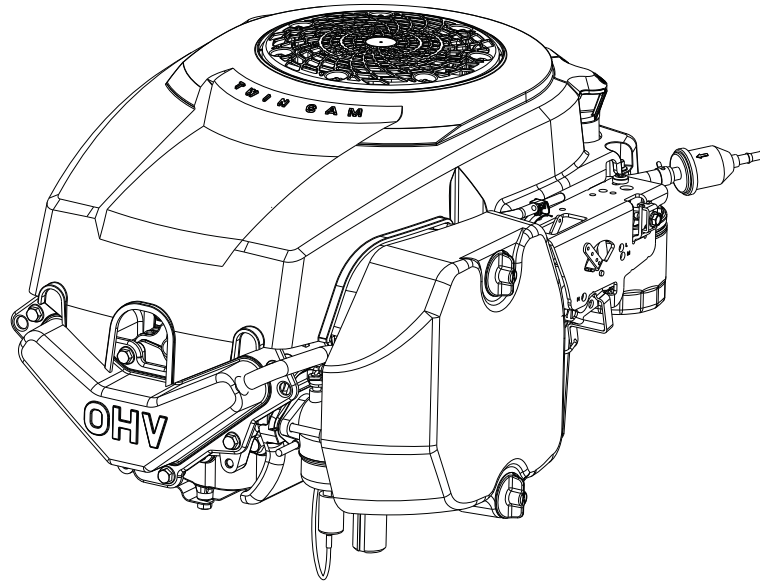


# KOHLER® Courage

SV470-SV620

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. Never run engine indoors or in enclosed spaces.
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.	

## 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 25 Hours or Annually<sup>1</sup>

• Service/replace low-profile precleaner.	Air Cleaner/Intake
• Replace air cleaner element (if not equipped with precleaner).	Air Cleaner/Intake

Every 100 Hours or Annually<sup>1</sup>

• Replace air cleaner element (if not equipped with precleaner).	Air Cleaner/Intake
• Change oil and filter.	Lubrication System
• Remove cooling shrouds and clean cooling areas.	Air Cleaner/Intake

Every 100 Hours

• Replace fuel filter.	
• Check that all fasteners are in place and components are properly secured.	Reassembly

Every 200 Hours<sup>2</sup>

• Have valve lash checked/adjusted.	Reassembly
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Every 300 Hours<sup>3</sup>

• Change oil and filter (KOHLE <sup>®</sup> PRO 10W-50 oil and KOHLE <sup>®</sup> PRO filter only).	Lubrication System
-----------------------------------------------------------------------------------------------------	--------------------

Every 500 Hours

• Replace spark plug and set gap.	Electrical System
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<sup>1</sup> Perform these procedures more frequently under severe, dusty, dirty conditions.

<sup>2</sup> Have a Kohler authorized dealer perform this service.

<sup>3</sup> Option only if using KOHLE<sup>®</sup> PRO oil and PRO filter.

## REPAIRS/SERVICE PARTS

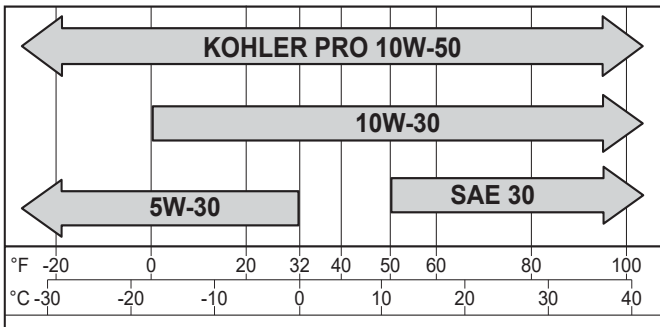
Kohler genuine service parts can be purchased from Kohler authorized dealers. To find a local Kohler authorized dealer visit [KohlerEngines.com](http://KohlerEngines.com) or call 1-800-544-2444 (U.S. and Canada).

# Maintenance


## OIL RECOMMENDATIONS

All-season KOHLER® PRO 10W-50 Synthetic Oil is the ideal oil for KOHLER® engines. It is specifically formulated to extend the oil and oil filter change interval to 300 Hours when paired with a KOHLER PRO Extended Life Oil Filter.

300-Hour oil and oil filter change intervals are exclusive to and only authorized on KOHLER engines that utilize both the KOHLER PRO 10W-50 Synthetic Oil and KOHLER PRO Extended Life Oil Filter. Alternative engine oils and oil filters may be used with KOHLER engines but require 100-Hour oil and oil filter change intervals for proper maintenance. Oil must be API (American Petroleum Institute) service class SJ or higher. Select viscosity based on air temperature at time of operation as shown 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.

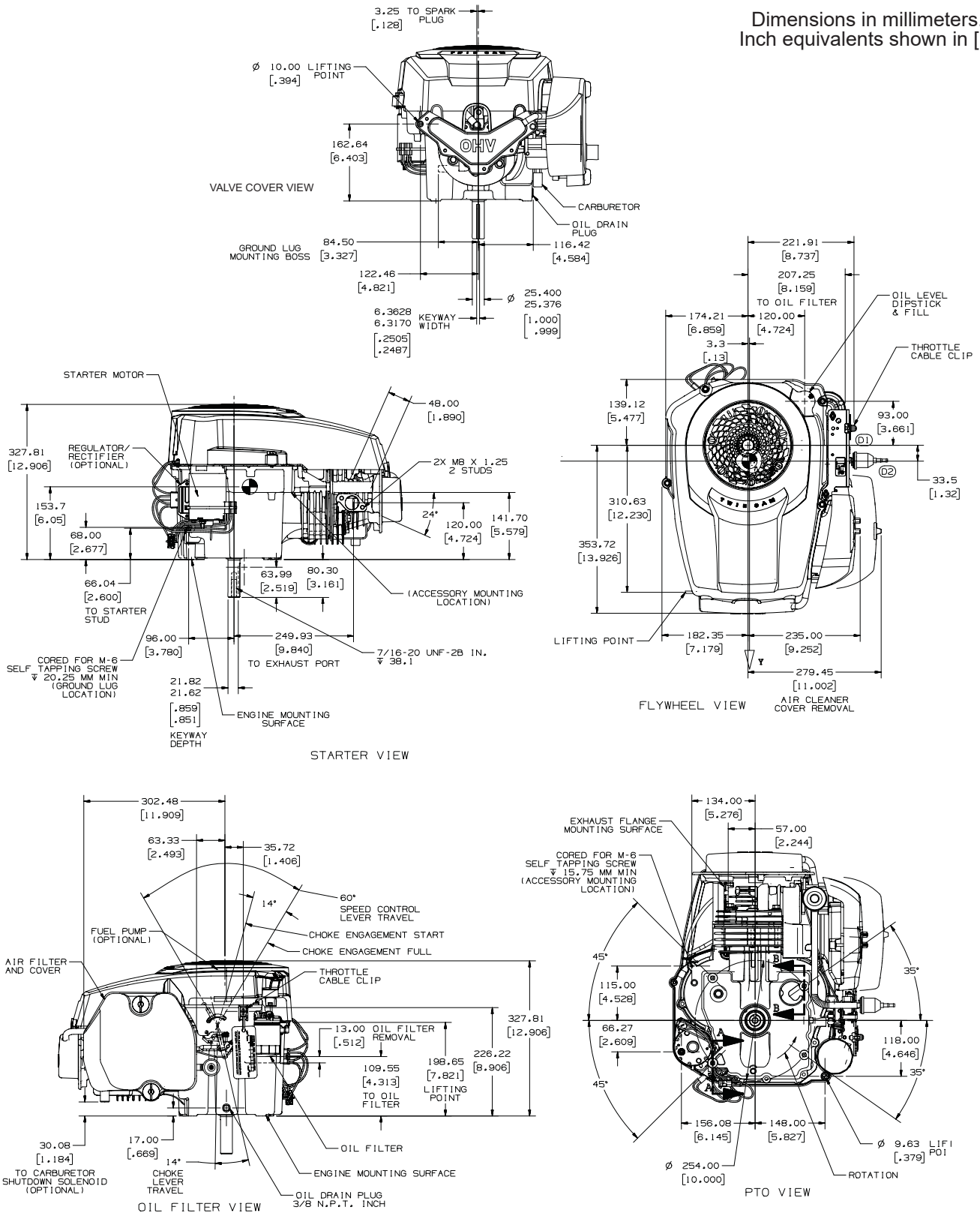
## STORAGE

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 carburetor (failures due to untreated fuel are not warrantable).
2. Change oil while engine is still warm from operation (NOT required if using KOHLER PRO 10W-50 full-synthetic oil). 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

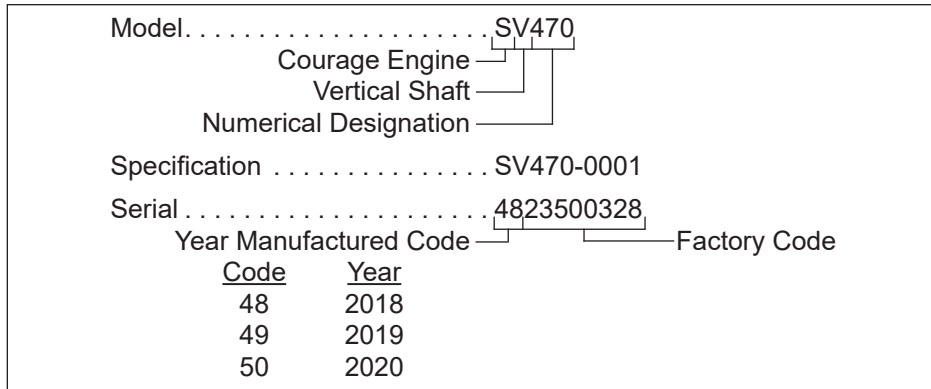
Dimensions in millimeters.  
Inch equivalents shown in [ ].



# 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>

	SV470/ SV471/ SV480	SV530/ SV540/ SV541	SV590/SV591/ SV600/SV601/ SV610/SV620
Bore	---	---	94 mm (3.70 in.)
Spec. 00XX:	84 mm (3.30 in.)	89 mm (3.50 in.)	---
Spec. 01XX:	89 mm (3.50 in.)	---	---
Spec. 02XX or higher:	94 mm (3.70 in.)	94 mm (3.70 in.)	---
Stroke	86 mm (3.38 in.)		
Displacement	---	---	597 cc (36.4 cu. in.)
Spec. 00XX:	477 cc (29.1 cu. in.)	535 cc (32.6 cu. in.)	---
Spec. 01XX:	535 cc (32.6 cu. in.)	---	---
Spec. 02XX or higher:	597 cc (36.4 cu. in.)	597 cc (36.4 cu. in.)	---
Oil Capacity (refill)	1.5 L (1.6 U.S. qt.)		
Maximum Angle of Operation (@ full oil level) <sup>4</sup>	25°		

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

	SV470/ SV471/ SV480	SV530/ SV540/ SV541	SV590/SV591/ SV600/SV601/ SV610/SV620
<b>Air Cleaner Base</b>			
Hex Nut Fastener	5.5 N·m (48 in. lb.)		
Mounting Screw Fastener (install dry)	8.0 N·m (70 in. lb.) into new hole 5.5 N·m (48 in. lb.) into used hole		
<b>Balance Weight</b>			
Screw	10.9-13.2 N·m (95.0-115.0 in. lb.)		
<b>Blower Housing and Sheet Metal</b>			
M6 Fastener	11.6 N·m (99 in. lb.) into new hole 7.7 N·m (68 in. lb.) into used hole		
<b>Cam Lever</b>			
Fastener	8.0-10.5 N·m (70-94.0 in. lb.) into new hole 7.1-8.6 N·m (61.8-74.8 in. lb.) into used hole		

<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>

SV470/  
SV471/  
SV480

SV530/  
SV540/  
SV541

SV590/SV591/  
SV600/SV601/  
SV610/SV620

### Carburetor

Fuel Bowl Retaining Screw Walbro Nikki	5.1-6.2 N·m (45-55 in. lb.) 10.8-12.8 N·m (96-113 in. lb.)
----------------------------------------------	---------------------------------------------------------------

### Closure Plate

Fastener	24.5 N·m (216 in. lb.)
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### Connecting Rod

Cap Fastener (torque in 2 increments)	5.5, 11.5 N·m (50, 100 in. lb.)
---------------------------------------	---------------------------------

### Crankcase

Oil Drain Plug	14.0 N·m (125 in. lb.)
----------------	------------------------

### Cylinder Head

Fastener (torque in 2 increments)	20.5, 41.0 N·m (180, 360 in. lb.)
Rocker Arm Pivot Stud	13.5 N·m (120 in. lb.)
Rocker Arm Adjustment Nut Set Screw	5.5 N·m (50 in. lb.)

### Electric Starter

Thru Bolt	3.3-3.9 N·m (30-35 in. lb.)
Mounting Nut	3.6 N·m (32 in. lb.)
Nut (top) Positive (+) Brush Lead Terminal	1.6-2.8 N·m (15-25 in. lb.)
Nut (flange) Positive (+) Brush Lead Terminal	2.2-4.5 N·m (20-40 in. lb.)

### Flywheel

M12 Retaining Screw	88.0 N·m (65 ft. lb.)
M10 Retaining Screw	66.5 N·m (49 ft. lb.)

### Governor

Lever Nut	7.0-8.5 N·m (60-75 in. lb.)
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### Ignition

Spark Plug	27 N·m (20 ft. lb.)
Module Fastener	6.0 N·m (55 in. lb.) into new hole 4.0 N·m (35 in. lb.) into used hole
Rectifier-Regulator Fastener	6.0 N·m (55 in. lb.) into new hole 4.0 N·m (35 in. lb.) into used hole

### Muffler

Retaining Nuts	24.4 N·m (216 in. lb.)
----------------	------------------------

### Oil Filter Pad Pipe Plug

1/8" N.P.T.F.	4.5-5.0 N·m (40-46 in. lb.)
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### Oil Pump

Mounting Screw	5.0-7.5 N·m (44.4-66.0 in. lb.) into new hole 3.8-4.6 N·m (33.3-40.3 in. lb.) into used hole
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<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

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

SV470/  
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SV600/SV601/  
SV610/SV620

### Oil Sentry™

Pressure Switch	4.5-5.0 N·m (40-45 in. lb.)
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### Speed Control

Bracket Assembly Fastener	11.0 N·m (95 in. lb.) into new hole 7.5 N·m (65 in. lb.) into used hole
---------------------------	----------------------------------------------------------------------------

### Stator

Mounting Screw	6.0 N·m (55 in. lb.) into new hole 4.0 N·m (35 in. lb.) into used hole
----------------	---------------------------------------------------------------------------

### Valve Cover

Fastener	11.0 N·m (95 in. lb.) into new hole 7.5 N·m (65 in. lb.) into used hole
----------	----------------------------------------------------------------------------

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

SV470/  
SV471/  
SV480

SV530/  
SV540/  
SV541

SV590/SV591/  
SV600/SV601/  
SV610/SV620

### Balance Weight

Bearing Surface I.D. New Max. Wear Limit	67.011/67.086 mm (2.6382/2.6412 in.) 67.140 mm (2.6430 in.)
Pin O.D. New Max. Wear Limit	11.950/11.975 mm (0.4705/0.4715 in.) 11.900 mm (0.4685 in.)
Guide Shoe Width New Max. Wear Limit	17.85/17.90 mm (0.703/0.705 in.) 17.75 mm (0.6988 in.)
Guide Shoe Hole I.D.-First Generation Balance Weight New Max. Wear Limit	12.000/12.025 mm (0.4724/0.4734 in.) 12.050 mm (0.4744 in.)
Linkage Pin O.D. (Crankcase)-Second Generation Balance Weight New Max. Wear Limit	11.964/11.975 mm (0.4710/0.4715 in.) 11.900 mm (0.4685 in.)
Balance Weight Linkage-Second Generation Balance Weight New Max. Wear Limit	11.985/12.010 mm (0.4719/0.4728 in.) 12.035 mm (0.4738 in.)

### Cam Gears

End Play	0.5/1.5 mm (0.019/0.059 in.)
Running Side Clearance	0.02/0.13 mm (0.001/0.005 in.)
Cam Gear-to-Cam Shaft Running Assembly	0.02/0.10 mm (0.001/0.004 in.)

### Closure Plate

Balance Weight Guide Channel Width New Max. Wear Limit	17.95/18.05 mm (0.707/0.711 in.) 18.13 mm (0.714 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.



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

**SV470/  
SV471/  
SV480**

**SV530/  
SV540/  
SV541**

**SV590/SV591/  
SV600/SV601/  
SV610/SV620**

### Connecting Rod

Connecting Rod-to-Crankpin Running Clearance New Max. Wear Limit	0.03/0.055 mm (0.0012/0.0022 in.) 0.07 mm (0.0025 in.)
Connecting Rod-to-Crankpin Side Clearance	0.25/0.59 mm (0.0098/0.0232 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	6.025/6.05 mm (0.2372/0.2382 in.) 6.063 mm (0.2387 in.)
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### Crankshaft

End Play (free)	0.225/1.025 mm (0.0089/0.040 in.)
Bore in Crankcase I.D. New Max. Wear Limit	41.965/41.990 mm (1.6521/1.6531 in.) 42.016 mm (1.654 in.)
Bore in Closure Plate I.D. New Max. Wear Limit	44.965/44.990 mm (1.7703/1.7713 in.) 45.016 mm (1.7723 in.)
Flywheel End Main Bearing Journal O.D. New, Before Serial No. 3703200003 New, After Serial No. 3703200013 O.D., Max. Wear Limit Max. Taper Max. Out of Round	44.913/44.935 mm (1.7682/1.7691 in.) 44.870/44.895 mm (1.7665/1.7675 in.) 44.84 mm (1.765 in.) 0.0220 mm (0.0009 in.) 0.025 mm (0.001 in.)
PTO End Main Bearing Journal O.D. New, Before Serial No. 3703200003 New, After Serial No. 3703200013 O.D., Max. Wear Limit Max. Taper Max. Out of Round	41.913/41.935 mm (1.6501/1.6510 in.) 41.855/41.880 mm (1.6478/1.6488 in.) 41.83 mm (1.647 in.) 0.020 mm (0.0008 in.) 0.025 mm (0.001 in.)
Bore in Closure Plate Running Clearance New, Before Serial No. 3703200003 New, After Serial No. 3703200013	0.030/0.077 mm (0.0012/0.0030 in.) 0.070/0.120 mm (0.0027/0.0047 in.)
Bore in Crankcase Running Clearance New, Before Serial No. 3703200003 New, After Serial No. 3703200013	0.030/0.077 mm (0.0012/0.0030 in.) 0.085/0.135 mm (0.0033/0.0053 in.)
Connecting Rod Journal O.D. New Max. Wear Limit Max. Taper Max. Out of Round	40.982/41.000 mm (1.6134/1.6141 in.) 40.964 mm (1.612 in.) 0.012 mm (0.0005 in.) 0.025 mm (0.001 in.)
T.I.R. PTO End, Crankshaft in Engine Entire Crankshaft , in V-Blocks	0.15 mm (0.0059 in.) 0.10 mm (0.0039 in.)
Eccentrics O.D. New Max. Wear Limit	66.940/66.970 mm (2.6354/2.6366 in.) 66.89 mm (2.633 in.)

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

# Specifications

CLEARANCE SPECIFICATIONS <sup>3</sup>	SV470/ SV471/ SV480	SV530/ SV540/ SV541	SV590/SV591/ SV600/SV601/ SV610/SV620
<b>Cylinder Bore</b>			
Cylinder Bore I.D. New	---	---	94.010/94.035 mm (3.701/3.702 in.)
Spec. 00XX:	84.010/84.035 mm (3.307/3.308 in.)	89.010/89.035 mm (3.504/3.505 in.)	---
Spec. 01XX:	89.010/89.035 mm (3.504/3.505 in.)	---	---
Spec. 02XX or higher:	94.010/94.035 mm (3.701/3.702 in.)	94.010/94.035 mm (3.701/3.702 in.)	---
Max. Wear Limit	---	---	94.073 mm (3.704 in.)
Spec. 00XX:	84.073 mm (3.310 in.)	89.073 mm (3.507 in.)	---
Spec. 01XX:	89.073 mm (3.507 in.)	---	---
Spec. 02XX or higher:	94.073 mm (3.704 in.)	94.073 mm (3.704 in.)	---
Max. Taper Max. Out of Round	0.05 mm (0.002 in.) 0.12 mm (0.0047 in.)		
<b>Cylinder Head</b>			
Max. Out-of-Flatness	0.8 mm (0.003 in.)		
<b>Governor</b>			
Governor Cross Shaft -to-Crankcase Running Clearance	0.013/0.075 mm (0.0005/0.003 in.)		
Cross Shaft O.D. New Max. Wear Limit	5.975/6.012 mm (0.2352/0.2367 in.) 5.962 mm (0.2347 in.)		
Governor Gear Shaft -to-Governor Gear Running Clearance	0.09/0.16 mm (0.0035/0.0063 in.)		
Gear Shaft O.D. New Max. Wear Limit	5.99/6.00 mm (0.2358/0.2362 in.) 5.977 mm (0.02353 in.)		
<b>Ignition</b>			
Spark Plug Gap	0.76 mm (0.030 in.)		
Module Air Gap	0.203/0.305 mm (0.008/0.012 in.)		
<b>Oil Pump</b>			
Pump Gears-to-Crankcase Side Clearance	0.165/0.315 mm (0.0065/0.0124 in.)		
<b>Piston, Piston Rings, and Piston Pin</b>			
Pin Bore I.D. New Max. Wear Limit	22.006/22.012 mm (0.8685/0.8666 in.) 22.025 mm (0.8671 in.)		
Pin O.D. New Max. Wear Limit	21.995/22.0 mm (0.8659/0.8661 in.) 21.994 mm (0.8658 in.)		
Top Compression Ring-to-Groove Side Clearance	0.04 mm (0.0016 in.)		
Middle Compression Ring-to-Groove Side Clearance	0.04 mm (0.0016 in.)		

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

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

**SV470/  
SV471/  
SV480**

**SV530/  
SV540/  
SV541**

**SV590/SV591/  
SV600/SV601/  
SV610/SV620**

### Piston, Piston Rings, and Piston Pin (Continued)

Top and Middle Compression Ring End Gap New Bore				
Top Ring				0.15/0.40 mm (0.006/0.016 in.)
Middle Ring				0.30/0.55 mm (0.012/0.022 in.)
Used Bore (max.)				0.77 mm (0.030 in.)
Thrust Face O.D. <sup>7</sup> New		---	---	93.928/93.942 mm (3.6980/3.6985 in.)
	Spec. 00XX:	83.948/83.962 mm (3.3050/3.3056 in.)	88.948/88.962 mm (3.5018/3.5024 in.)	---
	Spec. 01XX:	88.948/88.962 mm (3.5018/3.5024 in.)	---	---
	Spec. 02XX or higher:	93.928/93.942 mm (3.6980/3.6985 in.)	93.928/93.942 mm (3.6980/3.6985 in.)	---
Max. Wear Limit		---	---	93.828 mm (3.6940 in.)
	Spec. 00XX:	83.828 mm (3.3003 in.)	88.828 mm (3.4972 in.)	---
	Spec. 01XX:	88.828 mm (3.4972 in.)	---	---
	Spec. 02XX or higher:	93.828 mm (3.6940 in.)	93.828 mm (3.6940 in.)	---
Piston Thrust Face-to-Cylinder Bore <sup>7</sup> Running Clearance		0.045 mm (0.0018 in.)		0.0880 mm (0.0035 in.)

### Valves and Valve Lifters

Intake Valve Lash <sup>8</sup>	0.127 mm (0.005 in.)
Exhaust Valve Lash <sup>8</sup>	0.178 mm (0.007 in.)
Intake Valve Minimum Lift	8.9 mm (0.350 in.)
Exhaust Valve Minimum Lift	8.9 mm (0.350 in.)
Nominal Valve Seat Angle	45°
Intake Valve Stem-to-Valve Guide Running Clearance	0.038/0.076 mm (0.0015/0.003 in.)
Exhaust Valve Stem-to-Valve Guide Running Clearance	0.050/0.088 mm (0.0020/0.0035 in.)
Intake Valve Guide I.D. New	6.038/6.058 mm (0.2377/0.2385 in.)
Max. Wear Limit	6.135 mm (0.2415 in.)
Intake Valve Stem Diameter New	5.982/6.0 mm (0.2355/0.2362 in.)
Exhaust Valve Guide I.D. New	6.038/6.058 mm (0.2377/0.2385 in.)
Max. Wear Limit	6.160 mm (0.2425 in.)
Exhaust Valve Stem Diameter New	5.970/5.988 mm (0.235/0.2357 in.)




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

<sup>7</sup> Measure 8 mm (0.314 in.) above bottom of piston skirt at right angles to piston pin.






<sup>8</sup> Check valve lash every 200 hours, adjust as required.

# Specifications

## 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
	 4.8	 5.8	 8.8	 10.9	 12.9	
<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

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 and Aids

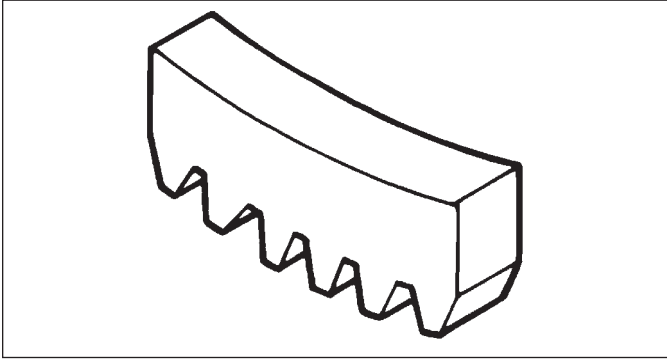
### TOOLS

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

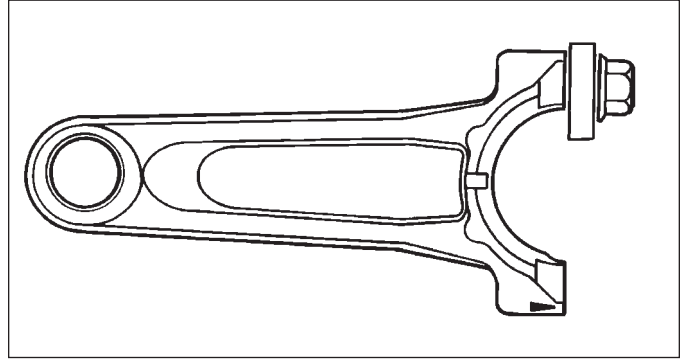
### FLYWHEEL HOLDING TOOL



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

## 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).

## Engine Loses Power

- 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

- 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

- 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>
	<p>Cleaning Solvents can cause severe injury or death.</p> <p>Use only in well ventilated areas away from ignition sources.</p>
<p>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.</p>	


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.

# Troubleshooting

## CRANKCASE VACUUM TEST

	<b>⚠ WARNING</b>
	Carbon Monoxide can cause severe nausea, fainting or death. Avoid inhaling exhaust fumes. Never run engine indoors or in enclosed spaces.
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 values 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.

## 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.

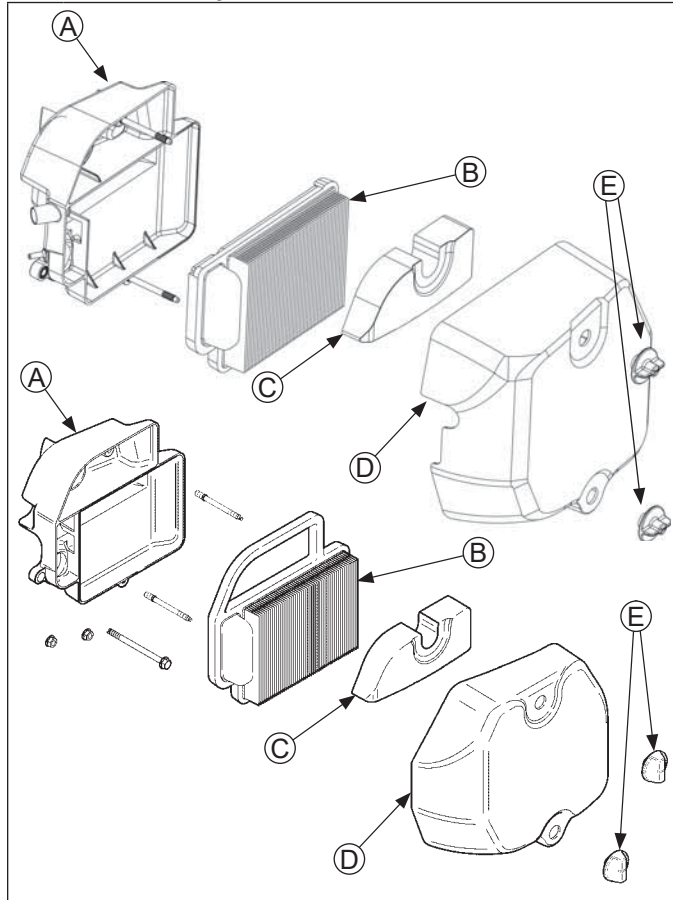
Condition	Conclusion
Air escaping from crankcase breather.	Ring or cylinder worn.
Air escaping from exhaust system.	Defective exhaust valve/improper seating.
Air escaping from intake.	Defective intake valve/improper seating.
Gauge reading in low (green) zone.	Piston rings and cylinder in good condition.
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/Intake

## AIR CLEANER

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

### Air Cleaner Components



<b>A</b>	Air Cleaner Base	<b>B</b>	Paper Element
<b>C</b>	Precleaner	<b>D</b>	Air Cleaner Cover
<b>E</b>	Air Cleaner Knob		

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.

Loosen knobs and remove air cleaner cover.

### Precleaner (if equipped)

1. Remove precleaner.
2. Replace or wash precleaner in warm water with detergent. Rinse and allow to air dry.
3. Saturate precleaner with new engine oil; squeeze out excess oil.
4. Reinstall precleaner into cover, aligning hole in precleaner with upper cover knob.

### Paper Element

1. Remove element from base; replace element.
2. Install element with pleated side out and seat rubber seal onto edges of base.

Reinstall air cleaner cover and secure with knobs.

### 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

Typical carbureted fuel system and related components include:

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

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 PUMP

Some engines are equipped with one of two optional pulse fuel pumps. One is mounted to speed control bracket, and other is mounted to air cleaner base.

Fuel pump has two internal chambers separated by a diaphragm. Air chamber is connected to engine crankcase by a rubber hose. Fuel chamber has an inlet from fuel tank, and an outlet to carburetor. Inlet and outlet each have an internal, one-way check valve.

Alternating negative and positive pressures in crankcase activate pump. When piston moves upward in cylinder, negative pressure (vacuum) is created in crankcase and in air chamber of pump. Diaphragm flexes toward negative pressure, and suction draws fuel past inlet check valve, into fuel chamber. Downward movement of piston causes a positive pressure in crankcase and air chamber, pushing diaphragm in opposite direction, putting pressure on fuel. Inlet check valve has now closed, so fuel is forced past outlet check valve, to carburetor.

## Repair

---

Pulse fuel pumps are not serviceable and must be replaced when faulty.

## Removal

---

### Speed Control Bracket Mounted Fuel Pump

1. Disconnect inlet, outlet, and pulse lines from fuel pump. Mark lines for proper reassembly.
2. Remove screws attaching fuel pump.

### Air Cleaner Base Mounted Fuel Pump

1. Remove dipstick and blower housing.
2. Disconnect inlet, outlet, and pulse lines from fuel pump. Mark lines for proper reassembly.
3. Remove fuel pump from bracket.

## Installation

---

### Speed Control Bracket Mounted Fuel Pump

1. Install new fuel pump, and secure with hex flange screws. Torque screws to 5.9 N·m (52 in. lb.). Do not over tighten.
2. Connect inlet, outlet, and pulse lines to their respective fittings on pump. Secure with clamps.

### Air Cleaner Base Mounted Fuel Pump

1. Install new fuel pump, pressing fuel pump onto bracket past locking tabs.
2. Connect inlet, outlet, and pulse lines to their respective fittings on pump. Secure with clamps.



# Fuel System

## 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 test.

1. Check for fuel in combustion chamber.
  - a. Disconnect and ground spark plug lead.
  - 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.

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**

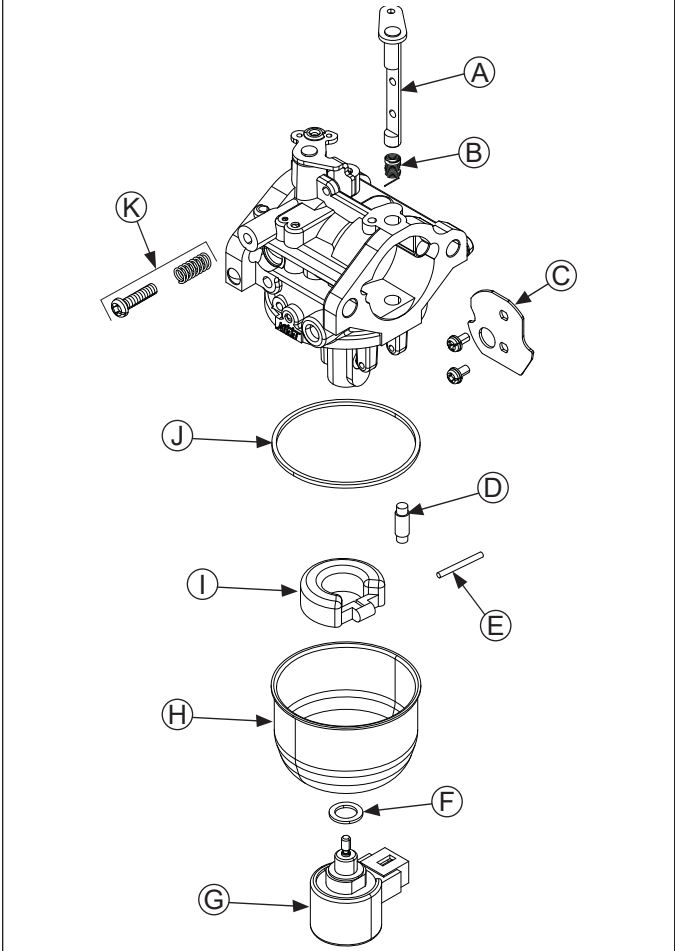


**WARNING**

Explosive Fuel can cause fires and severe burns.  
Do not fill fuel tank while engine is hot or running.

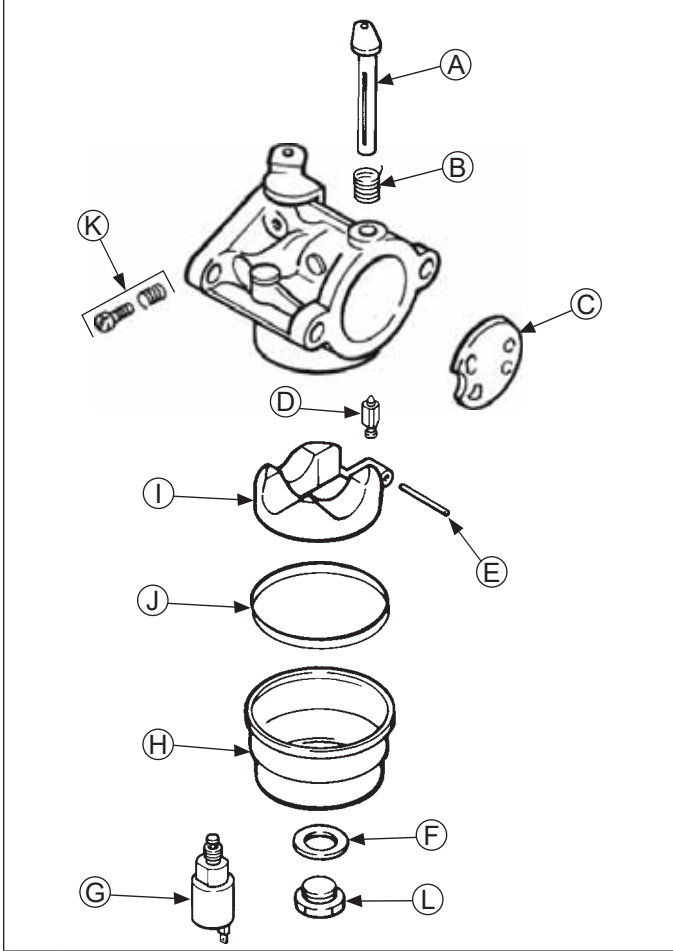
Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent.

**Nikki One-Barrel Carburetor Components**



<b>A</b>	Choke Lever and Shaft	<b>B</b>	Choke Return Spring
<b>C</b>	Choke Plate	<b>D</b>	Fuel Inlet Needle
<b>E</b>	Float Pin	<b>F</b>	Bowl Retaining Screw Gasket
<b>G</b>	Fuel Shut-Off Solenoid	<b>H</b>	Fuel Bowl
<b>I</b>	Float	<b>J</b>	Bowl Gasket
<b>K</b>	Low Idle Speed Adjusting Spring and Screw		

**Walbro One-Barrel Carburetor Components**



<b>A</b>	Choke Lever and Shaft	<b>B</b>	Choke Return Spring
<b>C</b>	Choke Plate	<b>D</b>	Fuel Inlet Needle
<b>E</b>	Float Pin	<b>F</b>	Bowl Retaining Screw Gasket
<b>G</b>	Fuel Shut-Off Solenoid	<b>H</b>	Fuel Bowl
<b>I</b>	Float	<b>J</b>	Bowl Gasket
<b>K</b>	Low Idle Speed Adjusting Spring and Screw	<b>L</b>	Bowl Retaining Screw

# Fuel System

These engines are equipped with either a Walbro or Nikki fixed main jet carburetor. Carburetors will have a low idle speed adjustment screw, and either fixed idle, or a limiter cap on idle fuel adjustment needle.

## 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.

## Troubleshooting-Carburetor Related Causes

Condition	Possible Cause	Conclusion
Engine starts hard, runs rough, or stalls at idle speed.	Low idle fuel mixture/speed improperly adjusted.	Adjust low idle speed screw, then adjust low idle fuel needle.
	Improper choke adjustment.	Correct choke adjustment.
Engine runs rich (indicated by black, sooty exhaust smoke, misfiring, loss of speed and power, governor hunting, or excessive throttle opening).	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.
	Dirt under fuel inlet needle.	Remove needle; clean needle and seat and blow with compressed air.
	Bowl vent or air bleeds plugged.	Remove fuel bowl, low idle fuel adjusting needle, and welch plugs. Clean vent, ports, and air bleeds. Blow out all passages with compressed air.
	Fuel bowl gasket leaks.	Remove fuel bowl and replace gasket.
Engine runs lean (indicated by misfiring, loss of speed and power, governor hunting, or excessive throttle opening).	Leaky, cracked, or damaged float.	Submerge float to check for leaks.
	Low idle fuel mixture is improperly adjusted.	Adjust low idle fuel needle.
Fuel leaks from carburetor.	Idle holes plugged; dirt in fuel delivery channels.	Remove fuel bowl, low idle fuel adjusting needle, and welch plugs. Clean main fuel jet and all passages; blow out with compressed air.
	Dirt under fuel inlet needle.	Remove fuel bowl, low idle fuel adjusting needle, and welch plugs. Clean vent, ports, and air bleeds. Blow out all passages with compressed air.
	Float is cracked or damaged.	Replace float.
	Bowl retaining screw gasket damaged.	Replace gasket.
	Bowl retaining screw loose.	Torque screw to specifications. Walbro 5.1-6.2 N·m (45-55 in. lb.) or Nikki 10.8-12.8 N·m (96-113 in. lb.).

## FUEL SYSTEM

### 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.

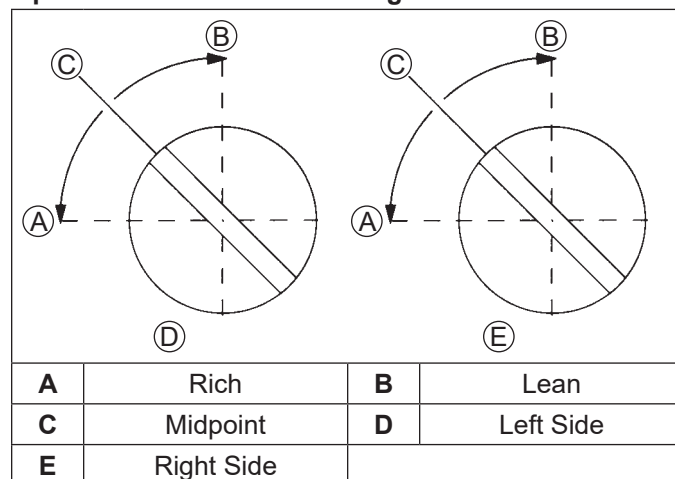
Place throttle control into idle or slow position. Turn low idle speed adjusting screw in or out to obtain allow idle speed of 1200 RPM ( $\pm 75$  RPM).

#### 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.

# Fuel System

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.

## Carburetor Servicing

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

If this engine is operated at an altitude of 4000 ft. (1219 meters) or above, a high altitude carburetor kit is required. To obtain high altitude carburetor 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 4000 ft. (1219 meters).

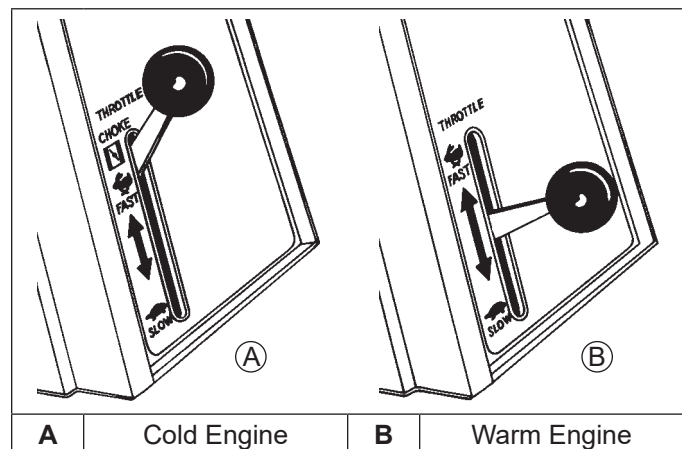
Operating this engine with the wrong engine configuration at a given altitude may increase its emissions, decrease fuel efficiency and performance, and result in damage to the engine.

## UNITIZED THROTTLE AND CHOKE CONTROL

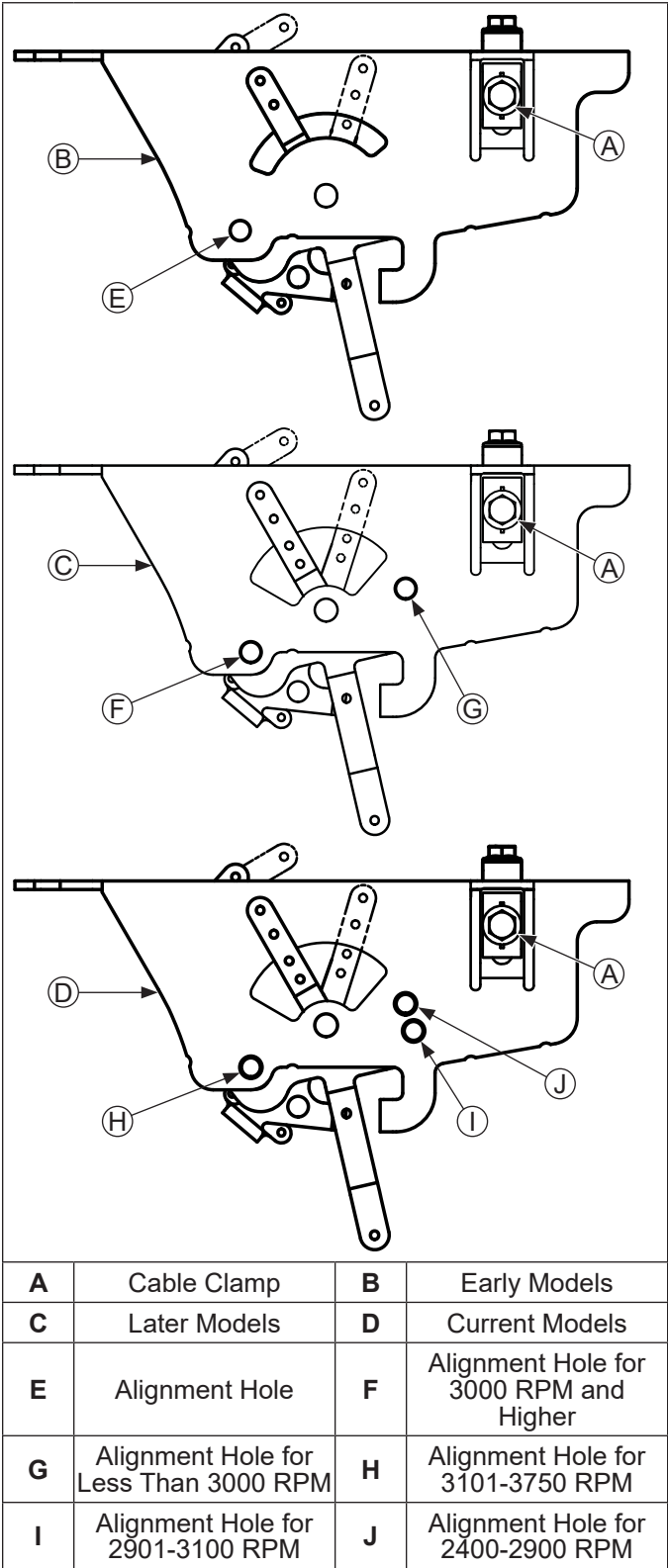
Some engines are equipped with a unitized throttle and choke control. This assembly controls choke and engine speed with a single lever.

## Throttle Cable Adjustment

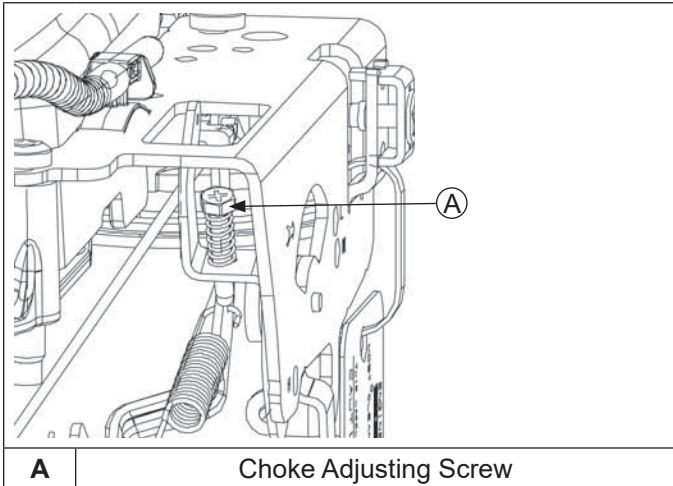
### Throttle/Choke Controls Details



Speed Control Bracket Alignment Hole Details



Choke Adjusting Screw Details



NOTE: Choke is placed ON by moving throttle control slightly past fast position. If throttle control does not have a designated choke ON position, be sure to leave sufficient throttle control travel past fast position. This will enable choke to be placed ON.

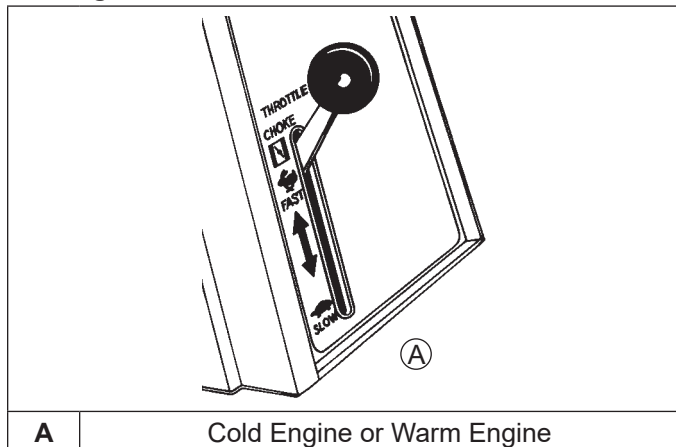
1. Loosen control cable clamp.
2. Place throttle control lever of equipment into fast or high speed position. Actuating tab of choke lever should be just below end of choke adjusting screw.
3. Early Models: Early models use a single alignment hole to set engine RPM. Align hole in throttle lever with hole in speed control bracket by inserting a pencil or 6.35 mm (1/4 in.) drill bit.  
 Later Models: Later models use a new control assembly, identified by two opposing alignment holes (close to throttle lever pivot), instead of one. Based upon intended high-speed (RPM) setting, throttle cable adjustment must be made by matching hole in control lever with correct alignment hole. Use lower (left side) hole for high-speed settings above 3000 RPM. Use upper (right side) hole for high-speed settings lower than 3000 RPM. Move throttle lever to align hole in lever with correct hole in control bracket. Insert a pencil or a 6.35 mm (1/4 in.) drill bit to hold in position.  
 Current Models: Current models use a new control assembly, identified by three alignment holes (close to throttle lever pivot). Based upon intended high-speed (RPM) setting, throttle cable adjustment must be made by matching hole in control lever with correct alignment hole. Use appropriate hole for corresponding high-speed settings. Move throttle lever to align hole in lever with correct hole in control bracket. Insert a pencil or a 6.35 mm (1/4 in.) drill bit to hold in position.
4. Pull on outer shield of throttle control cable to remove any slack. Tighten cable clamp securely.



# Fuel System

## Starting an Engine Equipped with Unitized Throttle and Choke Control

### Starting Throttle Control Details



**NOTE:** Do not crank engine continuously for more than 10 seconds at a time. If engine does not start, allow a 60 second cool down period between starting attempts. Failure to follow these guidelines can burn out starter motor.

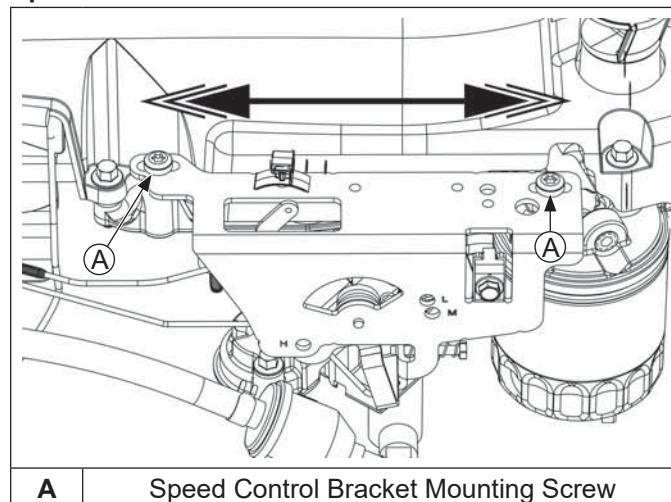
**NOTE:** If engine develops sufficient speed to disengage starter but does not keep running (a false start), engine rotation must be allowed to come to a complete stop before attempting to restart engine. If starter is engaged while flywheel is rotating, starter pinion and flywheel ring gear may clash,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

If starter does not turn engine over, shut starter off immediately. Do not make further attempts to start engine until condition is corrected. Do not jump start using another battery. See your Kohler authorized dealer for trouble analysis.

1. For a Cold or Warm Engine – Place throttle/choke control into fast/choke ON position. This will also place choke into ON position.
2. Make sure equipment is in neutral.
3. Activate starter switch. Release switch as soon as engine starts.
4. For Operation – After engine starts, move throttle/choke control from fast/choke ON position and set desired engine operating speed (between slow and fast position).

## High Speed (RPM) Adjustment

### Speed Control Bracket Details



Recommended maximum no-load high speed (RPM) for most engines is 3300 RPM. Actual high speed (RPM) depends on application. Refer to equipment manufacturer's instructions for specific information.

1. Make sure throttle cable is adjusted properly (see Throttle Cable Adjustment).
2. Start engine and allow it to warm up. Place throttle control lever into fast or high speed position. Turn choke adjusting screw out/counterclockwise, so there is clearance from choke lever, and that contact cannot occur during Step 4.
3. Early Models: Early models use a single alignment hole to set engine RPM. Align hole in throttle lever with hole in speed control bracket by inserting a pencil or 6.35 mm (1/4 in.) drill bit.

Later Models: Later models utilize a new design control assembly, identified by two opposing alignment holes (close to throttle lever pivot), instead of one. Based upon intended high speed (RPM) setting, throttle cable adjustment must be made matching hole in control lever with appropriate alignment hole. Use lower (left side) hole for high-speed settings 3000 RPM and above. Use upper (right side) hole for high-speed settings less than 3000 RPM. Move throttle lever to align hole in lever with appropriate hole in control bracket. Insert a pencil or a 6.35 mm (1/4 in.) drill bit to hold in position.

Current Models: Current models use a new control assembly, identified by three alignment holes (close to throttle lever pivot). Based upon intended high-speed (RPM) setting, throttle cable adjustment must be made by matching hole in control lever with correct alignment hole. Use appropriate hole for corresponding high-speed settings. Move throttle lever to align hole in lever with correct hole in control bracket. Insert a pencil or a 6.35 mm (1/4 in.) drill bit to hold in position.

- Loosen speed control bracket mounting screws. Slide bracket forward or backward, until desired high speed (RPM) is reached. Check speed with a tachometer.

To increase high speed (RPM), move bracket toward carburetor.

To decrease high speed (RPM), move bracket away from carburetor.

- Tighten speed control bracket mounting screws. Recheck speed with a tachometer and readjust if necessary.

Torque mounting screws as follows:

- Into new hole – 11.0 N·m (95 in. lb.).
- Into used hole – 7.5 N·m (65 in. lb.).

- Adjust choke (see Choke Adjustment which follows).

**Choke Adjustment**

This procedure must follow High Speed Adjustment just described. If not already completed, perform that operation first.

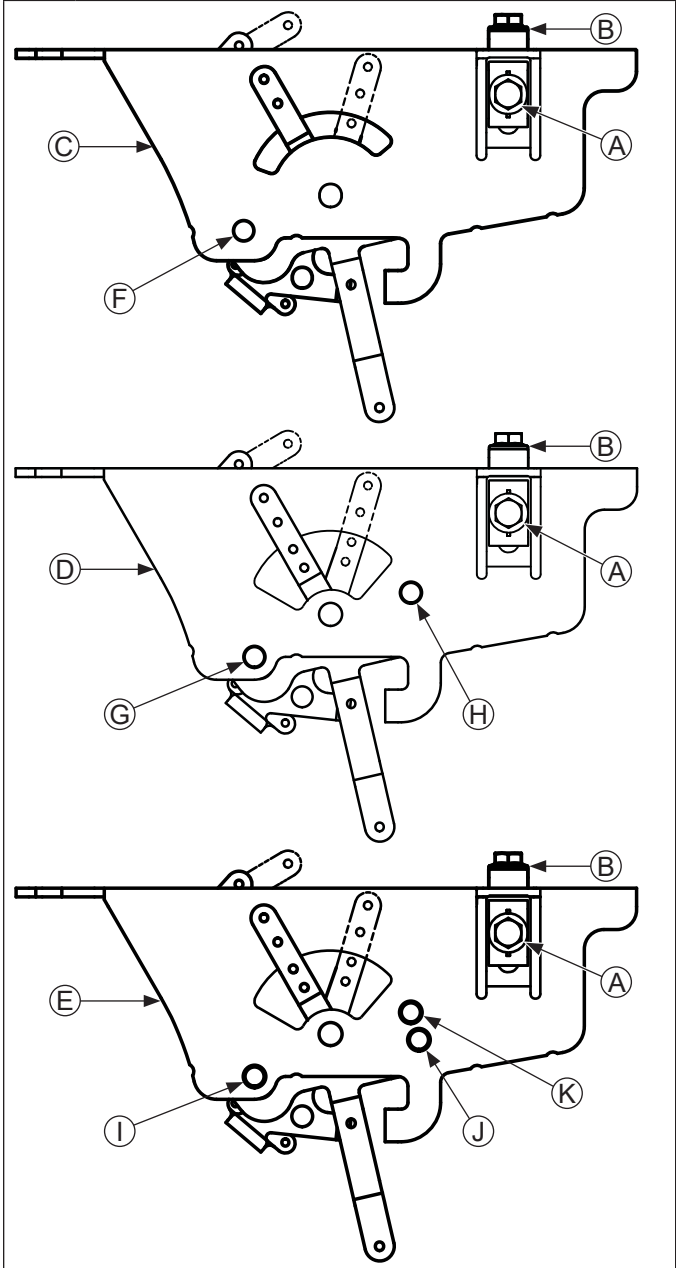
- Turn choke adjusting screw out (counterclockwise), until it no longer contacts choke lever.
- Then turn it back in (clockwise), until it just makes contact.
- While observing choke link, move throttle control lever to low idle (slow) position, then back to full throttle (fast). Choke link should not move as throttle moves through normal range. If it does, back adjusting screw out until it no longer moves.
- Move throttle control lever to choke position. Check if choke has fully closed by placing your finger on right side of lower end of choke lever/choke link and applying gentle pressure towards carburetor. If controls have been properly set, link should not move.

**SEPARATE THROTTLE AND CHOKE CONTROL**

Some engines are equipped with separate throttle and choke controls. This allows you to adjust choke and throttle controls individually.

**Install Separate Control Cables**

**Speed Control Bracket Alignment Hole**



<b>A</b>	Throttle Cable Clamp	<b>B</b>	Choke Cable Clamp
<b>C</b>	Early Models	<b>D</b>	Later Models
<b>E</b>	Current Models	<b>F</b>	Alignment Hole
<b>G</b>	Alignment Hole for 3000 RPM and Higher	<b>H</b>	Alignment Hole for Less Than 3000 RPM
<b>I</b>	Alignment Hole for 3101-3750 RPM	<b>J</b>	Alignment Hole for 2901-3100 RPM
<b>K</b>	Alignment Hole for 2400-2900 RPM		



# Fuel System

## Throttle Control Installation

1. Loosen two cable clamp screws on speed control bracket assembly.
2. Move application throttle control lever to maximum full (fast) throttle position, and then move it back 3/16" or 4.75 mm. Insert cable boden wire into throttle control lever on control plate.
3. Position throttle cable under cable clamp.
4. Early Models: Early models use a single alignment hole to set engine RPM. Align hole in throttle lever with hole in speed control bracket by inserting a pencil or 6.35 mm (1/4 in.) drill bit.

Later Models: Later models utilize a new design control assembly, identified by two opposing alignment holes (close to throttle lever pivot), instead of one. Based upon intended high speed (RPM) setting, throttle cable adjustment must be made matching hole in control lever with appropriate alignment hole. Use lower (left side) hole for high-speed settings 3000 RPM and above. Use upper (right side) hole for high-speed settings less than 3000 RPM. Move throttle lever to align hole in lever with appropriate hole in control bracket. Insert a pencil or a 6.35 mm (1/4 in.) drill bit to hold in position.

Current Models: Current models use a new control assembly, identified by three alignment holes (close to throttle lever pivot). Based upon intended high-speed (RPM) setting, throttle cable adjustment must be made by matching hole in control lever with correct alignment hole. Use appropriate hole for corresponding high-speed settings. Move throttle lever to align hole in lever with correct hole in control bracket. Insert a pencil or a 6.35 mm (1/4 in.) drill bit to hold in position.

5. Pull on outer shield of throttle control cable to remove any slack. Tighten cable clamp securely.
6. Move application throttle lever to slow position, then to full throttle. Check engine control to ensure it stops against stop screw, which means it is properly set.

## Choke Control Installation

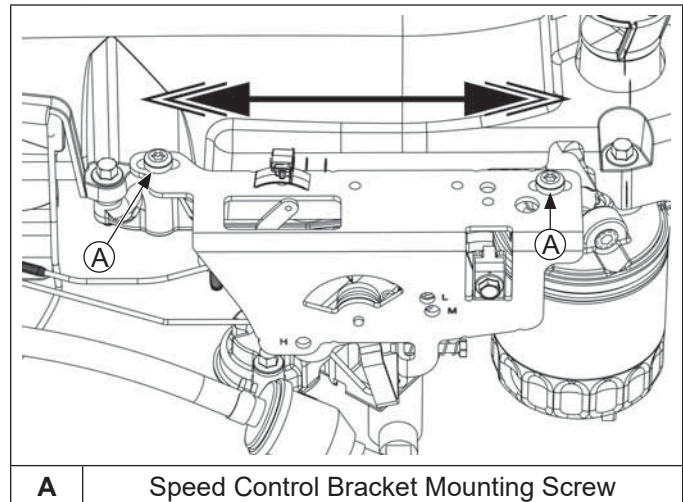
1. Connect choke cable boden wire to engine choke control lever on speed control bracket assembly.
2. Position choke cable under cable clamp.
3. Push/move choke control to off position in application panel until it bottoms, then pull it back approximately 1/16 in.
4. Push on choke cable, ahead of clamp on engine control plate, until choke lever stops. Do not force. Then tighten cable clamp screw.
5. Move choke control until it stops (on position). Check that choke link cannot be moved towards carburetor by applying finger pressure on lower link/lever below engine control plate. If choke link moves, readjust by following steps 3 and 4.
6. Push/move choke control in/down until it bottoms. Choke lever and link should be to right at end of its travel, with linkage free so engine does not run on partial choke.

## Starting an Engine Equipped with Separate Control Cables

1. Place throttle control midway between slow and fast positions. Place choke control into on position.
2. Start engine.
3. For a Cold Engine – Gradually return choke control to off position after engine starts and warms up.  
Engine/equipment may be operated during warm up period, but it may be necessary to leave choke partially on until engine warms up.
4. For a Warm Engine – Return choke to off position as soon as engine starts.

## Changing High Speed (RPM) on Engines with Separate Controls (Increase or Decrease RPM)

### Speed Control Bracket Details



1. Check that governor spring and installation matches intended high speed RPM operating range.
2. Start engine, move application throttle lever to full throttle/fast, and loosen mounting screws of main speed control bracket to allow repositioning.
3. To increase RPM: Move speed control bracket, towards carburetor. To decrease RPM: Move speed control bracket, away from carburetor. Check RPM with a tachometer and tighten screws when correct setting has been obtained.
4. To ensure that RPM has been obtained, move throttle lever to low idle/slow then back to full throttle/fast position and check RPM with a tachometer.

### Setting Low Idle RPM

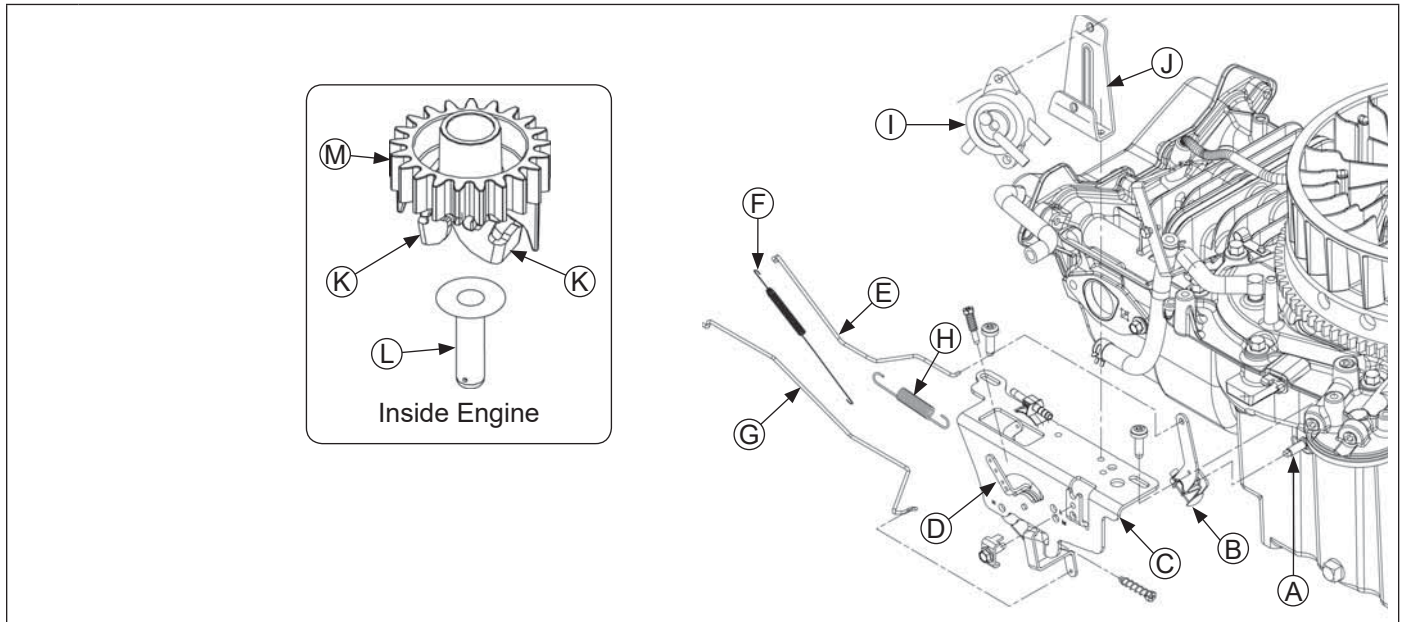
1. Move application control to slow position.
2. Using a tachometer, check RPM. Then, using a screwdriver, turn low idle speed screw inward (clockwise) to increase RPM, and outward (counterclockwise) to lower RPM.

## GOVERNOR

Governed speed setting is determined by position of throttle control. It can be variable or constant, depending on engine application.

Governor is designed to hold engine speed constant under changing load conditions. Most engines are equipped with a centrifugal flyweight mechanical governor. Governor gear/flyweight mechanism of mechanical governor is mounted inside closure plate and is driven off gear on crankshaft.

### Governor Components



<b>A</b>	Governor Cross Shaft	<b>B</b>	Governor Lever	<b>C</b>	Speed Control Bracket	<b>D</b>	Throttle Lever
<b>E</b>	Throttle Linkage	<b>F</b>	Throttle Linkage Spring	<b>G</b>	Choke Linkage	<b>H</b>	Governor Spring
<b>I</b>	Fuel Pump	<b>J</b>	Fuel Pump Bracket	<b>K</b>	Flyweight	<b>L</b>	Regulating Pin
<b>M</b>	Governor Gear						

This governor design works as follows:

- 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 throttle 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 arm is loosened or removed from cross shaft. Adjust as follows:

1. Make sure throttle linkage is connected to governor arm and throttle lever on carburetor.
2. Loosen nut holding governor lever to cross shaft.
3. Move governor lever toward carburetor as far as it will go (wide open throttle) and hold in this position.
4. Grasp cross shaft with a pliers, and turn shaft counterclockwise as far as it will go. Torque nut to 7.0-8.5 N·m (60-75 in. lb.).

# Governor System

## Governor Sensitivity Adjustment

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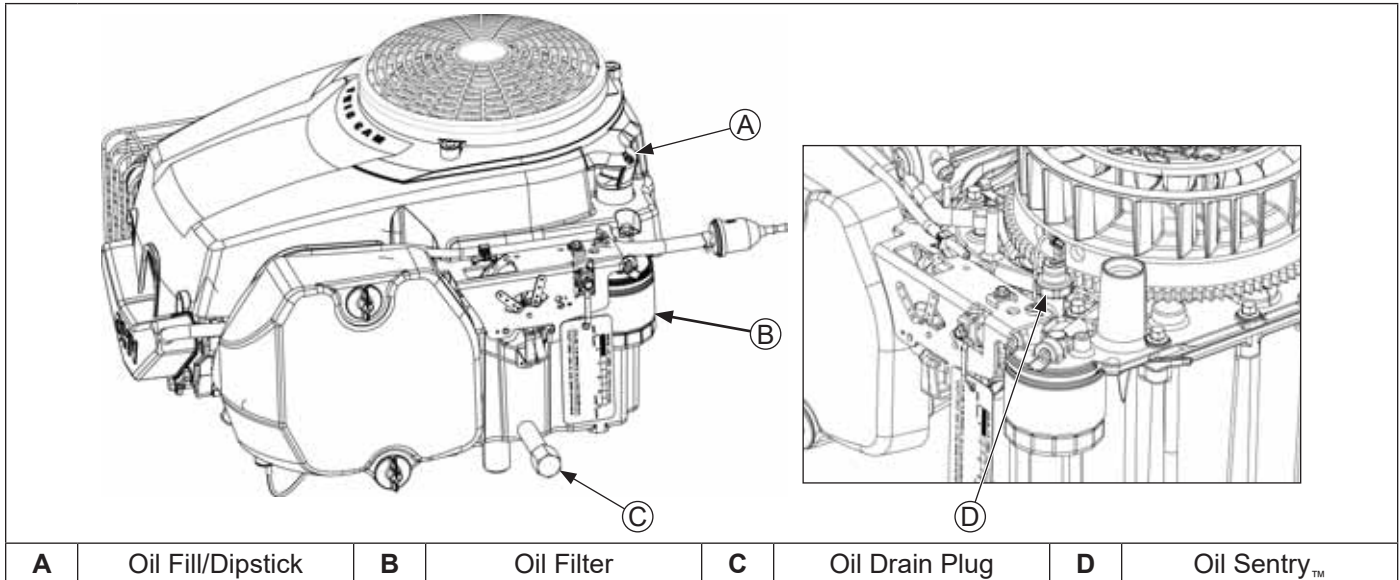
Governor sensitivity is adjusted by repositioning governor spring in holes in governor lever. If speed surging occurs with a change in load, governor is set too sensitive. If a big drop in speed occurs when a normal load is applied, governor should be set for greater sensitivity.

Desired high speed setting (RPM) will determine governor spring position in governor lever and throttle lever, as well as spring used.

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

A high-efficiency gerotor oil pump maintains high oil flow and oil pressure, even at low speeds and high operating temperatures. A pressure relief valve limits maximum pressure of system. Closure plate must be removed to service oil pickup, pressure relief valve, and oil pump.

## 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. 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 14.0 N·m (125 in. 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.

# Lubrication System

## 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 into center oil galley of filter adapter casting or into closure plate. Based on application an elbow adapter may also be used. On engines not equipped with Oil Sentry™, oil galley is sealed with a 1/8" pipe plug or completely sealed.

### Installation

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#### External Switch

1. Remove and discard pipe plug from center passage of oil filter mounting pad.
2. Apply pipe sealant with Teflon® (Loctite® PST® 592™ Thread Sealant or equivalent) to threads of 90° adapter (if used), and Oil Sentry™ switch. Install adapter (if used), and carefully tighten it to intended position. Do not over tighten or damage adapter.
3. Install switch into adapter or center passage. Torque switch to 4.5-5.0 N·m (40-45 in. lb.). Connect lead to terminal on Oil Sentry™ switch.

#### Switch Behind Blower Housing

1. Remove blower housing. Remove and discard pipe plug from closure plate.
2. Apply pipe sealant with Teflon® (Loctite® PST® 592™ Thread Sealant or equivalent) to threads of Oil Sentry™ switch.
3. Install switch into closure plate. Torque switch to 4.5-5.0 N·m (40-45 in. lb.). Connect lead to terminal on Oil Sentry™ switch.
4. Reinstall blower housing.

### 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 2-5 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 2-5 psi. Tester should indicate a change to continuity (switch closed) down to 0 psi.
4. Replace switch if it does not operate as specified.

## OIL PRESSURE

### Testing

---

On some models engine oil pressure can be tested using an oil pressure tester. Follow instructions included with tester. Pressure can be tested by removing oil filter and installing tester adapter on mounting pad, or by removing Oil Sentry™ pressure switch (or pipe plug) and threading tester hose directly into mounting hole.



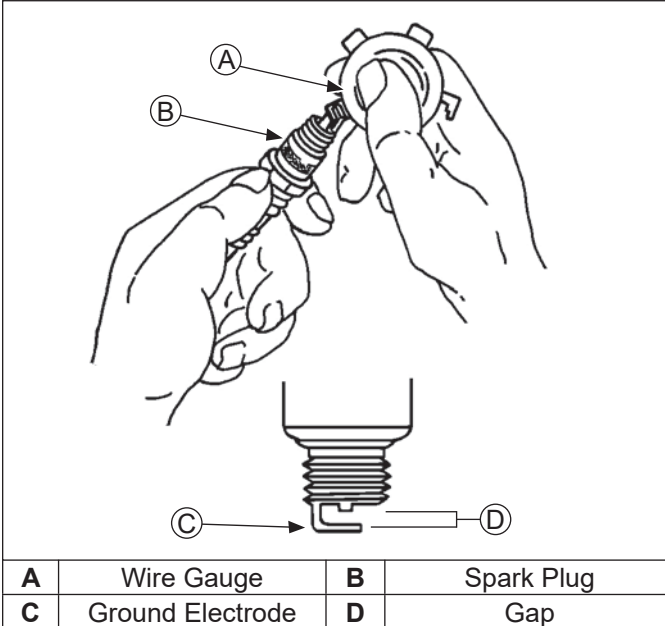
## SPARK PLUGS



### ⚠ CAUTION

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

### Spark Plug Component and Details



**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 (0.030 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.

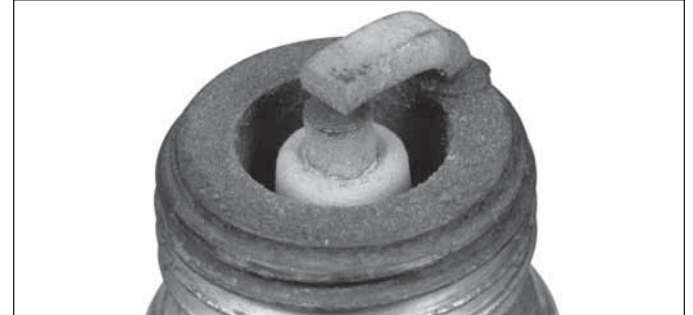
1. Check gap using wire feeler gauge. Adjust gap to 0.76 mm (0.030 in.).
2. Install plug into cylinder head.
3. Torque plug to 27 N·m (20 ft. lb.).

### 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.

# Electrical System

## 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 250 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. 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

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

### Battery Maintenance

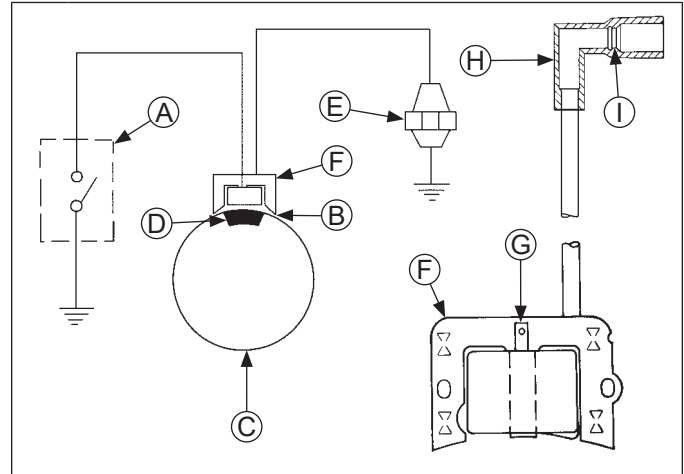
Regular maintenance is necessary to prolong battery life.

### Battery Test

To test battery, follow manufacturer's instructions.

## ELECTRONIC IGNITION SYSTEM

### Ignition System Components



<b>A</b>	Kill Switch/Off Position of Key Switch	<b>B</b>	Air Gap
<b>C</b>	Flywheel	<b>D</b>	Magnet
<b>E</b>	Spark Plug	<b>F</b>	Ignition Module
<b>G</b>	Kill Terminal	<b>H</b>	Spark Plug Boot
<b>I</b>	Spark Plug Terminal		

There is 1 type of ignition system used on these engines. This system uses an ignition module which energizes spark plug.

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.

### Fixed Ignition System

This system uses a capacitive discharge (CD) coil. 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.
- 1 electronic capacitive-discharge ignition module which mounts on engine crankcase.
- 1 kill switch (or key switch) which grounds module to stop engine.
- 1 spark plug.



## Electronic Ignition System Tests

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.

### 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.

### Test for Spark

NOTE: To maintain engine speeds normally obtained during cranking, do not remove engine spark plug.

1. Make sure spark plug lead is connected to spark plug.
2. Check condition of spark plug. Make sure gap is set to 0.76 mm (0.030 in.). If plug is in good condition, check/adjust gap and reinstall.
3.
  - a. Test for spark with ignition tester. Disconnect spark plug lead and connect it to post terminal of tester. Connect clip to a good ground, not spark plug.
  - b. Make sure engine ignition switch, kill switch, or key switch is in RUN position.
4. Crank engine (minimum speed 500 RPM), and observe tester. Visible and audible sparks should be produced.

Condition	Possible Cause	Conclusion
Audible and visible sparks are produced.	Ignition Module	Ignition module is OK.
Audible and visible sparks are not produced.	Ignition Module or Electrical System	Make sure engine ignition switch, kill switch, or key switch is in RUN position.  Check wires and terminals of ignition module and other components for accidental grounding and damaged insulation.  If wires and terminals are OK, ignition module is probably faulty and should be replaced. Test module further using an ohmmeter.

### Test Ignition Module with Ohmmeter

NOTE: This test cannot be performed unless module has been fired at least once.

Measure resistance of module secondary using an ohmmeter.

1. Zero ohmmeter.
2. Connect one ohmmeter lead to laminations. Connect other lead to spark plug terminal of high-tension lead.
3. With ohmmeter leads connected in this manner, resistance of secondary should be 7,900 to 18,400 ohms. Refer to Disassembly and Reassembly for complete ignition module removal and installation procedures.

Condition	Possible Cause	Conclusion
Resistance is within specified range.	Module Secondary	Module secondary is OK.
Resistance is low or 0 ohms.		Module secondary is shorted. Replace module.
Resistance is high or infinity ohms.		Module secondary is open. Replace module.

# Electrical System

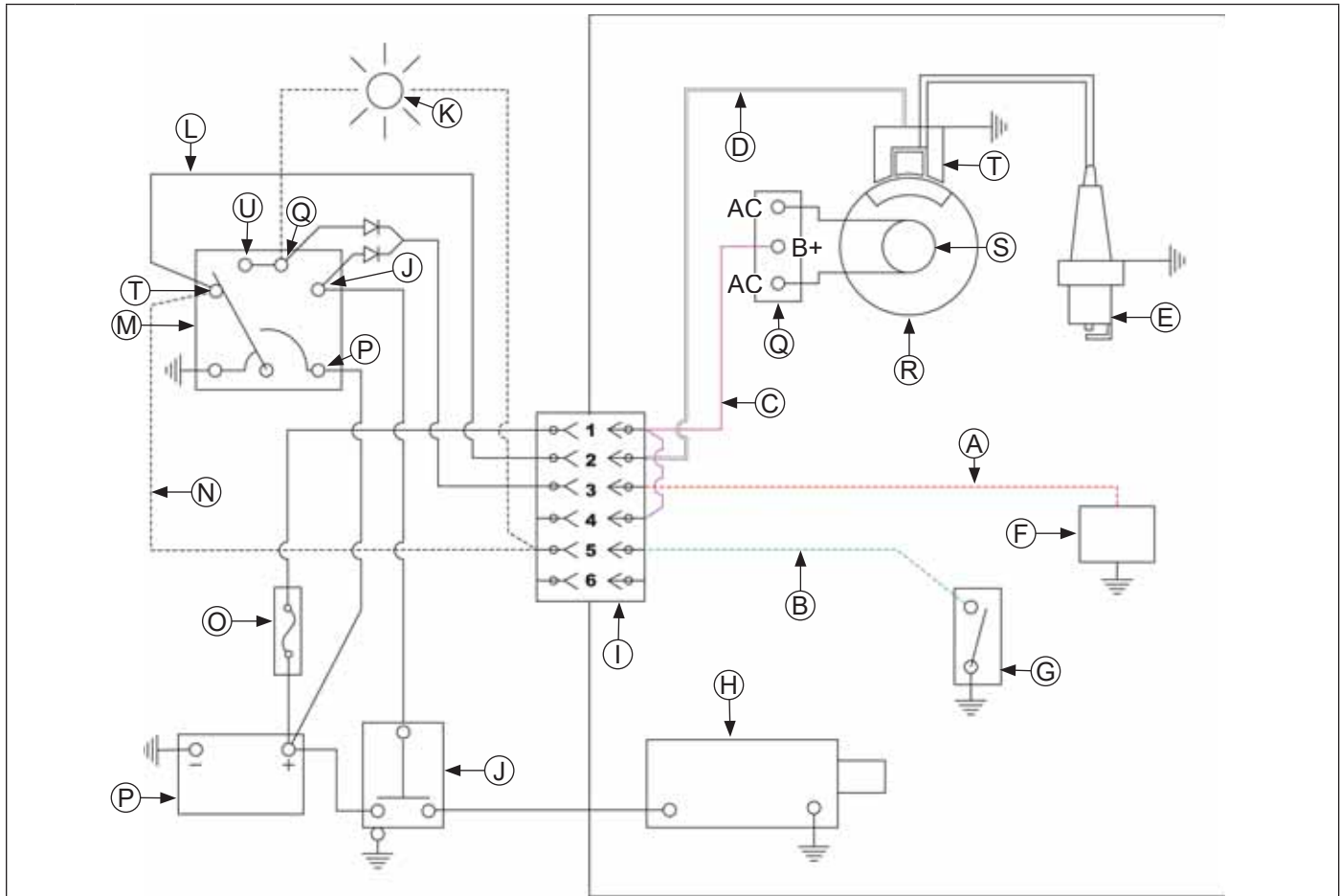
## BATTERY CHARGING SYSTEM

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.

Most engines are equipped with either a 9 or 15 amp, regulated battery charging system. Some have a 3 amp, regulated system with a 70 watt lighting circuit.

### Wiring Diagram-3 Amp Regulated Battery Charging System/70 Watt Lighting



<b>A</b>	Red	<b>B</b>	Green	<b>C</b>	Violet	<b>D</b>	White
<b>E</b>	Spark Plug	<b>F</b>	Optional Fuel Solenoid	<b>G</b>	Optional Oil Sentry™ Switch (Shutdown or Indicator)	<b>H</b>	Bendix Starter
<b>I</b>	Engine Connector	<b>J</b>	Starter Solenoid	<b>K</b>	Optional Oil Sentry™ Switch (Indicator Light)	<b>L</b>	Ground-To-Kill Lead
<b>M</b>	Key Switch	<b>N</b>	Optional Oil Sentry™ Shutdown	<b>O</b>	Optional Fuse	<b>P</b>	Battery
<b>Q</b>	Rectifier-Regulator	<b>R</b>	Flywheel	<b>S</b>	Stator	<b>T</b>	Ignition Module
<b>U</b>	Accessory						

## 3 Amp/70 Watt Lighting Stator

NOTE: Zero ohmmeter on each scale to ensure accurate readings. Voltage tests should be made with engine running at full throttle with no load. Battery must be fully charged.

To test charging system for no charge to battery:

1. With engine running in fast setting, measure voltage across battery terminals using a DC voltmeter.

Condition	Conclusion
Voltage is more than 12.5 volts.	Charging system is OK.
Voltage is 12.5 volts or less.	Stator or diode are probably faulty. Continue testing stator and diode.

2. Remove connector from rectifier-regulator. With engine running in fast position, measure AC voltage across stator leads using an AC voltmeter.

Condition	Conclusion
Voltage is 20 volts or more.	Stator winding is OK.
Voltage is less than 20 volts.	Test stator using an ohmmeter.

3. With charging lead disconnected from battery and engine stopped, measure resistance from charging lead to ground using an ohmmeter. Note reading. Reverse leads and measure resistance again.  
In one direction, resistance should be infinity ohms (open circuit). With leads reversed, some resistance should be measured (about midscale on Rx1 range).

Condition	Conclusion
Resistance is low in both directions.	Diode is shorted. Replace diode.
Resistance is high in both directions.	Diode or stator winding is open. Continue testing.

4. Cut sleeving on charging lead to expose diode connections.

Measure resistance from stator side of diode to ground using an ohmmeter.

Condition	Conclusion
Resistance is approximately 0.5 ohms.	Stator winding is OK, diode is open. Replace diode.
Resistance is 0 ohms.	Stator winding is shorted. Replace stator.
Resistance is infinity ohms.	Stator winding or lead is open. Replace stator.

To test charging system for no lights:

1. Make sure lights are not burned out.

Condition	Conclusion
Burned out lights.	Replace.

2. Disconnect lighting lead from wiring harness.  
With engine running in fast setting, measure voltage from lighting lead to ground using an AC voltmeter.

Condition	Conclusion
Voltage is 13 volts or more.	Stator is OK. Check for loose connections or shorts in wiring harness.
Voltage is less than 13 volts.	Test stator using an ohmmeter.

3. With engine stopped, measure resistance of stator from lighting lead to ground using an ohmmeter.

Condition	Conclusion
Resistance is approximately 0.2 ohms.	Stator is OK.
Resistance is 0 ohms.	Stator is shorted. Replace stator.
Resistance is infinity ohms.	Stator or lighting lead is open. Replace stator.

# Electrical System

## 3 Amp/70 Watt Braking Stator

NOTE: Zero ohmmeter on each scale to ensure accurate readings. Voltage tests should be made with engine running at full throttle with no load. Battery must be fully charged.

To test charging system for no charge to battery:

1. With engine running in fast setting, measure voltage across battery terminals using a DC voltmeter.

Condition	Conclusion
Voltage is more than 12.5 volts.	Charging system is OK.
Voltage is 12.5 volts or less.	Stator or diode are probably faulty. Continue testing stator and diode.

2. Remove connector from rectifier-regulator. With engine running in fast position, measure AC voltage across stator leads using an AC voltmeter.

Condition	Conclusion
Voltage is 5 volts or more.	Stator winding is OK.
Voltage is less than 5 volts.	Test stator using an ohmmeter.

3. With charging lead disconnected from battery and engine stopped, measure resistance from charging lead to ground using an ohmmeter. Note reading. Reverse leads and measure resistance again.

In one direction, resistance should be infinity ohms (open circuit). With leads reversed, some resistance should be measured (about midscale on Rx1 range).

Condition	Conclusion
Resistance is low in both directions.	Diode is shorted. Replace diode.
Resistance is high in both directions.	Diode or stator winding is open. Continue testing.

4. Disconnect lighting lead (yellow) from wiring harness.  
Measure resistance from lighting lead to ground using an ohmmeter.

Condition	Conclusion
Resistance is approximately 0.15 ohms.	Stator winding is OK, diode is open. Replace diode.
Resistance is 0 ohms.	Stator winding is shorted. Replace stator.
Resistance is infinity ohms.	Stator winding or lead is open. Replace stator.

To test charging system for no lights and battery charging (braking system):

1. Make sure lights are not burned out.  
To test battery charging system go to step 4, otherwise perform steps 2 and 3 only.

Condition	Conclusion
Burned out lights.	Replace.

2. Disconnect lighting lead (yellow) from wiring harness.  
With engine running in fast setting, measure voltage from lighting lead to ground using an AC voltmeter.

Condition	Conclusion
Voltage is 13 volts or more.	Stator is OK. Check for loose connections or shorts in wiring harness.
Voltage is less than 13 volts.	Test stator using an ohmmeter.

3. With engine stopped, measure resistance of stator from lighting lead to ground using an ohmmeter.

Condition	Conclusion
Resistance is approximately 0.15 ohms.	Stator is OK.
Resistance is 0 ohms.	Stator is shorted. Replace stator.
Resistance is infinity ohms.	Stator or lighting lead is open. Replace stator.

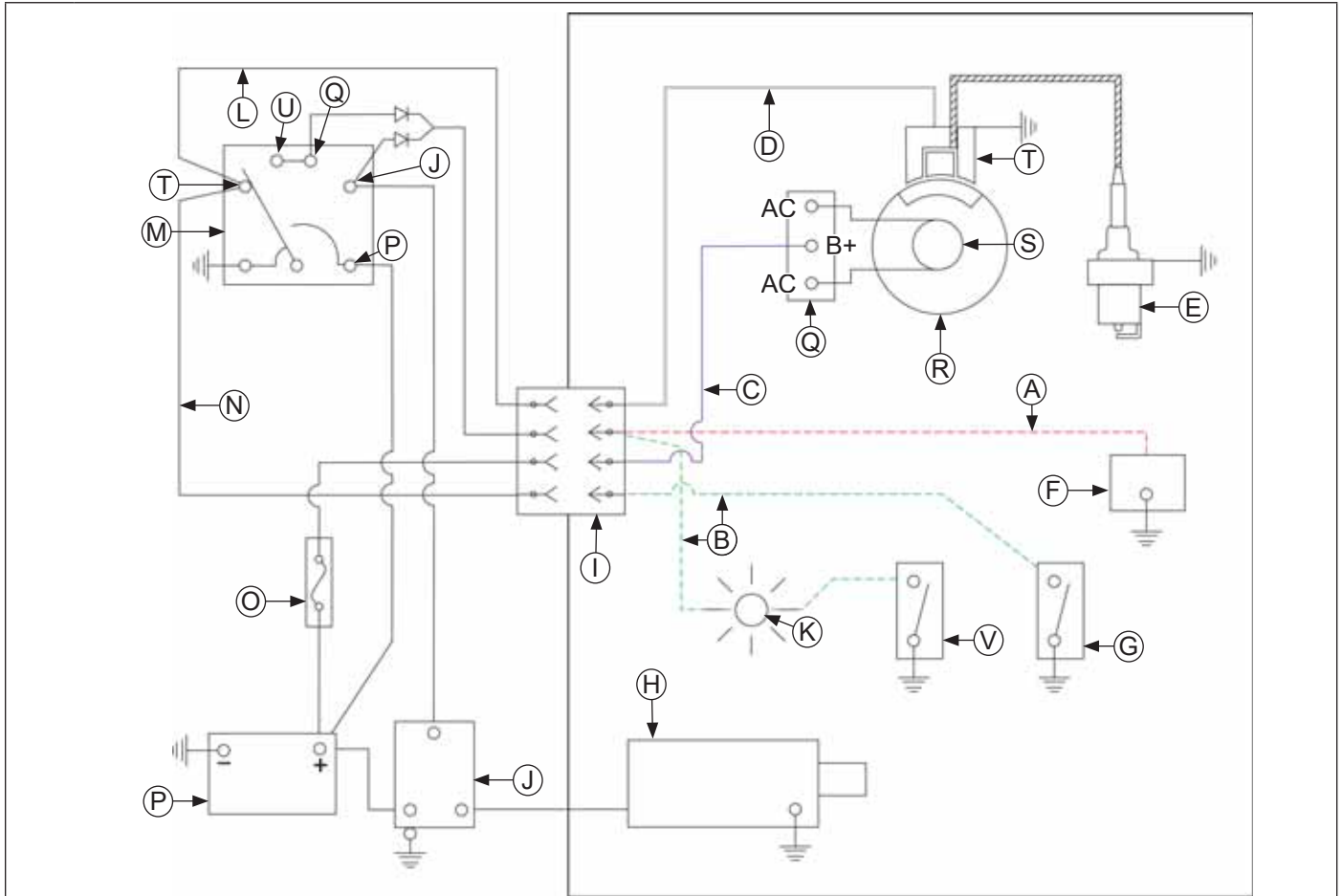
4. Disconnect braking lead (green) from wiring harness.  
With engine running in fast setting, measure voltage from braking lead to ground using an AC voltmeter.

Condition	Conclusion
Voltage is 35 volts or more.	Stator is OK. Circuitry on unit that grounds braking lead is shorted.
Voltage is less than 35 volts.	Test stator using an ohmmeter.

5. With engine stopped, measure resistance from braking lead to ground using an ohmmeter.

Condition	Conclusion
Resistance is 0.2-0.4 ohms.	Stator is OK.
Resistance is 0 ohms.	Stator is shorted. Replace stator.
Resistance is infinity ohms.	Stator or lighting lead is open. Replace stator.

## Wiring Diagram-9 or 15 Amp Regulated Battery Charging System



<b>A</b>	Red	<b>B</b>	Green	<b>C</b>	Violet	<b>D</b>	White
<b>E</b>	Spark Plug	<b>F</b>	Optional Fuel Solenoid	<b>G</b>	Optional Oil Sentry™ Switch (Shutdown)	<b>H</b>	Bendix Starter
<b>I</b>	Engine Connector	<b>J</b>	Starter Solenoid	<b>K</b>	Optional Oil Sentry™ Switch (Indicator Light)	<b>L</b>	Ground-To-Kill Lead
<b>M</b>	Key Switch	<b>N</b>	Optional Oil Sentry™ Shutdown	<b>O</b>	Optional Fuse	<b>P</b>	Battery
<b>Q</b>	Rectifier-Regulator	<b>R</b>	Flywheel	<b>S</b>	Stator	<b>T</b>	Ignition Module
<b>U</b>	Accessory	<b>V</b>	Optional Oil Sentry™ Switch (Indicator)				

# Electrical System

## 9/15 Amp Regulated Battery Charging System

NOTE: Zero ohmmeter on each scale before testing to ensure accurate readings. Voltage tests should be made with engine running at full throttle with no load. Battery must be fully charged.

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 0.1/0.2 ohms.	Stator is OK.
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.

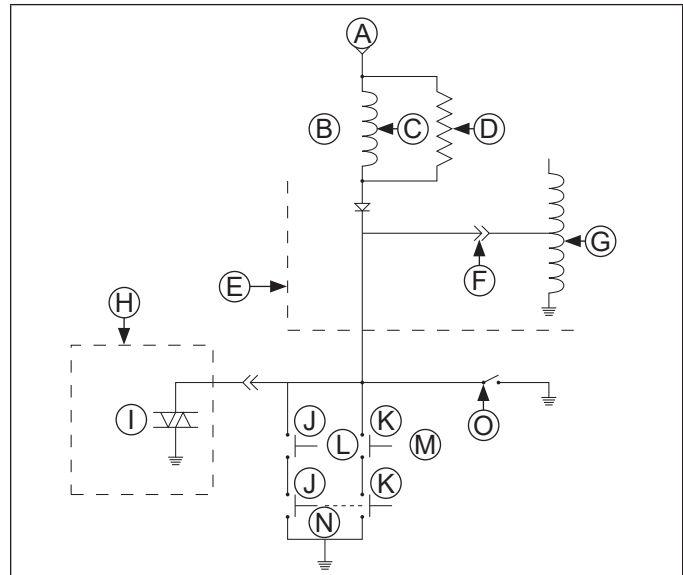
### Condition

### 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.

## BLADE STOP STATOR BRAKE CIRCUIT

### Wiring Diagram-Blade Stop Stator Brake Circuit



<b>A</b>	12V Switched Power	<b>B</b>	Stator Brake Relay Coil
<b>C</b>	90 Ω	<b>D</b>	680 Ω
<b>E</b>	Engine	<b>F</b>	Kill
<b>G</b>	CDI Ignition	<b>H</b>	Reverse Mow Module (OEM Supplied)
<b>I</b>	TRIAC	<b>J</b>	NO
<b>K</b>	NC	<b>L</b>	PTO
<b>M</b>	Brake	<b>N</b>	Seat
<b>O</b>	Key Switch		

Blade stop stator brake circuit is provided as a safety feature to ensure application can meet ANSI (American National Standards Institute) application blade stop requirements.

Circuit is activated if operator gets off of seat of application while mower blade system is activated or in certain reverse mow conditions.

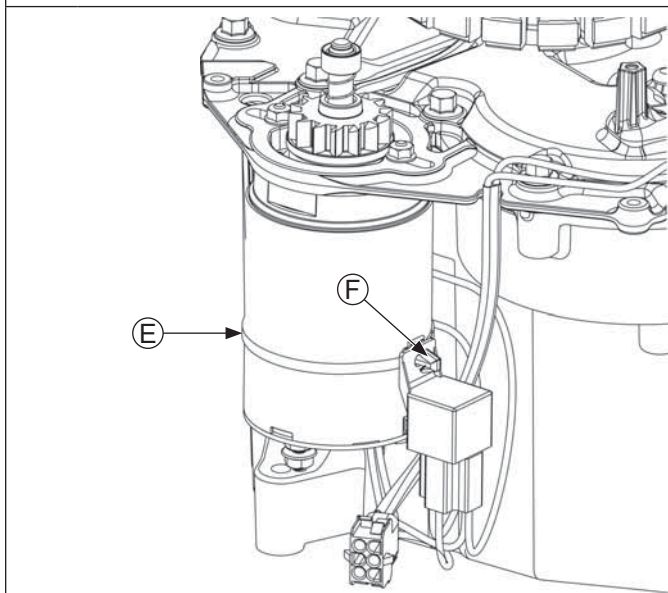
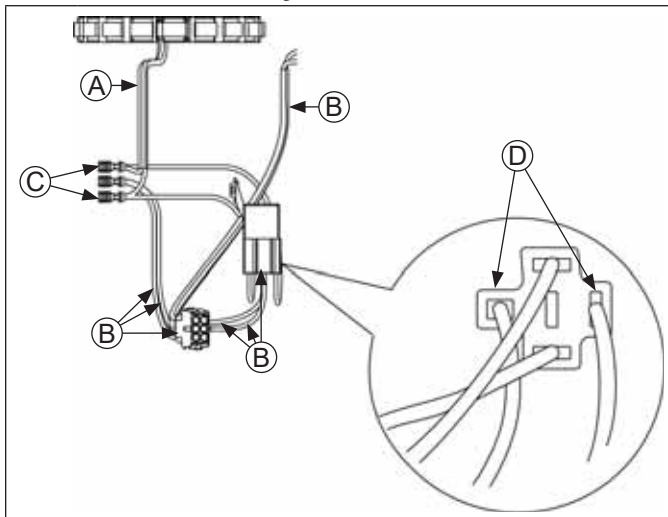
Circuit is activated by taking ignition shutdown (kill) lead to ground. This action turns on stator-brake relay which shorts charging AC stator leads to produce a magnetic field that will counter or resist rotation of flywheel. This added resistance to rotation decreases amount of time it takes for application deck blades to come to a full stop.



As Kohler blade stop stator brake circuit often is operated in conjunction with other application circuits, relay in Kohler circuit is specially configured with a 680 ohm resistor in parallel with relay coil. This is done to negate transient voltage signals that would be normally created by interrupting relay current once relay has been activated. Therefore, relay replacement must only be made with properly identified relay.

## Troubleshooting-Stator Brake System

### Stator Brake and Relay Harness Connections



<b>A</b>	Stator Assembly	<b>B</b>	Wiring Harness
<b>C</b>	Stator Leads to Rectifier-Regulator	<b>D</b>	Stator Leads
<b>E</b>	Wire Tie (Black)	<b>F</b>	Push Wing Mount (Black)

Problems that could occur with Kohler portion circuit generally could be caused by two component failures or an incorrect relay replacement, which will create following conditions.

To test for dead battery:

Brake relay has failed and is keeping stator shorted, so no charge current can be passed from rectifier-regulator to battery, eventually allowing battery to discharge.

1. Check battery voltage using a test meter with application off.
2. Check battery voltage using a test meter with application operating at maximum speed.

Battery voltage should increase from engine off condition to engine full speed condition.

Condition	Conclusion
Voltage does not increase.	Shut down engine, remove relay from its socket and re-test at full engine speed.  If battery voltage does not increase with engine operating, problem is likely not with stator brake relay. Continue testing stator and rectifier-regulator.

To test engine that will crank but will not start:

Brake stator relay is interacting with application safeties or reverse mow electronics, preventing normal engine start up.

1. Remove brake relay from its socket and attempt to restart engine.

Condition	Conclusion
Engine starts.	Relay is not correct for this application or transient protection resistor has failed. Replace relay with correct component.
Engine does not start.	Problem may exist with application reverse mow circuit, application safeties, or with key switch keeping ignition shutdown line tied to engine ground.

2. Remove engine shutdown (kill) lead from application wire harness and attempt to start engine again.

Condition	Conclusion
Engine does not start.	Fuel or ignition problem.



## 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.

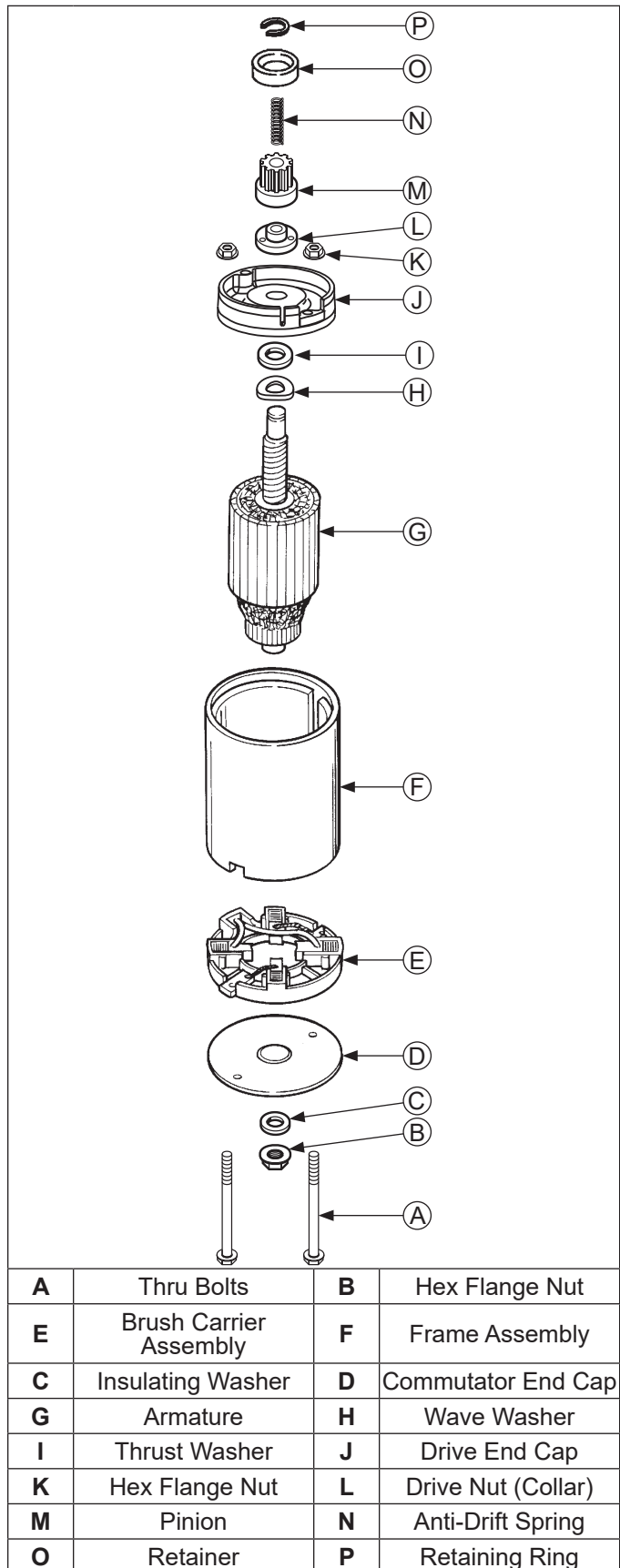
Engines in this series use inertia drive starters.

### 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.
Starter energizes but turns slowly.	Battery	Check specific gravity of battery. If low, recharge or replace battery as necessary. Battery too small, must be at least 250 cold-cranking amps.
	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.

## INERTIA DRIVE ELECTRIC STARTERS

### Inertia Drive Electric Starter



When power is applied to starter, armature rotates. As armature rotates, drive pinion moves out on splined 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, flywheel rotates faster than starter armature and drive pinion. This moves drive pinion out of mesh with ring gear and into retracted position. When power is removed from starter, armature stops rotating and drive pinion is held in retracted position by anti-drift spring.

### Starter Drive Service

It is not necessary to completely disassemble starter to service drive components.

1. Disassemble retaining ring, use tool.
2. Grasp spring retainer and push it toward starter, compressing anti-drift spring and exposing retaining ring.
3. Holding spring retainer in retracted position, assemble inner halves of removal tool around armature shaft with retaining ring in inner groove. Slide collar over inner halves to hold them in position.
4. Thread center screw into removal tool until you feel resistance. Use a wrench (1 1/8" or adjustable) to hold base of removal tool. Use another wrench or socket (1/2" or 13 mm) to turn center screw clockwise. Resistance against center screw will tell you when retaining ring has popped out of groove in armature shaft.
5. Remove drive components, and drive nut (collar) from armature shaft, paying attention to sequence. If splines are dirty, clean them with solvent.
6. Splines should have a light film of lubricant. Relubricate as necessary with Kohler bendix starter lubricant. Reinstall or replace drive components, assembling them in same sequence as they were removed.

### Retaining Ring Installation

1. Position retaining ring in groove in one of inner halves. Assemble other half over top and slide on outer collar.
2. Be certain drive components are installed in correct sequence onto armature shaft.
3. Slip tool over end of armature shaft, so retaining ring inside is resting on end of shaft. Hold tool with one hand, exerting slight pressure toward starter. Tap top of tool with a hammer until you feel retaining ring snap into groove. Disassemble and remove tool.
4. Squeeze retaining ring with pliers to compress it into groove.
5. Assemble inner halves with larger cavity around spring retainer. Slide collar over them and thread center screw in until resistance is felt.
6. Hold base of tool with a 1 1/8" wrench and turn center screw clockwise with a 1/2" or 13 mm wrench to draw spring retainer up around retaining ring. Stop turning when resistance increases. Disassemble and remove tool.

# Starter System

## Starter Disassembly

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1. Remove drive components following instructions for servicing drive.
2. Remove nut and insulating washer from positive (+) brush lead stud.
3. Remove thru bolts and recessed nuts.
4. Remove commutator end cap and lift out brush carrier assembly with brushes and springs.
5. Remove drive end cap, then pull armature with thrust washer and wave washer (if equipped) out of starter frame.

## Brush Replacement

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1. Remove nut and insulating washer from positive (+) brush lead stud.
2. Remove thru bolts and captured hex nuts.
3. Remove commutator end cap, then pull brush carrier assembly out of frame.

## Commutator Service

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Clean commutator with a coarse, lint free cloth. Do not use emery cloth.

If commutator is badly worn or grooved, turn it down on a lathe or replace armature.

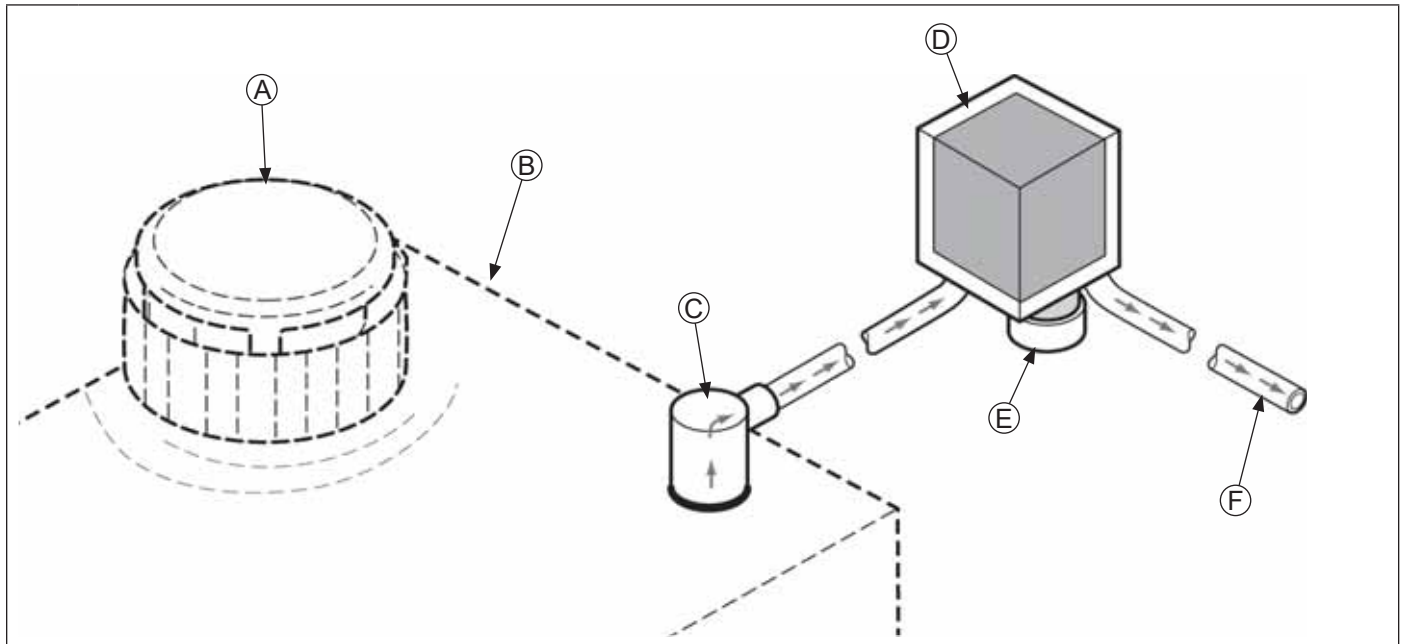
## Starter Reassembly

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1. Place wave washer, followed by thrust washer onto drive shaft of armature.
2. Insert armature into starter frame. Magnets will hold it in place.
3. Align holes with spaces between magnets and install drive end cap onto front of frame.
4. If brush assembly is not being replaced, position springs and brushes within their pockets in carrier; move them to retracted position, and install carton staples to retain them. Replacement brushes come pre-assembled in carrier housing, retained with two carton staples.
5. Hold brush holder assembly with positive brush lead stud up. Align molded sections with corresponding cutouts in starter frame and slide brush carrier assembly into place. Commutator will push carton staples out as brush assembly is inserted.
6. Position commutator end cap over brush assembly, aligning holes for stud terminal and thru bolts.
7. Install thru bolts and hex nuts. Torque to 3.3-3.9 N·m (30-35 in. lb.).
8. Install insulating washer and hex flange nut onto positive (+) brush lead stud. Make sure stud is centered and does not touch metal end cap. Torque hex flange nut to 2.2-4.5 N·m (20-40 in. lb.).  
After installation and connection of starter lead, torque outer nut to 1.6-2.8 N·m (12-25 in. lb.), do not over torque.
9. Lubricate drive shaft with Kohler bendix starter drive lubricant. Install drive components following instructions for servicing drive.

## EVAPORATIVE EMISSION COMPLIANT SYSTEM

### Carbon Canister System



<b>A</b>	Fuel Tank Cap	<b>B</b>	Fuel Tank	<b>C</b>	Roll Over Valve (ROV)	<b>D</b>	Carbon Canister
<b>E</b>	Canister Breather Filter	<b>F</b>	To Carburetor				

For engine to be Tier III compliant, it may be fitted with a Kohler supplied canister vapor recovery system, or a system developed and installed by Original Equipment Manufacturer (OEM). Details on Kohler system are included below.

#### Operation

Fuel vapors travel from fuel tank through tubing to carbon canister. On intake stroke of engine fuel vapors are drawn in through a port in carburetor and burned with fuel charge.

#### Maintenance

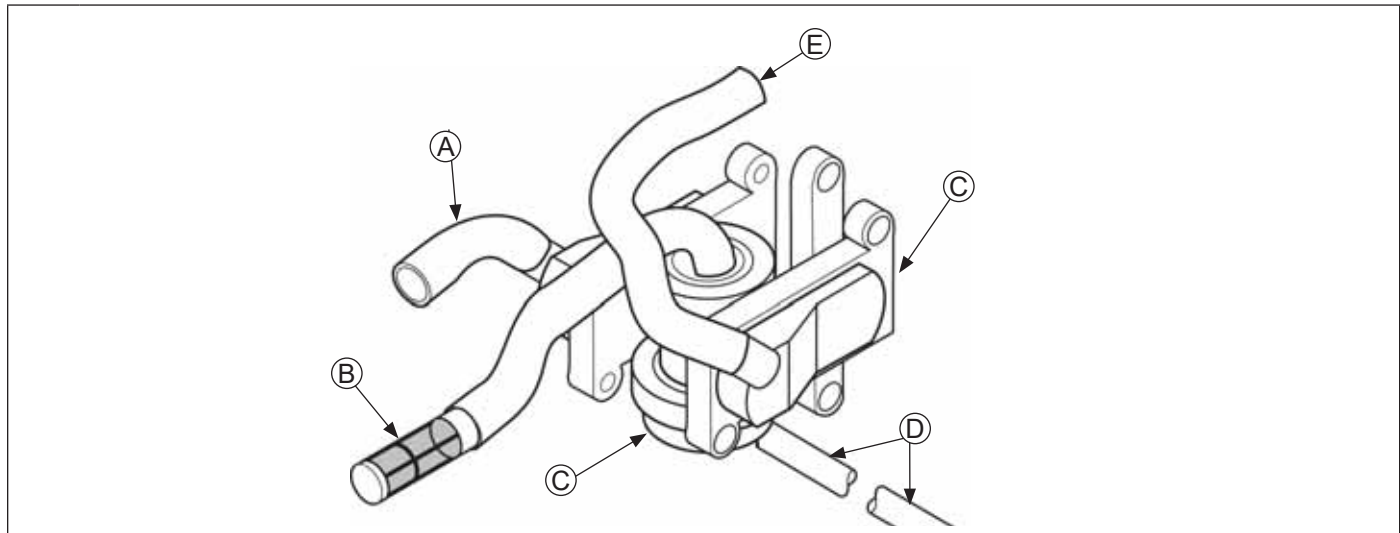
On Kohler-supplied canisters, breather filter can be removed and cleaned with hot soapy water, dried and reinstalled. Do not oil breather screen. This is done periodically or if system operation is suspect. Carbon canister is sealed and requires no maintenance.

In some applications or installations, OEM will have installed a different canister or fuel vapor recovery system. See OEM equipment documentation for service or maintenance information.

# Emission Compliant Systems

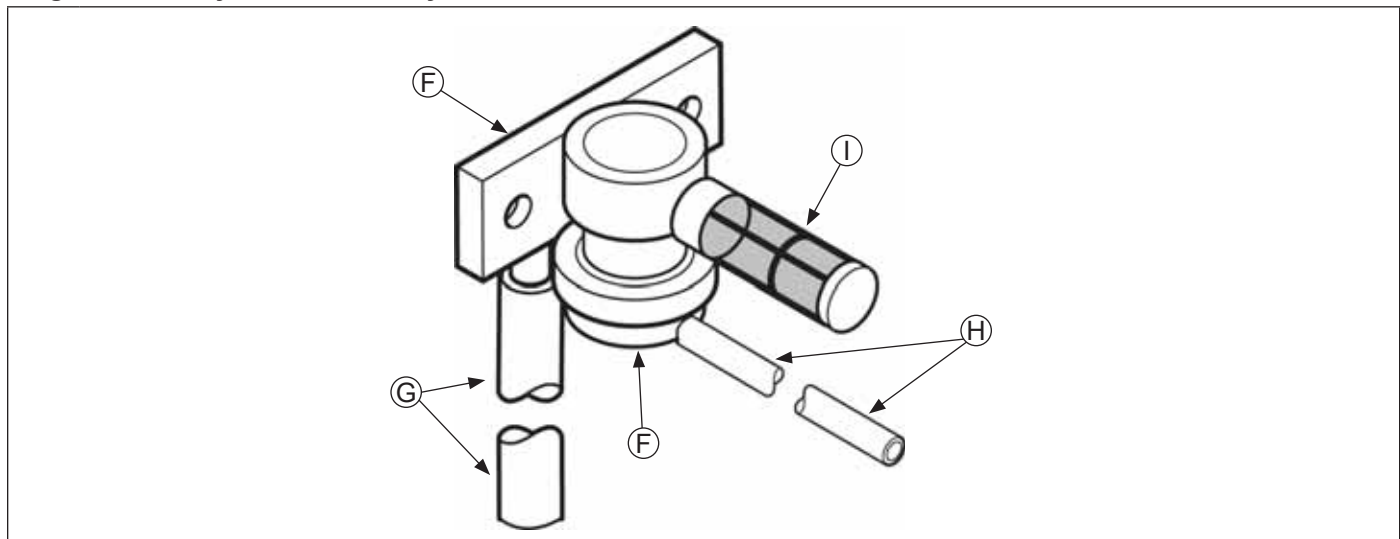
## SECONDARY EMISSION COMPLIANT SYSTEM

### Twin Secondary Air Induction System



<b>A</b>	Hose To Exhaust Manifold	<b>B</b>	Inlet Screen	<b>C</b>	Secondary Air Valve Assembly	<b>D</b>	Hose To Carburetor
<b>E</b>	Hose To Exhaust Manifold						

### Single Secondary Air Induction System



<b>F</b>	Secondary Air Valve Assembly	<b>G</b>	Hose To Exhaust Manifold	<b>H</b>	Hose To Carburetor	<b>I</b>	Inlet Screen
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For engine to be Tier III compliant, it may be fitted with a secondary air induction system (SAI).

#### Operation

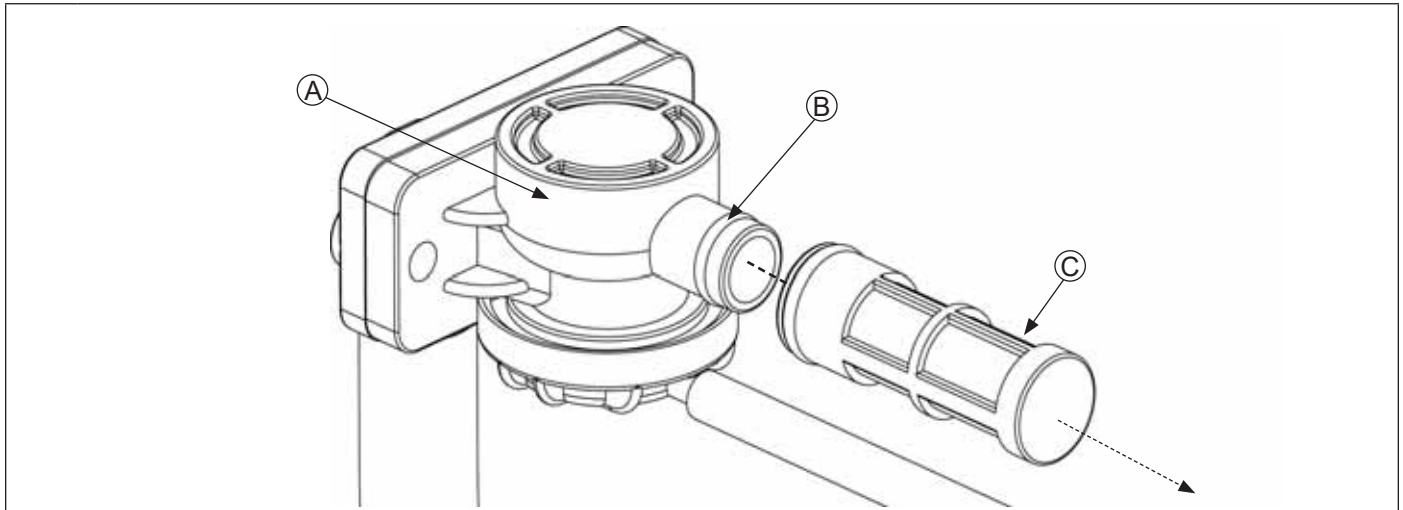
Intake pulse of engine activates secondary air valve. Air is drawn through an inlet screen of secondary air valve. Air is then drawn into exhaust manifold and muffler where it mixes with any unburned hydrocarbons, which then burn in heat of muffler. A hose is connected between a carburetor port and a diaphragm chamber in secondary air valve. Carburetor vacuum moves diaphragm to close valve when air induction is not required, primary idle.

#### Maintenance

Air inlet screen in secondary air valve can be removed, cleaned, and reinstalled. If inspection of system reveals any damage or decomposition of hoses, secondary air valve, or exhaust system, parts should be replaced.

## Remove Inlet Screen

### Inlet Components



<b>A</b>	Secondary Air Valve Assembly	<b>B</b>	Barb	<b>C</b>	Inlet Screen
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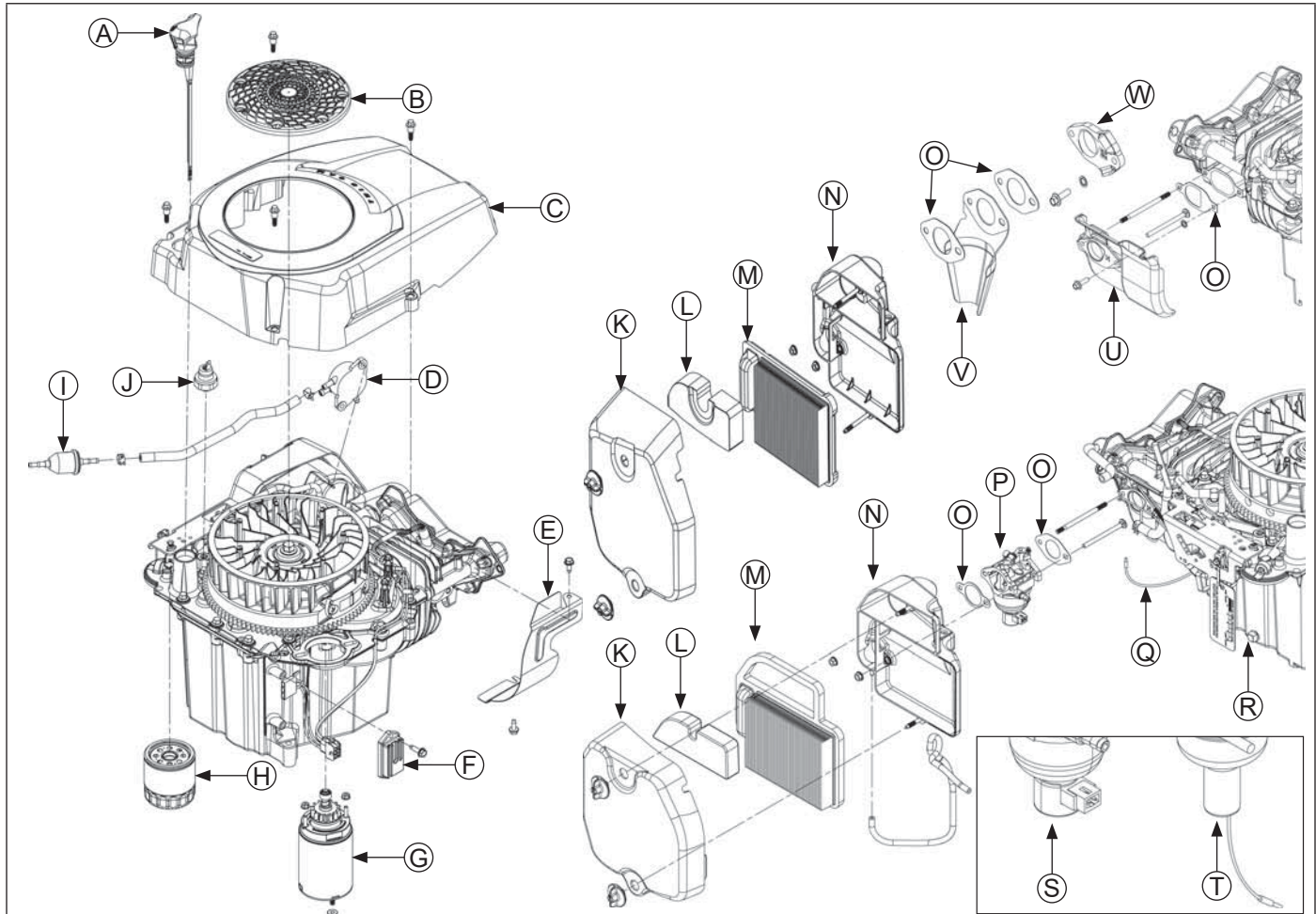
1. Remove inlet screen from secondary air valve assembly by grasping inlet screen at base and gently pulling away from valve assembly.
2. Use a soft brush to remove debris from screen.
3. Run water through inlet screen in reverse direction.
4. To reinstall, push inlet screen onto barb of secondary air valve assembly. An audible click will be heard when inlet screen is properly reinstalled.



# Disassembly/Inspection and Service

	<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.	

## External Engine Components



<b>A</b>	Oil Fill/Dipstick	<b>B</b>	Debris Screen	<b>C</b>	Blower Housing	<b>D</b>	Fuel Pump
<b>E</b>	Cylinder Head Baffle	<b>F</b>	Rectifier-Regulator	<b>G</b>	Electric Starter	<b>H</b>	Oil Filter
<b>I</b>	Fuel Filter	<b>J</b>	Oil Sentry™	<b>K</b>	Air Cleaner Cover	<b>L</b>	Precleaner
<b>M</b>	Air Cleaner Element	<b>N</b>	Air Cleaner Base	<b>O</b>	Gasket	<b>P</b>	Carburetor
<b>Q</b>	Ground Wire	<b>R</b>	Oil Drain Plug	<b>S</b>	Nikki Fuel Solenoid	<b>T</b>	Walbro Fuel Solenoid
<b>U</b>	Heat Deflector	<b>V</b>	Heat Shield	<b>W</b>	Carburetor Spacer		



## Disassembly/Inspection and Service

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.

### Drain Oil from Crankcase and Remove Oil Filter

1. Remove oil drain plug and oil fill cap/dipstick.
2. Allow ample time for oil to drain from crankcase.
3. Remove and discard oil filter.

### Remove Blower Housing

1. Remove screws securing blower housing to closure plate.
2. Lift blower housing and separate spark plug lead from corresponding slot.

### Remove Oil Sentry™ Pressure Switch (if equipped)

NOTE: Pressure switch is installed into center oil galley of filter adapter casting or into closure plate.

1. Disconnect lead from Oil Sentry™ pressure switch.
2. Remove pressure switch from center oil galley or adapter elbow of filter adapter casting or from closure plate.

### Disconnect Spark Plug Lead

Carefully pull on boot section and disconnect spark plug lead.

### Remove Muffler

1. Remove nuts or 5/16-18 cap screws attaching muffler or exhaust system to engine. Remove any attached brackets.
2. Remove muffler and gasket from exhaust port.

### Remove Cylinder Head Baffle

Remove screws attaching cylinder head baffle to cylinder head and remove cylinder head baffle.

### Remove Rectifier-Regulator

1. Unplug connector from rectifier-regulator.
2. Remove screws securing rectifier-regulator to crankcase. Remove rectifier-regulator.

### Remove Electric Starter


1. Disconnect starter lead from terminal stud.
2. Remove nuts securing starter to closure plate. Remove starter.

### Remove Air Cleaner

1. Disconnect inlet, outlet, and pulse lines from fuel pump if fuel pump is secured to air cleaner base. Mark lines for proper reassembly.
2. Loosen knobs and remove air cleaner cover.

3. Remove precleaner (if equipped), and air cleaner element with formed rubber seal.
4. Remove nut(s) and long mounting screw securing air cleaner base.
5. Disconnect breather hose from valve cover and remove air cleaner base and gasket (with fuel pump attached, if equipped).

### Remove External Governor Components, Carburetor, and Fuel Pump

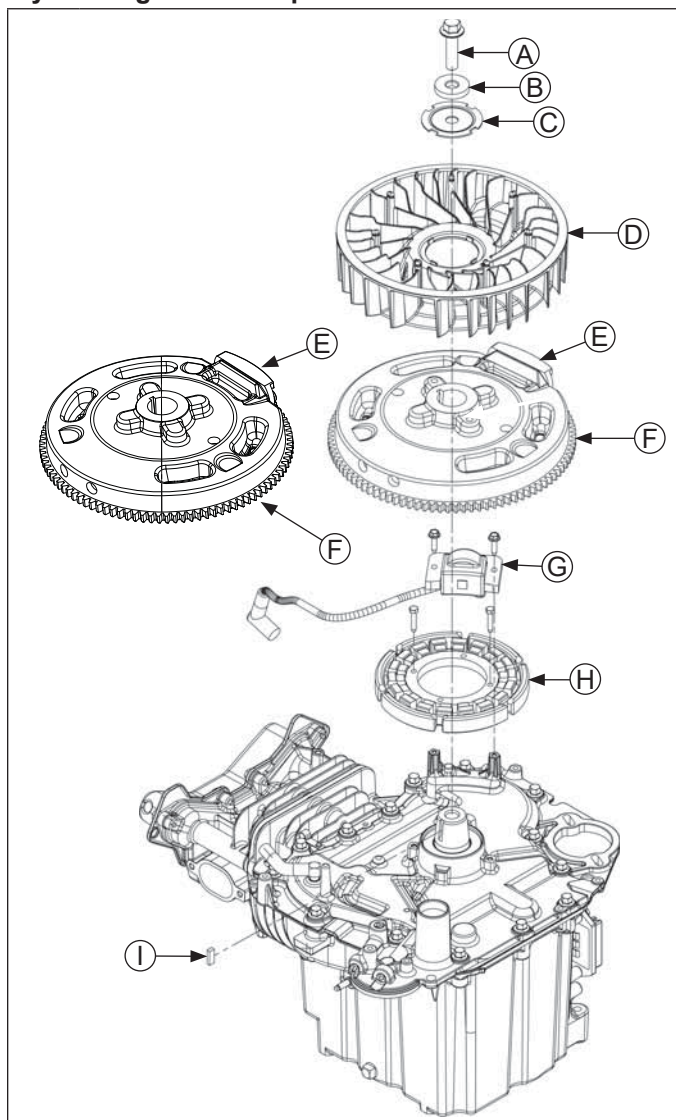
	<b>WARNING</b>
	Explosive Fuel can cause fires and severe burns. Do not fill fuel tank while engine is hot or running.
Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames.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

NOTE: It is recommended that a new governor lever be installed whenever removal is performed.

1. Shut off fuel supply. Disconnect fuel line from carburetor inlet fitting. If a fuel pump is used, disconnect pulse line from fitting on closure plate.
2. Remove heat deflector or carburetor spacer/heat shield (if equipped) mounting screw and special washer, which also secures ground lead for fuel shut-off solenoid, if so equipped.
3. If carburetor uses a fuel solenoid, carefully cut plastic tie strap and disconnect fuel solenoid lead from wiring harness.
4. Slide carburetor outward and disconnect throttle and choke linkages.
5. Mark mounted position of speed control bracket in slotted holes and remove screws securing speed control bracket to closure plate. Note or mark governor spring hole for correct installation later. Unhook governor spring, then remove control bracket (with fuel pump attached, if equipped) and linkages from engine.
6. Loosen nut and remove governor lever from governor cross shaft.
7. Remove carburetor gasket, then carefully remove heat deflector or carburetor spacer/heat shield (if equipped) and gaskets from intake stud. Heat deflector is made from a plastic that is quite brittle. Do not pry on corners, or you risk cracking/breaking deflector. If prying is necessary to loosen deflector, carefully pry near intake stud only. Remove mounting stud from cylinder only if required.
8. Remove insert from intake port (some models), if separate from heat deflector.

# Disassembly/Inspection and Service

## Flywheel/Ignition Components



<b>A</b>	Flywheel Screw	<b>B</b>	Washer
<b>C</b>	Fan Mounting Plate	<b>D</b>	Fan
<b>E</b>	Magnet	<b>F</b>	Flywheel
<b>G</b>	Ignition Module	<b>H</b>	Stator
<b>I</b>	Flywheel Key		

### Remove Ignition Module

1. Disconnect kill lead from ignition module.
2. Rotate flywheel magnet away from module.
3. Remove RFI sheathed spark plug lead from retaining clip, if so equipped.
4. Remove screws and ignition module.

### Remove Debris Screen, Fan, and Flywheel

**NOTE:** Always use a flywheel strap wrench or flywheel holding tool (see Tools and Aids) to hold flywheel when loosening or tightening flywheel and fan retaining fasteners. Do not use any type of bar or wedge between fins of cooling fan, as fins could become cracked or damaged.

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

1. Unsnap debris screen from cooling fan.
2. Remove retaining screw, washer and fan mounting plate, securing fan and flywheel to crankshaft.
3. Carefully lift cooling fan to disengage two drive pins and remove it from flywheel.

#### Flywheel with Puller Holes

1. Remove flywheel from crankshaft using a puller.
2. Remove flywheel key from crankshaft.

#### Flywheel without Puller Holes

1. Remove flywheel from crankshaft by pulling from under ring gear with large gear puller.
2. Remove flywheel key from crankshaft.

### Flywheel Inspection

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

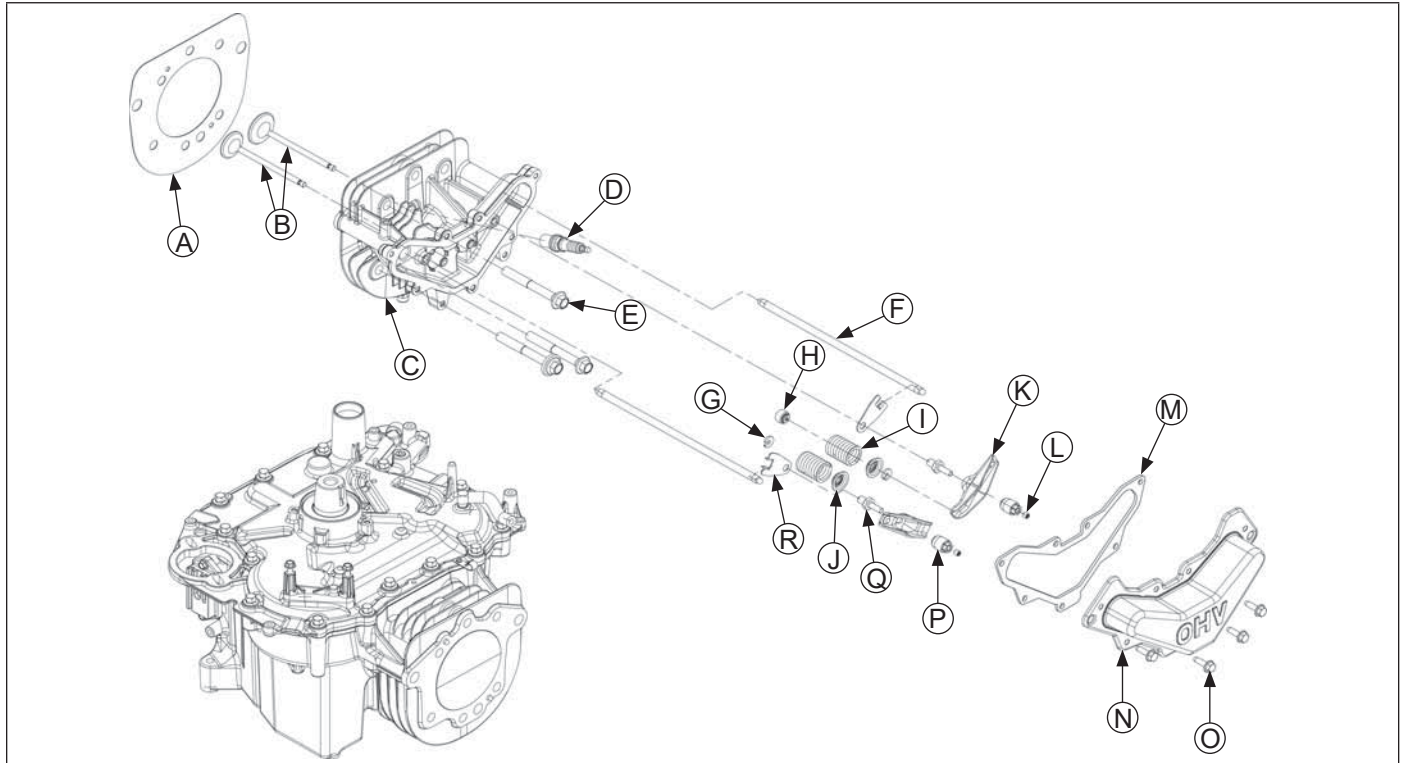
Inspect ring gear for cracks or damage. Ring gears are not available separately. Replace flywheel if ring gear is damaged.

### Remove Stator

**NOTE:** To disconnect B+ or stator leads from wiring harness connector, insert a small screwdriver, or similar narrow flat blade, and bend down locking tang of terminal(s). Gently pull lead(s) out of connector.

Remove screws securing stator to closure plate bosses.

## Cylinder Head Components



<b>A</b>	Gasket	<b>B</b>	Valve	<b>C</b>	Cylinder Head	<b>D</b>	Spark Plug
<b>E</b>	Cylinder Head Screw	<b>F</b>	Push Rod	<b>G</b>	Valve Spring Retainer	<b>H</b>	Valve Stem Seal
<b>I</b>	Valve Spring	<b>J</b>	Valve Spring Cap	<b>K</b>	Rocker Arm	<b>L</b>	Set Screw
<b>M</b>	Valve Cover Gasket	<b>N</b>	Valve Cover	<b>O</b>	Screw	<b>P</b>	Rocker Arm Pivot
<b>Q</b>	Rocker Arm Stud	<b>R</b>	Push Rod Guide Plate				

### Remove Valve Cover

#### Valve Cover with Gasket

1. Remove screws securing valve cover and any attached brackets.
2. Remove valve cover and gasket from cylinder head.

#### Valve Cover with RTV Sealant

**NOTE:** Valve cover is sealed to cylinder head using RTV silicone sealant. When removing valve cover, use care not to damage gasket surfaces of cover and cylinder head. To break RTV seal, hold a block of wood against 1 flat face of valve cover. Strike wood firmly with a mallet. If seal doesn't break loose after 1 or 2 attempts, repeat procedure on other side.

1. Remove screws securing valve cover and any attached brackets.
2. Using a brass wire brush and gasket remover or similar solvent, clean old RTV from surface of cylinder head and valve cover.

### Remove Cylinder Head

1. Loosen inner set screws (T15 TORX) and back off rocker arm adjusting nuts. Remove push rods and mark them, so they can be reinstalled in same location.

2. Remove screws securing cylinder head. Note thick washer used on screw closest to exhaust port.
3. Remove cylinder head and head gasket.
4. Remove drain back check ball (some models) from keyhole slot in crankcase. Models without a check ball have an internal drain back tube in crankcase.

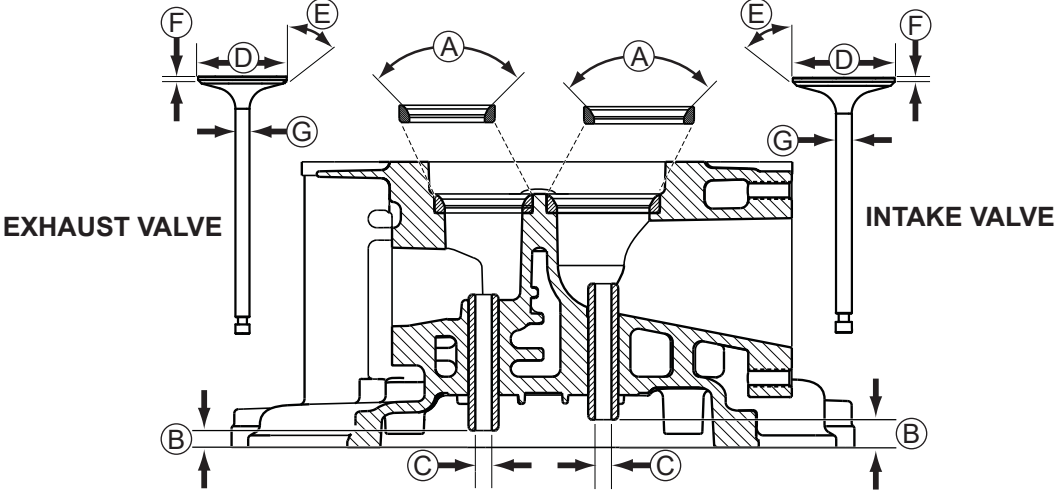
### Disassemble Cylinder Head

**NOTE:** Before disassembly, mark all valve train components that will be reused, to assure they are reassembled on same side.

1. Remove spark plug.
2. Remove adjustment nuts, pivots and rocker arms from pivot studs.
3. Remove rocker arm pivot studs and push rod guide plates.
4. Remove valves.
  - a. Compress valve springs using a valve spring compressor and remove keepers.
  - b. Remove compressor; then remove valve spring caps, valve springs, and valves.

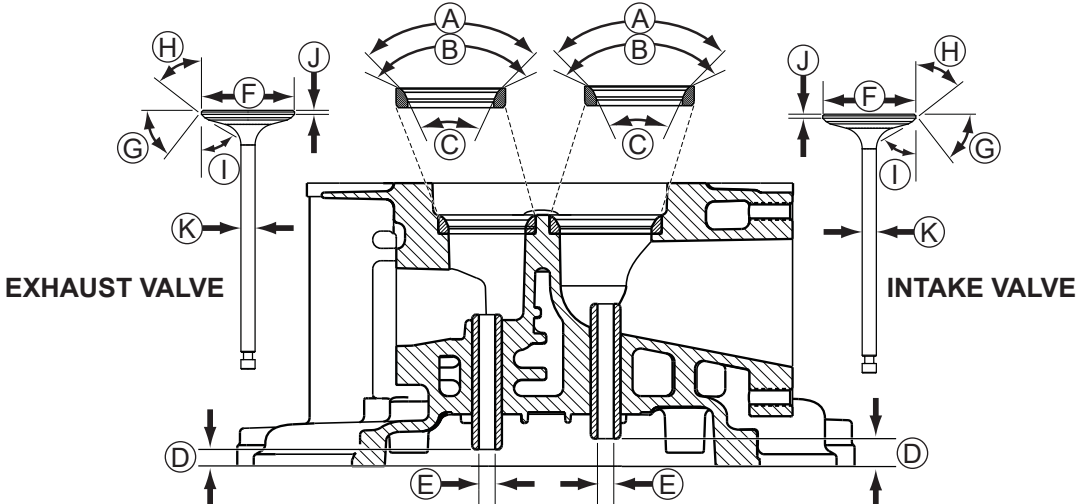
# Disassembly/Inspection and Service

## Model SV470/480/530/540/590/600/610 Valve Details



Dimension		Intake	Exhaust
A	Seat Angle	89°	89°
B	Guide Depth	10.20 mm	6.2 mm
C	Guide I.D.	6.038/6.058 mm	6.038/6.058 mm
D	Valve Head Diameter	37.625/37.375 mm	32.125/32.375 mm
E	Valve Face Angle	45°	45°
F	Valve Margin (Min.)	1.5 mm	1.5 mm
G	Valve Stem Diameter	5.982/6.00 mm	5.90/5.988 mm

## Model SV620 Valve Details



Dimension		Intake	Exhaust
A	Seat Angle	89°	89°
B	Seat Angle	111/109°	131/129°
C	Seat Angle	61/59°	51/49°
D	Guide Depth	10.20 mm	6.2 mm
E	Guide I.D.	6.038/6.058 mm	6.038/6.058 mm
F	Valve Head Diameter	37.625/37.375 mm	32.125/32.375 mm
G	Valve Face Angle	45°	45°
H	Valve Face Angle	39.275/39.525°	33.675/33.925°
I	Valve Face Angle	60°	60°
J	Valve Margin (Min.)	1.7 mm	1.7 mm
K	Valve Stem Diameter	5.982/6.000 mm	5.90/5.988 mm



## Inspection and Service

Carefully inspect valve mechanism parts. Inspect valve springs and related hardware for excessive wear or distortion. Check valves and valve seats for evidence of deep pitting, cracks, or distortion. Check running clearance between valve stems and 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 warped head, excessive corrosion, or 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 burned 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. 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. 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 6.135 mm (0.2415 in.) while 6.160 mm (0.2425 in.) is maximum allowed on exhaust guide. Guides are not removable. If guides are within limits but valve stems are worn beyond limits, replace valves.

### Valve Seat Inserts

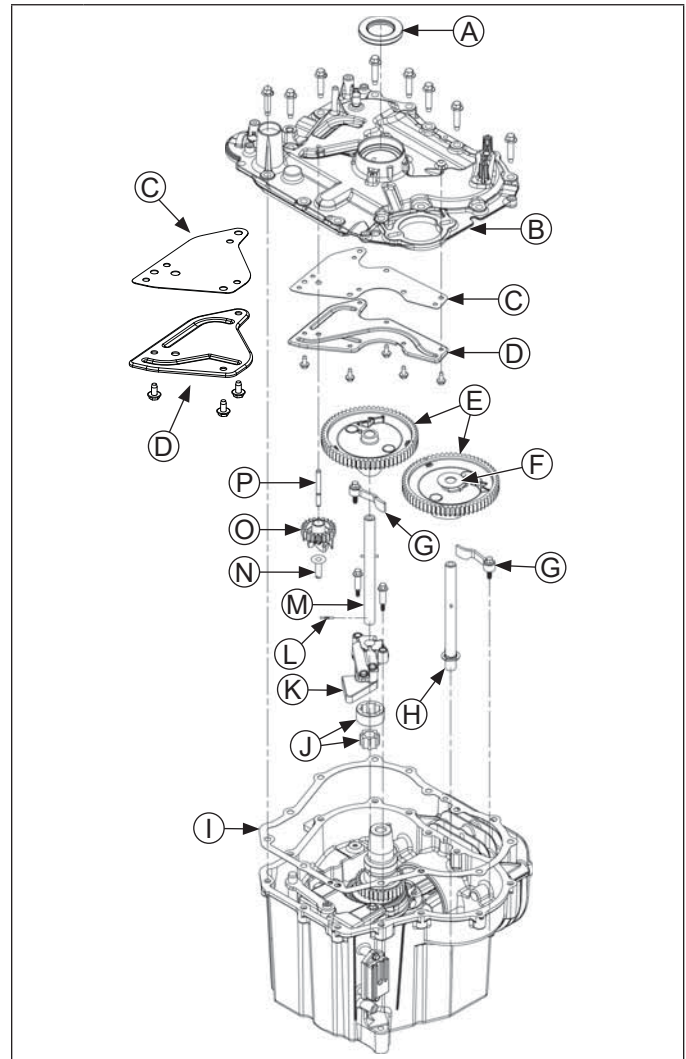
Hardened steel alloy intake and exhaust valve seat inserts are press fitted into cylinder head. Inserts are not replaceable, but they can be reconditioned if not too badly pitted or distorted. If seats are cracked or badly warped, cylinder head should be replaced.

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. With proper 45° valve face angle, and valve seat cut properly (44.5° as measured from center line when cut 89°) this would result in desired 0.5° (1.0° full cut) interference angle where maximum pressure occurs on valve face and seat.

### Lapping Valves

Reground or new valves must be lapped in, to provide a good seal. Use a hand valve grinder with suction cup for final lapping. Lightly coat valve face with fine grade of grinding compound, then rotate valve on seat with grinder. Continue grinding until 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 engine oil to prevent rusting.

## Cam/Closure Plate Components



<b>A</b>	Oil Seal	<b>B</b>	Closure Plate
<b>C</b>	Gasket	<b>D</b>	Oil Passage Cover
<b>E</b>	Cam Gears	<b>F</b>	Thrust Washer
<b>G</b>	Cam Levers	<b>H</b>	Cam Shaft (Exhaust)
<b>I</b>	Closure Plate Gasket	<b>J</b>	Gerotor Gears
<b>K</b>	Oil Pump	<b>L</b>	Cam Shaft Pin
<b>M</b>	Cam Shaft (Intake)	<b>N</b>	Regulating Pin
<b>O</b>	Governor Gear	<b>P</b>	Governor Gear Shaft

### Remove Closure Plate

1. Remove screws securing closure plate to crankcase. Note location and position of any attached clips or clamps.
2. A gasket is used between closure plate and crankcase. If necessary, carefully tap on bosses for starter or oil filter with a soft-faced mallet to loosen. Do not pry on gasket surfaces of crankcase or oil pan, as this can cause damage resulting in leaks.
3. Remove closure plate assembly and gasket.

## Disassembly/Inspection and Service

- If wiring harness needs to be separated from closure plate, pry open clamps and pull out through slot.

### Disassemble Closure Plate

NOTE: Governor gear is held onto shaft by small molded tabs in gear. When gear is removed these tabs are destroyed and gear must be replaced. Governor gear removal is required for closure plate disassembly and cleaning of oil passages.

- Remove governor gear and regulating pin assembly. Gently pry upward using blades of two small screwdrivers.
- Remove screws securing oil passage cover to closure plate. Remove cover and gasket.

### Governor Gear and Shaft Inspection

Inspect governor gear teeth. Look for any evidence of worn, chipped, or cracked teeth. If one or more of these problems is noted, replace governor gear.

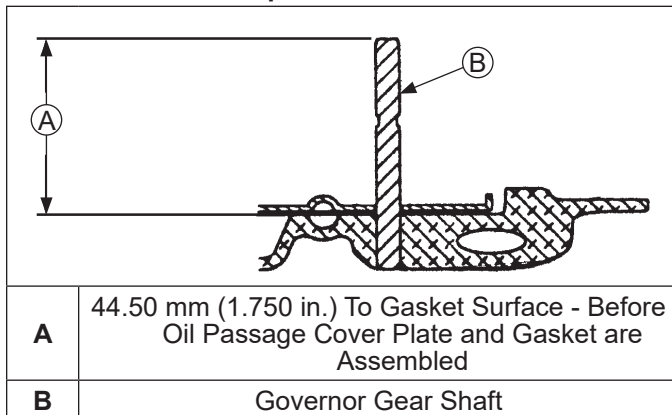
Gear is held onto governor shaft by molded tabs, which are damaged when gear is removed. Never reuse gear once it has been pulled from shaft. Replace governor shaft only if it is damaged or worn.

### Remove Governor Shaft

- Remove blower housing, flywheel, and cooling fan.
- Remove stator and crankshaft key.
- Remove closure plate screws and closure plate.
- Rotate engine to top dead center aligning timing marks on crankshaft and cam gears.
- Remove governor gear assembly and regulating pin from closure plate with two small screwdrivers.
- Locate governor pin from flywheel side. With a small punch, drive pin out of closure plate. This could also be done with a press. Do not remove governor pin with a vise grip or pliers, you may damage closure plate.
- Remove any old gasket material from mating surfaces of crankcase and closure plate. Use an aerosol gasket remover to help loosen any old gasket material. Do not scrape surfaces, as any scratches, nicks, or burrs can result in leaks.

### Install Governor Shaft

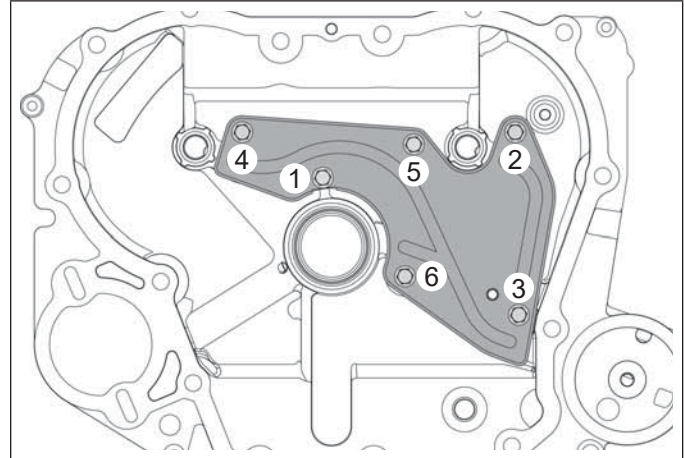
#### Governor Shaft Components and Details



- Install new pin by pressing or lightly tapping it into closure plate. It must be installed so that it protrudes 44.50 mm (1.750 in.), plus or minus 0.101 mm (0.004 in.) above crankcase boss.
- Install new governor regulating pin and governor gear assembly.
- Make sure governor gear assembly rotates freely.
- Check that timing marks are still aligned.
- Install a new closure plate gasket and install closure plate. Torque fasteners to 24.5 N·m (216 in. lb.).
- Complete engine reassembly following Reassembly procedures.
- When engine reassembly is completed, reset initial governor adjustment according to procedure in Governor System.

### Closure Plate and Passage Cover Inspection and Service

#### Passage Cover Torque Sequence



NOTE: Passage cover with 3 fasteners does not require a torque sequence.

If disassembly was performed, inspect and ensure oil passages in closure plate and passage cover are completely clean and not obstructed in any way. Check straightness of passage cover if required, against a flat surface.

Use a new passage cover gasket and install passage cover onto closure plate. Reinstall mounting screws and torque to 4.0 N·m (35 in. lb.), following sequence. Passage cover with 3 fasteners does not require a torque sequence.

### Remove Cam Gears, Cam Shafts, and Oil Pump

NOTE: ACR weight and spring normally captured by thrust washer and installation of closure plate, will fall out if exhaust cam gear is turned upside down.

NOTE: Cam gear assemblies may contain either two or four rivets.



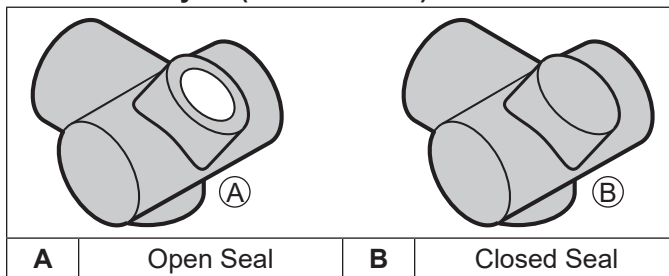
NOTE: Engine Serial No. 332740003 and lower, use a rubber outlet between oil pump outlet and lower bearing area. Some models use an open seal with an internal passage to feed oil to lower bearing. Some models use a closed or solid seal, and crankshaft is crossed-drilled to feed oil to lower bearing.

Engine Serial No. 332740003 and higher, outlet of oil pump is closed and no rubber seal is used.

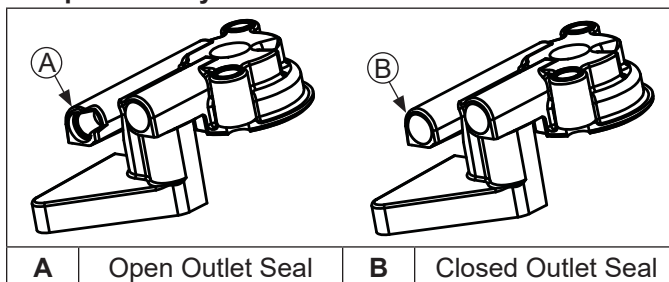
1. Remove thrust washer(s) and cam gears from cam shafts. Later models will have a thrust washer on exhaust side only.
2. Remove screws securing cam levers to crankcase. Mark cam levers for proper reassembly.
3. Pull exhaust side cam shaft and slotted thrust washer, out of crankcase.
4. If engine contains an internal drain back tube, unhook it from oil pump and pull it out of crankcase passage. Check for cracks, brittleness or damage. Replace if questionable in any way.
5. Remove screws securing oil pump and intake side cam shaft to crankcase. If a drain back tube is used, it may be unhooked and removed separately or together with oil pump. Carefully pull upward on cam shaft to remove assembly from crankcase cavity. A small rubber oil pump outlet seal on outlet of oil pump may become dislodged during removal. Do not lose it.
6. If necessary, oil pump can be separated from intake side cam shaft. Provide appropriate support for shaft, and drive out lower pin. Oil pump assembly can then be removed from cam shaft.

## Oil Pump Assembly and Pressure Relief Valve Inspection and Service

### Outlet Seal Styles (Some Models)



### Pump Outlet Styles



Closure plate must be removed to inspect and service oil pump. Check oil pump and gears for cracks, damage, wear, and smooth rotation. Replace pump if any binding is noted or reuse is questionable in any way.

A pressure relief valve is built into oil pump to limit maximum pressure. It is not serviceable. If a problem exists with pressure relief valve, oil pump assembly should be replaced.

### Automatic Compression Release (ACR)

These engines are equipped with an ACR mechanism. ACR lowers compression at cranking speeds to make starting easier.

#### Operation

ACR mechanism consists of an actuating spring and a pivoting flyweight/control pin assembly, located in exhaust side cam gear. A thrust washer and mounting closure plate hold ACR in position. At cranking speeds (700 RPM or lower), spring holds flyweight in and rounded surface of control pin protrudes above exhaust cam lobe. This pushes exhaust valve off its seat during first part of compression stroke. Compression is reduced to an effective ratio of about 2:1 during cranking.

After starting, when engine speed exceeds 700 RPM, centrifugal force overcomes force of the flyweight spring. Flyweight moves outward, rotating control pin to expose the flat surface, which is lower than cam lobe. Control pin no longer has any effect on exhaust valve, and engine operates at full power.

When engine is stopped, spring returns flyweight/control pin assembly to compression release position, ready for next start.

#### Benefits

As a result of reduced compression at cranking speeds, several important benefits are obtained:

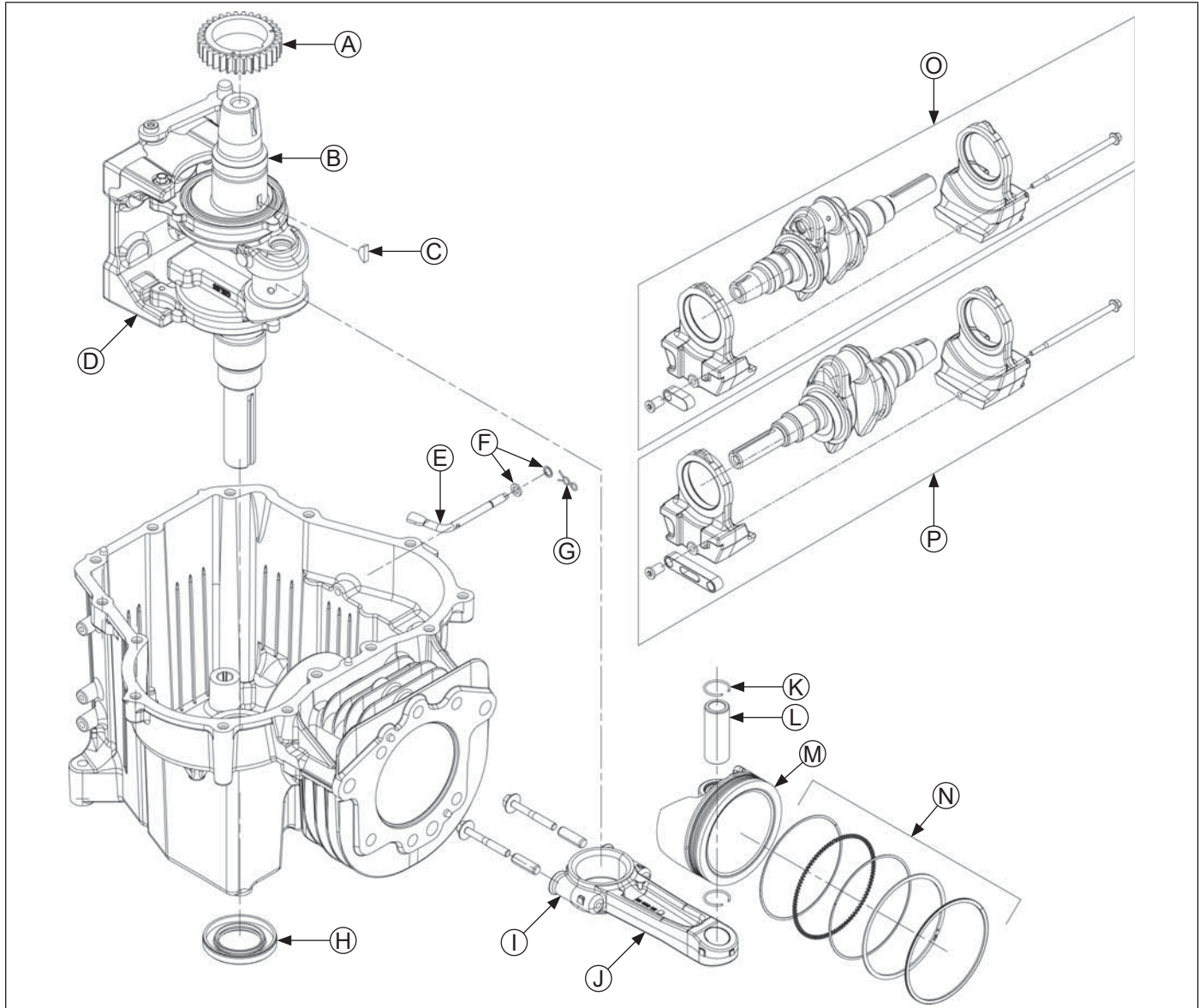
1. Manual (retractable) starting is much easier. Without ACR, manual starting would be virtually impossible.
2. Electric start models can use a smaller starter and battery which are more practical for application.
3. ACR eliminates need for a spark retard/advance mechanism. A spark retard/advance mechanism would be required on engines without ACR to prevent kickback which would occur during starting. ACR eliminates this kickback, making manual starting safer.
4. Choke control setting is less critical with ACR. If flooding occurs, excess fuel is blown out opened exhaust valve and does not hamper starting.
5. Engines with ACR start much faster in cold weather than engines without ACR.
6. Engines with ACR can be started with spark plugs which are worn or fouled. Engines without ACR are more difficult to start with those same spark plugs.

### Cam Gears Inspection and Service

Inspect gear teeth and cam lobes of intake and exhaust cam gears. If lobes exhibit excessive wear, or teeth are worn, chipped or broken, replacement of cam gear(s) will be necessary.

# Disassembly/Inspection and Service

## Balance Weight/Piston Assembly Components



<b>A</b>	Crankshaft Gear	<b>B</b>	Crankshaft	<b>C</b>	Crank Gear Key	<b>D</b>	Third Generation Balance Weight
<b>E</b>	Governor Cross Shaft	<b>F</b>	Washer	<b>G</b>	Hitch Pin	<b>H</b>	Oil Seal
<b>I</b>	End Cap	<b>J</b>	Connecting Rod	<b>K</b>	Wrist Pin Retainer	<b>L</b>	Wrist Pin
<b>M</b>	Piston	<b>N</b>	Piston Ring Set	<b>O</b>	First Generation Balance Weight	<b>P</b>	Second Generation Balance Weight

### Remove Connecting Rod and Piston

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

1. Rotate crankshaft so rod journal is in 9 o'clock position.
2. Remove screws and connecting rod cap.
3. Carefully push connecting rod and piston away from crankshaft and out of cylinder bore.

### Inspection and Service

Check bearing area (big end) for score marks and excessive wear. Service replacement connecting rods are available in STD crankpin size.

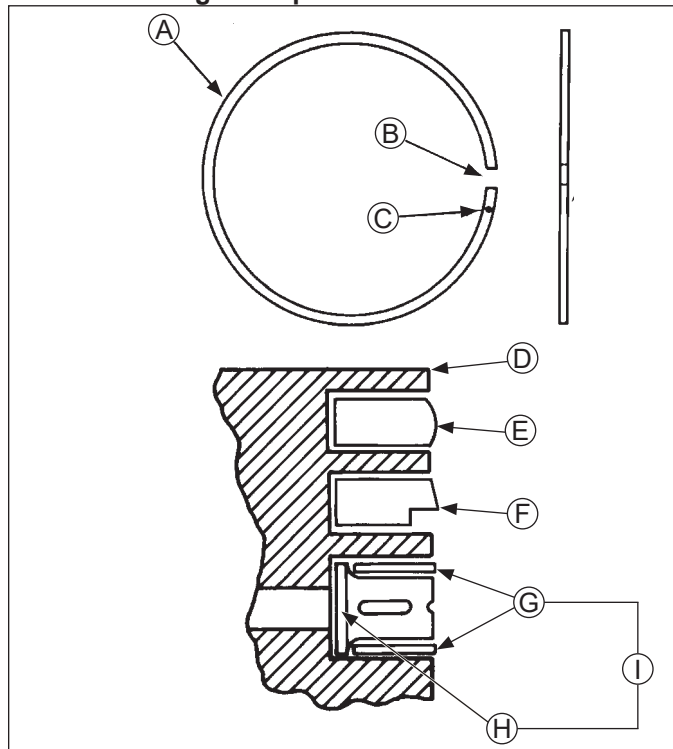
### Remove Piston from Connecting Rod

Remove wrist pin retainer and wrist pin. Separate piston from connecting rod.

## Piston and Rings

### Inspection

#### Piston and Rings Components and Details



<b>A</b>	Piston Ring	<b>B</b>	End Gap
<b>C</b>	Identification Mark	<b>D</b>	Piston
<b>E</b>	Top Compression Ring	<b>F</b>	Center Compression Ring
<b>G</b>	Rails	<b>H</b>	Expander
<b>I</b>	Oil Control Ring (3 Piece)		

Scuffing and scoring of pistons and cylinder walls occurs when internal 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 part of piston assembly; if pin boss 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 that 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 fins, improperly seated valve, or wrong spark plug.

Replacement pistons are available in STD and 0.08 mm (0.003 in.) oversize, which include new rings and piston pins. Service replacement piston ring sets are also available separately. Always use new piston rings when installing pistons. Never reuse old rings.

### Remove Piston Rings

1. Remove top and center compression rings using a ring expander.
2. Remove oil control ring rails, then remove spacer.

Some important points to remember when servicing piston rings:

1. Cylinder bore must be deglazed before service ring sets are used.
2. If cylinder bore is within wear limits (refer to Specifications) and old piston is within wear limits, 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 rings on piston, place each of top two rings in its running area in cylinder bore and check end gap. Compare to listed specifications.

### Clearance Specifications-Top and Middle Compression Ring End Gap

New Bore	
Top Ring	0.15/0.40 mm (0.006/0.016 in.)
Middle Ring	0.30/0.55 mm (0.012/0.022 in.)
Max. Used Bore	0.77 mm (0.030 in.)

5. After installing new compression (top and middle) rings on piston, check piston-to-ring side clearance. Maximum recommended side clearance for each ring is 0.04 mm (0.0016 in.). If side clearance is greater than specified, a new piston must be used.

### Install 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.



## Disassembly/Inspection and Service

To install 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. Compression ring (center groove): Install center ring using a piston ring installation tool. Make sure identification mark is up when ring is installed.
3. Compression ring (top groove): Install top ring using a piston ring installation tool. Make sure identification mark is up when ring is installed.

### Remove Crankshaft and Balance Weight Assembly

Carefully remove crankshaft and balance weight assembly from crankcase. On engines with Second Generation Balance Weight, carefully lift lower control link (for balance weight), off boss of crankcase as crankshaft is removed. Models with Third Generation Balance Weight have a balance weight guidance shaft and link which can be removed before removing crankshaft and balance weight assembly.

### Crankshaft and Crank Gear Inspection and Service

Inspect teeth of crank gear. If teeth are badly worn, chipped, or some are missing, replacement of crank gear will be necessary. Remove gear by pulling it off key and crankshaft.

Inspect crankshaft bearing journal surfaces for wear, scoring, grooving, etc. If they show signs of damage or are out of running clearance specifications, crankshaft must be replaced.

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

Inspect crankpin for wear, score marks or aluminum transfer. Slight score marks can be cleaned with crocus cloth soaked in oil. If wear limits are exceeded, it will be necessary to replace crankshaft.

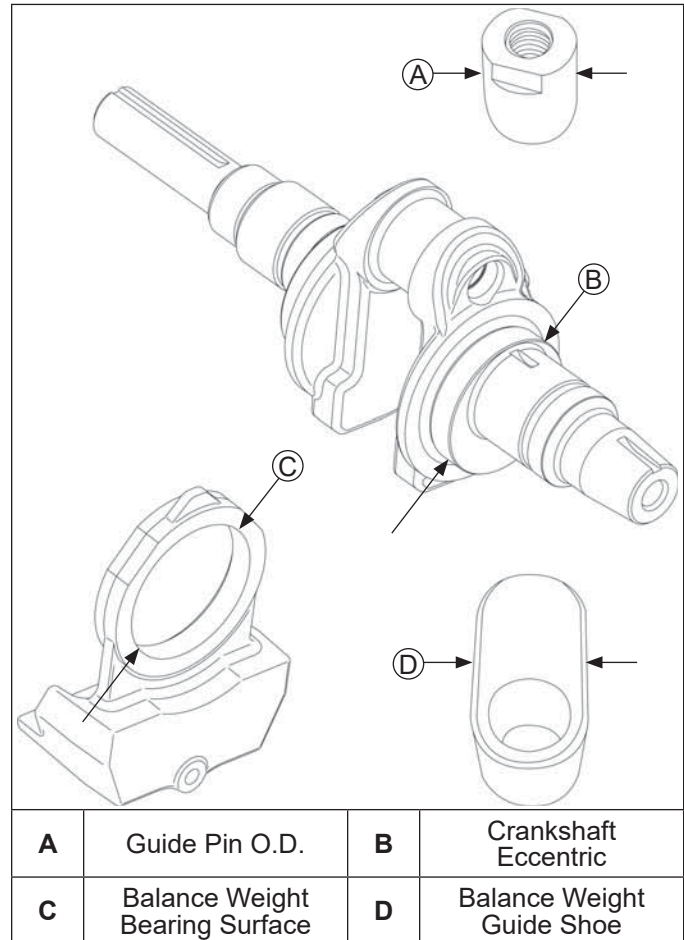
### Balance Weight Disassembly

If necessary, First and Second Generation Balance Weight Assembly can be separated from crankshaft. Disassemble only if required.

1. Remove crank gear from crankshaft and carefully remove key from keyway.
2. For first generation balance weight assembly: remove guide shoe from guide pin on flywheel side of assembly.  
For second generation balance weight assembly: remove link from guide pin on PTO side of assembly.
3. Remove long hex flange screw securing two balance weight halves together on crankshaft. Note orientation of all parts. Guide pin is on flywheel side for balance weight design with closure plate side guide shoe. Guide pin is on PTO side for balance weight design with lower control link. Hold guide pin with wrench or torx bit socket as required. Do not hold or damage outside diameter (O.D.) of guide pin.
4. Mark weights for proper reassembly and carefully slide balance weights off crankshaft eccentrics.

## Balance Weight Assembly

### Measurement Locations



NOTE: These procedures apply only to First and Second Generation Balance Weights. Third Generation Balance Weight should not be disassembled.

Balance weight assembly counterbalances crankshaft weights and internal forces during operation to minimize vibration. Several key areas of balance weight must be checked before installation and use. Additionally, mating components (crankshaft eccentrics and closure plate guide channel) must also be inspected for wear or damage.

Use these procedures to check balance weight and matching components.

### Balance Weight-to-Eccentric Clearance

NOTE: Do not use a feeler gauge to measure balance weight-to-eccentric clearance.

Before balance weight assembly is reassembled to crankshaft, running clearance to crankshaft eccentrics must be accurately checked. Failure to maintain required clearances will result in vibration or engine failure.

## Measuring Balance Weight to Crankshaft Eccentric Ring(s) Clearance

1. Use an inside micrometer, telescoping gauge, or bore gauge and measure inside diameter of balance weight bearing surface. Take two measurements 90° to each other on each weight.
2. Then use an outside micrometer and measure across each eccentric on crankshaft. Again take two measurements 90° to each other.
3. Running clearance is eccentric diameter subtracted from balance weight bearing diameter (step 1 minus step 2). If measurements are outside maximum wear limits listed in Specifications, affected component(s) must be replaced.

## Measuring Balance Weight Guide Pin and Guide Shoe-to-Closure Plate Guide Channel Running Clearance

1. Use an outside micrometer and measure outside width of balance weight guide shoe.
2. Use an inside micrometer, telescoping gauge or similar tool and measure width of guide channel in closure plate. Record these dimensions.
3. Use an outside micrometer again and measure O.D. of balance weight guide pin.
4. Use a split ball gauge or dial calipers and measure I.D. of corresponding hole in guide shoe. Record these dimensions.

If any of measurements taken are outside maximum wear limits listed in Specifications, affected component(s) must be replaced.

## Remove Governor Cross Shaft

1. Remove hitch pin and washer located on outside of governor cross shaft.
2. Slide shaft inward and remove it through inside of crankcase. Be careful not to lose small washer in inside portion of shaft.

## Remove PTO and Flywheel Side Oil Seals

Use a seal puller to remove PTO and flywheel side oil seals.

## Crankcase

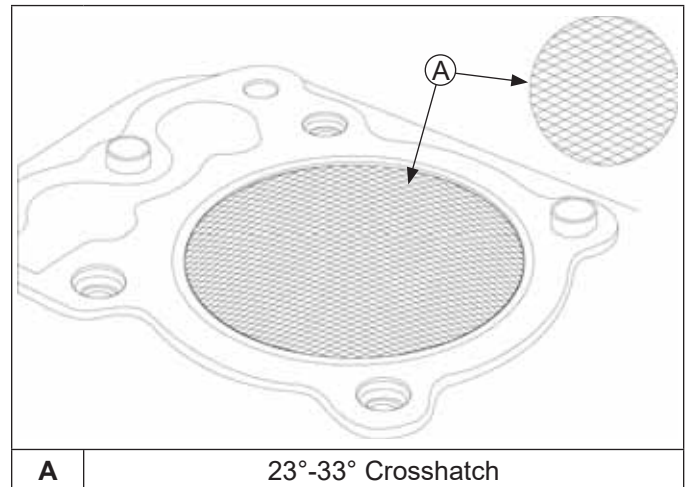
### Inspection and Service

Check all gasket surfaces to make sure they are free of gasket fragments and deep scratches or nicks.

Check cylinder wall for scoring. In severe cases, unburned fuel can wash necessary lubricating oil off piston and cylinder wall. Piston rings make metal to metal contact with wall, causing scuffing and scoring. Scoring of cylinder wall can also be caused by localized hot spots from blocked cooling fins or from inadequate or contaminated lubrication.

If cylinder bore is scored, worn, tapered, or out-of-round, resizing may be possible. Use an inside micrometer or telescoping gauge to determine amount of wear (refer to specifications). If wear exceeds published limits, a 0.08 mm (0.003 in.) oversize piston is available. If cylinder will not clean up at 0.08 mm (0.003 in.) oversize, a short block or replacement engine will need to be considered.

## 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 counter bore. 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 it so 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. Make sure bore is cool when measuring.
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 honing, 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 3 different locations.

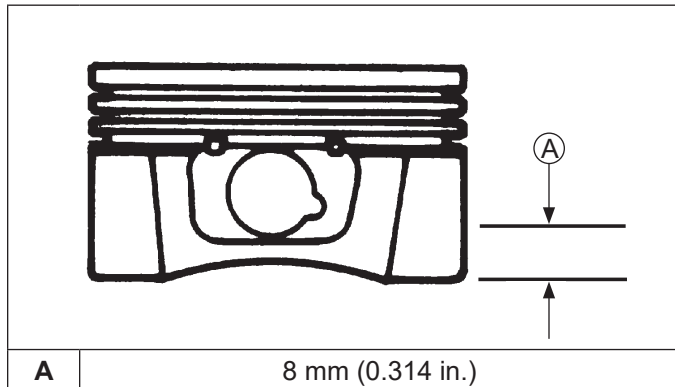
## Disassembly/Inspection and Service

### Clean Cylinder Bore after Honing

Proper cleaning of cylinder walls following honing is critical. 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 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.

### Measuring Piston-to-Bore Clearance Piston Detail



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

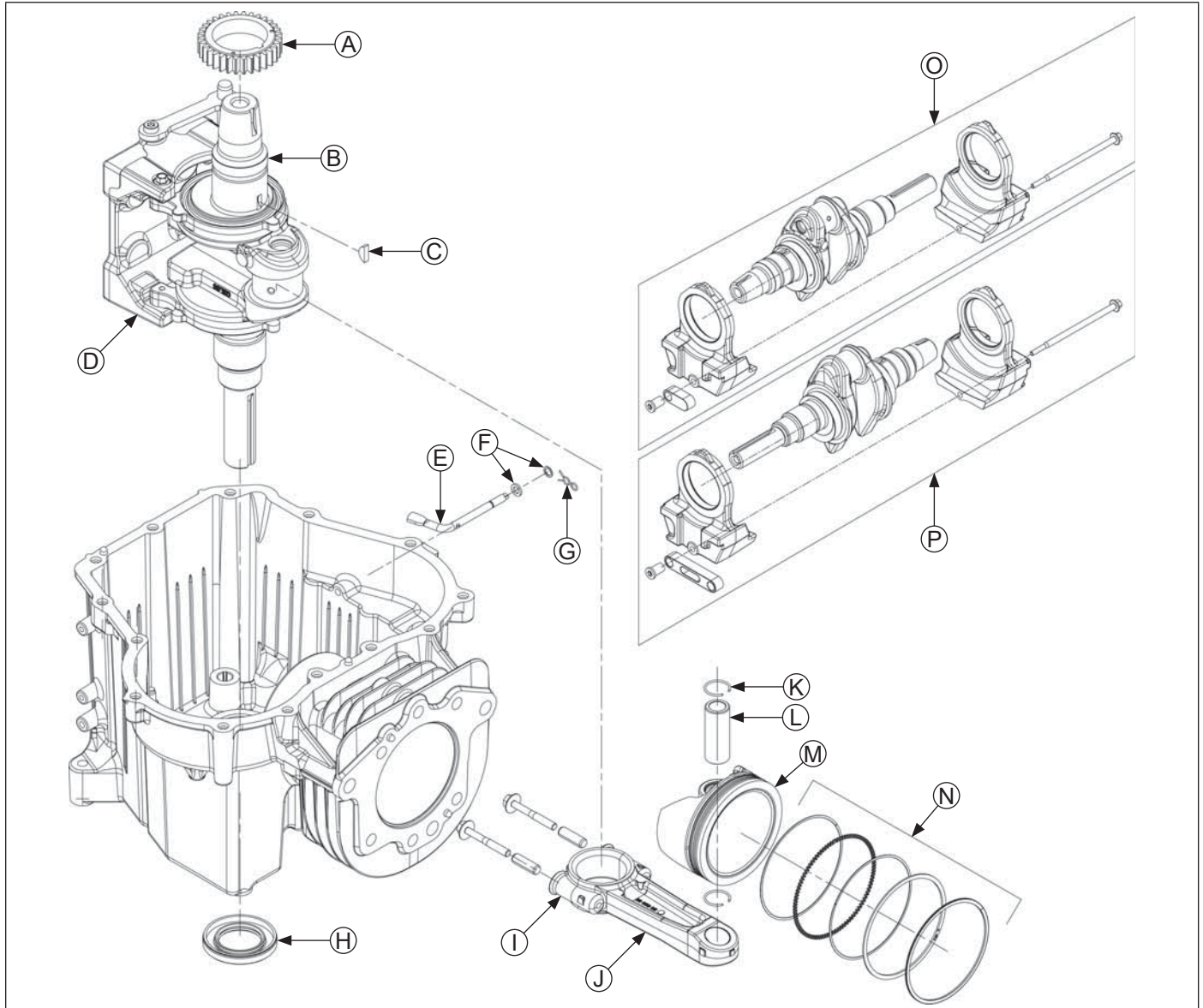
Before installing piston into cylinder bore, it is necessary that clearance be accurately checked. This step is often overlooked, and if clearances are not within specifications, engine failure will usually result.

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

1. Use a micrometer and measure diameter of piston 8 mm (0.314 in.) 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).



## Balance Weight/Piston Assembly Components



<b>A</b>	Crankshaft Gear	<b>B</b>	Crankshaft	<b>C</b>	Crank Gear Key	<b>D</b>	Third Generation Balance Weight
<b>E</b>	Governor Cross Shaft	<b>F</b>	Washer	<b>G</b>	Hitch Pin	<b>H</b>	Oil Seal
<b>I</b>	End Cap	<b>J</b>	Connecting Rod	<b>K</b>	Wrist Pin Retainer	<b>L</b>	Wrist Pin
<b>M</b>	Piston	<b>N</b>	Piston Ring Set	<b>O</b>	First Generation Balance Weight	<b>P</b>	Second Generation Balance Weight

**NOTE:** Make sure engine is assembled using all specified torque values, torque 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.

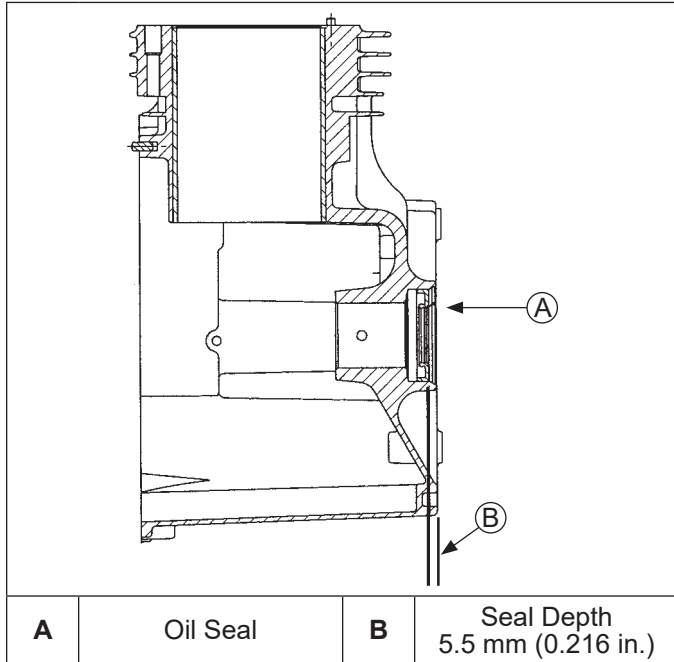
Make sure all traces of any cleaner are removed before engine is assembled and placed into operation. Even small amounts of these cleaners can quickly break down lubricating properties of engine oil.

Check closure plate, crankcase, cylinder heads, and valve covers to be certain all old gasket 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 PTO Side Oil Seal

### PTO Seal Depth Details



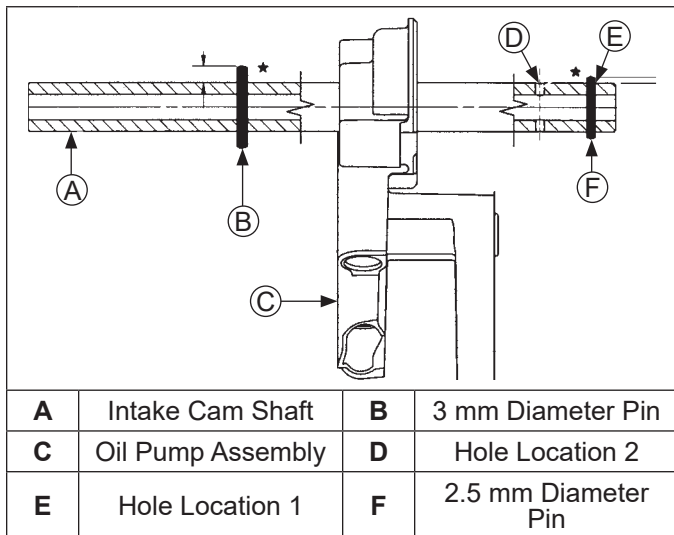
Use a seal driver and install to a depth of 5.5 mm (0.216 in.) into crankcase.

### Install Governor Cross Shaft

1. Place thin thrust washer onto governor cross shaft as far as it will go.
2. Lightly lubricate shaft with oil, and install it from inside crankcase.
3. Slide thick thrust washer onto shaft from outside as far as it will go. Secure by inserting hitch pin in machined groove.

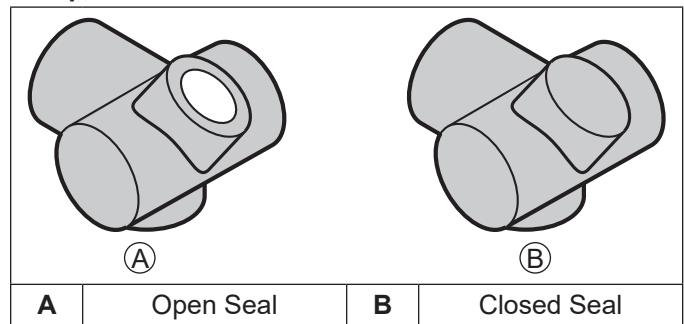
## Install Oil Pump Assembly and Intake Cam Shaft

### Assembled Intake Cam Shaft Details

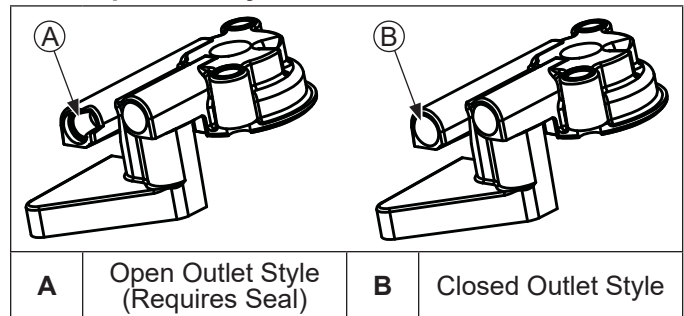


1. If oil pump assembly was removed from intake cam shaft, reassemble it onto shaft. Press fit of drive pins in holes may be one of two designs. One style of tube has drive pin holes machined to be a clearance (slip) fit on one side and a press fit on other accepting smooth style drive pins. Later design tubes have holes uniformly machined and use knurled style drive pins. Support cam shaft (clearance holes up, when applicable), and install shorter 2.5 mm (0.098 in.) diameter pin in outer hole, closest to bottom end. Center pin in shaft.
2. If it was removed, install and center longer, 3 mm (0.118 in.) diameter drive pin into upper hole.
3. Lightly grease gerotor gears and install into oil pump, with short drive pin fitted into slot of inner gear.

### Pump Outlet Seals



### Oil Pump Outlet Styles



4. Determine if outlet of oil pump is open or closed. Open style pumps require use of a rubber seal between pump outlet and lower main bearing area. Some models use an open style seal with an internal passage to feed oil to lower bearing. Some models use a closed seal without an oil passage, and crankshaft is crossed-drilled for lower bearing lubrication. Both styles of outlet seals are shown. If a new seal is to be ordered, be sure it is same style as what was removed. Lightly lubricate ends of oil pump outlet seal with oil and install in into outlet of oil pump.

5. Install intake cam shaft down into crankcase boss. Seat rubber oil pump outlet seal into machined pocket. If an open style outlet seal is used, check to make sure small feed hole is open and aligned with lower main bearing oil feed hole. Use a 3/32" allen wrench, or a light with a mirror. Push steel sleeves in pump housing down until bottomed against mounting surface. Install two M5 mounting screws. Hold pump outlet against main bearing area and torque screws to 6.2 N·m (55 in. lb.) into new holes, or 4.0 N·m (35 in. lb.) into used holes.
6. If engine uses a drain back tube, insert round flanged end into hole near base of cylinder and clip it onto oil pump body.

## Install Crankshaft and Balance Weight

NOTE: If installing a crankshaft with third generation balance weight, steps 1 and 2 do not need to be performed.

1. Assemble crankshaft balance weight if removed from crankshaft.
  - a. Lubricate crankshaft eccentrics and balance weight bearing surfaces with oil.
  - b. Install two balance weight halves onto crankshaft eccentrics as marked or originally installed.
  - c. First generation balance weight assembly: Align weights and install balance weight screw, through mounting holes, from PTO side. Thread it into guide pin outside weight on flywheel side. Hold guide pin with a wrench or Torx bit, and torque screw to 11.3 N·m (100 in. lb.). Do not hold, or damage outside diameter (O.D.) of guide pin.  
 Second generation balance weight assembly: Align weights and insert balance weight screw, through mounting holes from flywheel side. Thread it into guide pin outside weight on PTO side. Hold guide pin with a wrench or Torx bit, and torque screw to 11.3 N·m (100 in. lb.). Do not hold, or damage outside diameter (O.D.) of guide pin. Apply grease to inner diameter (I.D.) of each hole in control link and install one end over guide pin.
2. Carefully install crank gear key in keyway.
3. First generation balance weight assembly: Carefully install crankshaft into crankcase, through PTO seal, and seat fully into place. Rotate crankshaft so journal for connecting rod is away from cylinder.  
 Second generation balance weight assembly: Make sure pivot pin on boss in lower section of crankcase is clean and free of any nicks, or surface irregularities. Apply a small amount of grease to O.D.  
 Third generation balance weight assembly: Carefully install crankshaft into crankcase, through PTO seal, and seat fully into place.

4. First generation balance weight assembly: Install balance weight guide shoe onto guide pin with solid end toward crankshaft.  
 Second generation balance weight assembly: Apply a small amount of grease to O.D. of guide pin on PTO side of counterweight and install control link. Carefully install crankshaft with link (hold in position as required), through PTO seal. Slightly rotate counterweight assembly and guide outer end of link over stationary guide pin in crankcase. Seat link and crankshaft fully into place, do not force either part into position.  
 Third generation balance weight assembly: Apply a small amount of engine oil to ends of guidance shaft. Install guidance shaft through links into boss of crankcase.

## Install Piston Rings

NOTE: For detailed piston inspection procedures and piston ring installation refer to Disassembly/ Inspection and Reconditioning.

## Install Piston to Connecting Rod

Assemble piston, connecting rod, piston pin, and piston pin retainers.

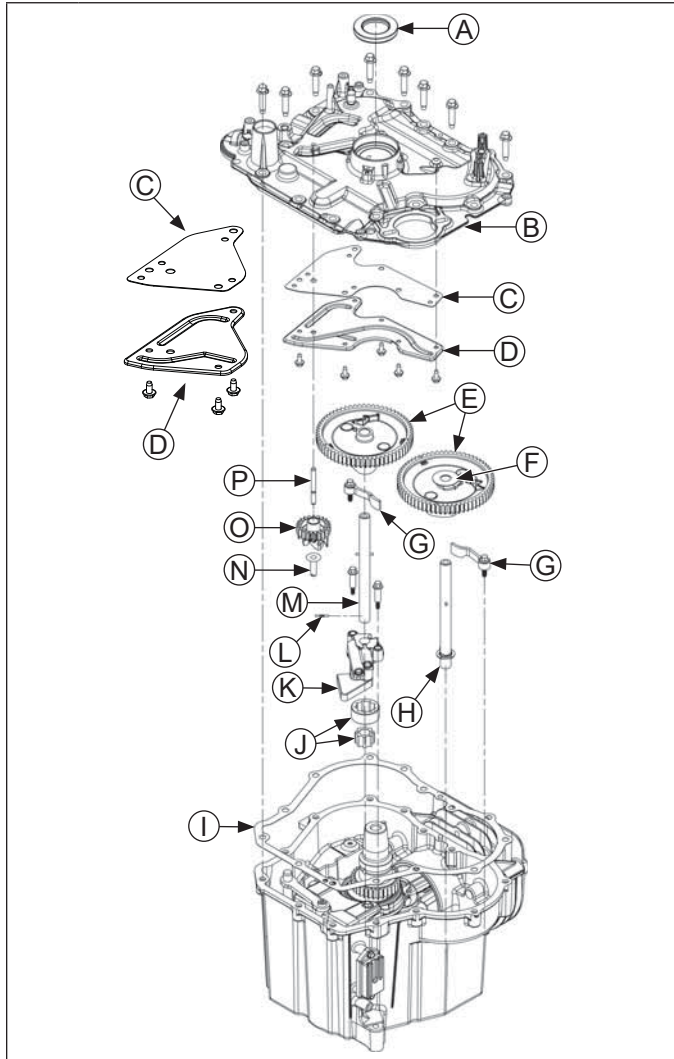
## Install Piston and Connecting Rod

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

1. Stagger piston rings in grooves until end gaps are 120° apart. Lubricate cylinder bore, crankshaft journal, connecting rod journal, piston, and rings with engine oil.
2. Compress piston rings using a piston ring compressor. Orient FLY mark on piston toward flywheel side of crankcase. Place ring compressor on top surface of crankcase and make certain it is seated down around entire circumference. Use a soft, rubber grip hammer handle and tap piston/connecting rod into bore. First tap should be rather firm, so oil ring moves from compressor into bore in one smooth, quick motion. Otherwise oil ring rails may spring out and jam between ring compressor and top of bore.
3. Guide connecting rod down and rotate crankshaft to mate journals. Install rod cap.
4. Install screws and torque in 2 increments, first to 5.5 N·m (50 in. lb.), finally to 11.5 N·m (100 in. lb.).

# Reassembly

## Cam/Closure Plate Components



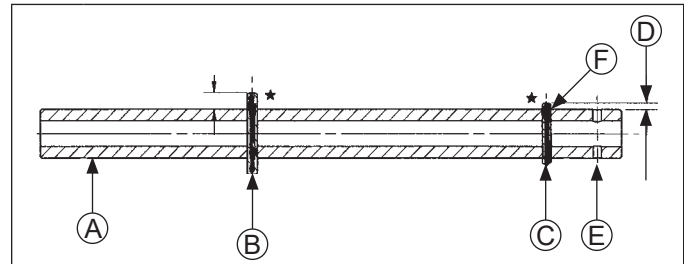
<b>A</b>	Oil Seal	<b>B</b>	Closure Plate
<b>C</b>	Gasket	<b>D</b>	Oil Passage Cover
<b>E</b>	Cam Gears	<b>F</b>	Thrust Washer
<b>G</b>	Cam Levers	<b>H</b>	Cam Shaft (Exhaust)
<b>I</b>	Closure Plate Gasket	<b>J</b>	Gerotor Gears
<b>K</b>	Oil Pump	<b>L</b>	Cam Shaft Pin
<b>M</b>	Cam Shaft (Intake)	<b>N</b>	Regulating Pin
<b>O</b>	Governor Gear	<b>P</b>	Governor Gear Shaft

### Install Cam Levers

Install two cam levers as shown. Dimple for seating push rod must face up. Secure each cam lever using an M6 screw. Torque screws to 7.5 N·m (65 in. lb.). Lubricate dimple and bottom side of cam lever with light grease or oil.

## Install Exhaust Cam Shaft and Cam Gear

### Drive Pin Locations for Exhaust Cam Shaft



<b>A</b>	Exhaust Cam Shaft	<b>B</b>	3 mm Diameter Pin
<b>C</b>	2.5 mm Diameter Pin	<b>D</b>	1.86 mm
<b>E</b>	Hole Location 1	<b>F</b>	Hole Location 2

- If drive pins were removed from exhaust cam shaft, follow same procedure used earlier for intake cam shaft and reinstall them.
- Apply a dab of grease to formed groove in thrust washer. Slide washer onto cam shaft so short drive pin is seated in groove. Grease will hold washer in position. Pivot exhaust cam lever toward push rod bore, then insert cam shaft into counterbore of crankcase. Make sure pin stays in groove of thrust washer.
- Lubricate cam surfaces of cam gears with light grease or oil.
- Assemble and install ACR (automatic compression release) into exhaust cam gear if removed for servicing.
  - Install spring onto ACR weight with loop around post, and formed upper leg hooked behind upper section.
  - Install ACR assembly into hole of exhaust cam gear and hook long leg behind notched tab.
- Lift exhaust cam lever and install exhaust cam gear with assembled ACR onto cam shaft, engaging slot with upper drive pin. Rotate gear and shaft so EX timing mark on cam gear is in 8 o'clock position. Install thrust washer onto cam shaft.

### Install Intake Cam on Cam Shaft

NOTE: Cam gear assemblies may contain either two or four rivets.

Lift intake cam lever and install intake cam gear onto intake cam shaft, engaging slot with upper drive pin. Rotate gear and shaft so IN timing mark on cam gear is in 4 o'clock position. Early models only: install thrust washer (if used originally), onto cam shaft.

### Install Crank Gear

Orient crankshaft so key is in 12 o'clock position. Hold crank gear with timing marks visible and slide it onto crankshaft and key, so timing marks on crank gear align with timing marks on cam gears.

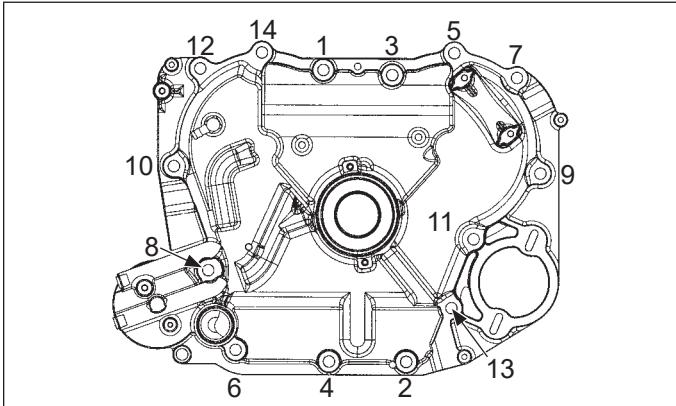


## Install Flywheel Side Oil Seal

Lubricate outside diameter and lip of flywheel end oil seal. Support closure plate and install oil seal. Using a seal driver, drive seal to a depth of 5 mm (0.196 in.) in seal bore.

## Install Closure Plate Gasket, Closure Plate, and Wiring Harness

### Closure Plate Fastener Torque Sequence



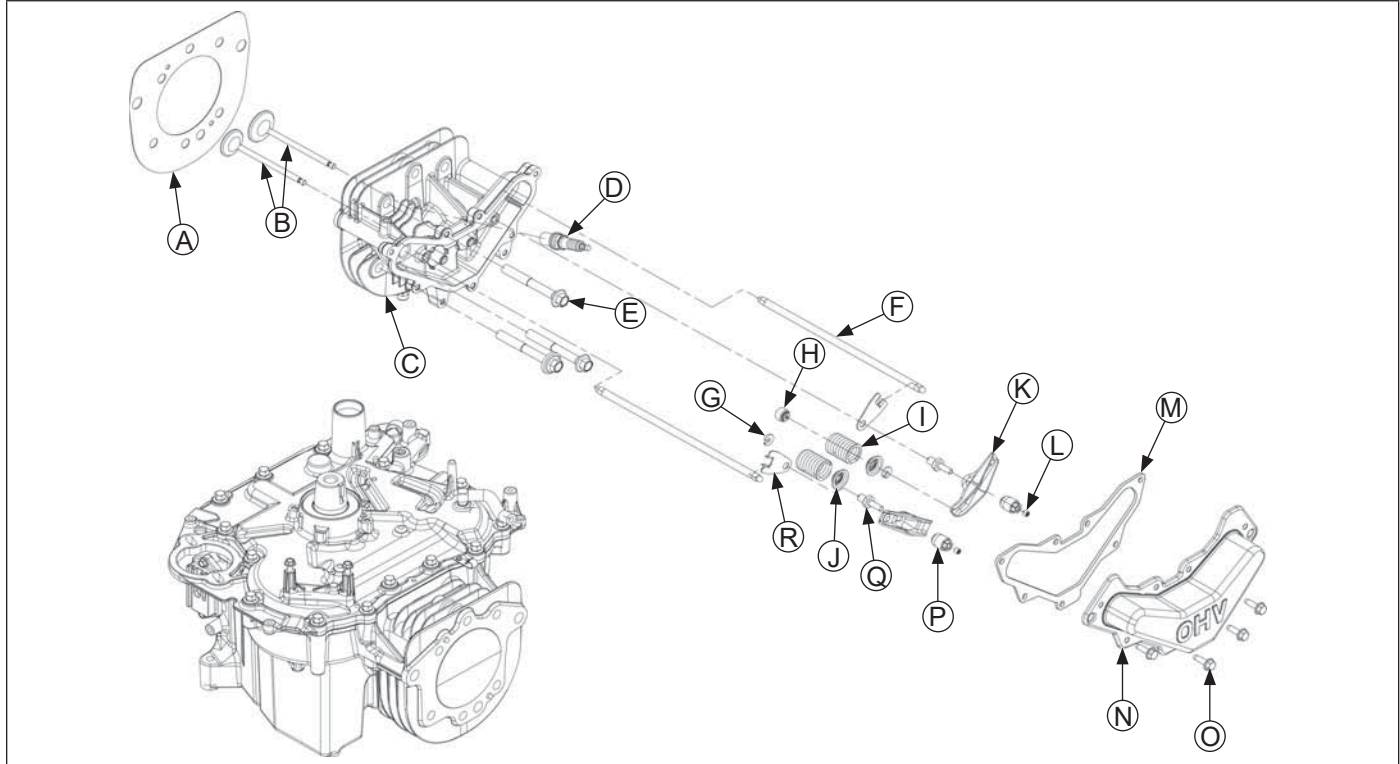
NOTE: A special gasket used between closure plate and crankcase controls crankshaft endplay, no shimming is required. Do not use RTV sealant in place of gasket.

NOTE: Engines with first generation balance weight: Apply grease to outside flat surfaces of balance weight guide shoe. Position guide shoe so solid end is toward crankshaft. Make sure guide shoe stays in this position during step 2.

1. Make sure sealing surfaces of crankcase and closure plate are clean, dry, and free of any nicks or burrs. Install a new closure plate gasket onto crankcase.
2. Ensure gasket, cover plate, and governor gear assembly, have been properly assembled to closure plate. Start closure plate onto crankcase. Be sure guide shoe (models with First Generation Balance Weight), is aligned with guide channel in closure plate, and cam shafts and governor gear shaft are aligned with their mating bearing surfaces. As closure plate is lowered into final position, rotate crankshaft slightly to help engage governor gear.
3. Install screws securing closure plate to crankcase, with any clamps for wiring harness and sheathed RFI suppression spark plug lead (#5 location, if equipped). If wiring harness was separated from closure plate, route harness through clamps and slot in closure plate. Close clamps to retain harness.
4. Torque closure plate fasteners to 24.5 N·m (216 in. lb.) using sequence shown.

# Reassembly

## Cylinder Head Components



<b>A</b>	Gasket	<b>B</b>	Valve	<b>C</b>	Cylinder Head	<b>D</b>	Spark Plug
<b>E</b>	Cylinder Head Screw	<b>F</b>	Push Rod	<b>G</b>	Valve Spring Retainer	<b>H</b>	Valve Stem Seal
<b>I</b>	Valve Spring	<b>J</b>	Valve Spring Cap	<b>K</b>	Rocker Arm	<b>L</b>	Set Screw
<b>M</b>	Valve Cover Gasket	<b>N</b>	Valve Cover	<b>O</b>	Screw	<b>P</b>	Rocker Arm Pivot
<b>Q</b>	Rocker Arm Stud	<b>R</b>	Push Rod Guide Plate				

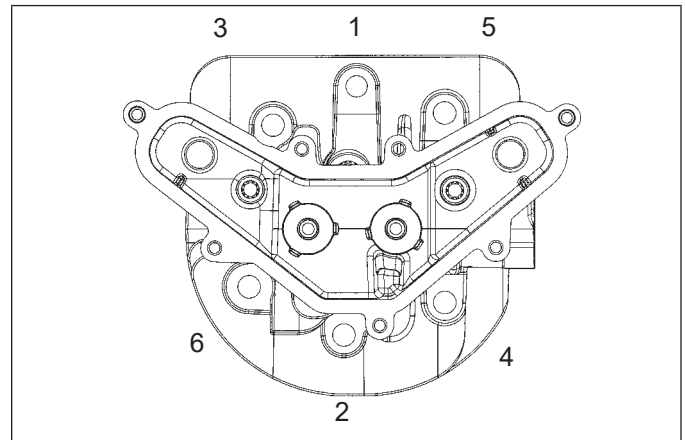
### Assemble Cylinder Head

Prior to assembly, lubricate all components with engine oil, including tips of valve stems and valve guides. Using a valve spring compressor, install following items in order listed.

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

### Install Cylinder Head

#### Cylinder Head Torque Sequence



**NOTE:** Do not reuse cylinder head screws or gasket, always replace with new parts.

**NOTE:** If crankshaft has not been turned since installation of crank gear, turn it one (1) complete revolution. This will set piston at top dead center (TDC) of compression stroke, for proper valve lash adjustment later.



1. Check to make sure there are no nicks or burrs on sealing surfaces of cylinder head or crankcase.
2. If engine uses a drain back check ball, install it into keyhole slot in top of crankcase.
3. Install a new cylinder head gasket.
4. Install cylinder head and start six screws. Install thick washer on screw closest to exhaust port.
5. Using torque sequence shown, torque cylinder head screws in two stages; initially to 20.5 N·m (180 in. lb.), and finally to 41.0 N·m (360 in. lb.).

## Install Rocker Arms and Push Rods

**NOTE:** Installation and seating of push rods into cam lever recesses during this sequence is critical. Position engine with cylinder head up if possible, to aid with proper installation of push rods and rocker arms, and adjusting valve lash.

**NOTE:** If being reused, push rods should always be installed in their original position.

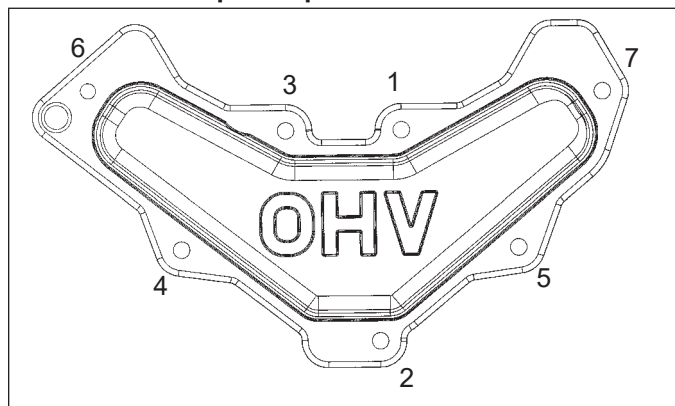
1. Position push rod guide plates on cylinder head with extruded edges down over push rod bores. Secure by installing rocker arm pivot studs. Torque studs to 13.5 N·m (120 in. lb.).
2. Apply grease to contact surfaces of rocker arms and adjusting nuts and install them onto pivot studs.
3. Note mark or tag identifying push rod as either intake or exhaust. Apply grease to ends of push rods. Insert push rods into push rod bores and seat lower end into dimpled recess of cam levers. It may be necessary to lift or shift lower end of push rod slightly, and feel rod seats into recess. Once seated, hold it in place as you position rocker arm. Push rod must stay in recess while rocker arms are positioned and adjusted.
4. With engine at TDC of compression stroke, insert correct size flat feeler gauge (see below) between appropriate valve stem and rocker arm. Tighten adjustment nut with a wrench until a slight drag is felt on feeler gauge. Hold nut in position and torque set screw (T15 Torx drive) to 5.5 N·m (50 in. lb.). To prevent damage to nut, torque Torx screw only. Perform adjustment procedure on other valve.

## Clearance Specifications-Valve

Intake Valve	0.127 mm (0.005 in.)
Exhaust Valve	0.178 mm (0.007 in.)

## Install Valve Cover

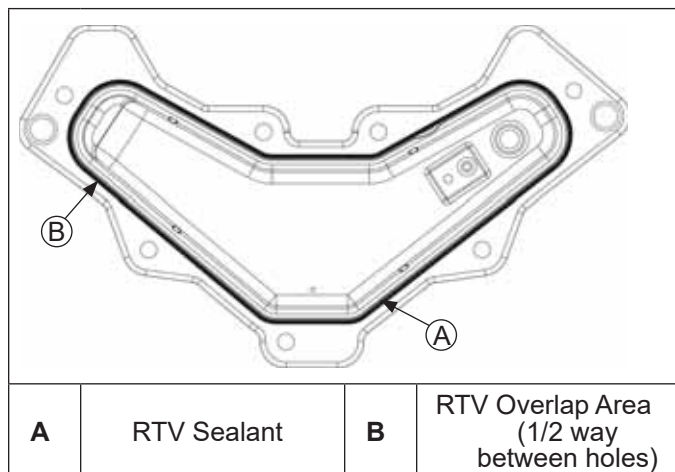
### Valve Cover Torque Sequence



### Valve Cover with Gasket

1. Make sure sealing surfaces of valve cover and cylinder head are clean, and free of any nicks or burrs.
2. Install a new valve cover gasket, followed by valve cover. Position any brackets mounted on valve cover and start seven mounting screws.
3. Torque valve cover screws to 11.0 N·m (95 in. lb.) into new holes, or 7.5 N·m (65 in. lb.) into used holes, using sequence shown.

### Valve Cover with RTV



**NOTE:** Always use fresh sealant. Using outdated sealant can result in leakage. Refer to Tools and Aids for important information on sealant dispenser.

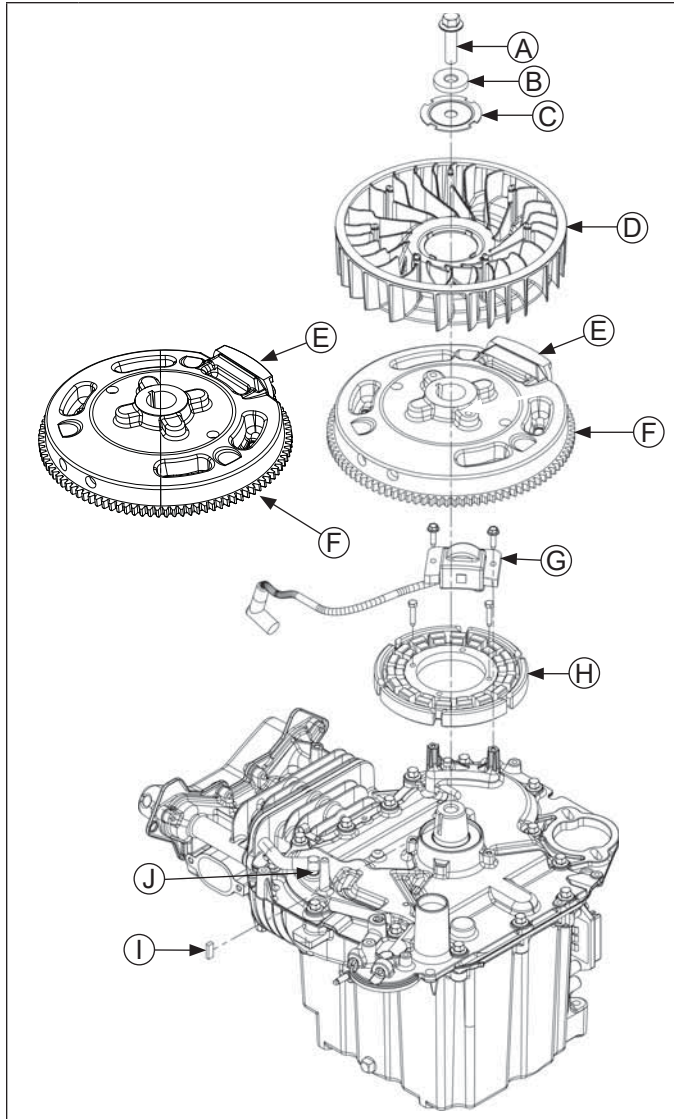
**NOTE:** To ensure proper adhesion of sealant to both sealing surfaces, perform step 3 immediately (5 minutes maximum) after application of RTV.

1. Prepare sealing surface of cylinder head and valve cover.
2. Apply a 1.6 mm (1/16 in.) bead of sealant to valve cover as shown, noting RTV overlap area.
3. Position cover on cylinder head. Position any brackets mounted on valve cover and start seven mounting screws.

# Reassembly

- Torque valve cover screws to 11.0 N·m (95 in. lb.) into new holes, or 7.5 N·m (65 in. lb.) into used holes, using sequence shown.

## Flywheel/Ignition Components



<b>A</b>	Flywheel Screw	<b>B</b>	Washer
<b>C</b>	Fan Mounting Plate	<b>D</b>	Fan
<b>E</b>	Magnet	<b>F</b>	Flywheel
<b>G</b>	Ignition Module	<b>H</b>	Stator
<b>I</b>	Flywheel Key	<b>J</b>	Pulse Line Fitting

## Install Stator and Wiring Harness

### Install Stator

- Position stator onto mounting bosses so leads lay in channel and recess of closure plate. They will become captured when blower housing is installed. If a clamp was used to retain leads, remove screw in No. 13 location and install clamp. Hold clamp in position and torque screw to 24.5 N·m (216 in. lb.)

- Install two screws to secure stator and torque to 6.0 N·m (55 in. lb.), into new holes, or 4.0 N·m (35 in. lb.), into used holes.

### Install Wiring Harness

Check locking tang on terminal of violet B+ wiring harness lead is angled upward. Insert terminal into center location of rectifier-regulator plug connector until it locks into place. If not already inserted, two AC leads from stator go in outer locations.

### Install Pipe Plug or Fitting and Pulse Line for Fuel Pump

- Apply pipe sealant with Teflon® (Loctite® PST® 592™ Thread Sealant or equivalent), to 1/8" pipe plug or 90° fitting (as equipped). Install and tighten into tapped vacuum port of closure plate. Torque plug to 4.5-5.0 N·m (40-45 in. lb.). Turn outlet of a fitting to 8 o'clock position.
- If a fitting is used, connect fuel pump pulse line and secure with clamp. If fuel pump is attached to air cleaner base, do not connect pulse line at this time.

### Install Fan and Flywheel

	<b>CAUTION</b>
	Damaging Crankshaft and Flywheel can cause personal injury.
<p>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.</p>	

**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 mounting screw is torqued to specification.

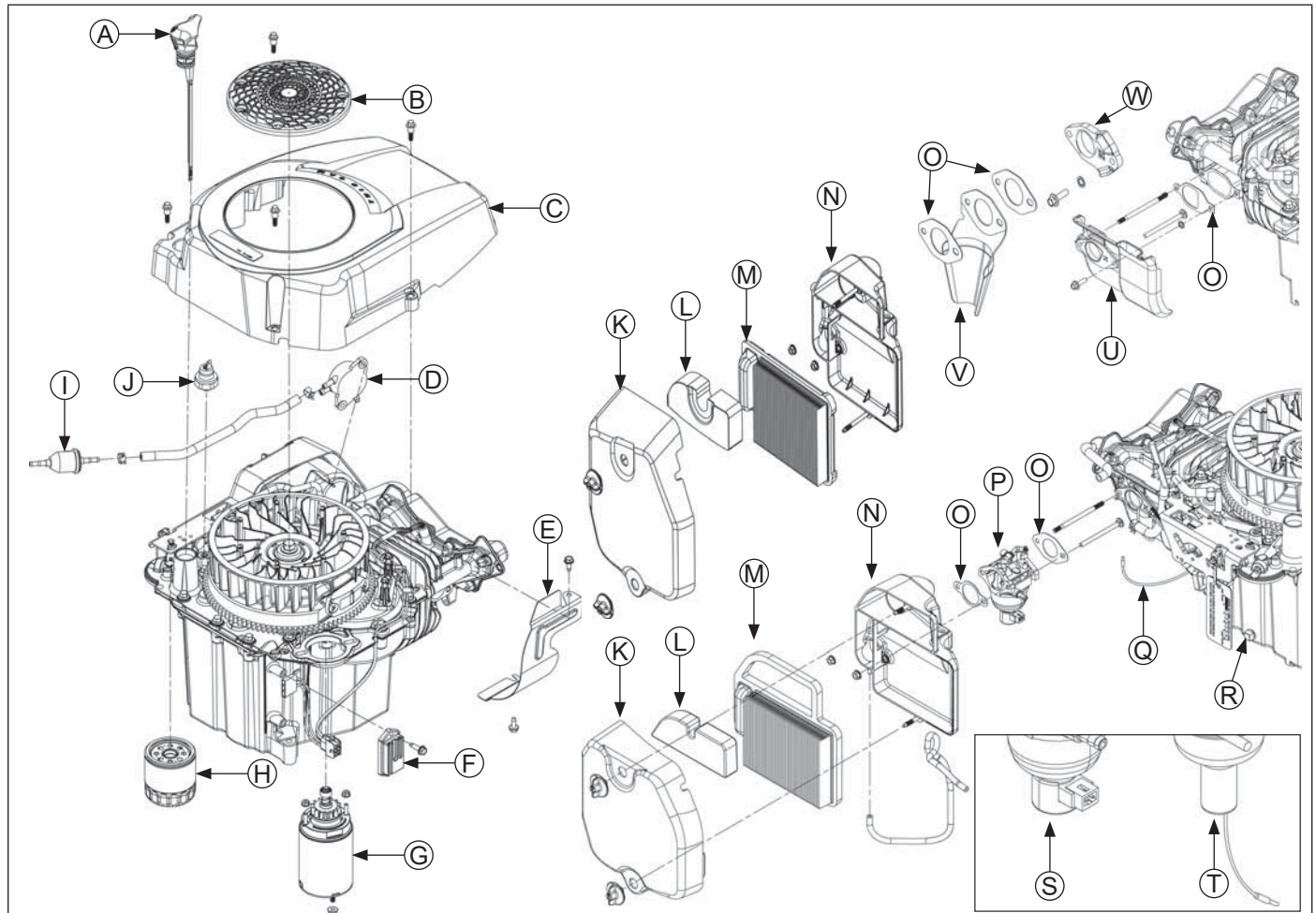
**NOTE:** Make sure flywheel key is installed properly in keyway. Flywheel can become cracked or damaged if key is not properly installed.

**NOTE:** Always use a flywheel strap wrench or flywheel holding tool to hold flywheel when tightening flywheel fastener. Do not use any type of bar or wedge between cooling fins or flywheel ring gear, as these parts could become cracked or damaged.

- Install appropriate key into crankshaft keyway. Based on crankshaft keyway style, use either a woodruff or straight key. Make sure key is fully seated.
- Install flywheel onto crankshaft aligning keyway with key. Be careful not to shift or unseat key.
- Position fan onto flywheel, so locating pins drop into corresponding recesses.
- Install fan mounting plate onto fan, aligning four cutouts, followed by heavy flat washer and screw.

- Use a flywheel strap wrench or holding tool to hold flywheel and torque screw. For an M10 screw, torque to 66.5 N·m (49 ft. lb.). For an M12 screw, torque to 88.0 N·m (65 ft. lb.).

## External Engine Components



<b>A</b>	Oil Fill/Dipstick	<b>B</b>	Debris Screen	<b>C</b>	Blower Housing	<b>D</b>	Fuel Pump
<b>E</b>	Cylinder Head Baffle	<b>F</b>	Rectifier-Regulator	<b>G</b>	Electric Starter	<b>H</b>	Oil Filter
<b>I</b>	Fuel Filter	<b>J</b>	Oil Sentry™	<b>K</b>	Air Cleaner Cover	<b>L</b>	Precleaner
<b>M</b>	Air Cleaner Element	<b>N</b>	Air Cleaner Base	<b>O</b>	Gasket	<b>P</b>	Carburetor
<b>Q</b>	Ground Wire	<b>R</b>	Oil Drain Plug	<b>S</b>	Nikki Fuel Solenoid	<b>T</b>	Walbro Fuel Solenoid
<b>U</b>	Heat Deflector	<b>V</b>	Heat Shield	<b>W</b>	Carburetor Spacer		

### Install Electric Starter

Install electric starter to closure plate and secure with nuts. Make sure wires are clear of any moving parts and torque nuts to 3.6 N·m (32 in. lb.).

### Install Ignition Module

- Rotate flywheel so magnet is away from ignition module bosses. Using screws, install ignition module to crankcase bosses with kill terminal up. Move module as far away from flywheel as possible. Tighten screws sufficiently to keep module in position.
- Rotate flywheel to align magnet with ignition module.
- Insert a 0.25 mm (0.010 in.) flat feeler gauge between magnet and ignition module. Loosen screws so magnet pulls against feeler gauge.
- Torque screws to 6.0 N·m (55 in. lb.) into new holes, or 4.0 N·m (35 in. lb.) into used holes.
- Rotate flywheel back and forth checking for clearance between magnet and ignition module. Make sure magnet does not strike module. Recheck air gap with a feeler gauge and readjust if necessary. Final air gap: 0.203/0.305 mm (0.008/0.012 in.).
- Connect kill lead to tab terminal on ignition module.



# Reassembly

- If equipped with a sheathed RFI suppression spark plug lead, place lead in retaining clip so braided wires will be in direct contact with clip when closed. Carefully close clip with a pliers until a 0.127 mm (0.005 in.) gap exists between ends. Do not pinch or flatten clip.

## Install Spark Plug

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

## Install Heat Deflector, Carburetor, Linkage and Air Cleaner Base

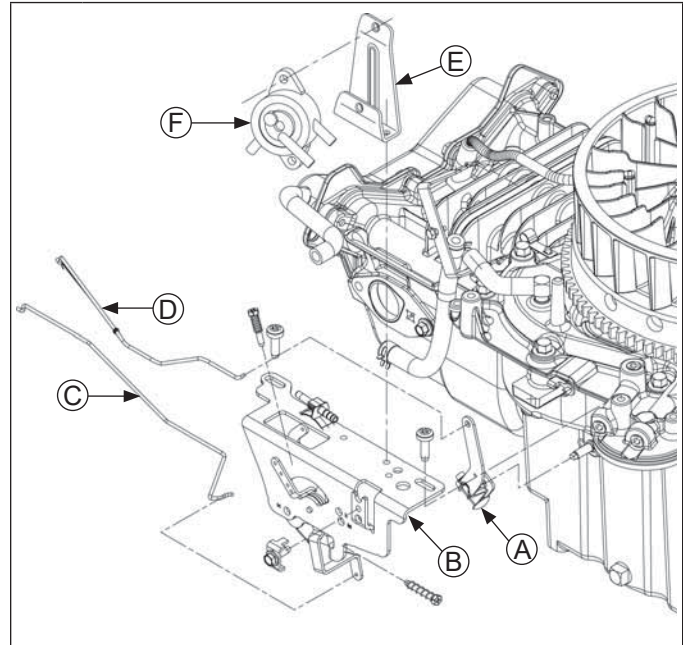
- If carburetor mounting stud was removed, reinstall it in outer cylinder location (closest to head). Use an E5 Torx® socket or two nuts tightened together, and turn stud in until tight.
- Make sure all gasket surfaces are clean and free of any nicks or damage.
- Install a new intake gasket onto carburetor stud, then install heat deflector or carburetor spacer. Curved section of heat deflector should be down, toward engine. If deflector contains a molded protruding point, it should be towards back inserted into intake port. Be sure protruding point goes through large hole in gasket, to keep it aligned.
- Models with one screw and one mounting stud only: Insert a 3/16" diameter rod, approximately 4" long, into open mounting hole in heat deflector/carburetor spacer to serve as a temporary alignment pin. Be careful not to force rod or damage threads.
- Install heat shield (if equipped) with gasket or a new carburetor gasket onto mounting stud(s) and/or alignment pin.
- Attach choke and throttle linkages to carburetor and install carburetor assembly. If governor lever was not disconnected, slide it onto governor shaft with lever up.
- If carburetor has a fuel solenoid, fasten ground lead to crankcase boss, with toothed washer between eyelet terminal and boss. Torque screw to 8.0 N·m (70 in. lb.). Connect solenoid power lead to wiring harness and secure with a tie strap.
- Connect fuel line to carburetor and secure with a hose clamp.
- Install air cleaner base (with fuel pump attached, if equipped).
  - Install a new air cleaner base gasket. Check two metal spacers are in air cleaner base mounting holes and install base onto stud(s), and or alignment pin. Make sure upper mounting tab is positioned above closure plate boss. Install nut(s) and finger tighten.
  - Models with one screw and one mounting stud only: Apply hand pressure to keep parts from shifting, then carefully remove alignment pin and install DRY long M6 thread forming screw. DO NOT OIL. Check to make sure all gaskets are still in proper position.

- Torque nut(s) to 5.5 N·m (48 in. lb.). Torque screw to 8.0 N·m (70 in. lb.) into a new hole, or 5.5 N·m (48 in. lb.) into a used hole, do not over tighten. An M6 screw for upper tab will be installed when blower housing is mounted.

- Attach breather hose to valve cover and air cleaner base.

## Install and Adjust Governor Lever

### Speed Control Bracket Details



<b>A</b>	Governor Lever	<b>B</b>	Speed Control Bracket
<b>C</b>	Choke Linkage	<b>D</b>	Throttle Linkage
<b>E</b>	Fuel Pump Bracket	<b>F</b>	Fuel Pump

NOTE: It is recommended a new governor lever be installed whenever removal is performed.

- Install governor lever onto governor shaft with lever section up. Connect throttle linkage using black linkage bushing.
- Move governor lever toward carburetor, to limit of its travel (wide-open throttle) and hold in this position. Do not apply excessive pressure, flexing or distorting linkage. Grasp cross shaft with a pliers, and turn shaft counterclockwise as far as it will go. Torque nut to 7.0-8.5 N·m (60-75 in. lb.).

### Mounting Speed Control Bracket

- Attach governor spring to governor lever and throttle lever of speed control bracket, in original holes. If holes were not marked during disassembly, refer to Governor Spring Location charts. Connect choke linkage from carburetor to actuating lever of speed control bracket.
- Attach speed control bracket to mounting locations on engine with M6 screws. Position bracket as marked during disassembly. Torque screws to 11.0 N·m (95 in. lb.) into new holes, or 7.5 N·m (65 in. lb.) into used holes.

Early Style Governor Spring Location

High Speed RPM	Governed Idle RPM	Governor Lever Hole	Throttle Lever Hole	White Spring	Green Spring	Black Spring
3201-3400		B	A			X
3201-3400		B	A		X	
3201-3400	1601-1800	B	A	X		

Later Style Governor Spring Location

High Speed RPM	Governed Idle RPM	Governor Lever Hole	Throttle Lever Hole	Red Spring	Alignment Hole
Less than 3000 RPM		B	A	X	D
Less than 3000 RPM		B	A	X	C

Current Style Governor Spring Location

High Speed RPM	Governed Idle RPM		Governor Lever Hole	Throttle Lever Hole	Red Spring	Alignment Hole
	89mm Bore	94mm Bore				
2400-2900	1500-2150	1750-2150	B	A	X	C
2901-3100	1500-2150	1750-2150	B	A	X	D
3101-3750	1500-2150	1750-2150	B	A	X	E

# Reassembly

## Install Fuel Pump (if equipped)

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NOTE: If fuel pump is attached to air cleaner base, fuel lines and pulse line should still be connected to fuel pump. Connect pulse line to pulse fitting and secure with clamp.

1. Attach fuel pump mounting bracket to speed control bracket with two M5 screws. Torque screws to 6.5 N·m (55 in. lb.) into new holes, or 4.0 N·m (35 in. lb.) into used holes.
2. Attach fuel pump to bracket so pulse fitting is oriented in four o'clock position. Secure with two M6 screws. Torque screws to 9.5 N·m (84 in. lb.) into new holes, or 5.9 N·m (52 in. lb.) into used holes. Do not over tighten.
3. Connect pulse and fuel lines to fuel pump and secure with clamps.

## Install Rectifier-Regulator

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1. Using M6 screws, mount rectifier-regulator onto crankcase bosses, with cooling fins out. Torque screws to 6.0 N·m (55 in. lb.) into new holes, or 4.0 N·m (35 in. lb.) into used holes.
2. Attach connector to rectifier-regulator terminals.

## Install Cylinder Head Baffle

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Attach cylinder head baffle to cylinder head using screws. Torque screws to 10.2-12.4 N·m (90-110 in. lb.) into new holes, or 7.0-8.5 N·m (62-75 in. lb.) into used holes.

## Install Oil Sentry™ or Pipe Plug

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Apply pipe sealant with Teflon® (Loctite® PST® 592™ Thread Sealant or equivalent), to threads of 1/8" pipe plug or adapter. Install and tighten into port on closure plate. Torque pipe plug to 4.5-5.0 N·m (40-45 in. lb.). If a switch was installed, apply sealant to threads of Oil Sentry™ switch and install into adapter, center passage or closure plate behind blower housing. Torque switch to 4.5-5.0 N·m (40-45 in. lb.). Connect green wiring harness lead to terminal on switch.

## Install Blower Housing and Debris Screen

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1. Position blower housing on engine and route spark plug lead through underside slot.
2. Check stator leads are within notch of blower housing. Align mounting locations, then install four M6 shouldered mounting screws. If a flat washer was used under head on one screw, install screw in location closest to oil fill/dipstick.  
  
Torque screws to 11.6 N·m (99 in. lb.) into new holes, or 7.7 N·m (68 in. lb.) into used holes.
3. Snap debris screen onto cooling fan.

## Install Air Cleaner Element, Precleaner, and Air Cleaner Cover

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1. Install air cleaner element with pleated side out. Seat rubber seal onto all edges of air cleaner base.
2. Install precleaner (if equipped), into upper section of air cleaner cover.
3. Install air cleaner cover and secure with two retaining knobs.

## Install Muffler

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1. Install gasket, muffler, and nuts on exhaust port studs. Leave nuts slightly loose.
2. If an auxiliary muffler bracket is used, install M6 screw(s) into bracket.
3. Torque nuts to 24.4 N·m (216 in. lb.). Torque screws to 7.5 N·m (65 in. lb.).

## Install Drain Plug, Oil Filter, and Oil

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1. Install oil drain plug. Torque plug to 14 N·m (125 in. lb.).
2. 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.
3. Apply a thin film of clean oil to rubber gasket on new filter.
4. Refer to instructions on oil filter for proper installation.
5. Fill crankcase with new oil. Level should be at top of indicator on dipstick.
6. Reinstall oil fill cap/dipstick and tighten securely.

## Prepare Engine for Operation

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Engine is now completely reassembled. Before starting or operating engine, be sure following have been done.

1. All hardware is tightened securely.
2. Oil drain plug, Oil Sentry™ pressure switch (if equipped), and a new oil filter are installed.
3. Crankcase is filled with correct amount, weight, and type of oil.



## Testing Engine

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

1. Set engine up on a test stand. Install an oil pressure gauge. Start engine and check to be certain oil pressure (5 psi or more) is present.
2. Run engine for 5-10 minutes between idle and mid-range. Adjust throttle and choke controls and high-speed setting as necessary. Make sure maximum engine speed does not exceed 3300 RPM. Adjust carburetor idle fuel needle and/or idle speed screw as necessary. Refer to Fuel System and Governor System.



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