tap plug into plug bore until it seats at bottom of bore. Make sure plug is tapped in evenly to prevent leakage.

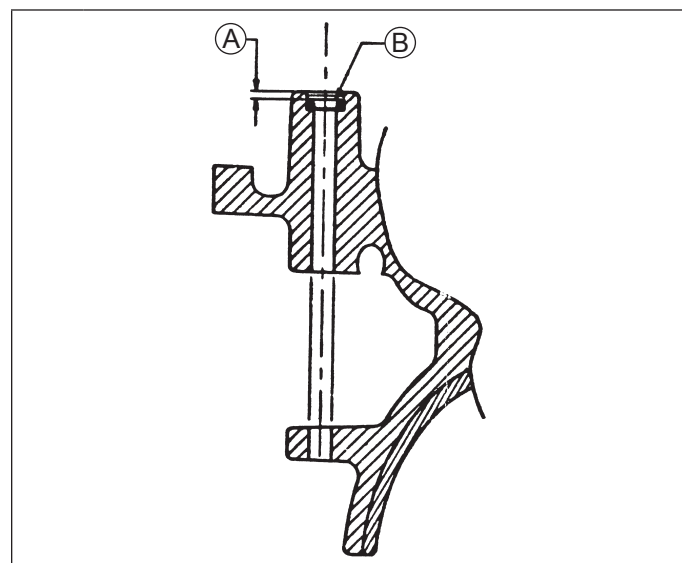
### Remove Governor Cross Shaft

NOTE: Always use a new retaining ring when reassembling. Do not reuse old retaining ring.

1. Remove retaining ring and nylon washer from governor cross shaft.
2. Remove cross shaft and small washer out through inside of crankcase.

### Governor Cross Shaft Oil Seal

#### Cross Shaft Oil Seal Details



<b>A</b>	2.0 mm (0.0787 in.)
<b>B</b>	Governor Cross Shaft Seal

Remove governor cross shaft oil seal from crankcase and replace it with a new one if seal is damaged and/or leaks. Install new seal to depth shown using a seal installer.



## Remove Flywheel End Oil Seals

Remove flywheel end crankshaft and camshaft oil seals from crankcase.

## Crankcase

### Inspection and Service

NOTE: If bore is beyond wear limit, a new miniblock or short block will be required.

Check all gasket surfaces to make sure they are free of gasket fragments. Gasket surfaces must also be free of deep scratches or nicks.

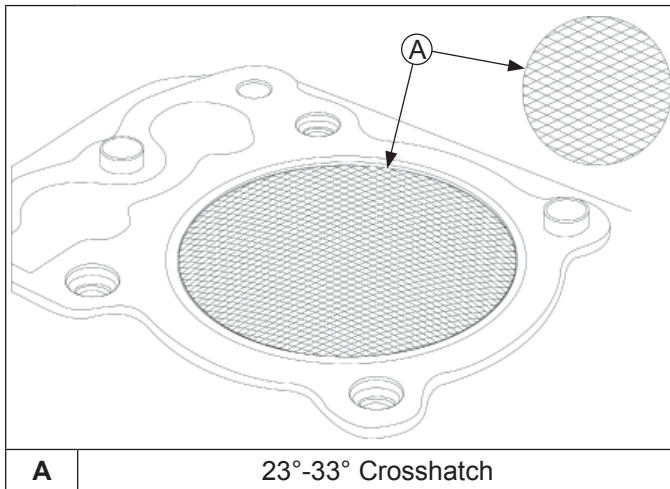
Inspect main bearing (if equipped) for wear or damage. Replace crankcase using a mini-block or short block if required.

Check cylinder bore for scoring. In severe cases, unburned fuel can cause scuffing and scoring of cylinder wall. It washes necessary lubricating oils off piston and cylinder wall. As raw fuel seeps down cylinder wall, piston rings make metal to metal contact with wall. Scoring of cylinder wall can also be caused by localized hot spots resulting from a cooling system problem or from inadequate or contaminated lubrication.

If cylinder bore is badly scored, excessively worn, tapered, or out-of-round, resizing is necessary. Use an inside micrometer to determine amount of wear, then select nearest suitable oversize of either 0.08 mm (0.003 in.), 0.25 mm (0.010 in.), or 0.50 mm (0.020 in.). Resizing to one of these oversizes will allow usage of available oversize piston and ring assemblies. Initially, resize using a boring bar, then use following procedures for honing cylinder.

## Honing

### Detail



While most commercially available cylinder hones can be used with either portable drills or drill presses, use of a low speed drill press is preferred as it facilitates more accurate alignment of bore in relation to crankshaft crossbore. Honing is best accomplished at a drill speed of about 250 RPM and 60 strokes per minute. After installing coarse stones in hone, proceed as follows:

1. Lower hone into bore and after centering, adjust so that stones are in contact with cylinder wall. Use of a commercial cutting-cooling agent is recommended.

2. With lower edge of each stone positioned even with lowest edge of bore, start drill and honing process. Move hone up and down while resizing to prevent formation of cutting ridges. Check size frequently.
3. When bore is within 0.064 mm (0.0025 in.) of desired size, remove coarse stones and replace with burnishing stones. Continue with burnishing stones until within 0.013 mm (0.0005 in.) of desired size and then use finish stones (220-280 grit) and polish to final size. A crosshatch should be observed if honing is done correctly. Crosshatch should intersect at approximately 23-33° off horizontal. Too flat an angle could cause rings to skip and wear excessively, too steep an angle will result in high oil consumption.
4. After resizing, check bore for roundness, taper, and size. Use an inside micrometer, telescoping gauge, or bore gauge to take measurements. These measurements should be taken at three locations in cylinder—at top, middle, and bottom. Two measurements should be taken (perpendicular to each other) at each three locations.

## Clean Cylinder Bore After Honing

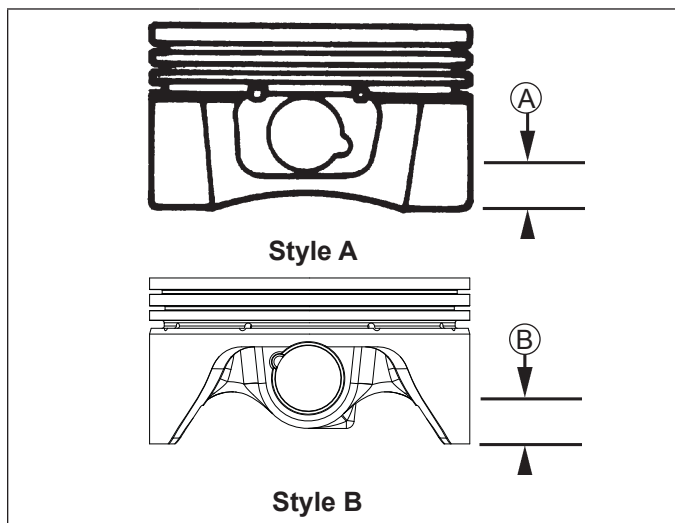
Proper cleaning of cylinder walls following boring and/or honing is very critical to a successful overhaul. Machining grit left in cylinder bore can destroy an engine in less than one hour of operation after a rebuild.

Final cleaning operation should always be a thorough scrubbing with a brush and hot, soapy water. Use a strong detergent that is capable of breaking down machining oil while maintaining a good level of suds. If suds break down during cleaning, discard dirty water and start again with more hot water and detergent. Following scrubbing, rinse cylinder with very hot, clear water, dry it completely, and apply a light coating of engine oil to prevent rusting.

# Disassembly/Inspection and Service

## Measuring Piston-to-Bore Clearance

### Piston Detail



Model	Dimension A	Dimension B
LH630/LH640	6 mm (0.2362 in.)	--
LH685/LH690	6 mm (0.2362 in.)	13 mm (0.5118 in.)
LH750/LH755	6 mm (0.2362 in.)	6 mm (0.2362 in.)

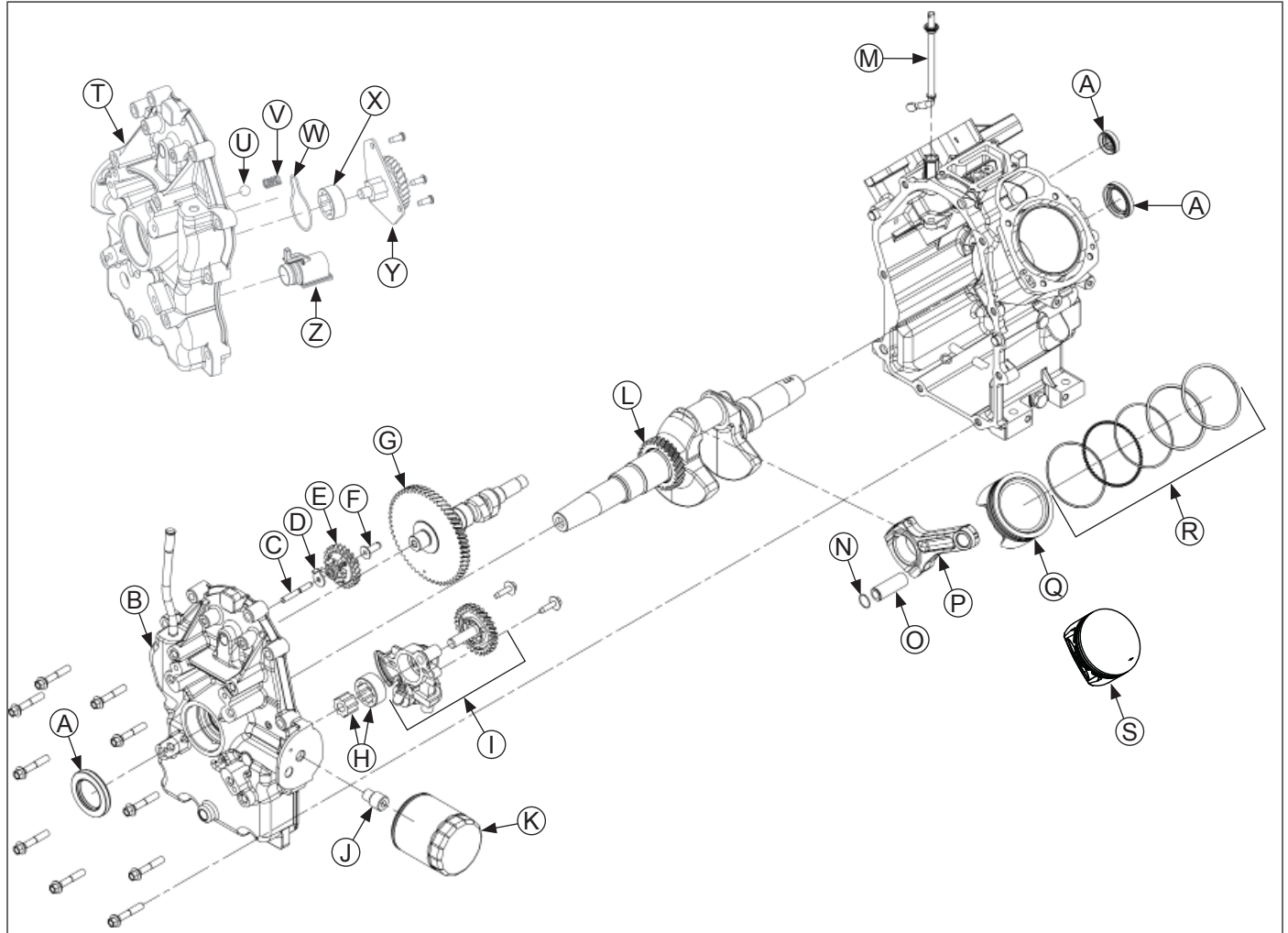
NOTE: Do not use a feeler gauge to measure piston-to-bore clearance—it will yield inaccurate measurements. Always use a micrometer.

Before installing piston into cylinder bore, it is necessary that clearance be accurately checked. This step is often overlooked, and if clearances are not within specifications, engine failure will usually result.

Use following procedure to accurately measure piston-to-bore clearance:

1. Use a micrometer and measure diameter of piston above bottom of piston skirt and perpendicular to piston pin.
2. Use an inside micrometer, telescoping gauge, or bore gauge and measure cylinder bore. Take measurement approximately 63.5 mm (2.5 in.) below top of bore and perpendicular to piston pin.
3. Piston-to-bore clearance is difference between bore diameter and piston diameter (step 2 minus step 1).

## Crankcase Components



<b>A</b>	Oil Seal	<b>B</b>	Closure Plate (Style A)	<b>C</b>	Governor Gear Shaft	<b>D</b>	Locking Tab Thrust Washer
<b>E</b>	Governor Gear	<b>F</b>	Regulating Pin	<b>G</b>	Camshaft	<b>H</b>	Gerotor Gears (Style A)
<b>I</b>	Oil Pump Assembly (Style A)	<b>J</b>	Nipple	<b>K</b>	Oil Filter	<b>L</b>	Crankshaft
<b>M</b>	Governor Cross Shaft	<b>N</b>	Piston Pin Retainer	<b>O</b>	Piston Pin	<b>P</b>	Connecting Rod
<b>Q</b>	Piston (Style B)	<b>R</b>	Piston Ring Set	<b>S</b>	Piston (Style A)	<b>T</b>	Closure Plate (Style B)
<b>U</b>	Ball (Style B)	<b>V</b>	Spring (Style B)	<b>W</b>	Oil Pump Cover O-ring (Style B)	<b>X</b>	Outer Gerotor Gear (Style B)
<b>Y</b>	Oil Pump Assembly (Style B)	<b>Z</b>	Oil Pick-Up (Style B)				

**NOTE:** Make sure engine is assembled using all specified torque values, tightening sequences and clearances. Failure to observe specifications could cause severe engine wear or damage. Always use new gaskets. Apply a small amount of oil to threads of critical fasteners before assembly, unless a sealant or Loctite® is specified or preapplied.

Make sure all traces of any cleaner are removed before engine is assembled and placed into operation. Even small amounts of these cleaners can quickly break down lubricating properties of engine oil.

Check closure plate, crankcase, cylinder heads, and valve covers to be certain that all old sealing material has been removed. Use gasket remover, lacquer thinner, or paint remover to remove any remaining traces. Clean surfaces with isopropyl alcohol, acetone, lacquer thinner, or electrical contact cleaner.

# Reassembly

## Install Flywheel End Oil Seal and Camshaft Oil Seal

1. Check to make sure that there are no nicks or burrs in crankshaft and camshaft seal bores of crankcase.
2. Apply a light coat of engine oil to outside diameter of flywheel end oil seal.
3. Install oil seal into crankcase using a seal driver. Make sure oil seal is installed straight and true in bore, until tool bottoms against crankcase.
4. Apply a light coat of engine oil to outside diameter of camshaft oil seal.
5. Install camshaft oil seal to a depth of 1.0-1.5 mm (0.039-0.059 in.) below top of seal bore. Do not bottom seal in bore or oil passage may be obstructed.

## Install Governor Cross Shaft

1. Lubricate governor cross shaft bearing surfaces in crankcase with engine oil. Apply a small amount of grease to lips of oil seal.
2. Slide small lower washer onto governor cross shaft and install cross shaft from inside of crankcase.
3. Install nylon washer onto governor cross shaft, then start push-on retaining ring. Hold governor shaft up in position, then place a 0.25 mm (0.010 in.) feeler gauge on top of nylon washer, and push retaining ring down shaft to secure. Remove feeler gauge, which will have established proper end play.
4. Pivot governor cross shaft so bottom end faces cylinder 1 side.

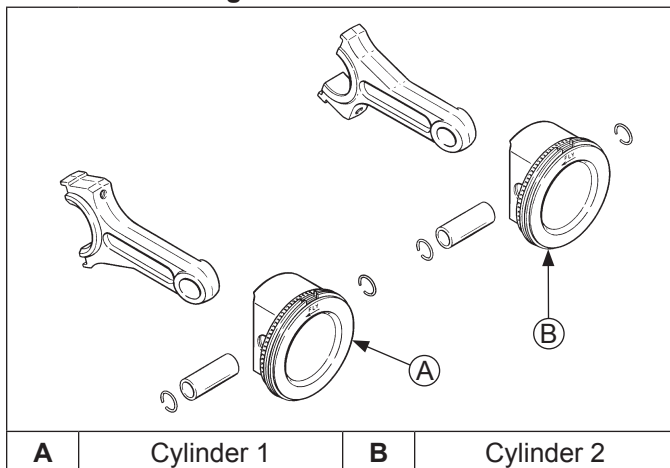
## Install Crankshaft

NOTE: Apply cellophane tape over crankshaft keyway to prevent cutting oil seal during installation.

1. Lightly lubricate lips of crankshaft seal with grease.
2. Carefully slide flywheel end of crankshaft into crankcase through oil seal.

## Install Connecting Rods with Pistons and Rings

### Piston/Connecting Rod Details



NOTE: Cylinders are numbered on crankcase. Make sure to install piston, connecting rod and end cap into its appropriate cylinder bore, as previously marked at time of disassembly. Do not mix end caps and connecting rods.

NOTE: Proper orientation of piston/connecting rod assemblies inside engine is extremely important. Improper orientation can cause extensive wear or damage.

NOTE: Make sure to align chamfer of connecting rod with chamfer of its mating end cap. When installed, flat faces of connecting rods should face each other. Faces with raised rib should be toward outside.

1. Stagger piston rings in grooves until end gaps are 120° apart. Oil ring rails should also be staggered.
2. Lubricate cylinder bore, piston, and piston rings with engine oil. Compress rings of cylinder 1 piston using a piston ring compressor.
3. Lubricate crankshaft journals and connecting rod bearing surfaces with engine oil.
4. Make sure FLY stamping on pistons is facing towards flywheel side of engine. Use a hammer with rubber grip and gently tap piston down into cylinder. Be careful that oil ring rails do not spring free, between bottom of ring compressor and top of cylinder.
5. Guide lower end of connecting rod and rotate crankshaft to join two. Install rod cap to connecting rod using screws and torque in increments to 11.3 N·m (100 in. lb.).
6. Repeat above procedure for other connecting rod and piston assembly.

## Install Camshaft

1. Inspect edges of camshaft keyway, make sure they are not nicked or burred. Use a seal protector (11/16") to prevent damaging seal lips, or dislodging inner spring when camshaft is installed. Cellophane tape over keyway is also recommended.
2. Lubricate camshaft bearing surfaces of crankcase and camshaft with engine oil. Apply a small amount of grease to lips of oil seal.
3. Rotate crankshaft and position timing mark of crankshaft gear at 12 o'clock position.
4. Turn governor cross shaft clockwise until lower end of shaft contacts crankcase (cylinder 1 side). Make sure cross shaft remains in this position while installing camshaft.
5. Slide camshaft into bearing surface of crankcase, positioning timing mark of camshaft gear at 6 o'clock position. Make sure that camshaft gear and crankshaft gear mesh, and timing marks are aligned.

## Checking/Setting Camshaft End Play

1. Install shim removed during disassembly onto camshaft.
2. Position end play tool on camshaft.
3. Apply pressure on end play checking tool (pushing camshaft toward crankshaft). Use a feeler gauge to measure end play between shim and end play tool. Camshaft end play should be 0.076/0.127 mm (0.003/0.005 in.).
4. If camshaft end play is not within specified range, remove original shim and reinstall end play tool. Use a feeler gauge to determine clearance between camshaft and tool. Subtract 0.100 mm (0.004 in) from measured clearance to obtain required shim thickness. Refer to table below and install shim that matches calculated thickness. Repeat steps 1-3 to verify that correct end play exists.

### Camshaft Shims

White: 0.69215/0.73025 mm (0.02725/0.02875 in.)  
 Blue: 0.74295/0.78105 mm (0.02925/0.03075 in.)  
 Red: 0.79375/0.83185 mm (0.03125/0.03275 in.)  
 Yellow: 0.84455/0.88265 mm (0.03325/0.03475 in.)  
 Green: 0.89535/0.99345 mm (0.03525/0.03675 in.)  
 Gray: 0.94615/0.98425 mm (0.03725/0.03875 in.)  
 Black: 0.99695/1.03505 mm (0.03925/0.04075 in.)

## Oil Pump Assembly

Oil pump is mounted to inside of closure plate. If service was required, and oil pump was removed, refer to assembly procedures under Oil Pump Assembly in Reassembly.

## Governor Assembly

Governor assembly is located inside closure plate. If service was required, and governor was removed, refer to assembly procedures under Governor Assembly in Reassembly.

## Thrust Bearing, Washer and Shim

Some specifications use a thrust bearing, thrust washer, and shim to control end play of crankshaft. If these items were noted during disassembly, make sure they were reinstalled in proper sequence, as illustrated. A different procedure must be followed to check and adjust crankshaft end play on these models.

Race for thrust bearing presses loosely into closure plate. If it is not already installed, push it into crankshaft bore inside closure plate. Pack thrust bearing with heavy grease and stick bearing into race. Wipe some grease on face of thrust washer and stick it onto thrust bearing. Wipe some grease on face of original shim and stick it onto thrust washer.

Install closure plate onto crankcase without applying RTV sealant and secure it with only two or three fasteners at this time. Use a dial indicator to check crankshaft end play. End play should be 0.070/0.590 mm (0.0027/0.0232 in.). Shims are available in five color-coded thicknesses listed below if adjustment is needed.

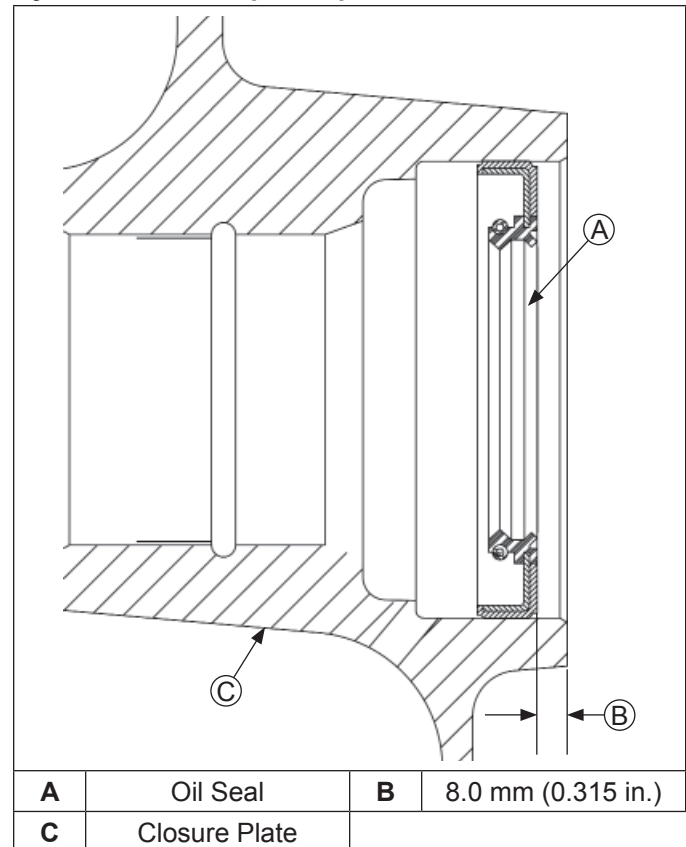
## Crankshaft End Play Shims

Remove closure plate. If end play requires adjustment, remove original shim and install appropriate size replacement.

BLUE	0.48-0.52 mm (0.050 mm Nominal) (0.019 in.)
BLACK	0.667-0.705 mm (0.686 mm Nominal) (0.27 in.)
GREEN	0.8366-0.9127 mm (0.8750 mm Nominal) (0.34 in.)
YELLOW	1.9652-1.1414 mm (1.1033 mm Nominal) (0.043 in.)
RED	1.2938-1.3700 mm (1.3319 mm Nominal) (0.052 in.)

## Install Closure Plate Oil Seal

### Cylinder Head Torque Sequence

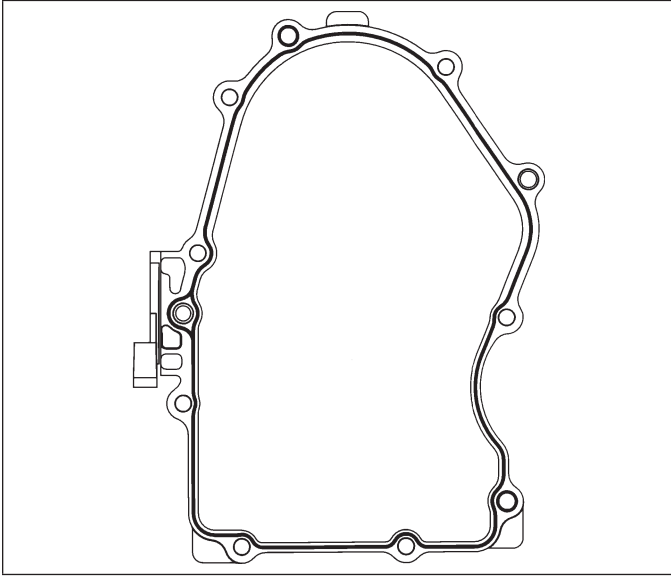


1. Check to make sure that there are no nicks or burrs in crankshaft bore of closure plate.
2. Apply a light coat of engine oil to outside diameter of oil seal.
3. Drive oil seal into closure plate using a seal driver. Make sure oil seal is installed straight and true in bore to depth shown.

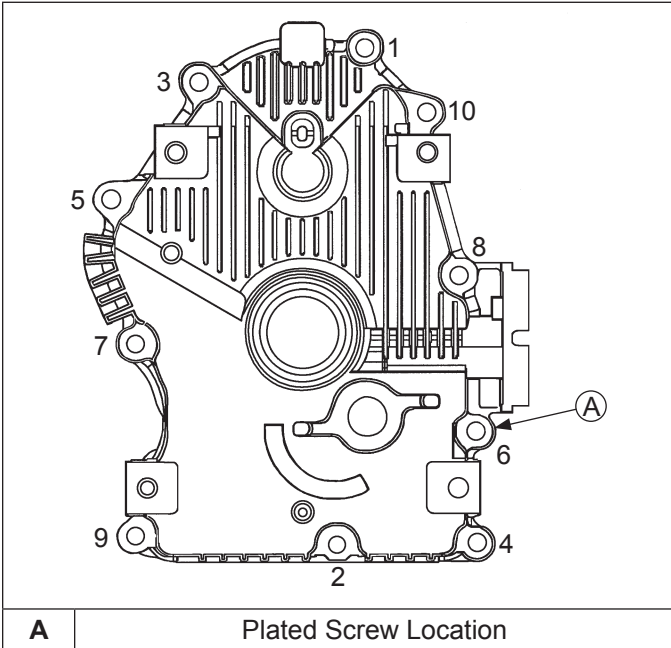
# Reassembly

## Install Closure Plate Assembly

### Closure Plate Sealant Pattern



### Torque Sequence



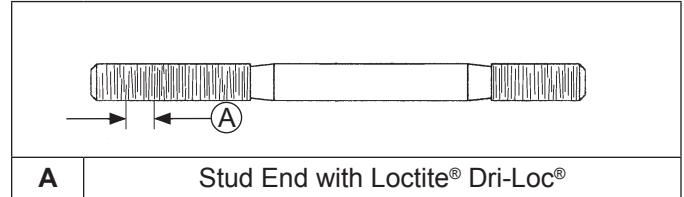
RTV silicone sealant is used as a gasket between closure plate and crankcase. Always use fresh sealant. Using outdated sealant can result in leakage.

1. Be sure sealing surfaces have been cleaned and prepared.
2. Check to make sure that there are no nicks or burrs on sealing surfaces of closure plate or crankcase.
3. Apply a 1/16" bead of sealant to sealing surface of closure plate.
4. Make sure end of governor cross shaft is lying against bottom of cylinder 1 inside of crankcase.
5. If alignment pins were removed previously, install them in their respective locations in crankcase.

6. Install closure plate on crankcase. Carefully seat camshaft and crankshaft into their mating bearings. Rotate crankshaft to help engage oil pump and governor gear meshes.
7. Install screws securing closure plate to crankcase. If a thick flat washer was used on one of screws, install it in number 10 location. Install silver plated (ground) screw in its original location (normally number 4 or 6 location). Torque fasteners, in torque sequence shown to 24.4 N·m (216 in. lb.).

## Install Cylinder Studs

### Piston/Connecting Rod Details

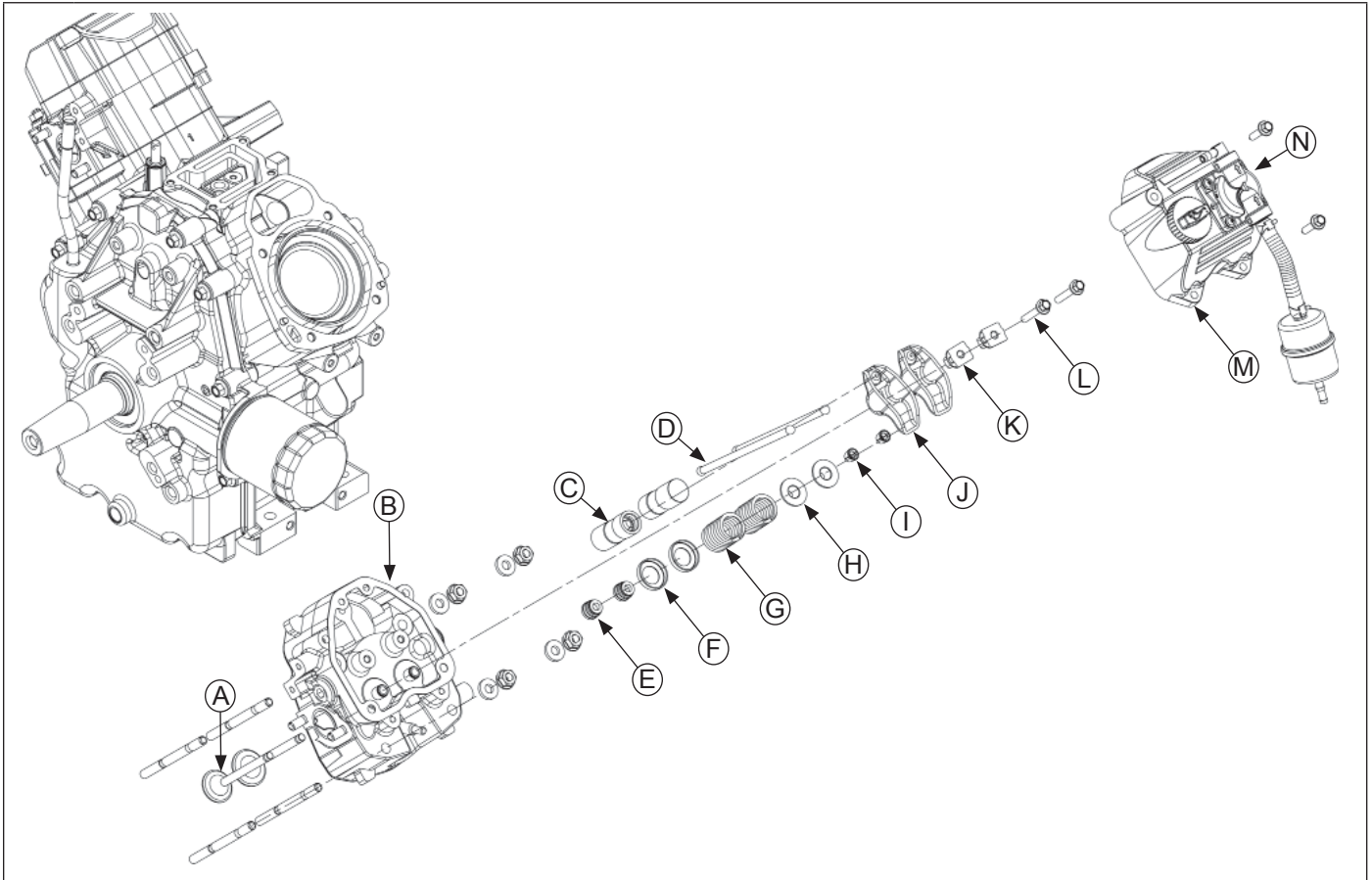


NOTE: Do not reinstall or attempt to reuse any cylinder studs that have been removed. Discard any removed stud(s) and replace with new.

If any of cylinder studs were removed, install new stud(s) as follows:

1. Identify longer threaded end of new stud containing Loctite® Dri-Loc®.
2. Tighten nuts together on shorter threaded section, with identification mark on end.
3. Thread end of stud with Loctite® into crankcase, until an exposed stud height of 75 mm (2 61/64 in.) is obtained. End with dash mark must be out. When threading in studs, use a steady tightening motion, without interruption, until proper height is obtained. Frictional heat from engaging threads may otherwise cause locking compound to set up prematurely. Remove two nuts.
4. Repeat steps 1-3 for each of studs.

## Cylinder Head Components



<b>A</b>	Valve	<b>B</b>	Head	<b>C</b>	Hydraulic Lifter	<b>D</b>	Push Rods
<b>E</b>	Valve Stem Seal	<b>F</b>	Valve Spring Cap	<b>G</b>	Spring	<b>H</b>	Valve Spring Retainers
<b>I</b>	Valve Spring Keepers	<b>J</b>	Rocker Arms	<b>K</b>	Rocker Arm Pivot	<b>L</b>	Rocker Arm Screw
<b>M</b>	Valve Cover	<b>N</b>	Fuel Pump				

### Install Hydraulic Lifters

NOTE: Hydraulic lifters should always be installed in same position as before disassembly.

1. Lubricate lifters and lifter bores in crankcase with engine oil.
2. Install lifters into their respective lifter bores according to location and cylinder number marked during assembly.

### Valve Stem Seals

These engines use valve stem seals on intake and exhaust valves. Always use a new seal before valves are installed in cylinder head. Also, replace seals if they are deteriorated or damaged in any way. Never reuse an old seal.

### Assemble Cylinder Heads

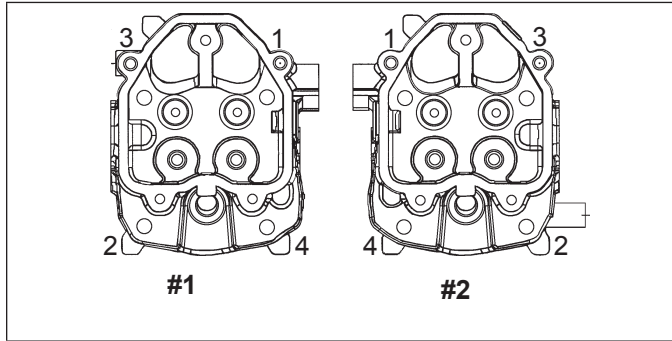
Prior to installation, lubricate all components with engine oil, paying particular attention to lip of valve stem seal, valve stems and valve guides. Install following items in order listed below using a valve spring compressor.

- Valve stem seals.
- Intake and exhaust valves.
- Valve spring caps.
- Valve springs.
- Valve spring retainers.
- Valve spring keepers.

# Reassembly

## Install Cylinder Heads

### Cylinder Head Torque Sequence



NOTE: Match numbers embossed on cylinder heads and crankcase.

1. Check to make sure there are no nicks or burrs on sealing surfaces of cylinder head or crankcase.
2. Rotate crankshaft to position piston in cylinder 1 to top dead center (TDC) on compression stroke.
3. Install a new cylinder head gasket.
4. Install cylinder 1 head onto number 1 side mounting studs.
5. Install a plain washer onto each stud and secure with a nut.
6. Torque nuts in two steps, first to 16.9 N·m (150 in. lb.) and then to 33.9 N·m (300 in. lb.), using torque sequence shown.
7. Repeat installation procedure for cylinder 2 side head.

### Install Push Rods and Rocker Arms

NOTE: Push rods must always be installed in same position as before disassembly.

1. Note mark or tag identifying push rod as either intake or exhaust for cylinder 1. Lightly apply engine oil or grease to ends of push rods and install. Make sure that each push rod ball seats in its respective hydraulic lifter socket.
2. Apply grease to contacting surfaces of rocker arms and rocker arm pivots. Install rocker arms and rocker arm pivots on cylinder head.
3. Install new rocker arm screws with Dri-Loc® thread locking compound on threads. Torque screws to 11.3 N·m (100 in. lb.). When tightening, use a steady motion, without interruption, until proper torque is achieved. Frictional heat from engaging threads may otherwise cause locking compound to set prematurely. If new screws are not available, apply Loctite® 242® to bottom 4 or 5 threads. Then install and torque screws to 11.3 N·m (100 in. lb.).
4. Use a spanner wrench or rocker arm lifting tool to lift rocker arms and position push rods underneath.
5. Rotate crankshaft so piston in cylinder 2 is at top dead center on compression stroke, and repeat steps for remaining cylinder. Do not interchange parts from one cylinder head with parts from other cylinder head.

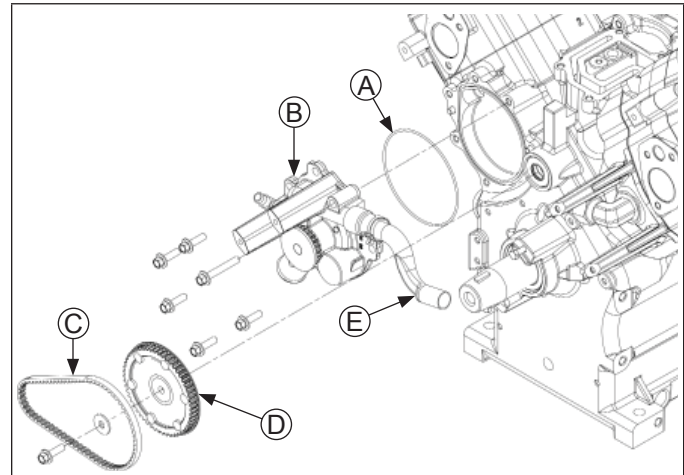
6. Rotate crankshaft to check for free operation of valve train. Check clearance between valve spring coils at full lift. Minimum allowable clearance is 0.25 mm (0.010 in).

### Install Valve Covers

1. Make sure sealing surfaces of cylinder heads and valve covers are clean and free of all old gasket material.
2. Install new valve cover gaskets onto valve covers.
3. Install valve covers with gaskets in their original locations.
4. Install lower mounting screws in each cover, and finger tighten only. Upper screws will be installed later.

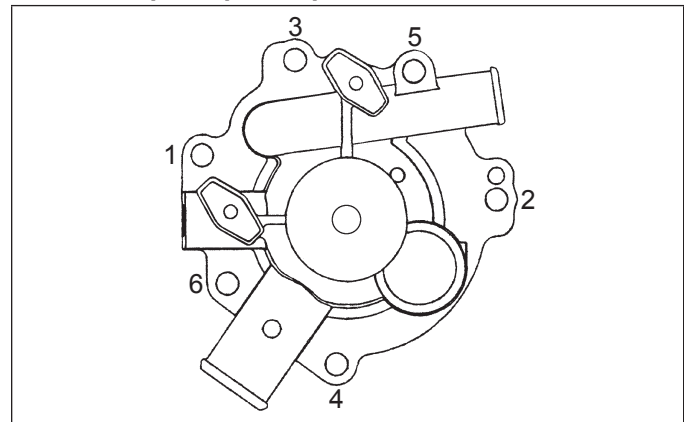
### Install Water Pump, Drive Belt, and Transfer Tube Assembly

#### Water Pump Components



<b>A</b>	O-ring	<b>B</b>	Water Pump
<b>C</b>	Water Pump Belt	<b>D</b>	Camshaft Pulley
<b>E</b>	Transfer Tube		

#### Water Pump Torque Sequence



NOTE: A mark or dot of paint applied to top, of pulley, indicating keyway location, will make installation easier.



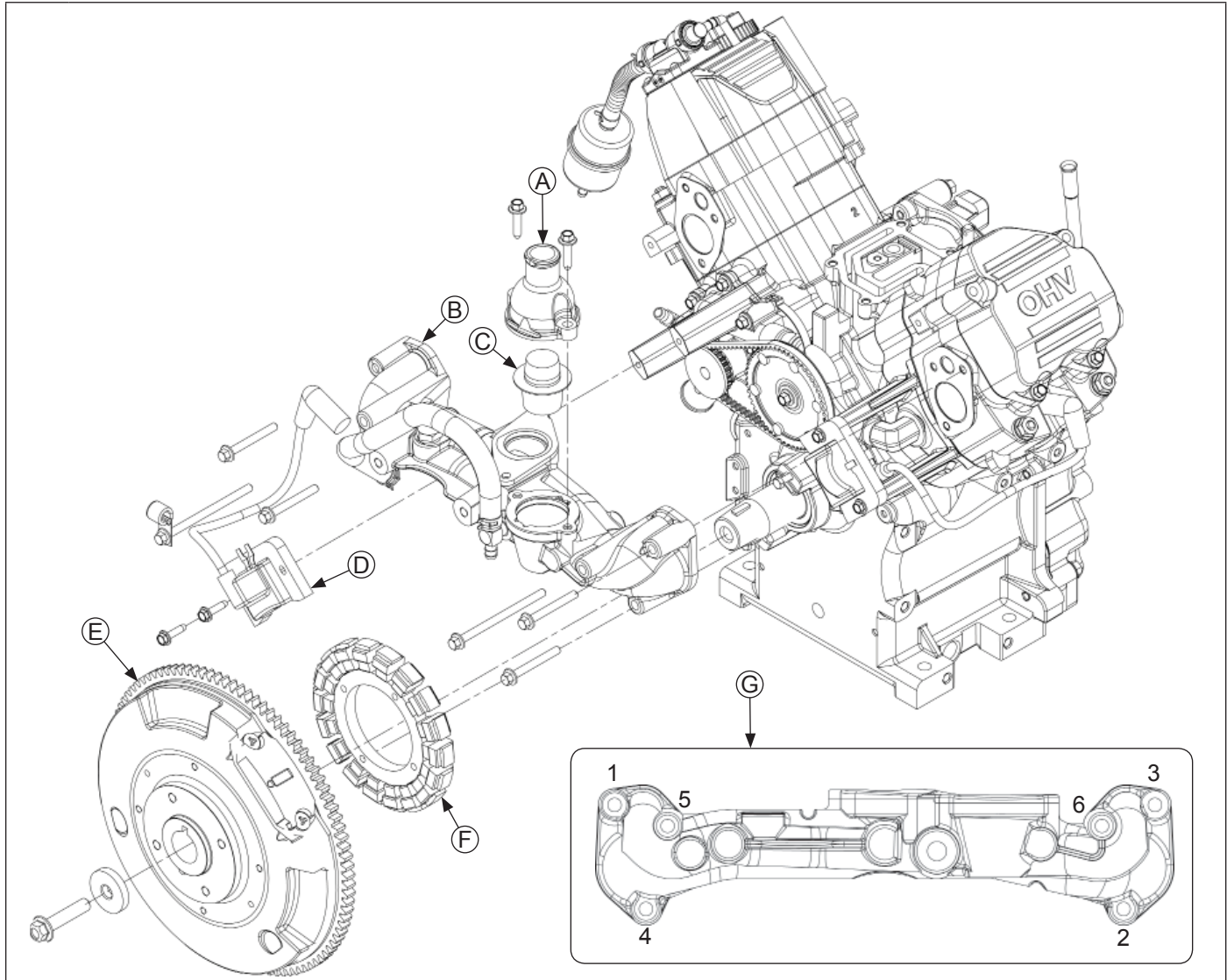
NOTE: When installation is complete, tangs of two hose clamps should face outward, away from flywheel and slightly down.

1. Remove seal protector and/or protective tape (if used) from over keyway and make sure end of camshaft is clean and free of any nicks or damage. Install and fully seat key, squarely into keyway. Be careful not to contact camshaft seal. Test fit cam pulley onto shaft and key; it must slide on without force or restriction. Remove pulley.
2. If water pump by-pass hose fitting was removed previously, apply pipe sealant with Teflon® (Loctite® 592™ or equivalent) on threads and tighten it into pump. Orient fitting so outlet points in 11 o'clock position as shown.
3. Check sealing surfaces of water pump and crankcase. They must be clean and free of any nicks or damage.
4. Apply a small amount of grease in several locations to hold new water pump O-ring in place. Install a new O-ring in groove of crankcase. Do not use RTV sealant in place of O-ring, or attempt to reinstall a used O-ring.
5. Apply rubber lubricant to inner surfaces of short hose section. Assemble hose to outlet of water pump and secure with larger diameter clamp. Orient clamp so tangs extend out in 3 to 4 o'clock position.
6. Slide smaller diameter clamp onto extruded end of formed metal tube and insert this end of tube into hose section. Position tube so its formed offset leads down and away from outlet, perpendicular to pump. Install clamp onto hose and position tangs of clamp parallel to those of first clamp.
7. Holding pump assembly elevated, assemble transfer tube to 90° fitting in crankcase as follows:
  - a. For new/first time tube installation:
    1. Place a new ferrule/compression ring in 90° fitting of crankcase and loosely install hex cap onto threads of fitting.
    2. Insert plain end of transfer tube through hex and compression ring.
  - b. For reinstallation of an existing tube:
    1. Insert end of transfer tube, with compression ring, into 90° fitting of crankcase.
    2. Start hex cap onto threaded section of fitting.

90° fitting in crankcase is installed and sealed at factory, in a specific position. Special tools and procedures are involved. Do not loosen, remove, or alter mounting position of this fitting at any time.
8. Carefully push water pump down from raised position, thereby rotating tube 90° within end connections. Guide pump into position over O-ring; aligning two mounting pins and five screw hole locations. Start screws, with longer screw nearest pump outlet. Torque screws to 9.9 N·m (88 in. lb.) in sequence shown.
9. Push down on formed tube and hold in this position to prevent it from pivoting upward when tightening hex cap. Torque hex cap to 22.6 N·m (200 in. lb.), to secure joint connection. Support fitting with a wrench while torquing, if possible, to prevent applying unnecessary pressure on fitting and joint. Check that formed tube and hose section have not been pulled up.
10. Install drive belt onto cogged pulley of water pump, then around cam pulley. Slide cam pulley, with belt attached, down onto keyway end of camshaft. Be careful not to push key out of keyway and/or into seal when installing pulley.
11. Check or use a feeler gauge to see that there is at least 3.17 mm (0.125 in.) clearance between underside of pulley, and hose, tube, and clamps. Remove pulley and reposition tube or clamps if required. Install flat washer and screw, to secure pulley in place. Torque screw to 9.9 N·m (88 in. lb.).

# Reassembly

## Flywheel/Ignition/Intake Manifold Components



<b>A</b>	Thermostat Housing	<b>B</b>	Intake Manifold	<b>C</b>	Thermostat	<b>D</b>	Ignition Module
<b>E</b>	Flywheel	<b>F</b>	Stator	<b>G</b>	Torque Sequence		

### Install Intake Manifold

1. Check that gasket surfaces of intake manifold and cylinder heads are clean and free of any nicks or damage.
  2. Install new intake manifold gaskets onto port surfaces of cylinder heads.
  3. Set intake manifold, with by-pass hose and wiring harness attached, down into position onto gaskets and cylinder heads. Install and finger tighten screws in their appropriate locations. Make sure clamps for wiring harness are positioned on long screw on each side. Torque six intake manifold mounting screws in two steps: first to 7.4 N·m (66 in. lb.), finally to 9.9 N·m (88 in. lb.) in sequence shown.
  4. Install and tighten pipe plug or temperature warning switch, if removed previously from threaded port of intake manifold. Use pipe sealant with Teflon® (Loctite® 592™ or equivalent) on threads. Torque to 22.6 N·m (200 in. lb.).
  5. Connect wire leads to temperature warning switch, audible alarm, and/or Oil Sentry™ switch as equipped.
- If thermostat and thermostat housing were removed from intake manifold, reassemble them at this time.
6. Make sure sealing surfaces of housing and manifold are clean and free of nicks or damage.
  7. Install thermostat into recess in intake manifold, so larger spring end is down. Place a new thermostat housing gasket onto manifold surface, aligning screw holes. Make sure that one of notches in gasket is aligned with by-pass slot in manifold and thermostat housing. Do not use a substitute gasket.

8. Position thermostat housing on gasket and intake manifold. Notch in manifold, gasket and thermostat housing must all be aligned. Install and torque screws to 9.9 N·m (88 in. lb.).
9. Apply rubber lubricant to inside end of upper radiator hose, and install hose to thermostat housing, if separated for servicing. Secure with clamp. Make sure tangs of clamp point toward cylinder 1, away from fan.


### Install Coolant By-pass Hose (If separated from intake manifold through individual component servicing)

1. If connector fitting for by-pass hose was removed from manifold, reinstall it at this time. Apply pipe sealant with Teflon® (Loctite® 592™ or equivalent) onto threads and tighten, so fitting faces/points toward 2 side, long intake manifold screw.
2. Attach coolant by-pass hose to fittings in water pump and intake manifold. Secure with clamps.
3. Connect wire leads to temperature warning switch, audible alarm, and/or Oil Sentry™ switch, as equipped.

### Install Stator Assembly

1. Place a small amount of pipe sealant with Teflon® (Loctite® 592™ or equivalent) into holes for stator mounting screws. Position stator assembly onto mounting studs so leads are at bottom, and directed out toward cylinder 1 side, in 3 o'clock position. Align mounting holes and install screws. Torque each screw to 6.2 N·m (55 in. lb.).

### Install Flywheel

	<b>CAUTION</b>
	Damaging Crankshaft and Flywheel can cause personal injury.
Using improper procedures can lead to broken fragments. Broken fragments could be thrown from engine. Always observe and use precautions and procedures when installing flywheel.	

NOTE: Before installing flywheel make sure crankshaft taper and flywheel hub are clean, dry, and completely free of lubricants. Presence of lubricants can cause flywheel to be overstressed and damaged when screw is torqued to specifications.

NOTE: Always use a flywheel strap wrench or holding tool to hold flywheel when tightening flywheel fastener. Do not use any type of bar or wedge to hold flywheel, as component damage and personal injury could result.

NOTE: Make sure flywheel key is installed properly in keyway. Flywheel can become cracked or damaged if key is improperly installed.

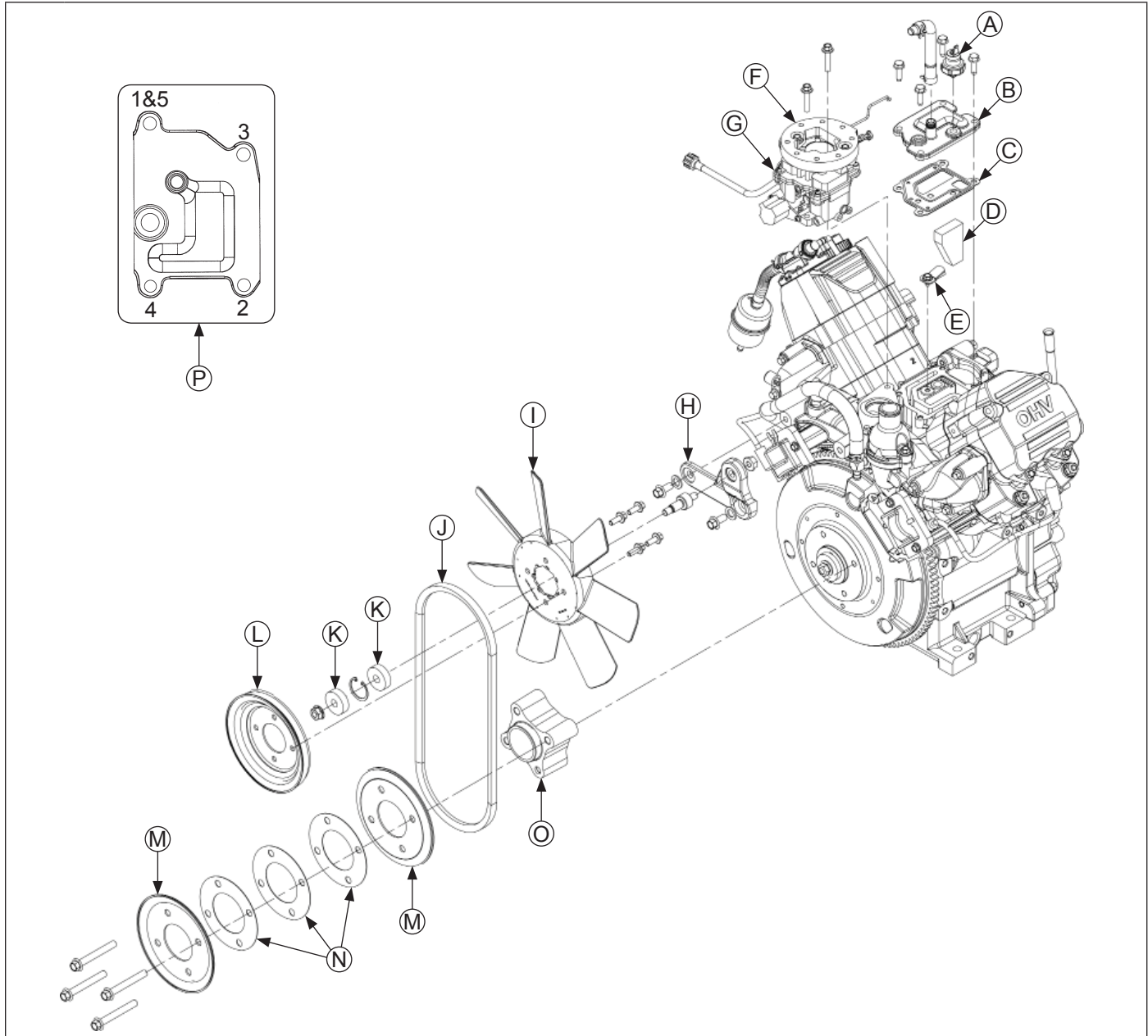
1. Install woodruff key into keyway of crankshaft. Make sure that key is properly seated and parallel with shaft.
2. Thread starter mounting bolts into hub of flywheel, or use flywheel puller to serve as a handle and set flywheel in place.
3. Install screw and washer.
4. Use a flywheel holding tool to hold flywheel and torque screw to 66.4 N·m (49 ft. lb.).
5. Using a light, visually check that sufficient clearance exists between cooling system components and bottom of flywheel.
  - If clearance is OK, continue with installation of ignition modules.
  - If clearance is insufficient or contact is noted, remove flywheel and adjust as required. Reinstall flywheel and recheck for adequate clearance.

### Install Ignition Modules

1. Rotate flywheel magnet away from ignition module mounting bosses.
2. Install ignition modules, with ground terminal out, onto crankcase mounting bosses, using screws. Slide ignition modules away from flywheel as far as possible, and tighten four screws.
3. Rotate flywheel to position magnet directly under one of ignition modules.
4. Insert a 0.25 mm (0.010 in.) flat feeler gauge or shim stock between magnet and ignition module. Loosen screws enough to allow magnet to pull module against feeler gauge.
5. Torque screws to 4.0 N·m (35 in. lb.).
6. Repeat steps 3 to 5 for other ignition module.
7. Rotate flywheel back and forth checking for clearance between magnet and ignition modules. Make sure magnet does not strike modules. Recheck gap with a feeler gauge and readjust if necessary. Final air gap: 0.203/0.305 mm (0.008/0.012 in.).
8. Connect kill leads to ignition modules. Push (bend) loop portion of clamp on cylinder 1 side back, as far as possible, for maximum clearance from fan.

# Reassembly

## External Engine Components



<b>A</b>	Oil Sentry™	<b>B</b>	Breather Cover	<b>C</b>	Gasket	<b>D</b>	Fiber Filter
<b>E</b>	Breather Reed Assembly	<b>F</b>	Adapter Plate	<b>G</b>	Carburetor	<b>H</b>	Fan Mounting Bracket
<b>I</b>	Fan	<b>J</b>	Fan Belt	<b>K</b>	Bearing	<b>L</b>	Pulley
<b>M</b>	Pulley Half	<b>N</b>	Spacer Shims	<b>O</b>	Adapter	<b>P</b>	Torque Sequence

### Install Spark Plugs

1. Check gap using wire feeler gauge. Adjust gap to 0.76 mm (0.03 in.).
2. Install plug into cylinder head.
3. Torque plug to 27 N·m (20 ft. lb.).

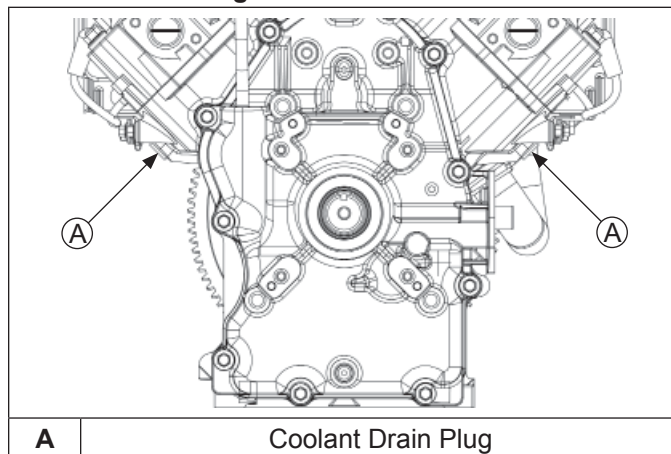
### Install Reed and Breather Cover Assembly

1. Make sure sealing surfaces of crankcase and breather cover are clean and free of all old gasket material. Clean with an aerosol type gasket remover or cleaning solvent. DO NOT scrape surfaces as this can result in leakage.
2. Check to make sure there are no nicks or burrs on sealing surfaces.

3. Install breather reed and breather reed retainer onto crankcase and secure with screw. Hold assembly in line when tightening. Torque screw to 3.9 N·m (35 in. lb.).
4. Install breather filter into cavity in crankcase.
5. Carefully install breather cover gasket and breather cover onto crankcase.
6. Install and torque four breather cover screws to 7.3 N·m (65 in. lb.) in sequence shown.
7. Install pipe plug or Oil Sentry™ switch (as equipped), into tapped breather port if removed earlier. Apply pipe sealant with Teflon® (Loctite® 592™ or equivalent) to threads. Torque to 4.5 N·m (40 in. lb.). If Oil Sentry™ switch is mounted to side of crankcase, torque switch to 12.4 N·m (110 in. lb.).
8. If vacuum fitting was removed from crankcase (vacuum fuel pump), apply pipe sealant with Teflon® (Loctite® 592™ or equivalent) to threads of fitting and install. With crankcase upright, fitting must point to 1:30 position.

## Reinstall Coolant Drain Plugs

### Coolant Drain Plug Details



Reinstall brass coolant drain plugs in sides of crankcase, (and also cylinder head plugs, if removed during head servicing). Apply pipe sealant with Teflon® (Loctite® 592™ or equivalent) to threads and reinstall plugs. Torque plugs to 36.7 N·m (325 in. lb.).

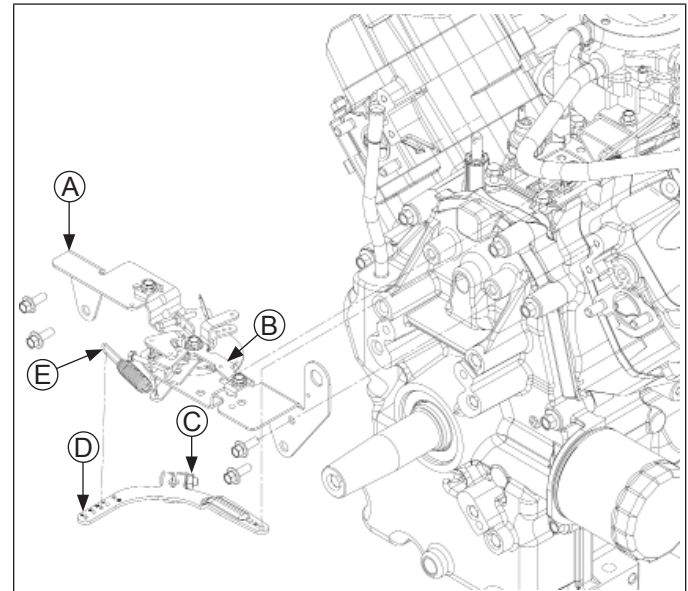
## Install Carburetor and Adapter

1. If separated, install breather tube to breather cover.
2. Install carburetor gasket on intake manifold.
3. Attach longer ends of throttle linkage and spring to carburetor (if disconnected previously), then install carburetor onto intake manifold. Install and torque mounting screws to 6.2-7.3 N·m (55-65 in. lb.).
4. If adapter was separated from carburetor, install a new gasket and mount adapter with breather hose connection port facing rear. Install and torque mounting screws to 7.3 N·m (65 in. lb.).

5. Connect upper end of breather hose to fitting on rear of adapter.
6. Connect long end of choke linkage to carburetor.
7. If a mechanical fuel pump is used, install fuel line between outlet of fuel pump and carburetor inlet, and secure with clamps.

## Install External Governor Controls and Main Control Bracket

### Control Panel Details



<b>A</b>	Control Panel	<b>B</b>	Choke Lever
<b>C</b>	Governor Lever Nut	<b>D</b>	Governor Lever
<b>E</b>	Governor Spring		

1. Install governor lever onto governor cross shaft. If separated, connect throttle link to governor lever with plastic bushing. Hook dampening spring into small (middle) hole.
2. Move governor lever TOWARDS carburetor as far as it will go (wide open throttle) and hold in this position.
3. Insert a nail into hole in cross shaft and rotate shaft COUNTERCLOCKWISE as far as it will turn. Then torque nut to 6.8 N·m (60 in. lb.).
4. Connect choke lever of main control bracket to choke linkage from carburetor. Mount main control bracket to cylinder heads with four screws. Torque screws to 10.7 N·m (95 in. lb.) into new holes, or 7.3 N·m (65 in. lb.) into used holes.
5. Connect dampening spring to throttle lever. Hook governor spring from throttle control bracket in appropriate governor lever hole, as indicated in chart below. Note that hole positions are counted from pivot point of governor lever.

## Install Lower Crankshaft Pulley, Pulley Adapter, and Cooling Fan Assembly

NOTE: Do not assemble lower pulley with belt between pulley halves, as pinching of belt or damage to pulley can occur.

## Reassembly

1. Make sure shoulder of flywheel hub and adjacent face surface are clean and free of any nicks or damage.
2. Install crankshaft pulley adapter onto flywheel hub, so offset for pulley is out, and holes are aligned. Make sure adapter rests squarely on face of flywheel.
3. Assemble front and rear pulley halves placing shims as indicated.
  - a. For a new belt: Assemble with 2 or 3 shims between pulley halves, and remaining shim (if any) on outside (front) of outer pulley half.
  - b. For a used belt: Assemble with 2 shims between pulley halves and remaining shim(s) on outside (front) of outer pulley half.

Install and snug pulley assembly. Final belt tension and pulley assembly will be made after fan/upper pulley assembly is installed.

4. Install upper fan mounting bracket to intake manifold with screws.

Torque:

M6 Screws to 7.3 N·m (65 in. lb.)

M8 Screws to 24.4 N·m (216 in. lb.)

By-pass hose and wires must be positioned within cutout in intake manifold. Be careful not to pinch harness wires between bracket and intake manifold when tightening.

5. If disassembled, reassemble fan and pulley assembly.
 

Make sure one flat washer is placed between bearings in hub. Other washer is located under front nut. Torque fan/pulley/hub mounting screws to 6.8 N·m (60 in. lb.).
6. If fan shaft was removed from upper mounting bracket, apply Loctite® 242® to rear threads. Install and torque rear nut to 15.8 N·m (140 in. lb.). Install fan and pulley assembly onto fan shaft and upper mounting bracket.
7. Apply Loctite® 242® to front threads of fan shaft. Install flat washer and nut to secure. Torque nut to 15.8 N·m (140 in. lb.).
8. Carefully work belt into place on pulleys. Check belt tension. There should be no more than 9.53 - 12.7 mm (3/8" - 1/2") belt deflection per side with 10 lbs. of applied tension.
 

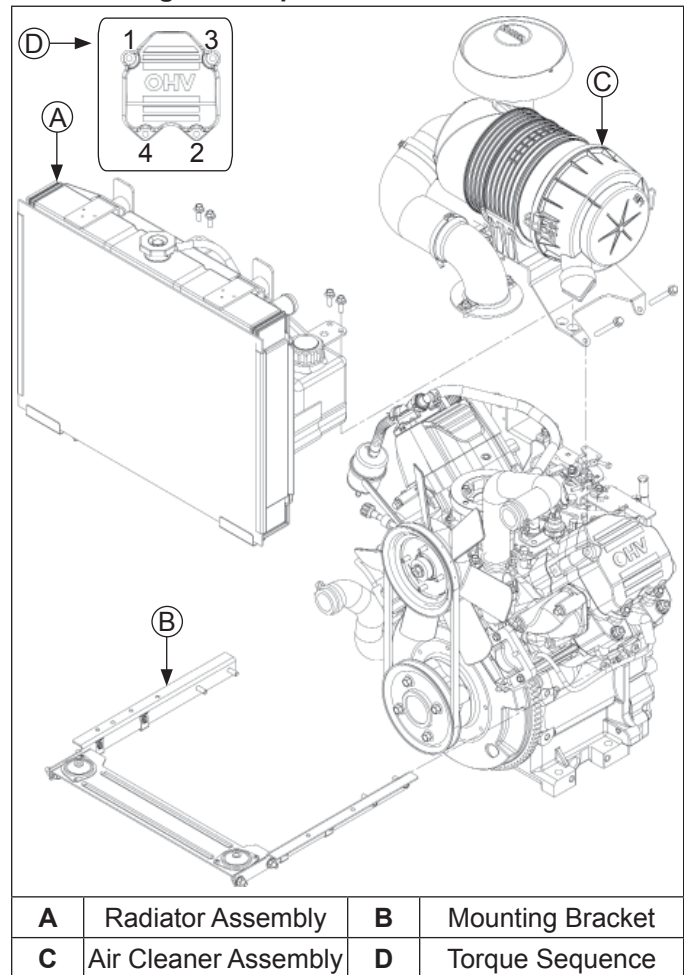
If belt tension is low, remove belt and relocate a shim from between pulley halves to outside (front). Reinstall belt and recheck tension. Repeat procedure until correct tension is reached. If shims have all been moved to outside, and belt is still too loose, replace belt.

When proper tension is obtained, individually remove each capscrew, apply Loctite® 242® to threads of lower pulley and reinstall. Torque four bolts in a criss-cross sequence to 24.3 N·m (215 in. lb.).

9. Mount RH and LH lower radiator supports with cross support bracket attached, to crankcase, using screws. Snug screws only at this time.

## Install Air Cleaner Assembly

### External Engine Components

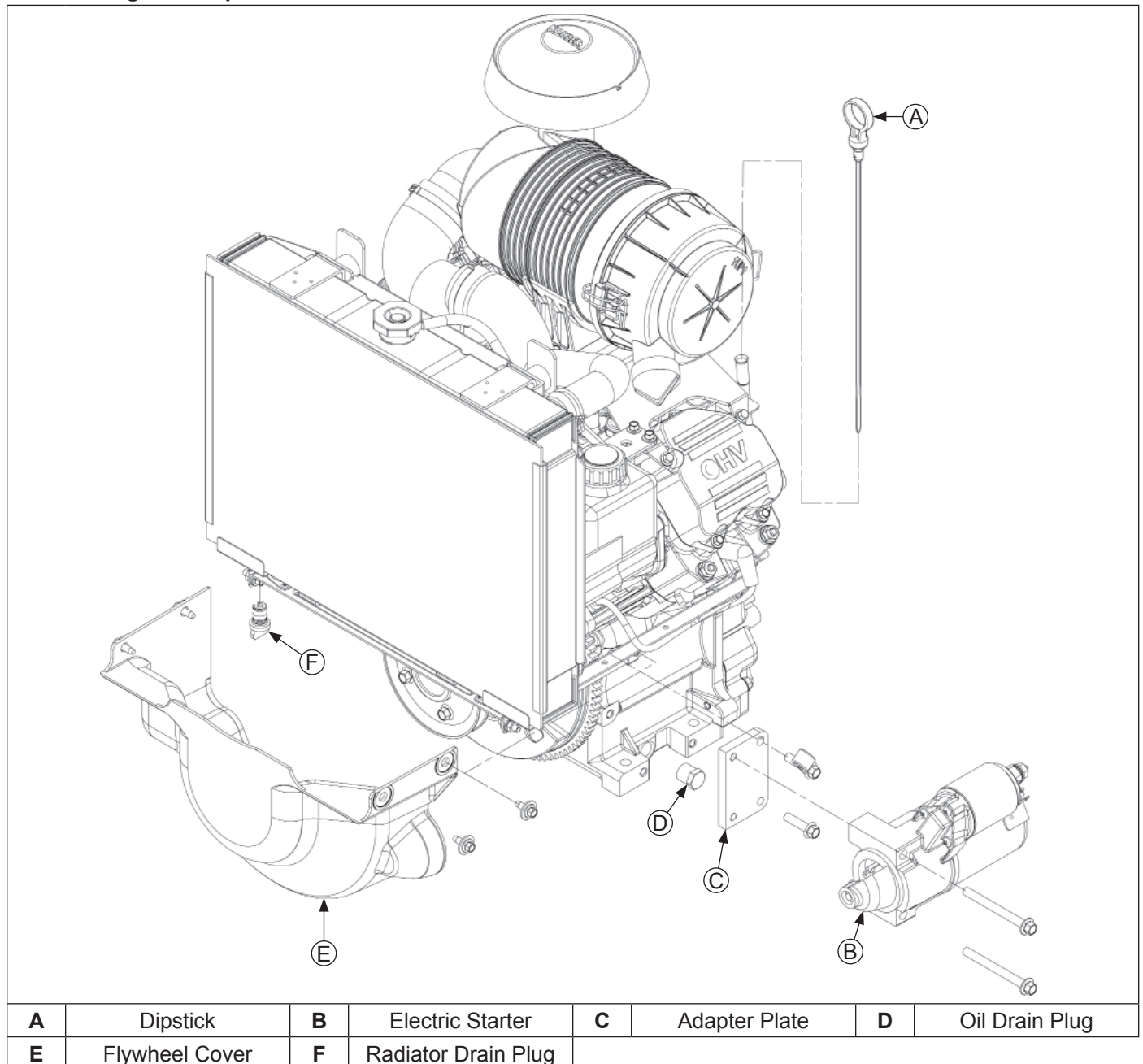


1. Install a new elbow adapter gasket onto carburetor adapter.
2. Set air cleaner/mounting bracket assembly, with hose and elbow attached, in position on engine. Align all of mounting holes. Start and finger tighten each of mounting screws. Make sure fuel line is outside of main bracket when installed.
3. Torque elbow mounting screws to 7.3 N·m (65 in. lb.). Then torque eight valve cover mounting screws to 6.2 N·m (55 in. lb.) in sequence shown.
4. If removed, install rain cap and secure with clamp. Check position of dust ejector, it should face downward. Adjust end cap position as required.
5. Connect wires for audible alarm, if used.

## Install Radiator Assembly

1. Reassemble components of radiator assembly, including upper and lower radiator hoses. Rubber lubricant may be applied to inner surfaces of hoses to make installation easier. Secure with hose clamps. Radiator subassembly should look as shown.
2. Tighten radiator drain plug.
3. Carefully set radiator assembly into place, guiding lower radiator hose inside RH support bracket. Make sure that cooling fins do not come in contact with fan blades as radiator is installed.
4. Position upper radiator support brackets on top of air cleaner mounting bracket. Install and finger tighten four mounting screws.
5. Connect upper and lower radiator hoses to inlets of radiator and water pump. Secure with hose clamps. Make sure tangs of upper clamp face away from fan.
6. Check for adequate clearance between fan and shroud. Adjust lower radiator supports as required, then torque four mounting screws to 9.9 N·m (88 in. lb.).
7. Hold radiator assembly in position; then torque screws securing two upper radiator supports to 9.9 N·m (88 in. lb.).

## External Engine Components



## Reassembly

- If securing upper brackets to top radiator mounts were loosened, torque to 9.9 N·m (88 in. lb.).
- If a pulse style fuel pump is used, install it to tapped holes in cylinder 2 side, upper radiator support bracket and torque two screws to 6.8-7.3 N·m (60-65 in. lb.). Connect outlet line between pump and carburetor and vacuum line to crankcase fitting. Secure with clamps.

### Install Starter Adapter

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- Install starter adapter to crankcase, so cutout is offset down and facing away from flywheel side. Install mounting screws, and position clamp for stator leads on upper screw. Torque screws to 15.3 N·m (135 in. lb.).
- Place stator leads within clamp and close loop.
- If violet B+ charge lead is separate from main harness, secure it to wiring harness with a tie strap, directly above clamp.

### Install Starter Assembly

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NOTE: Stator leads and rectifier-regulator plug must be above starter.

- Mount starter to adapter plate using screws.
- Make sure starter is square to flywheel, and torque screws to 15.3 N·m (135 in. lb.).
- Attach leads to appropriate starter solenoid terminals.
- To avoid damage or breakage, do not over-tighten nut when attaching positive battery cable. Torque nut to 6-9 N·m (53-79 in. lb.).

### Install Lower Flywheel Cover, Rectifier-Regulator and Mounting Plate

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- Install/make sure small metal spacers are positioned in mounting holes of lower flywheel cover.
- Attach lower flywheel cover to cylinder 2 (oil filter) side lower radiator support bracket, using M6 screws and flat washers. Finger tighten only at this time.
- Align lower flywheel cover with cylinder 1 (starter) side lower radiator support bracket holes. Position rectifier-regulator mounting plate, behind cover and install remaining two screws or nuts and flat washers. Torque four fasteners to 9.9 N·m (88 in. lb.). If screws and Timmerman nuts/clips are used torque to 2.2-2.8 N·m (20-25 in. lb.).
- If removed, mount rectifier-regulator to plate with two screws and attach connector plug.

### Install Muffler

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- Install new exhaust gaskets and attach muffler and mounting hardware. Torque screws to 9.9 N·m (88 in. lb.).
- Install nuts to exhaust studs. Torque nuts to 24.4 N·m (216 in. lb.).

### Install Oil Filter and Fill Crankcase with Oil

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NOTE: Make sure both oil drain plugs are installed and torqued to specifications to prevent oil leakage.

- Install oil drain plug(s). Torque plug(s) to 13.6 N·m (10 ft. lb.). If oil drain valve is used, make sure valve body is closed and cap is on.
- Place new filter in shallow pan with open end up. Fill with new oil until oil reaches bottom of threads. Allow 2 minutes for oil to be absorbed by filter material.
- Apply a thin film of clean oil to rubber gasket on oil filter.
- Refer to instructions on oil filter for proper installation.
- Fill crankcase with new oil. Level should be at top of indicator on dipstick.
- Reinstall oil fill cap/dipstick and tighten securely.

### Install Coolant

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- Use equal parts of ethylene glycol (antifreeze) and water only. Distilled or deionized water is recommended, especially in areas where water contains a high mineral content. Propylene glycol based antifreeze is not recommended.
- Fill cooling system, through radiator, with coolant mix. Allow coolant to drain into lower areas. Fill overflow reservoir midway between FULL and ADD marks, then install radiator and reservoir caps.

### Reconnect Battery and Spark Plug Leads

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Connect leads to spark plugs. Reconnect positive (+) battery lead first, and negative (-) lead last when connecting battery.

### Testing Engine

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It is recommended engine be operated on a test stand or bench prior to installation in equipment.

- Make sure all hardware is tightened, and hose clamps are properly secured.
- Set up engine on a test stand. Install an oil pressure gauge. Start engine and check to be certain that oil pressure (20 psi or more) is present. Run for 5-10 minutes between idle and mid-range.
- Check all cooling system components and joint connections for leaks.
- Make sure maximum engine speed does not exceed 3750 RPM (no load). Adjust throttle, choke controls and high speed stop as necessary. Refer to Fuel System section.
- Place throttle control into idle or slow position and check low idle speed (RPM). Refer to Fuel System if adjustment is required.
- Stop engine.
- Recheck oil and coolant levels. Oil level should be at F mark on dipstick, and coolant level in reservoir should be midway between ADD and FULL marks. Add additional amounts as required.











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