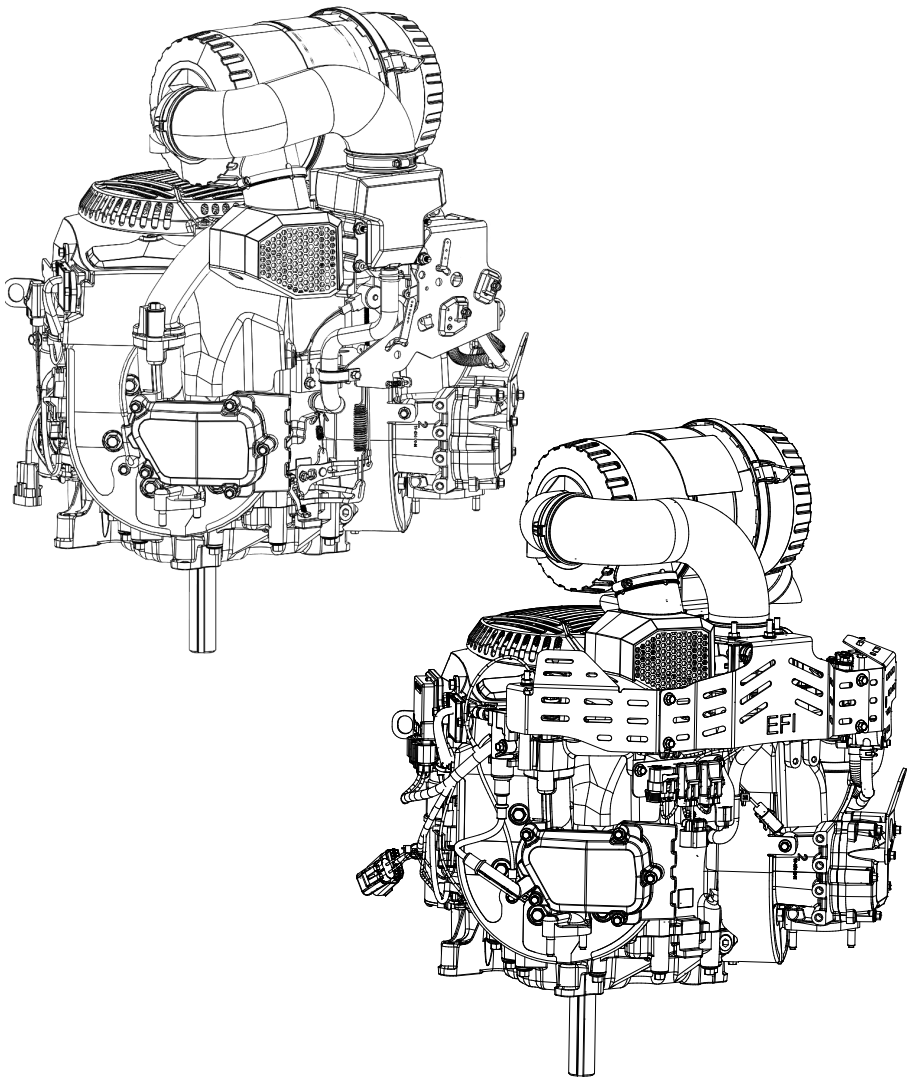
rehlko

Command PRO
CV829, CV832

Command PRO EFI
ECV830, ECV834

Service Manual



Kohler Engines
is now Rehlko.

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.

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.

⚠ 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.

⚠ WARNING

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.

⚠ WARNING

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.

⚠ WARNING

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.

⚠ WARNING

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.

⚠ WARNING

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.

⚠ CAUTION

Electrical Shock can cause injury.

Do not touch wires while engine is running.

⚠ CAUTION

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.

⚠ CAUTION

Failure to utilize or reassemble debris screen as designed could result in debris screen failure and serious personal injury.

⚠ WARNING

High Pressure Fluids can puncture skin and cause severe injury or death.

Do not work on fuel system without proper training or safety equipment.

Fluid puncture injuries are highly toxic and hazardous. If an injury occurs, seek immediate medical attention.

⚠ WARNING

Explosive Fuel can cause fires and severe burns.

Fuel system ALWAYS remains under HIGH PRESSURE.

Wrap a shop towel completely around fuel pump module connector. Press release button(s) and slowly pull connector away from fuel pump module allowing shop towel to absorb any residual fuel in high pressure fuel line. Any spilled fuel must be completely wiped up immediately.

MAINTENANCE INSTRUCTIONS

⚠ WARNING

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.

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 Rehlko authorized dealer.

MAINTENANCE SCHEDULE	
Every 100 Hours or Annually[1]	
• Change oil. Oil filter is recommended.	Lubrication System
• Check oil cooler fins, clean as necessary (if equipped).	
• Remove cooling shrouds and clean cooling areas.	Air Cleaner/Intake
• Check air cleaner element.	
Every 200 Hours	
• Change oil filter.	Lubrication System
Every 300 Hours[2]	
• Replace Fuel Filter	
• Change oil and filter (Xtended Life PRO 10W-50 oil and Xtended Life PRO filter only)	Lubrication System
Every 600 Hours[1]	
• Replace heavy-duty air cleaner element and inner element.	Air Cleaner/Intake
• Replace spark plugs and set gap.	Electrical System
Every 600 Hours[3]	
• Have valve lash checked/adjusted.	

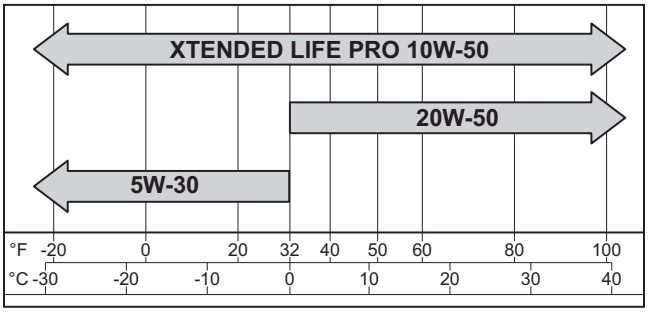
[1] Perform these procedures more frequently under severe, dusty, dirty conditions.
[2] Option only if using Xtended Life PRO oil and Xtended Life PRO filter.
[3] Have a Rehlko authorized dealer perform this service.

REPAIRS/SERVICE PARTS

Rehlko genuine service parts can be purchased from Rehlko authorized dealers. To find a local Rehlko authorized dealer visit engines.rehlko.com or call 1-800-544-2444 (U.S. and Canada).

OIL RECOMMENDATIONS

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



FUEL RECOMMENDATIONS

⚠ 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.

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.

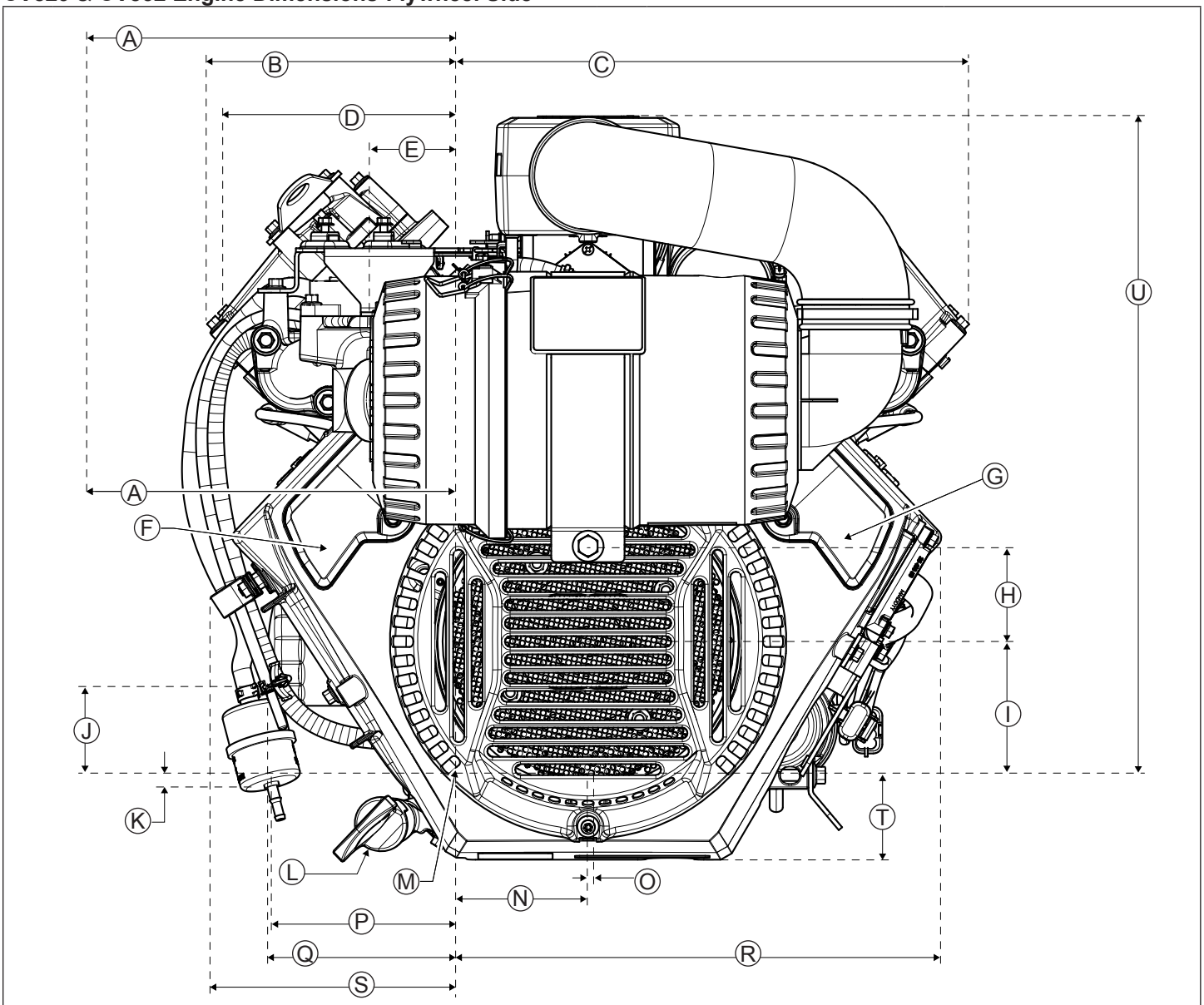
- Octane rating of 87 (R+M)/2 or higher.
- Research Octane Number (RON) 90 octane minimum.
- Gasoline up to 10% ethyl alcohol, 90% unleaded is acceptable.
- Methyl Tertiary Butyl Ether (MTBE) and unleaded gasoline blend (max 15% MTBE by volume) are approved.
- Do not add oil to gasoline.
- Do not overfill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

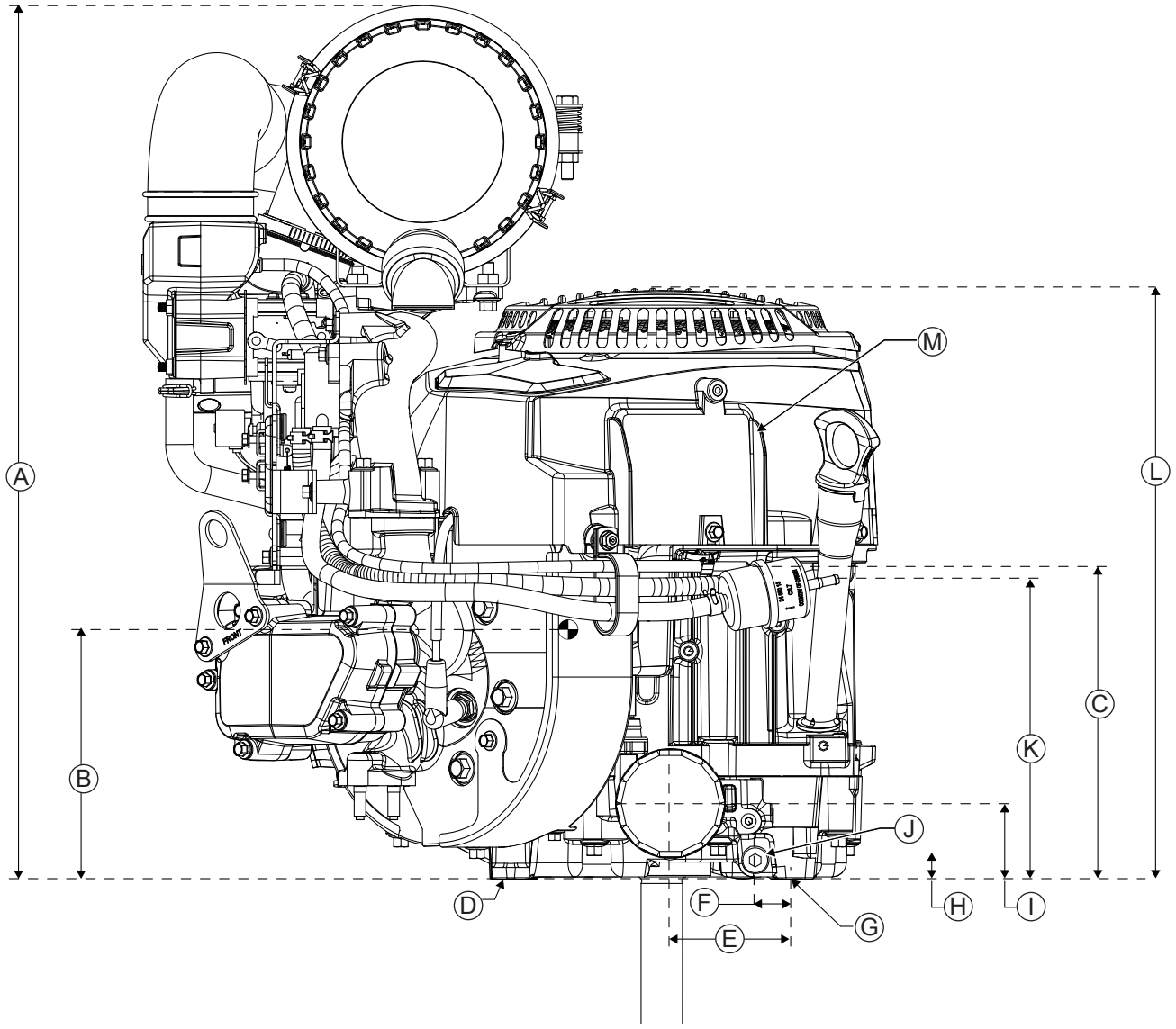
1. Add Xtended Life PRO or equivalent to fuel tank. Run engine 2-3 minutes to get stabilized fuel into fuel system (failures due to untreated fuel are not warrantable).
2. Change oil while engine is still warm from operation. Remove spark plug(s) and pour about 1 oz. of engine oil into cylinder(s). Replace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

CV829 & CV832 Engine Dimensions-Flywheel Side



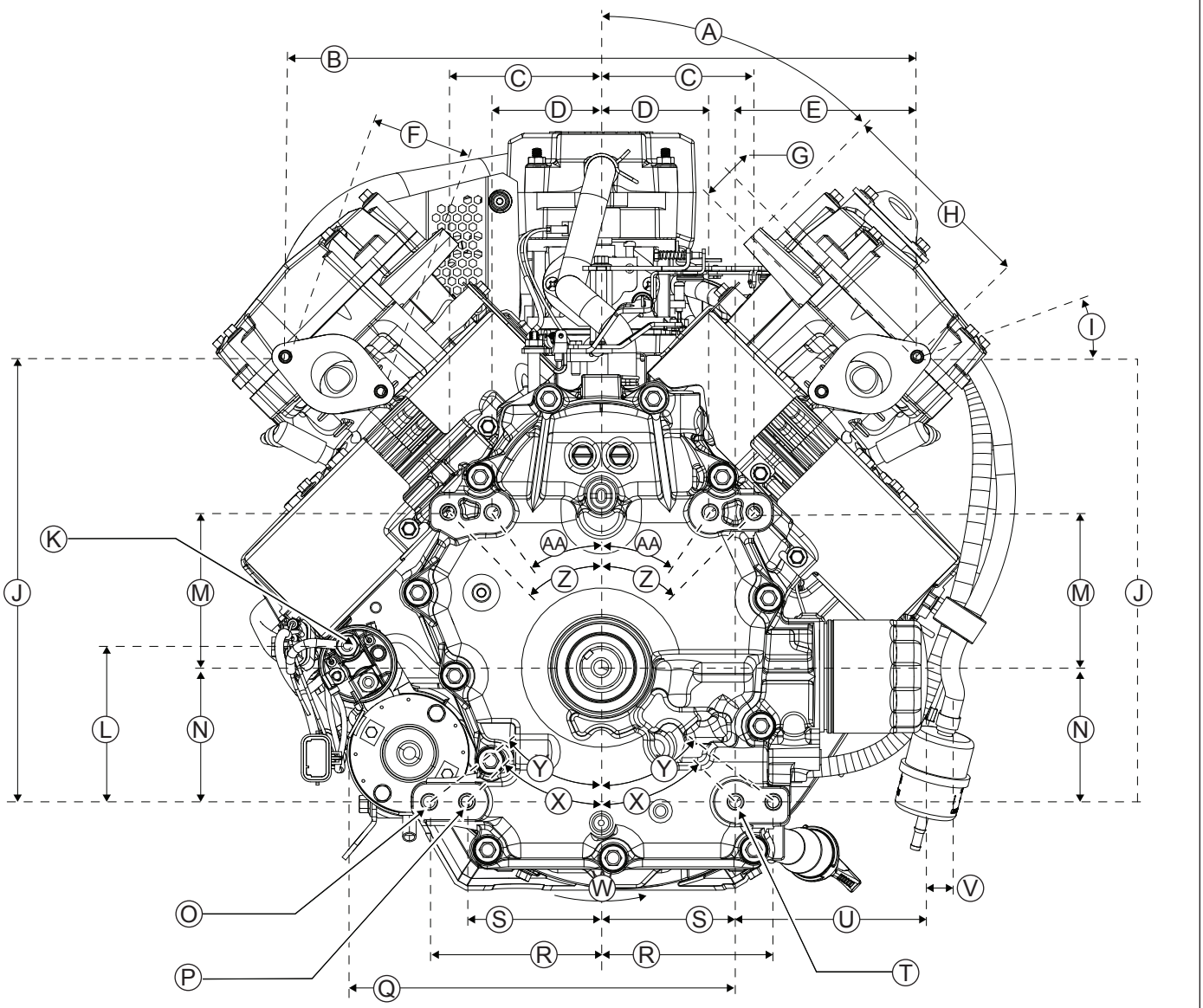
A	Air Filter Element Removal 251.7 mm (9.91 in.)	**B**	Valve Cover Screw 170.2 mm (6.70 in.)	**C**	Valve Cover Screw 349.8 mm (13.77 in.)	**D**	Air Filter Cover Removal 158.9 mm (6.26 in.)
E	56.9 mm (2.24 in.)	**F**	Cylinder #2 Clean Out Cover	**G**	Cylinder #1 Clean Out Cover	**H**	Center of Gravity 64.0 mm (2.52 in.)
I	89.8 mm (3.54 in.)	**J**	Evap Hose 59.1 mm (2.33 in.)	**K**	Fuel Filter 9.4 mm (0.37 in.)	**L**	Oil Fill & Dipstick (Yellow)
M	Mounting Hole "A" (In oil pan)	**N**	89.8 mm (3.54 in.)	**O**	Center of Gravity 4.3 mm (0.17 in.)	**P**	Fuel Filter 125.7 mm (4.95 in.)
Q	Evap Hose 128.6 mm (5.06 in.)	**R**	Blower Housing 330.7 mm (13.02 in.)	**S**	Hose Clamp 167.5 mm (6.60 in.)	**T**	Blower Housing 59.2 mm (2.33 in.)
U	448.6 mm (17.86 in.)						

CV829 & CV832 Engine Dimensions-Oil Filter Side



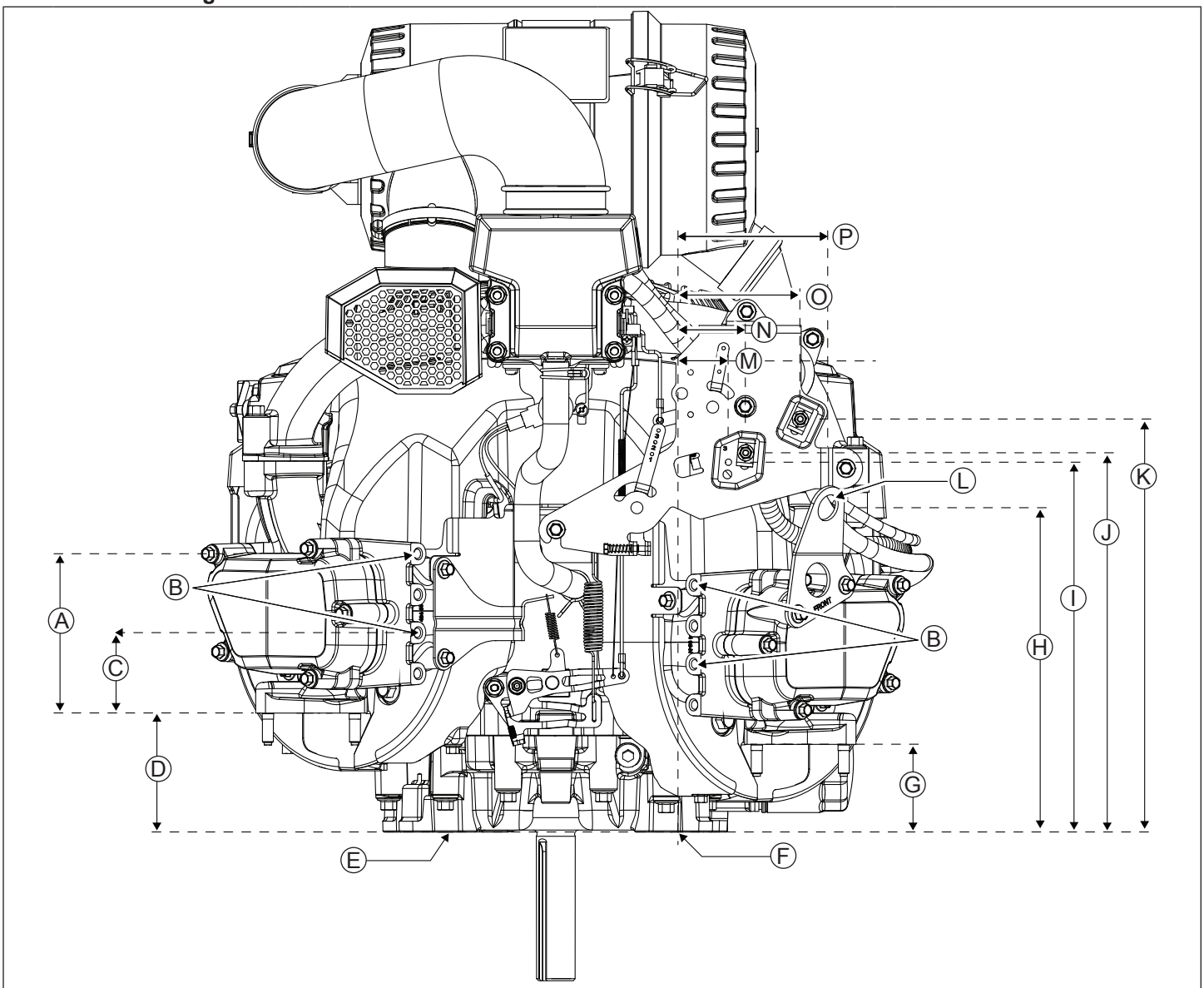
A	Air Cleaner Top 603.2 mm (23.75 in.)	**B**	Center of Gravity 172.3 mm (6.78 in.)	**C**	Evap Hose 216.0 mm (8.50 in.)	**D**	Engine Mounting Surface
E	Oil Filter 83.8 mm (3.30 in.)	**F**	25.3 mm (1.00 in.)	**G**	Mounting Hole “A”	**H**	13.0 mm (0.51 in.)
I	Oil Filter 52.2 mm (2.06 in.)	**J**	Oil Drain Plug 3/8 in. NPTF	**K**	Fuel Filter 207.2 mm (8.16 in.)	**L**	Guard Top 407.9 mm (16.06 in.)
M	Oil Cooler (Optional)						

CV829 & CV832 Engine Dimensions-Engine Mounting Surface (PTO End)



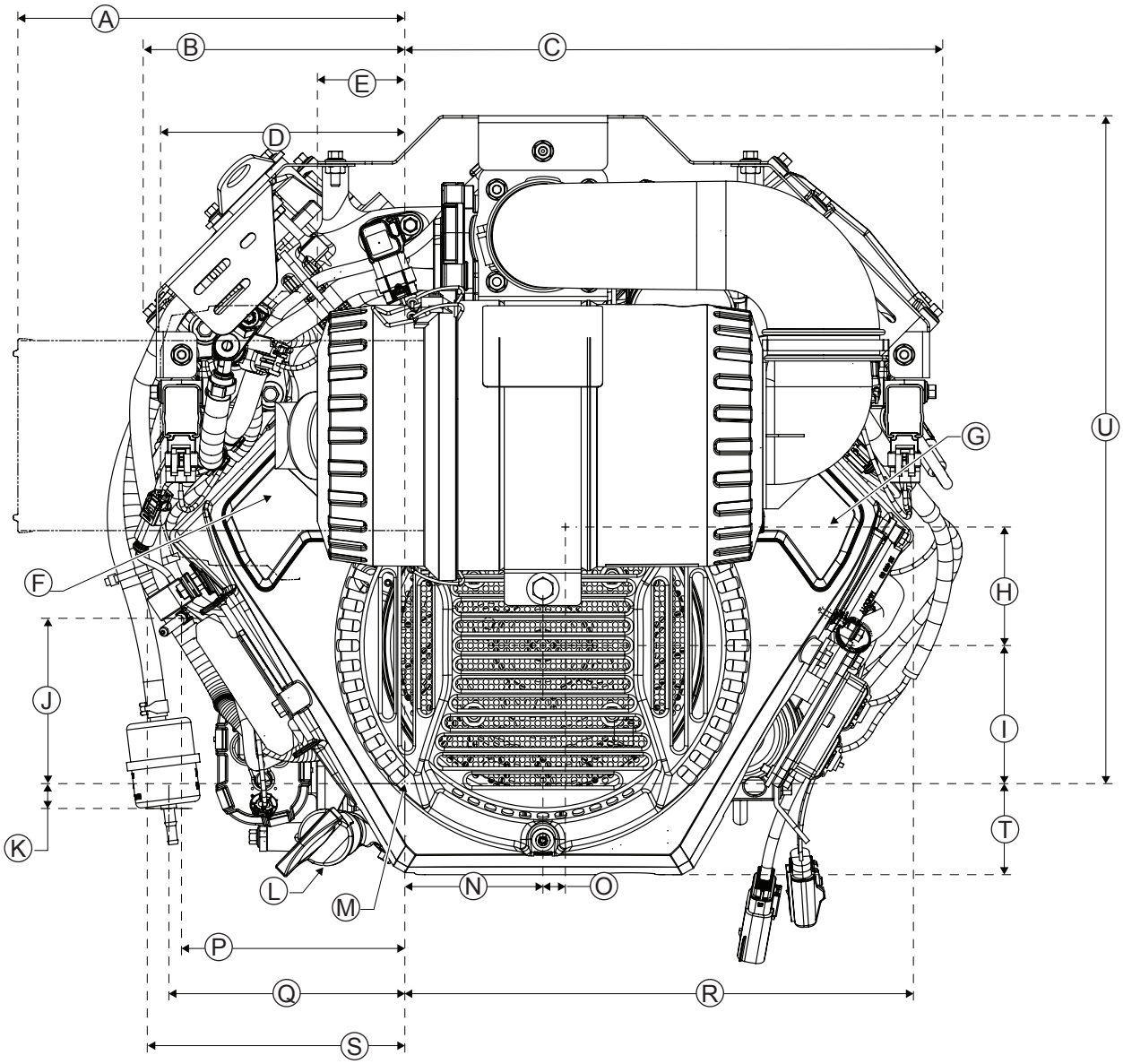
A	2 X 45°	**B**	422.6 mm (16.64 in.)	**C**	102.4 mm (4.03 in.)	**D**	72.8 mm (2.87 in.)
E	121.5 mm (4.78 in.)	**F**	2X 68.0 mm (2.68 in.)	**G**	2X 20.8 mm (0.82 in.)	**H**	2X 135.2 mm (5.32 in.)
I	2 X 20°	**J**	298.0 mm (11.73 in.)	**K**	M8 X 1.25 Stud/Nut	**L**	Starter Stud 104.5 mm (4.11 in.)
M	2X 104.0 mm (4.10 in.)	**N**	2X 89.8 mm (4.10 in.)	**O**	4 X 3/8-16 UNC-2B in. 33 mm (1.30 in.) Deep on a Ø 292.1 mm (11.5 in.) B.C.	**P**	4 X 3/8-16 UNC-2B in. 33 mm (1.30 in.) Deep on a Ø 254 mm (10.0 in.) B.C.
Q	Starter Stud 259.7 mm (10.22 in.)	**R**	115.1 mm (4.53 in.)	**S**	89.8 mm (3.54 in.)	**T**	Mounting Hole "A"
U	128.5 mm (5.06 in.)	**V**	Oil Filter Removal 18.0 mm (0.72 in.)	**W**	Direction of Rotation	**X**	45°
Y	52°	**Z**	44.5°	**AA**	35°		

CV829 & CV832 Engine Dimensions-Valve Cover Side



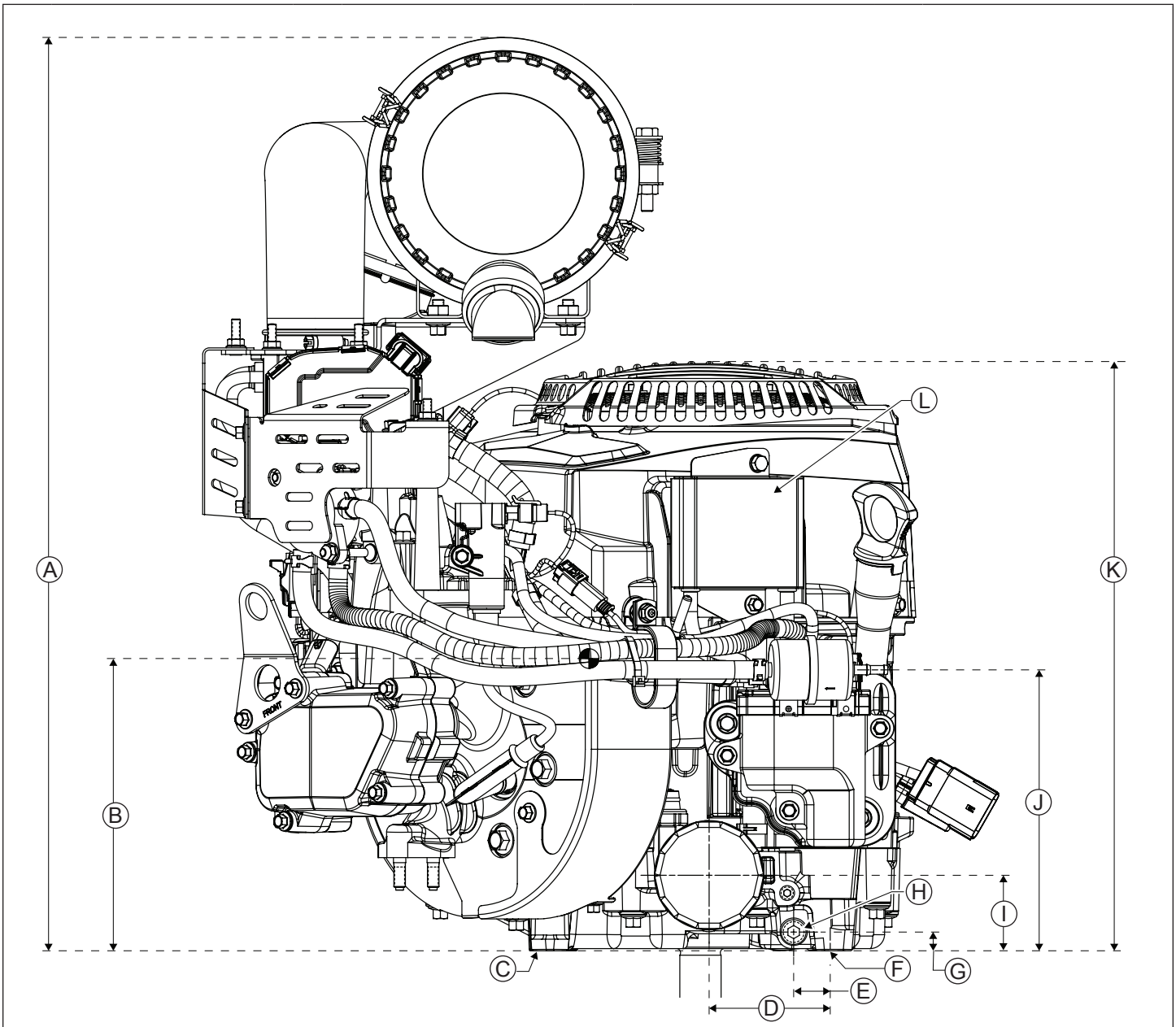
A	2X 117.0 mm (4.61 in.)	**B**	M8 X 1.25 mm Muffler Bracket Support Mounting Locations (Optional)	**C**	2X 59.0 mm (2.32 in.)	**D**	Exhaust Port #1 87.5 mm (3.44 in.)
E	Engine Mounting Surface	**F**	Mounting Hole "A"	**G**	Exhaust Port #2 64.5 mm (2.54 in.)	**H**	238.3 mm (9.38 in.)
I	271.8 mm (10.70 in.)	**J**	278.7 mm (10.97 in.)	**K**	303.5 mm (11.95 in.)	**L**	Lift Hook Location #1
M	36.9 mm (1.45 in.)	**N**	49.5 mm (1.95 in.)	**O**	89.6 mm (3.53 in.)	**P**	110.1 mm (4.33 in.)

ECV830 & ECV834 Engine Dimensions-Flywheel Side



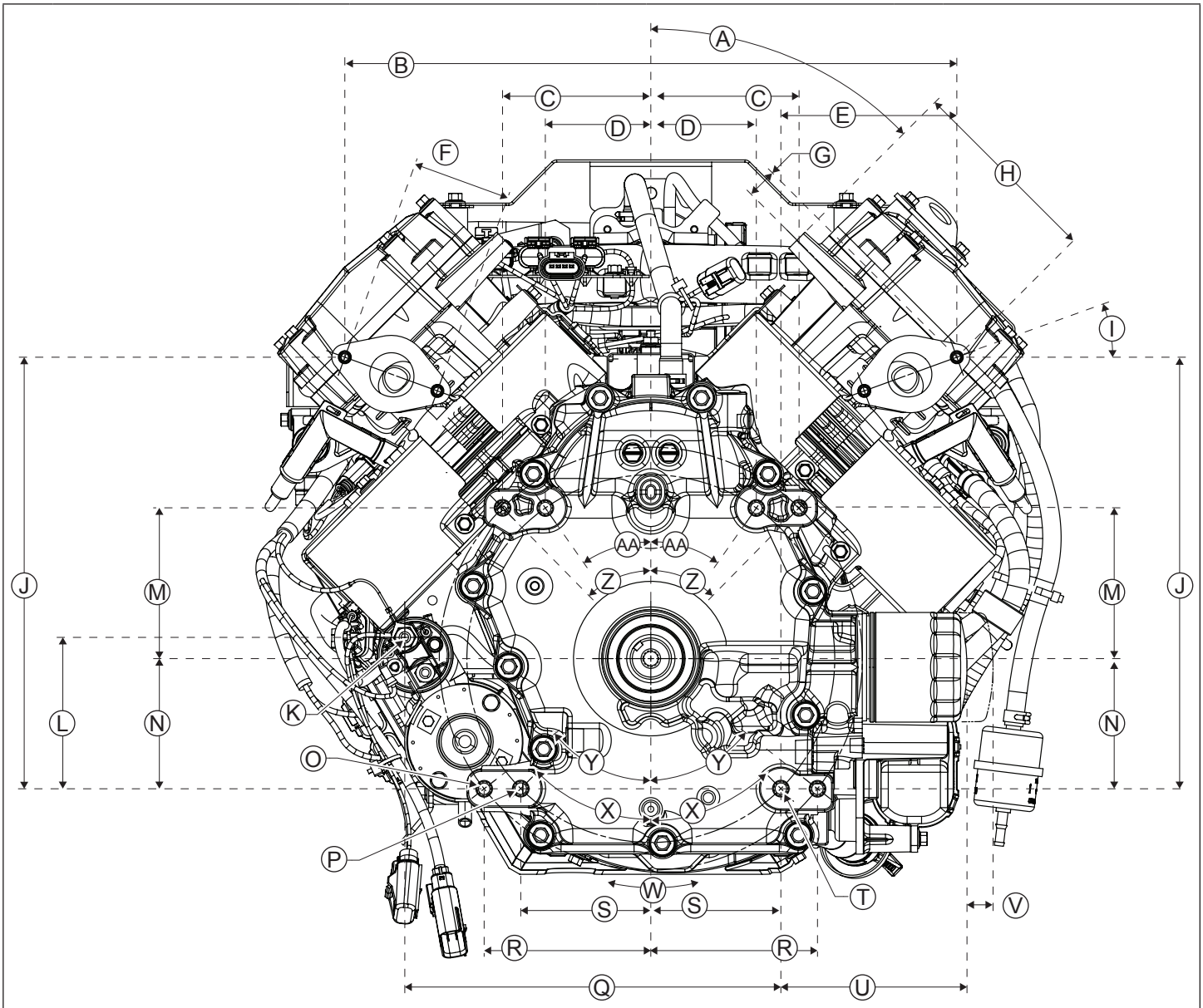
A	Air Filter Element Removal 251.7 mm (9.91 in.)	**B**	Valve Cover Screw 170.2 mm (6.70 in.)	**C**	Valve Cover Screw 349.8 mm (13.77 in.)	**D**	Air Filter Cover Removal 158.9 mm (6.26 in.)
E	56.9 mm (2.24 in.)	**F**	Cylinder #2 Clean Out Cover	**G**	Cylinder #1 Clean Out Cover	**H**	Center of Gravity 77.0 mm (3.03 in.)
I	89.8 mm (3.54 in.)	**J**	Evap Hose 107.5 mm (4.23 in.)	**K**	Fuel Filter 16.2 mm (0.64 in.)	**L**	Oil Fill & Dipstick (Yellow)
M	Mounting Hole "A" (In oil pan)	**N**	89.8 mm (3.54 in.)	**O**	Center of Gravity 4.3 mm (0.17 in.)	**P**	Evap Hose 145.2 mm (5.72 in.)
Q	Fuel Filter 153.5 mm (6.04 in.)	**R**	Blower Housing 330.7 mm (13.02 in.)	**S**	Hose Clamp 167.5 mm (6.60 in.)	**T**	Blower Housing 59.2 mm (2.33 in.)
U	434.3 mm (17.10in.)						

ECV830 & ECV834 Engine Dimensions-Oil Filter Side



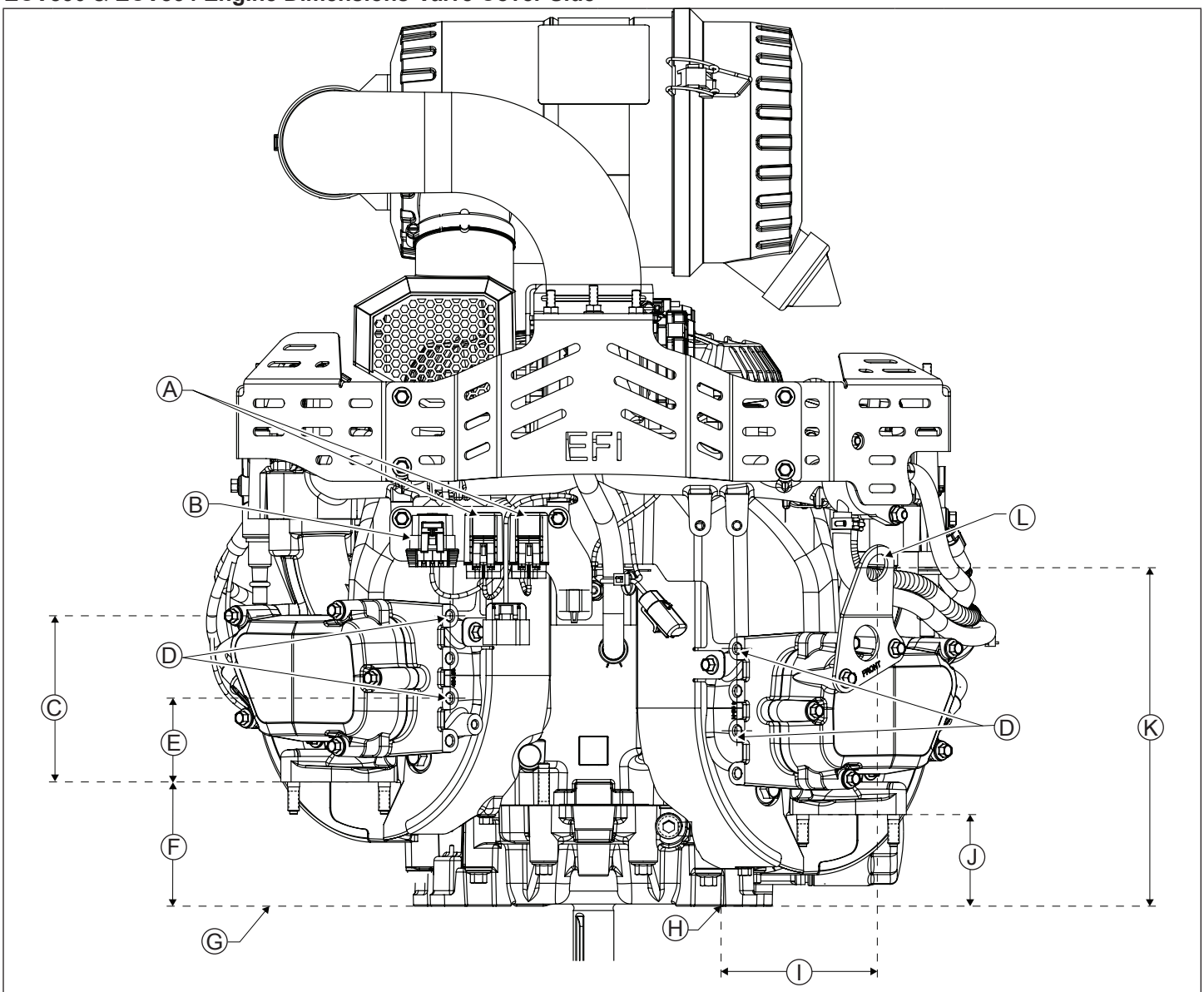
A	632.2 mm (24.89 in.)	**B**	Center of Gravity 202.3 mm (7.96 in.)	**C**	Engine Mounting Surface	**D**	Oil Filter 83.8 mm (3.30 in.)
E	25.3 mm (1.00 in.)	**F**	Mounting Hole “A”	**G**	13.0 mm (0.51 in.)	**H**	Oil Drain Plug 3/8 in. NPTF
I	Oil Filter 52.2 mm (2.06 in.)	**J**	Fuel Filter 194.4 mm (7.65 in.)	**K**	Guard Top 407.9 mm (16.06 in.)	**L**	Oil Cooler (Optional)

ECV830 & ECV834 Engine Dimensions-Engine Mounting Surface (PTO End)



A	2 X 45°	**B**	422.6 mm (16.64 in.)	**C**	102.4 mm (4.03 in.)	**D**	72.8 mm (2.87 in.)
E	121.5 mm (4.78 in.)	**F**	2X 68.0 mm (2.68 in.)	**G**	2X 20.8 mm (0.82 in.)	**H**	2X 135.2 mm (5.32 in.)
I	2 X 20°	**J**	298.1 mm (11.74 in.)	**K**	M8 X 1.25 Stud/Nut	**L**	Starter Stud 104.5 mm (4.11 in.)
M	2X 104.0 mm (4.10 in.)	**N**	2X 89.8 mm (3.54 in.)	**O**	4 X 3/8-16 UNC-2B in. 33 mm (1.30 in.) Deep on a Ø 292.1 mm (11.5 in.) B.C.	**P**	4 X 3/8-16 UNC-2B in. 33 mm (1.30 in.) Deep on a Ø 254 mm (10.0 in.) B.C.
Q	Starter Stud 259.7 mm (10.22 in.)	**R**	115.1 mm (4.53 in.)	**S**	89.8 mm (3.54 in.)	**T**	Mounting Hole "A"
U	128.5 mm (5.06 in.)	**V**	Oil Filter Removal 18.0 mm (0.71 in.)	**W**	Direction of Rotation	**X**	45°
Y	52°	**Z**	44.5°	**AA**	35°		

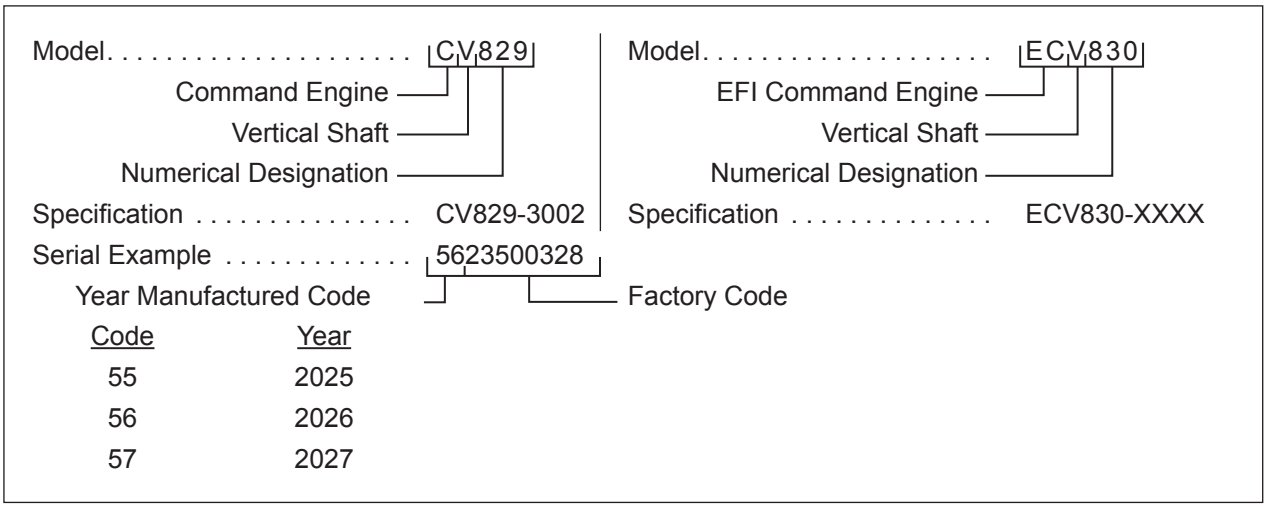
ECV830 & ECV834 Engine Dimensions-Valve Cover Side



A	Engine Fuses	**B**	Diagnostic Connector	**C**	2X 117.0 mm (4.61 in.)	**D**	M8 x 1.25 Muffler Bracket Support Mounting Locations (Optional)
E	2X 59.0 (2.32 in.)	**F**	Exhaust Port #1 87.5 mm (3.44 in.)	**G**	Engine Mounting Surface	**H**	Mounting Hole "A"
I	110.1 mm (4.33 in.)	**J**	Exhaust Port #2 64.5 mm (2.54 in.)	**K**	238.3 mm (9.38 in.)	**L**	Lift Hook Location #1

ENGINE IDENTIFICATION NUMBERS

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



GENERAL SPECIFICATIONS[4,7]	CV829	CV832	ECV830	ECV834
Bore	87 mm (3.40 in.)			
Stroke	74.7 mm (2.90 in.)			
Displacement	888 cc (54.2 cu. in.)			
Oil Capacity (refill)	1.9 L (2.0 U.S. qt.)			
Maximum Angle of Operation (@ full oil level)[5]	25°			

TORQUE SPECIFICATIONS[4,6]	CV829	CV832	ECV830	ECV834
Baffles and Brackets				
Crankcase to Crankcase Baffle M6 Screw	New Hole 11.3 N·m (100 in. lb.) Used Hole 7.7 N·m (68 in. lb.)			
Crankcase Baffle M6 Nut	8.2 N·m (73 in. lb.)			
Cylinder Barrel Baffle M6 Screw	8.2 N·m (73 in. lb.)			
Valley Baffle Assembly M6 Screw	8.2 N·m (73 in. lb.)			
Exhaust Support Bracket to Head (for muffler)	12.4 N·m (110 in. lb.)			
Exhaust Support Bracket to Muffler	12.4 N·m (110 in. lb.)			
Blower Housing				
M6 Screw (Blower Housing to Crankcase)	4.8 N·m (42 in. lb.)			
M6 Grass Screen	10.2 N·m (90 in. lb.)			
M5 Fan Guard	3.3 N·m (30 in. lb.)			
M6 Nut (Blower Housing to Crankcase)	4.8 N·m (42 in. lb.)			
M5 Clean-out cover bolt	3.1 N·m (27 in. lb.)			
Breather Assembly				
Breather Cover	First 4.5 N·m (40 in. lb.) Final 11.3 N·m (100 in. lb.)			
Breather Reed Retainer	11.3 N·m (100 in. lb.)			

[4] Values are in Metric units. Values in parentheses are English equivalents.

[5] Exceeding maximum angle of operation may cause engine damage from insufficient lubrication.

[6] Lubricate threads with engine oil prior to assembly.

[7] Any and all horsepower (hp) references by Rehlko are Certified Power Ratings and per SAE J1940 & J1995 hp standards. Details on Certified Power Ratings can be found at engines.rehlko.com.

TORQUE SPECIFICATIONS[4,6]	CV829	CV832	ECV830	ECV834
Intake Manifold/Air Cleaner Assembly				
Carburetor Stud	3.4 N·m (30 in. lb.)			
Carburetor Ground Wire to Valley Baffle	9.6 N·m (85 in. lb.)			
Carburetor to Intake Elbow M6 Mounting Nut	10.7 N·m (95 in. lb.)			
Intake Manifold to Cylinder Head M8 Bolt	28.2 N·m (250 in. lb.)			
HDAC Bracket mounting to intake manifold	22.6 N·m (200 in. lb.)			
Carburetor Ground Wire to Baffle	9.4 N·m (83 in. lb.)			
Throttle Body to Intake Manifold			6.9 N·m (61 in. lb.)	
Fuel Injector to Manifold			8.1 N·m (72 in. lb.)	
TMAP Sensor			8.1 N·m (72 in. lb.)	
Intake Manifold Guard (Nuts/Studs)			9.0 N·m (80 in. lb.)	
Charging System				
Rectifier-Regulator ground wire (on metal starter bracket)	New Hole 5.1 N·m (45 in. lb.) Used Hole 2.3 N·m (20 in. lb.)			
Rectifier-Regulator ground wire (on regulator)	New Hole 5.1 N·m (45 in. lb.) Used Hole 2.3 N·m (20 in. lb.)			
Rectifier-Regulator Fastener (to blower housing)	1.7 N·m (12 in. lb.)			
Connecting Rod				
Cap Fastener (torque in increments)	First 4.0-5.7 N·m (35-50 in. lb.) Final 10.7-12.4 N·m (95-110 in. lb.)			
Crankcase				
Oil Fill Tube Bolt	4.8 N·m (42 in. lb.)			
Cylinder Head				
Head Bolt (torque in increments)	First 23.7 N·m (210 in. lb.) Final 44 N·m (390 in. lb.)			
Rocker Arm Stud	28.2 N·m (250 in. lb.)			
Rocker Pivot Set Screw	7.8 N·m (69 in. lb.)			
ECU				
ECU Mounting Fastener			8.1 N·m (72 in. lb.)	
Engine Lifting Bracket (near starter)				
M5 Retaining Bolt to blower housing	3.8 N·m (34 in. lb.)			
Ground Bolt	5.0 N·m (45 in. lb.)			
Flywheel				
Retaining Bolt	71.6 N·m (53 ft. lb.)			
Fuel Pump				
Pulse Pump to Intake Manifold (Carb)	8.2 N·m (73 in. lb.)			
Pulse Pump to Manifold (Nut)			3.4 N·m (30 in. lb.)	
Pulse Pump Stud to Manifold			9.0 N·m (80 in. lb.)	
Electric Fuel Pump Module Baffle to Crankcase			12.4 N·m (110 in. lb.)	
Electric Fuel Pump Module to Baffle			10.8 N·m (96 in. lb.)	

[4] Values are in Metric units. Values in parentheses are English equivalents.

[6] Lubricate threads with engine oil prior to assembly.

TORQUE SPECIFICATIONS[4,6]	CV829	CV832	ECV830	ECV834
Governor (Mechanical)				
Governed Idle Bracket (attaches to cylinder head #1)	8.2 N·m (73 in. lb.)			
Governor Lever Shaft Nut (M6)	10.7 N·m (95 in. lb)			
Governor Lever Screw (M5x12)	5.1 N·m (45 in. lb.) Left Hand Thread			
Harness Ground				
Wire Harness Ground Stud			29.2 N·m (21 ft. lb.)	
Engine Wire Harness Ground (Nut)			9.0 N·m (80 in. lb.)	
Ignition				
Spark Plug	27 N·m (20 ft. lb.)			
Ignition Coil Fastener	New Hole 10.2 N·m (90 in. lb.) Used Hole 3.9 N·m (35 in. lb.)		12.2 N·m (108 in. lb.)	
Muffler				
Retaining Nut	27.8 N·m (246 in. lb.)			
Bracket Fastener	16.0 N·m (142 in. lb.)			
Oxygen Sensor M12			19.5 N·m (14 ft. lb.)	
Oxygen Sensor M18			43.9 N·m (32 ft. lb.)	
Oil Cooler (Optional)				
Fastener Top Bottom (M6)	3.3 N·m (30 in. lb.) 4.8 N·m (42 in. lb.)			
Oil Pan				
Fastener	25.6 N·m (227 in. lb.)			
Oil Drain Plug	14.9 N·m (11 ft. lb.)			
Oil Pressure Switch	9.0 N·m (80 in. lb.)			
Oil Pump Cover Fastener	New Hole 9.6 N·m (85 in. lb. Used Hole 6.0 N·m (53 in. lb.)			
Oil Filter	11.9 N·m (9 ft. lb.)			
Solenoid (starter)				
Nut, Positive (+) Lead	8.0-11.0 N·m (71-97 in. lb.)			
Starter Assembly				
Mounting Bolt	16.0 N·m (142 in. lb.)			
Stator				
Mounting Bolt	New Hole 9.3 N·m (82 in. lb.) Used Hole 4.0 N·m (35 in. lb.)			
Valve Cover				
Fastener	12.4 N·m (110 in. lb.)			
Lift Bracket on Cylinder #2	10.2 N·m (90 in. lb.)			

[4] Values are in Metric units. Values in parentheses are English equivalents.

[6] Lubricate threads with engine oil prior to assembly.

CLEARANCE SPECIFICATIONS[4]	CV829	CV832	ECV830	ECV834

Camshaft

End Play	0.200/0.548 mm (0.008/0.022 in.)
Running Clearance	0.025/0.105 mm (0.0010/0.0041 in.)
Bore I.D. New Max. Wear Limit	 20.000/20.025 mm (0.7874/0.7884 in.) 20.038 mm (0.7889 in.)
Bearing Surface O.D. New Max. Wear Limit	 19.920/19.975 mm (0.7842/0.7864 in.) 19.917 mm (0.7841 in.)
Cam Lobe Profile. [8] Exhaust Intake	 35.73 mm (1.407 in.) 35.76 mm (1.408 in.)

Connecting Rod

Crankpin End I.D. @ 70°F New Max. Wear Limit	 44.030/44.037 (1.7335/1.7337 in.) 0.070 mm (0.0028 in.)
Connecting Rod-to-Crankpin Running Clearance New Max. Wear Limit	 0.030/0.055 mm (0.0012/0.0022 in.) 0.070 mm (0.0028 in.)
Connecting Rod-to-Crankpin Side Clearance	0.300/0.645 mm (0.0118/0.0254 in.)
Connecting Rod-to-Piston Pin Running Clearance	0.015/0.028 mm (0.0006/0.0011 in.)
Piston Pin End I.D. @ 70°F New Max. Wear Limit	 20.015/20.023 mm (0.7880/0.7883 in.) 20.036 MM (0.7888 in.)

Crankshaft

End Play (free)	0.073/0.762 (0.0029/0.0300 in.)
Bore (in crankcase) New With Main Bearing Installed Max. Wear Limit	 45.015/45.145 mm (1.7722/1.7774 in.) 45.158 mm (1.7778 in.)
Crankshaft Bore (in crankcase)-to-Crankshaft Running Clearance	0.015/0.167 mm (0.0006/0.0066 in.)
Bore (in oil pan) New With Main Bearing Installed Max. Wear Limit	 45.015/45.145 mm (1.7722/1.7774 in.) 45.158 mm (1.7778 in.)
Crankshaft Bore (in oil pan)-to-Crankshaft Running Clearance	0.015/0.167 mm (0.0006/0.0066 in.)
Crankshaft Oil Pan End Main Bearing Journal O.D. - New O.D. - Max. Wear Limit Max. Taper Max. Out-of-Round	 44.978/45.000 mm (1.7708/1.7717 in.) 44.908 mm (1.7680 in.) 0.022 mm (0.0009 in.) 0.025 mm (0.0010 in.)
Crankshaft Connecting Rod Journal O.D. - New O.D. - Max. Wear Limit Max. Taper Max. Out-of-Round Width	 43.98/44.00 mm (1.7316/1.7323 in.) 43.971 mm (1.7311 in.) 0.018 mm (0.0007 in.) 0.025 mm (0.0010 in.) 53.000/53.145 mm (2.0866/2.0923 in.)
T.I.R. PTO End, Crank in Engine Entire Crank, in V-Blocks	 0.279 mm (0.0110 in.) 0.025 mm (0.0001 in.)

[4] Values are in Metric units. Values in parentheses are English equivalents.

[8] Minimum dimension, measured from base circle to top of lobe.

CLEARANCE SPECIFICATIONS[4]	CV829	CV832	ECV830	ECV834
Crankshaft Cont.				
Crankshaft Flywheel End Main Bearing Journal O.D. - New O.D. - Max. Wear Limit Max. Taper Max. Out-of-Round	44.978/45.00 mm (1.770/1.771 in.) 44.908 mm (1.7680 in.) 0.022 mm (0.0009 in.) 0.025 mm (0.0010 in.)			
Cylinder Bore				
I.D. New Max. Wear Limit	87.000/87.025 mm (3.4252/3.4262 in.) 87.075 mm (3.4281 in.)			
Cylinder Head				
Max. Out-of-Flatness	0.076 mm (0.003 in.)			
Ignition				
Spark Plug Gap	0.76 mm (0.030 in.)			
Piston, Piston Rings, and Piston Pin				
Piston-to-Piston Pin Running Clearance	0.007/0.017 mm (0.0003/0.0007 in.)			
Pin Bore I.D. New Max. Wear Limit	20.007/20.012 mm (0.7877/0.7879 in.) 20.132 mm (0.7926 in.)			
Pin O.D. New Max. Wear Limit	19.995/20.000 mm (0.7872/0.7874 in.) 19.994 mm (0.7872 in.)			
Top Compression Ring-to-Groove Side Clearance	0.025/0.065 mm (0.0010/0.0026 in.)			
Middle Compression Ring-to-Groove Side Clearance	0.025/0.065 mm (0.0010/0.0026 in.)			
Oil Control Ring-to-Groove Side Clearance	0.06/0.19 mm (0.0024/0.0074 in.)			
Top Compression Ring End Gap New Bore Used Bore (max.)	0.125/0.225 mm (0.0049/0.0089 in.) 0.436 mm (0.0172 in.)			
Middle Compression Ring End Gap New Bore Used Bore (max.)	0.9/1.1 mm (0.0354/0.0433 in.) 1.353 mm (0.0533 in.)			
Thrust Face O.D.[8] New Max. Wear Limit	86.966 mm (3.4239 in.) 86.82 mm (3.4181 in.)			
Piston Thrust Face-to-Cylinder Bore[8] Running Clearance	0.027/0.066 mm (0.0011/0.0026 in.)			

[4] Values are in Metric units. Values in parentheses are English equivalents.

CLEARANCE SPECIFICATIONS[4]	CV829	CV832	ECV830	ECV834
Valves and Valve Tappets				
Intake and Exhaust Valve Lash	0.050/0.127 mm (0.0020/0.0050 in.)			
Tappet to Crankcase Running Clearance	0.013/0.073 mm (0.0005/0.0029 in.)			
Intake Valve Stem-to-Valve Guide Running Clearance	0.043/0.081 mm (0.0017/0.0032 in.)			
Exhaust Valve Stem-to-Valv e Guide Running Clearance	0.055/0.093 mm (0.0022/0.0037 in.)			
Intake Valve Guide I.D. New Max. Wear Limit	7.043/7.063 mm (0.2773/0.2781 in.) 7.137 mm (0.2810 in.)			
Exhaust Valve Guide I.D. New Max. Wear Limit	7.038/7.058 mm (0.2771/0.2779 in.) 7.157 mm (0.2818 in.)			
Intake Valve Minimum Lift	9.5 mm (0.3681 in.)			
Exhaust Valve Minimum Lift	9.5 mm (0.3681 in.)			
Nominal Valve Face Angle	45°			

[4] Values are in Metric units. Values in parentheses are English equivalents.

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	
Tightening Torque: N·m (in. lb.) ± 20%				
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						
	Property Class					Noncritical Fasteners Into Aluminum
Size	4.8	5.8	8.8	10.9	12.9	
Tightening Torque: N·m (in. lb.) ± 10%						
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)
Tightening Torque: N·m (ft. lb.) ± 10%						
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.

NOTE: Not all tools listed are required to service this engine.

SEPARATE TOOL SUPPLIERS

Rehlko Tools
Contact your local Rehlko 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.
Alcohol Content Tester For testing alcohol content (%) in reformulated/oxygenated fuels.	Rehlko 25 455 11-S
Camshaft Endplay Plate For checking camshaft endplay.	SE Tools KLR-82405
Camshaft Seal Protector (Aegis) For protecting seal during camshaft installation.	SE Tools KLR-82417
Dual Gauge Cylinder Leakdown Tester 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)	Rehlko 25 761 46-S Design Technology Inc. DTI-731-03
Dealer Tool Kit Complete kit of Rehlko required tools. Components of 25 761 58-S Dual Gauge Cylinder Leakdown Test Tool Oil Pressure Test Kit	Rehlko 25 761 58-S Rehlko 25 761 46-S Rehlko 25 761 06-S
EFI Service Kit For troubleshooting and setting up an EFI engine. Components of 24 761 01-S Fuel Pressure Tester Shrader Valve Adapter Hose Noid Light 90° Adapter (Shrader) Code Plug, Red Wire Code Plug, Blue Wire Code Plug, Yellow Wire CAN Bus Reset Tool, Green Wire Wire Probe Set (2 pieces regular wire with clip; 1 piece fused wire) Hose Removal Tool, Dual Size/End (also sold as individual Rehlko tool) K-Line Adapter Jumper Lead Wiring Harness	Rehlko 24 761 01-S Design Technology Inc. DTI-019 DTI-037 DTI-021 DTI-023 DTI-027 DTI-029 DTI-028 DTI-030 DTI-031 DTI-033 Rehlko 25 176 23-S
Flywheel Puller For properly removing flywheel from engine.	SE Tools KLR-82408
Flywheel Anchor Bolts, Washers, Nuts Tool Used with Flywheel Puller to properly removing flywheel from 5400 Series engine.	Rehlko 25 086 753-S
Hose Removal Tool, Dual Size/End (also available in EFI Service Kit) Used to properly remove fuel hose from engine components.	Rehlko 25 455 20-S
Inductive Tachometer (Digital) For checking operating speed (RPM) of an engine.	Design Technology Inc. DTI-110
Jumper Lead Tool For use with Stepper Motor Controller Tool to test rotary stepper motor.	Rehlko 25 518 43-S
Mobile KDS Gen 2 (Wireless) Module (New CAN Bus/ETB Capable) Replaces the previous Rehlko 25 761 45-S mobile Android or iOS EFI diagnostics. Components of 25 761 55-S 7 Pin to DB9 Cable 7 Pin to 4 Pin Adapter K-Line Adapter Jumper Lead Wiring Harness	Rehlko 25 761 55-S Rehlko 25 761 48-S Rehlko 25 761 53-S Rehlko 25 176 23-S

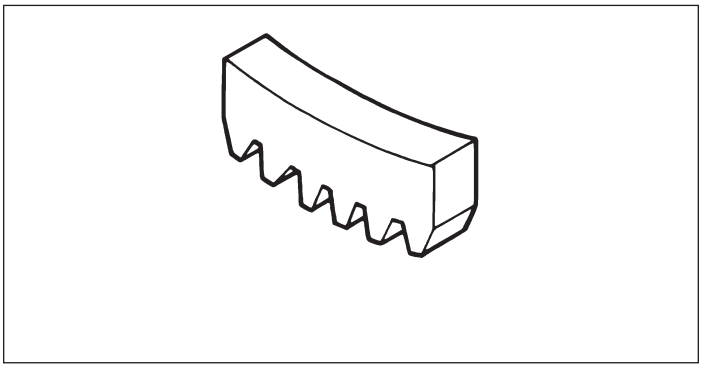
TOOLS

Description	Source/Part No.
Mobile (Wireless) CAN Bus Cable Upgrade Kit Updates the previous Rehlko 25 761 45-S mobile (wireless) Android or iOS tool to allow CAN Bus/ETB communications and the ability to perfrom diagnostics. Components of 25 761 56-S 7 Pin to DB9 Cable 7 Pin to 4 Pin Adapter K-Line Adapter Jumper Lead Wiring Harness	Rehlko 25 761 56-S Rehlko 25 761 48-S Rehlko 25 761 53-S Rehlko 25 176 23-S
Oil Pressure Test Kit For testing/verifying oil pressure on pressure lubricated engines.	Rehlko 25 761 06-S
Reamer Handle For hand reaming using Rehlko 25 455 12-S reamer.	Design Technology Inc. DTI-K830
Rehlko® Diagnostic System (KDS) Gen 2 For Laptop or Desktop PC. Components of 25 761 50-S Engine Communication Module 7 Pin to DB9 Cable USB Module to PC Cable 7 Pin to 4 Pin Adapter K-Line Adapter Jumper Lead Wiring Harness	Rehlko 25 761 50-S Rehlko 25 761 47-S Rehlko 25 761 48-S Rehlko 25 761 49-S Rehlko 25 761 53-S Rehlko 25 176 23-S
Replacement Cable and Adapter Kit For laptop or desktop PC or mobile (wireless). Components of 25 761 57-S 7 Pin to DB9 Cable 7 Pin to 4 Pin Adapter	Rehlko 25 761 57-S Rehlko 25 761 48-S Rehlko 25 761 53-S
Starter Servicing Kit (All Starters) 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
Stepper Motor Controller Tool For testing operation of stepper motor/Digital Linear Actuator (DLA).	Rehlko 25 455 21-S
Triad/OHC Timing Tool Set For holding cam gears and crankshaft in timed position while installing timing belt.	Rehlko 28 761 01-S
Valve Guide Reamer (K and M Series) For properly sizing valve guides after installation.	Design Technology Inc. DTI-K828
Valve Guide Reamer O.S. (Command Series) 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.	Rehlko 25 455 12-S

AIDS

Description	Source/Part No.
Camshaft Lubricant (Valspar ZZ613)	Rehlko 25 357 14-S
Dielectric Grease	Loctite® 51360
P80 Emulsion Lubricant	Rehlko 25 357 80-S
RTV Silicone Sealant Loctite® 5900® Heavy Body in 4 oz. aerosol dispenser. Only oxime-based, oil resistant RTV sealants, such as those listed, are approved for use. Permatex® the Right Stuff® 1 Minute Gasket™ or Loctite® Nos. 5900® or 5910® are recommended for best sealing characteristics.	Rehlko 25 597 07-S Loctite® 5910® Loctite® Ultra Black 598™ Loctite® Ultra Blue 587™ Loctite® Ultra Copper 5920™ Permatex® the Right Stuff® 1 Minute Gasket™
Spline Drive Lubricant	Rehlko 25 357 12-S

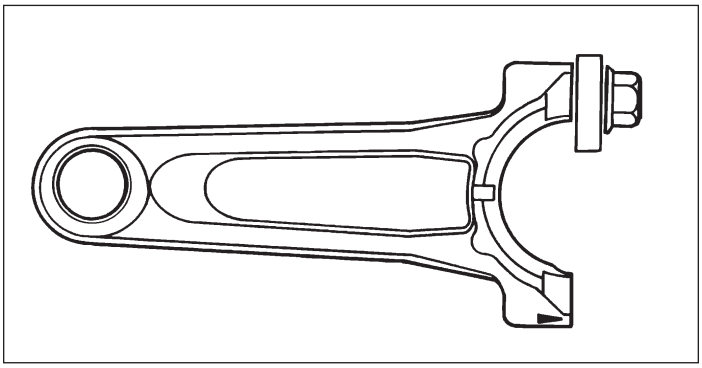
FLYWHEEL HOLDING TOOL



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 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 EFI engine troubles are listed below and vary by engine specification. These systems should be checked **before** more indepth troubleshooting begins. Once these systems are eliminated then additional troubleshooting can begin. Thorough diagnosis of a Rehlko EFI engine requires the use of Special Tools to scan for DTC's, read live sensor data and measure fuel pressure. These Special Tools are listed in the Tools and Aids section of this service manual. Failure to use these special tools may lead to misdiagnosis and unnecessary parts replacement.

Engine Cranks But Will Not Start

- Battery connected backwards.
- Blown fuse.
- Clogged fuel line or fuel filter.
- Empty fuel tank.
- Carburetor solenoid malfunction.
- Faulty electronic control unit.
- Faulty ignition coil(s).
- Faulty spark plug(s).
- Ignition module(s) faulty or improperly gapped.
- Fuel pump malfunction-vacuum hose clogged or leaking.
- Fuel shut-off valve closed.
- 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).
- Spark plug lead(s) disconnected.

Engine Starts But Does Not Keep Running

- Faulty cylinder head gasket.
- Faulty carburetor.
- Faulty or misadjusted 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

- Clogged fuel line or fuel filter.
- Engine overheated.
- Faulty ACR mechanism (Retractable Start).
- Faulty or misadjusted 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

- 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 (Retractable Start).
- Seized internal engine components.

Engine Runs But Misses

- Engine overheated.
- Carburetor adjusted incorrectly.
- Faulty spark plug(s).
- Ignition coil(s) faulty.
- Incorrect crankshaft position sensor air gap (only on engines with earlier design bracket with slots allowing adjustment).
- 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

- Engine overheated.
- Faulty spark plug(s).
- Idle speed adjusting screw improperly set (this is not a feature on engines equipped with an electronic throttle body).
- Inadequate fuel supply.
- Low compression.
- Quality of fuel (dirt, water, stale, mixture).
- Restricted fuel tank cap vent.

Engine Overheats

- Cooling fan broken.
- Excessive engine load.
- High crankcase oil level.
- Lean fuel mixture.
- Low crankcase oil level.
- Cooling system components clogged or restricted.

Engine Knocks

- 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 (on engines equipped with electronic throttle body governor is digitally controlled and not adjustable).
- 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 throttle body 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

⚠ WARNING

Cleaning Solvents can cause severe injury or death.

Use only in well ventilated areas away from ignition sources.

Carburetor cleaners and solvents are extremely flammable. Follow cleaner manufacturer's warnings and instructions on its proper and safe use. Never use gasoline as a cleaning agent.

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

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

CRANKCASE VACUUM TEST

⚠ WARNING

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.

⚠ WARNING

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 (inches of water gauge only). 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 (inches of water gauge only):

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 at no-load high speed 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 is within specification if the gauge displays any negative value (any amount of crankcase vacuum).

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

Any amount of vacuum is acceptable. If reading is below specification, or if pressure is present, check table below for possible causes and conclusions.

COMPRESSION TEST

NOTE: For EFI engines utilizing an Engine Control Unit (ECU) controlled Electronic Throttle Body (ETB). The ETB precisely regulates airflow and is typically not fully open during normal engine cranking, which would restrict maximum airflow and result in an inaccurate (low) compression reading. Rehlko® Diagnostic System (KDS) Gen 2 must be used to accurately measure compression.

NOTE: Rehlko® Diagnostic System (KDS) Gen 2 system tests as mentioned within this manual, are available to dealers only. Special tests are not activated within KDS tool for non Rehlko dealers.

A compression test is best performed on a warm engine. Clean any dirt or debris away from base of spark plug before removing it. **Be sure battery is fully charged and throttle is wide open during test.** Some models (retractable start) 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.

Step-by-Step Procedure

1. Preparation: Warm the engine to operating temperature. (If equipped) Disconnect high pressure fuel pump electrical connector from high pressure fuel pump module. A trouble code will be set and will be cleared during a later step. Clean dirt/debris from base of spark plugs before removing them. For carbureted engines, be sure choke is off during testing.
2. Access: Remove all spark plugs and install compression tester gauge.
3. (EFI engine): Wide Open Throttle (WOT) Command:

   Connect the Diagnostic System (KDS).

   Select Engine and Navigate to the "Tests" function.

   Select "Compression Test" and follow on screen instructions.
4. Test: Crank the engine (typically 4-6 compression strokes) until the gauge peaks. Record the reading.
5. (EFI engine) Completion: Complete all listed steps in "Compression Test" shown on KDS.
6. Results: Compression should be at least 160 psi and should not vary more than 15% between cylinders.

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.

Dual Gauge Test Procedure

1. Run engine until oil temperature reaches and maintains 150°F (66°C) or more for a minimum of 5 minutes. Ideally, engine should be run under normal load conditions.
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 from kit 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 engine cannot rotate off TDC in either direction.
4. Connect an air source (at least 100 PSI) to tool.
5. Turn regulator knob clockwise (increase direction). Confirm both gauges read approximately the same air pressure from 0 to 80 PSI. Note any discrepancies between gauges for leakage calculation. Release pressure by turning regulator knob completely counterclockwise before proceeding.
6. Install adapter hose into spark plug hole of cylinder being tested. Use 12 mm x 14 mm adapter if required.
7. Firmly hold engine at TDC. Connect other end of adapter hose to tool quick connect. Turn regulator knob clockwise (increase direction) until left gauge needle reads 20 PSI.

NOTE: When piston is at TDC, little to no holding force should be required when air pressure is applied to cylinder. If excess holding force is required, this indicates piston is not at TDC. Readjust as necessary before proceeding.

8. Slowly turn regulator knob clockwise until left hand gauge maintains selected test pressure (see chart below).

Left Gauge Regulated Pressure Selection
80 PSI Recommended for engines over 200 cc or those exhibiting high leakage at 35 PSI setting.
35 PSI Recommended for single cylinder walk-behind push mower applications.

9. Compare right gauge reading to Test Pressure Chart on next page to identify percentage of leakage. Also refer to Leakdown Test Results chart on next page for colors, conditions, and action required.
10. For engines exhibiting leakage in yellow or red zone, repeat test procedure. Operate engine under normal load conditions prior to test. Confirm piston is at TDC during test.

NOTE: To prevent damage to gauge assembly, always turn pressure regulator knob to zero (counterclockwise) after each test.

Test Pressure Chart for Dual Gauge Tool

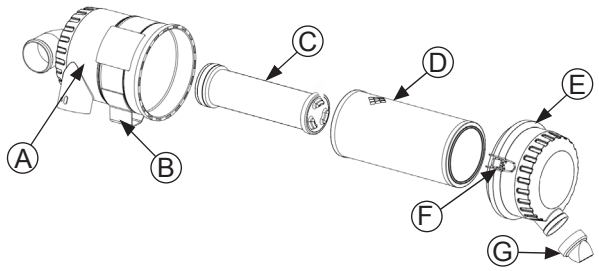
Left Gauge Regulated Pressure Selection	Right Gauge Reading in PSI										
80 PSI Recommended for engines over 200 cc or those exhibiting high leakage at 35 PSI setting.	80	72	64	56	48	40	32	24	16	8	0
35 PSI Recommended for single cylinder walk-behind push mower applications.	35	31.5	28	24.5	21	17.5	14	10.5	7	3.5	0
Percentage of leakage	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
	Green Zone					Yellow Zone			Red Zone		

Leakdown Test Results

Test Result	Condition	Action
Gauge reading in low (green) zone.	Piston rings and cylinder in good condition.	No further action required.
Gauge reading in moderate (yellow) zone.	Air escaping from crankcase breather and/or dipstick tube.	Some wear present causing leakage from combustion chamber to crankcase. Repair not required at this time if breather system is functioning normally.
	Air escaping from exhaust.	Exhaust valve leakage present, possibly due to carbon deposits. Repair not required. Carbon cleaning could be performed to reduce leakage.
	Air escaping from intake.	Intake valve leakage present, possibly due to carbon deposits. Repair not required. Carbon cleaning could be performed to reduce leakage.
Gauge reading in high (red) zone. **Confirm consecutive leakdown test has been performed AFTER engine has been operated under normal load conditions.**	Air escaping from crankcase breather and/or dipstick tube.	Excess wear present causing leakage from combustion chamber to crankcase. Breather system will not function normally and will fail crankcase vacuum test if this condition is truly present. Engine disassembly and analysis required to determine root cause and correction.
	Air escaping from exhaust.	Excess exhaust valve leakage present, possibly due to carbon deposits and/or valve to seat sealing issues. Carbon cleaning may reduce leakage. Valve grind and/or component replacement may be necessary. Excess oil consumption and/or excess heat is a suspect cause and must be resolved to prevent reoccurrence.
	Air escaping from intake.	Excess intake valve leakage present, possibly due to carbon deposits and/or valve to seat sealing issues. Carbon cleaning may reduce leakage. Valve grind and/or component replacement may be necessary. Excess oil consumption through intake valve and/or excess heat is a suspect cause and must be resolved to prevent reoccurrence. Inspect breather system components and intake valve stem sealing.

AIR CLEANER

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



A	Body	**B**	Bracket
C	Inner Element (if equipped)	**D**	(Primary) Filter Element
E	End Cap	**F**	Retaining Clip
G	Duck Bill		

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

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

1. Unhook retaining clips and remove end cap(s).
2. Check and clean inlet screen (if equipped).
3. Pull air cleaner element out of housing and replace. Check condition of inner element (if equipped); replace when dirty.
4. Check all parts for wear, cracks, or damage. Confirm duck bill is properly installed.
5. Install new element(s).
6. Reinstall end cap(s) onto air cleaner body with duck bill in downward position; secure with retaining clips.

BREATHER TUBE

Ensure both ends of breather tube are properly connected.

AIR COOLING

	⚠ WARNING
	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.	

NOTE: Operating engine with a restricted air intake screen or radiator, damaged/ broken fan assembly, or missing fan shroud will cause engine damage due to over heating.

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. See Maintenance Schedule.

⚠ 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.

Typical electronic fuel injection (EFI) system and related components include:

- Fuel pump module and lift pump.
- Fuel filter.
- High pressure fuel line.
- Fuel line(s).
- Fuel injectors.
- Electronic throttle body (ETB)/intake manifold.
- Electronic control unit (ECU).
- Ignition coils.
- Engine temperature sensor.
- Throttle position sensor (TPS) is contactless and not serviceable.
- Crankshaft position sensor.
- Oxygen sensor.
- Temperature/manifold absolute pressure (TMAP) sensor.
- Malfunction indicator light (MIL)-optional.
- 30 Amp fuse (charging system).
- Refer to equipment manual for fuse detail in OEM supplied wiring harness (high output charging system).
- 10 Amp fuse (ignition switch).
- 10 Amp fuse (battery power).
- Wire harness assembly & affiliated wiring.

FUEL RECOMMENDATIONS

Refer to Maintenance.

FUEL LINE

Low permeation fuel line must be installed on all Rehlko engines to maintain EPA and CARB regulatory compliance.

OPERATION

NOTE: When performing voltage or continuity tests, avoid putting excessive pressure on or against connector pins. Flat pin probes are recommended for testing to avoid spreading or bending terminals.

NOTE: Replacement ECUs are shipped unprogrammed (blank). The ECU MUST be programmed/flashed with the correct engine-specific calibration file using the Rehlko Diagnostic System (KDS) software. Failure to program/flash the ECU will result in a no-start condition.

EFI system is designed to provide peak engine performance with optimum fuel efficiency and lowest possible emissions. Ignition and injection functions are electronically controlled, monitored and continually corrected during operation to maintain ideal air/fuel ratio.

Central component of system is Electronic Control Unit (ECU) which manages system operation, determining best combination of fuel mixture, ignition timing, throttle opening and/or engine RPM for current operating conditions.

ETB engines feature an ECU that uses CAN BUS/J1939 communication protocols and may be linked to other electronic control modules installed on the application. Refer to the equipment manufacturer's manual for confirmation of additional modules and operational details

Native fault codes on ETB engines are transmitted in J1939 protocol. For consistency and familiarity, Rehlko service literature and the diagnostic tool continue to display and reference the equivalent SAE P-code (example: P0122).

A lift fuel pump is used to move fuel from tank through an in-line fuel filter and fuel line. Fuel is then pumped to fuel pump module. Fuel pump module regulates fuel pressure to a system operating pressure of 39 psi. Fuel is delivered from fuel pump module through high pressure fuel line into injectors, which inject fuel into intake ports. ECU controls amount of fuel by varying length of time that injectors are on. This can range from 2 to over 12 milliseconds depending on fuel requirements. Controlled injection of fuel occurs every other crankshaft revolution, or once for each 4-stroke cycle. When intake valve opens, air/fuel mixture is drawn into combustion chamber, compressed, ignited, and burned.

ECU controls amount of fuel being injected and ignition timing by monitoring primary sensor signals for engine temperature, operator requested engine speed (RPM), and throttle position (load). These primary signals are compared to preprogrammed maps in ECU computer chip, and ECU adjusts fuel delivery to match mapped values. After engine reaches operating temperature, an exhaust gas oxygen sensor provides feedback to ECU based upon amount of unused oxygen in exhaust, indicating whether fuel mixture being delivered is rich or lean. Based upon this feedback, ECU further adjusts fuel input to re-establish ideal air/fuel ratio. This operating mode is referred to as closed loop operation. EFI system operates closed loop when all three of following conditions are met:

- Engine temperature is greater than 50-60°C (122-140°F).
- Oxygen sensor has warmed sufficiently to provide a signal (minimum 400°C, 752°F).
- Engine operation is at a steady state (not starting, warming up, accelerating, etc.).

During closed loop operation ECU has ability to readjust and learn adaptive controls, providing compensation for changes in overall engine condition and operating environment, so it will be able to maintain ideal air/fuel ratio. This system requires a minimum engine temperature greater than 50-60°C (122-140°F) to properly adapt. These adaptive values are maintained as long as ECU is not reset.

During certain operating periods such as cold starts, warm up, acceleration, high load, etc., a richer air/fuel ratio is required and system operates in an open loop mode. In open loop operation oxygen sensor output is used to ensure engine is running rich, and controlling adjustments are based on primary sensor signals and programmed maps only. This system operates open loop whenever three conditions for closed loop operation (above) are not being met.

ECU is brain or central processing computer of entire EFI and ETB/electronic governor system. During operation, sensors continuously gather data which is relayed through wiring harness to input circuits within ECU. Signals to ECU include: ignition (on/off), crankshaft position and speed (RPM), throttle position, requested customer speed input, oil temperature, intake air temperature, exhaust oxygen levels, manifold absolute pressure, and battery voltage.

ECU compares input signals to programmed maps in its memory to determine appropriate fuel and spark requirements for immediate operating conditions. ECU then sends output signals to set injector duration, ignition timing, and ETB throttle opening.

ECU continually performs a diagnostic check of itself, each sensor, and system performance. If a fault is detected, ECU can turn on a Malfunction Indicator Light (MIL) (if equipped) on equipment control panel, store fault code in its fault memory, and go into a default operating mode. Depending on significance or severity of fault, normal operation may continue. A technician can access stored fault codes using the Rehlko Diagnostic System (KDS) Gen 2, see Tools and Aids.

ECU requires a minimum of 6.0 volts to operate.

To prevent engine over-speed and possible failure, a rev-limiting feature is programmed into ECU. If maximum RPM limit (4500) is exceeded, ECU suppresses injection signals, cutting off fuel flow. This process repeats itself in rapid succession, limiting operation to preset maximum.

Wiring harness used in EFI system connects electrical components, providing current and ground paths for system to operate. All input and output signaling occurs through two special all weather connectors that attach and lock to ECU. Connectors are Black and Grey and keyed differently to prevent being attached to ECU incorrectly.

Condition of wiring, connectors, and terminal connections is essential to system function and performance. Corrosion, moisture, and poor connections are as likely cause of operating problems and system errors as an actual component. Refer to Electrical System for additional information.

EFI system is a 12 VDC negative ground system, designed to operate down to a minimum of 6.0 volts. If system voltage drops below this level, operation of voltage sensitive components such as ECU, fuel pump, ignition coils, and injectors will be intermittent or disrupted, causing erratic operation or hard starting. A fully charged, 12 volt battery with a minimum of 350 cold cranking amps is important in maintaining steady and reliable system operation. Battery condition and state of charge should always be checked first when troubleshooting an operational problem.

Keep in mind that EFI-related problems are often caused by wiring harness or connections. Even small amounts of corrosion or oxidation on terminals can interfere with milliamp currents used in system operation.

Cleaning connectors and grounds will solve problems in many cases. In an emergency situation, simply disconnecting and reconnecting connectors may clean up contacts enough to restore operation, at least temporarily.

If a fault code indicates a problem with an electrical component, disconnect ECU connector and test for continuity between component connector terminals and corresponding terminals in ECU connector using an ohmmeter. Little or no resistance should be measured, indicating that wiring of that particular circuit is OK.

Crankshaft position sensor is essential to engine operation; constantly monitoring rotation and speed (RPM) of crankshaft. There are 23 consecutive teeth cast into flywheel. One tooth is missing and is used to reference crankshaft position for ECU.

During rotation, an AC voltage pulse is created within sensor for each passing tooth. ECU calculates engine speed from time interval between consecutive pulses. Gap from missing tooth creates an interrupted input signal, corresponding to specific crankshaft position near BDC for cylinder #1. This signal serves as a reference for control of ignition timing by ECU. Synchronization of inductive speed pickup and crankshaft position takes place during first two revolutions each time engine is started. Sensor must be properly connected at all times. If sensor becomes disconnected for any reason, engine will quit running.

Throttle position sensor (TPS) is used to indicate throttle plate angle to ECU. Since throttle (by way of governor or customer speed input/ETB throttle opening) reacts to engine load, angle of throttle plate is directly related to load on engine.

TPS is sealed and not serviced separately. Mounted on electronic throttle body and operated directly off end of throttle shaft, TPS works as a potentiometer, varying voltage signal to ECU in direct correlation to angle of throttle plate. This signal, along with other sensor signals, is processed by ECU and compared to internal preprogrammed maps to determine required fuel and ignition settings for amount of load.

TPS auto-learn is an automated process. No adjustment is required.

Engine temperature sensor is used by system to help determine fuel requirements for starting (a cold engine needs more fuel than one at or near operating temperature).

Mounted in crankcase next to breather cover, it has a temperature-sensitive resistor that extends into oil flow. Resistance changes with oil temperature, altering voltage sent to ECU. Using a table stored in its memory, ECU correlates voltage drop to a specific temperature. Using fuel delivery maps, ECU then knows how much fuel is required for starting at that temperature.

Temperature/Manifold Absolute Pressure (TMAP) sensor is an integrated sensor that checks both intake air temperature and manifold absolute pressure.

Intake Air Temperature control is a thermally sensitive resistor that exhibits a change in electrical resistance with a change in its temperature. When sensor is cold, resistance of sensor is high. As sensor warms up, resistance drops and voltage signal increases. From voltage signal, ECU can determine temperature of intake air.

Purpose of sensing air temperature is to help ECU calculate air density. Higher air temperature less dense air becomes. As air becomes less dense ECU knows that it needs to lessen fuel flow to achieve correct air/fuel ratio. If fuel ratio was not changed engine would become rich, possibly losing power and consuming more fuel.

Manifold Absolute Pressure check provides immediate manifold pressure information to ECU. TMAP sensor measures difference in pressure between outside atmosphere and vacuum level inside intake manifold and monitors pressure in manifold as primary means of detecting load. Data is used to calculate air density and determine engine's mass air flow rate, which in turn determines required ideal fueling. MAP also stores instant barometric pressure reading when key is turned ON.

Oxygen sensor functions like a small battery, generating a voltage signal to ECU based upon difference in oxygen content between exhaust gas and ambient air.

Tip of sensor protrudes into exhaust gas. When oxygen concentration on one side of tip is different than that of other side, a voltage signal up to 0.98 volt is generated and sent to ECU. Voltage signal tells ECU if engine is straying from ideal fuel mixture, and ECU then adjusts injector pulse accordingly.

Oxygen sensor functions after being heated to a minimum of 400°C (752°F). A heater inside sensor heats electrode to optimum temperature in about 10 seconds. Oxygen sensor receives ground through wire, eliminating need for proper grounding through muffler. If problems indicate a bad oxygen sensor, check all connections and wire harness. Oxygen sensor can also be contaminated by leaded fuel, certain RTV and/or other silicone compounds, fuel injector cleaners, etc. Use only those products indicated as O2 Sensor Safe.

Fuel injectors mount into intake manifold, and high pressure fuel line attaches to them at top end. Replaceable O-rings on both ends of injector prevent external fuel leakage and also insulate it from heat and vibration. A special clip connects each injector to high pressure fuel line and holds it in place. O-rings and retaining clip must be replaced any time fuel injector is separated from its normal mounting position.

When key switch is on, fuel pump module will pressurize high pressure fuel line to 39 psi, and voltage is present at injector. At proper instant, ECU completes ground circuit, energizing injector. Valve needle in injector is opened electromagnetically, and pressure in high pressure fuel line forces fuel down through inside. Director plate at tip of injector contains a series of calibrated openings which directs fuel into manifold in a cone-shaped spray pattern.

Injectors have sequential fueling that open and close once every other crankshaft revolution. Amount of fuel injected is controlled by ECU and determined by length of time valve needle is held open, also referred to as injection duration or pulse width. Time injector is open (milliseconds) may vary in duration depending on speed and load requirements of engine.

A high-voltage, solid-state, battery ignition system is used with EFI system. ECU controls ignition output and timing through transistorized control of primary current delivered to coils. Based on input from crankshaft position sensor, ECU determines correct firing point for speed at which engine is running. At proper instant, it interrupts flow of primary current in coil, causing electromagnetic flux field to collapse. Flux collapse induces an instantaneous high voltage in coil secondary which is strong enough to bridge gap on spark plug. Each coil fires every other revolution (during normal running).

ETB EFI engines are equipped with either a 20 amp or high output charging system to accommodate combined electrical demands of ignition system and specific application. Charging system troubleshooting information is provided in Electrical System.

An electric fuel pump module and a lift pump are used to transfer fuel in EFI system. Types of lift pumps are: a pulse fuel pump, a mechanical fuel pump, or a low pressure electric fuel pump. Pumping action is created by either oscillation of positive and negative pressures within crankcase through a hose, or by direct lever/pump actuation off rocker arm movement. Pumping action causes diaphragm on inside of pump to pull fuel in on its downward stroke and to push it into fuel pump module on its upward stroke. Internal check valves prevent fuel from going backward through pump. Fuel pump module receives fuel from lift pump, increases and regulates pressure for fuel injectors.

Fuel pump module is rated for a minimum output of 13.5 liters (3.51 gallons) per hour and regulated at 270 kilopascals (39 psi).

When key switch is turned ON and all safety switch requirements are met, ECU activates fuel pump module for about six seconds, which pressurizes system for start-up. If key switch is not promptly turned to start position, engine fails to start, or engine is stopped with key switch ON (as in case of an accident), ECU switches off pump preventing continued delivery of fuel. In this situation, MIL will go on, but it will go back off after 4 cranking revolutions if system function is OK. Once engine is running, fuel pump remains on.

Precision components inside fuel pump module are not serviceable. DO NOT attempt to open fuel pump module. Damage to components will result and warranty will be void. Because fuel pump module is not serviceable, engines are equipped with a special 10-micron EFI fuel filter to prevent harmful contamination from entering module.

If there are two filters in system, one before lift pump will be a standard 51-75 micron filter, and one after lift pump will be special 10-micron filter. Be sure to use an approved 10-micron filter for replacement.

High pressure fuel line is an assembly of hoses, injector caps and a fuel connector to fuel pump module. High pressure fuel line feeds fuel to top of injectors through injector caps. Caps are fastened to intake manifold and injectors are locked into place. A small retaining clip provides a secondary lock.

High pressure fuel line is serviced as a complete assembly to prevent tampering and safety hazards. Components are not individually serviceable.

Vent hose assembly is intended to vent fuel vapor out of fuel pump module and direct fuel vapor into electronic throttle body. Most EFI engines are equipped with an engine mounted purge port on #2 cylinder barrel baffle. This capped purge port can be used by OEM to vent fuel tanks or used in conjunction with a carbon canister kit for evaporative emissions compliance. Purge port connects to vent hose assembly and directs all fuel vapor into electronic throttle body. If purge port remains unused, port must remain capped to prevent dirt from entering engine.

EFI engines have no carburetor, so throttle function (regulate incoming combustion airflow) is achieved with a throttle valve in a separate electronic throttle body (ETB) attached to intake manifold. ETB is an assembly of three functional components: 1) A mechanical throttle body to control air flow to engine. 2) A DC electric motor and gear reduction to drive and position throttle blade. 3) A non-contact throttle position sensor to measure throttle position. This technology is common on many modern automobiles, including a return spring feature. Return spring will mechanically return throttle blade to a home position if power is lost or interrupted to drive motor. Home position is above normal low idle position, but typically is low RPM and very low load.

ETB (Electronic throttle body)/intake manifold provides mounting for fuel injectors, throttle position sensor, TMAP sensor, high pressure fuel line, and air cleaner assembly.

ETB Engine idle speed is not adjustable and is preset and controlled by ECU. Standard idle speed setting for EFI engines is 1500 RPM, but certain applications might require a different setting.

The ECU continuously monitors engine speed, load, temperatures, and other parameters via sensors, while receiving the primary speed request from the OEM controller through one of two possible interfaces:

- Analog voltage input (0–5 V)
- CANBUS communication

Consult OEM service information to confirm interface type.

For starting and warm up, ECU will adjust fuel and ignition timing, based upon ambient temperature, engine temperature, and loads present. In cold conditions, idle speed will be different than normal for a few moments. Idle speed typically starts higher than normal, but gradually decreases to established setting as operation continues. Engine must be completely warmed up, in closed loop operating mode for accurate idle check.

IMPORTANT NOTES!

- Thorough diagnosis of a Rehlko EFI engine requires the use of Special Tools to scan for DTC's, read live sensor data and measure fuel pressure. These Special Tools are listed in the Tools and Aids section of this service manual. Failure to use these special tools may lead to misdiagnosis and unnecessary parts replacement.
- Cleanliness is essential and must be maintained at all times when servicing or working on EFI system. Dirt, even in small quantities, can cause significant problems.
- Clean any joint or fitting with parts cleaning solvent before opening to prevent dirt from entering system.
- Always depressurize fuel system through fuel connector on fuel pump module before disconnecting or servicing any fuel system components.
- Never attempt to service any fuel system component while engine is running or ignition switch is ON.
- Do not use compressed air if system is open. Cover any parts removed and wrap any open joints with plastic if they will remain open for any length of time. New parts should be removed from their protective packaging just prior to installation.
- Avoid direct water or spray contact with system components.
- Do not disconnect or reconnect ECU wiring harness connector or any individual components with ignition on. This can send a damaging voltage spike through ECU.
- Do not allow battery cables to touch opposing terminals. When connecting battery cables attach positive (+) cable to positive (+) battery terminal first, followed by negative (-) cable to negative (-) battery terminal.
- Never start engine when cables are loose or poorly connected to battery terminals.
- Never disconnect battery while engine is running.
- Never use a quick battery charger to start engine.
- Do not charge battery with key switch ON.
- Always disconnect negative (-) battery cable before charging battery, and also unplug harness from ECU before performing any welding on equipment.

REHLKO DIAGNOSTIC SYSTEM (see Tools and Aids)

- Software features: Reading/clearing DTCs (diagnostic trouble codes), live data streaming (sensors, RPM, temperatures, load, etc.), data logging, graphs, access to built-in service manuals, TPS (throttle position sensor) initialization/reset, oxygen sensor diagnostics, and system testing. Supports all Rehlko EFI engines equipped with 4 or 7-pin diagnostic connector
- Only the PC (Windows) version of the Rehlko Diagnostic System (Gen 2) is capable of flashing/programming a replacement ECU.
- Mobile (KDS) Gen 2 and the mobile apps (Android/iOS) do not support ECU flashing, but remain fully functional for reading/clearing codes, live data, TPS initialization, active tests, etc.
- Every diagnostic kit (PC and Mobile) includes a software license serial number and quick-start guide explaining the software installation and registration process.
- Tool Registration: Communication with an ETB (Electronic Throttle Body) engine requires tool registration per the instructions provided in the diagnostic kit. ETB engines are not listed in engine menu by default.
- Dealer Access Restriction: Access to advanced Special Test Functions is limited to authorized Rehlko dealers only. These features are not activated within the diagnostic tool for non-Rehlko dealer service centers.

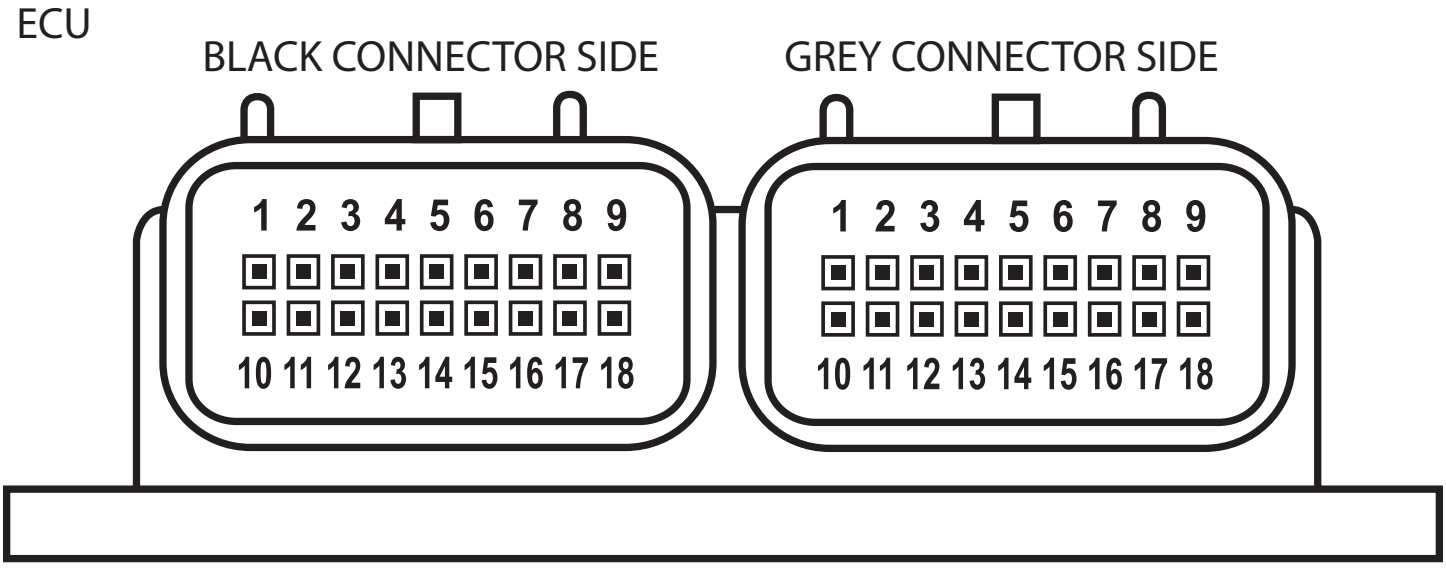
ELECTRICAL COMPONENTS

Electronic Control Unit (ECU)

Pinout of ECU

Black Connector Side	
Pin #	**Description**
1	Ignition Coil #1 Ground
2	Battery Ground
3	Not Used
4	Crankshaft Position Sensor Input High
5	Fuel Injector Output #1 Ground
6	Fuel Injector Output #2 Ground
7	Oxygen Sensor Heater
8	Intake Air Temperature (TMAP) Sensor Input
9	Fuel Pump Ground
10	Ground for TPS, TMAP, O2, and Temp sensors
11	Manifold Absolute Pressure (TMAP) sensor input
12	Throttle Position Sensor (TPS) input
13	Crankshaft Position Sensor Low
14	Engine Temperature Sensor input
15	Ignition Switch (Switched +12V)
16	Power for TPS and TMAP sensor (+5V)
17	Oxygen Sensor (O2) input
18	Battery Power (Permanent +12V)

Grey Connector Side	
Pin #	**Description**
1	Not Used
2	Not Used
3	Malfunction Indicator Light (MIL) Ground
4	Not Used
5	Not Used
6	Tach Out
7	CAN Low
8	CAN High
9	Battery Ground
10	Ignition Coil #2 Ground
11	ETB Motor High
12	ETB Motor Low
13	Desired Engine Speed Input (0-5V)
14	Safety Switch Ground
15	Not Used
16	ECU Reset
17	Fuel Pump Control (+12V)
18	Not Used



Never attempt to disassemble ECU. It is sealed to prevent damage to internal components. Warranty is void if case is opened or tampered with in any way.

All operating and control functions within ECU are preset. No internal servicing or readjustment may be performed. If a problem is encountered, and you determine ECU to be faulty, contact your source of supply.

ECU pins are coated at factory with a thin layer of electrical grease to prevent fretting and corrosion. Do not attempt to remove grease from ECU pins.

Relationship between ECU and throttle position sensor (TPS) is very critical to proper system operation. TPS to throttle shaft positioning is an automated process performed at key cycle and cannot be altered.

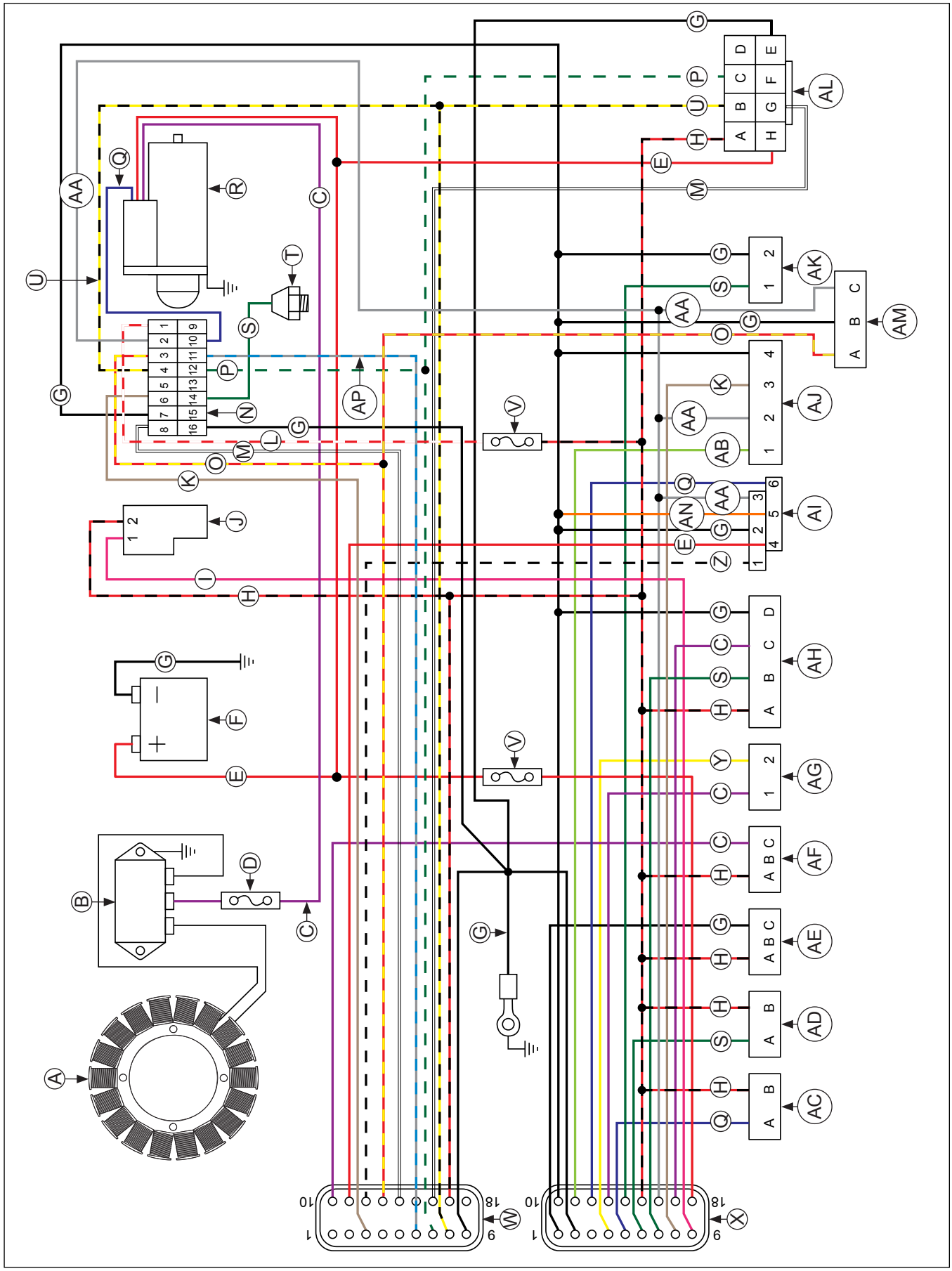
Any service to ECU, TPS/Electronic Throttle Body, or fuel pump module replacement should include ECU Reset.

This will clear all trouble codes, all closed loop learned offsets, all max values, and all timers besides permanent hour meter.

This system will NOT reset when battery is disconnected!

ECU Reset Procedure

1. Turn key/ignition OFF.
2. Install Green colored wire jumper from Rehlko EFI service kit on to diagnostic port (or connect white wire to black wire (terminals G and E) in diagnostic port).
3. Turn key/ignition ON, then OFF and count 10 seconds.
4. Turn key/ignition ON, then OFF and count to 10 seconds a second time.
5. Remove Green colored wire jumper. Turn key/ignition ON, then OFF and count to 10 seconds a third time. ECU is reset.



ETB EFI Wiring Harness 20 Amp

ETB EFI Wiring Harness 20 Amp Detail							
A	Stator	**B**	Rectifier-Regulator	**C**	Purple	**D**	30A Fuse
E	Red	**F**	Battery	**G**	Black	**H**	Red/Black
I	Pink	**J**	Fuel Pump Module	**K**	Tan	**L**	Red/White
M	White	**N**	16-Terminal Connector	**O**	Red/Yellow	**P**	Green/White
Q	Dark Blue	**R**	Starter Motor	**S**	Dark Green	**T**	Oil Pressure Switch
U	Yellow/Black	**V**	10A Fuse	**W**	Grey Connector	**X**	Black Connector
Y	Yellow	**Z**	Black/White	**AA**	Grey	**AB**	Light Green
AC	Fuel Injector #1	**AD**	Fuel Injector #2	**AE**	Ignition Coil #1	**AF**	Ignition Coil #2
AG	Crankshaft Position Sensor	**AH**	Oxygen Sensor	**AI**	Electronic Throttle Control	**AJ**	TMAP Sensor
AK	Engine Temperature Sensor	**AL**	Diagnostic Connector (8 Bay, 7 Pin)	**AM**	Throttle Position Sensor	**AN**	Orange
AO	Grey/Blue						

Troubleshooting Guide

Condition	Possible Cause
Engine Starts Hard or Fails to Start When Cold.	Fuel pump not running.
	Faulty spark plugs.
	Old/stale fuel.
	Incorrect fuel pressure.
	Crankshaft position sensor loose or faulty.
	TPS set incorrect (ECU Reset).
	TPS faulty.
	Engine temp sensor faulty.
	Faulty coils.
	Low system voltage.
	Faulty injectors.
	Faulty battery.
	Loose or corroded connections.
Engine Starts Hard or Fails to Start When Hot.	Faulty spark plugs.
	Fuel pump not running.
	Fuel pressure low.
	Insufficient fuel delivery.
	TPS set incorrect (ECU Reset).
	Crankshaft position sensor loose or faulty.
	TPS faulty.
	Engine temp sensor faulty.
	Faulty injectors.
	Vapor lock.

Condition	Possible Cause
Engine Stalls or Idles Roughly (cold or warm).	Faulty spark plugs.
	Insufficient fuel delivery.
	TPS set incorrect.
	TPS faulty.
	Faulty engine temperature sensor.
	Faulty injectors.
Engine Misses, Hesitates, or Stalls Under Load.	Fuel injector(s), fuel filter, fuel line, or fuel pick-up dirty/restricted.
	Dirty air cleaner.
	Insufficient fuel pressure or fuel delivery.
	Vacuum (intake air) leak.
	Improper governor operation.
	TPS faulty.
	Bad coil(s), spark plug(s), or wires.
Low Power	Faulty/malfunctioning ignition system.
	Dirty air filter.
	Insufficient fuel delivery.
	Plugged/restricted exhaust.
	One injector not working.
	Basic engine problem exists.
	TPS faulty.
	Throttle plate in electronic throttle body not fully opening to WOT.

Fault Code Summary

Fault Code	Connection or Failure Description	SAE J1939 Fault Codes	
		SPN	FMI
P0031	Oxygen Sensor Heater Circuit Low Voltage	**3056**	**5**
P0032	Oxygen Sensor Heater Circuit High Voltage	**3056**	**6**
P0107	Manifold Absolute Pressure Sensor Circuit Low Voltage or Open	**102**	**4**
P0108	Manifold Absolute Pressure Sensor Circuit High Voltage	**102**	**3**
P0112	Intake Air Temperature Sensor Circuit Low Voltage	**105**	**4**
P0113	Intake Air Temperature Sensor Circuit High Voltage or Open	**105**	**3**
P0117	Engine Temperature Sensor Circuit Low Voltage	**110**	**4**
P0118	Engine Temperature Sensor Circuit High Voltage or Open	**110**	**3**
P0122	Throttle Position Sensor Circuit Low Voltage or Open	**51**	**4**
P0123	Throttle Position Sensor Circuit High Voltage	**51**	**3**
P0131	Oxygen Sensor 1 Circuit Low Voltage, or Open	**3056**	**4**
P0132	Oxygen Sensor 1 Circuit High Voltage	**3056**	**3**
P0171*	Maximum Adaptation Limit Exceeded	**4237**	**0**
P0172*	Minimum Adaptation Limit Exceeded	**4237**	**1**
P0174	Lean Fuel Condition at High Load (Open Loop)	**4237**	**31**
P0201	Injector 1 Circuit Malfunction	**651**	**31**
P0202	Injector 2 Circuit Malfunction	**652**	**31**
P0217	Overheat Condition	**110**	**0**
P0230	Fuel Pump Module Circuit Low Voltage or Open	**1347**	**5**
P0232	Fuel Pump Module Circuit High Voltage	**1347**	**6**
P0336	Crankshaft Position Sensor Noisy Signal	**636**	**2**
P0337	False Start Detected/CKP Sensor Signal	**636**	**8**
P0351	Cylinder 1 Ignition Coil Malfunction	**1268**	**31**
P0352	Cylinder 2 Ignition Coil Malfunction	**1269**	**31**
P0562	System Voltage Low	**168**	**4**
P0563	System Voltage High	**168**	**3**
P2100	Throttle Actuator Control Motor Circuit Open (Low Current Fault)	**5419**	**5**
P2119	Throttle Actuator Stuck	**5419**	**7**

NOTE: Any fault code marked with an asterisk (*) must be cleared using the ECU reset procedure See page 34.

ECU continuously monitors engine operation against preset performance limits. If operation is outside limits, ECU activates MIL, if equipped, and stores a diagnostic code in its fault memory. If component or system returns to proper function, ECU will turn off MIL. If MIL stays illuminated, it warns customer a fault is currently occurring, and dealer service is required. Upon receipt, dealer technician can access fault code(s) to help determine what portion of system is malfunctioning.

MIL (Malfunction Indicator Lamp) activated Diagnostic Trouble Codes (DTCs) are retrieved using the Rehlko Diagnostic System (KDS) Gen 2 (see Tools and Aids.) via the 7-pin diagnostic connector on the engine.

KDS Gen 2 Tool Activation and Access:

- Tool Registration: To enable advanced features and additional engine families, including special test functions for ETB (Electronic Throttle Body), tool registration (per the instructions provided in the kit) is required.
- Dealer Access Restriction: Access to advanced Special Test Functions is limited to authorized Rehlko dealers only. These features are not activated within the KDS tool for non-Rehlko dealer service centers.

After problem has been corrected, fault codes may be cleared by using Clear Codes command on Rehlko Diagnostic System (KDS) Gen 2.

Fault Code Summary lists fault codes, and what they correspond to. Diagnostic Code Summary is a list of individual codes with an explanation of what triggers them, what symptoms might be expected, and probable causes.

Note: Special Tools are listed in the Tools and Aids section of this service manual. Failure to use these special tools may lead to misdiagnosis and unnecessary parts replacement.

MIL may not be provided with engine. If equipment manufacturer has not added a MIL to equipment, one can be added easily for quick diagnostics. Main engine to vehicle connection will have a tan wire which is ground for MIL. Either incandescent or LED type bulbs can be used for MIL as long as they do not draw more than 0.1 amps. Bulb needs to be rated at 1.4 Watts or less, or needs to have a total resistance of 140 Ω or more. LEDs typically draw less than 0.03 amps. Attach +12 volts to positive terminal of bulb and attach ground terminal of bulb to tan wire.

ECU circuit will flow small amount of current. This may dimly illuminate LED type bulb. On is bright. Resistor can be added in series if LED type bulb is used to eliminate glow.

Diagnostic Code Summary

Fault Code	SPN	FMI
Code P0031	**3056**	**5**

NOTE: Codes P0031 and P0032 may have been mistakenly activated by turning key ON with oxygen sensor disconnected. If either code status is inactive, that code may have set during assembly or a previous repair and may not be related to current event. Clear codes and retest to confirm. If code status is active, refer to Oxygen Sensor (O2) earlier in this section, to test and troubleshoot.

Component:	Oxygen Sensor Heater
Function:	Sensor heater ensures that sensor reaches operating temperature
Fault:	O2S Heater Circuit Low Voltage
Condition:	System voltage too low, open connection or faulty sensor.
Possible Causes:	Engine Wiring Harness Related ● Pin circuit wiring or connectors. ECU Black pin 7 or broken wire. Oxygen Sensor Related ● Sensor connector or wiring problem. Poor system ground from ECU to engine or battery to engine.
Testing:	See Troubleshooting-Oxygen (O2) Sensor on page 46.

Fault Code	SPN	FMI
Code P0032	**3056**	**6**

NOTE: Codes P0031 and P0032 may have been mistakenly activated by turning key ON with oxygen sensor disconnected. If either code status is inactive, that code may have set during assembly or a previous repair and may not be related to current event. Clear codes and retest to confirm. If code status is active, refer to Oxygen Sensor (O2) earlier in this section, to test and troubleshoot.

Component:	Oxygen Sensor Heater
Function:	Sensor heater ensures that sensor reaches operating temperature
Fault:	O2S Heater Circuit High Voltage
Condition:	System voltage too high, shorted connection or faulty sensor.
Possible Causes:	Oxygen Sensor Related ● Sensor connector or wiring problem. ● Sensor damaged. ● Pin circuit wiring or connectors at Black 7. ECU Related ● ECU-to-harness connection problem.
Testing:	See Troubleshooting-Oxygen (O2) Sensor on page 46.

Fault Code	SPN	FMI
Code P0107	**102**	**4**

Component:	Manifold Absolute Pressure (TMAP)
Function:	Measures intake manifold pressure and transmits data to ECU
Fault:	MAP Circuit Low Voltage or Open
Condition:	Intake manifold leak, open connection or faulty sensor.
Possible Causes:	TMAP Sensor Related ● Sensor malfunction. ● Vacuum leaks from loose manifold or sensor. Wire Harness Related ● Poor grounding or open circuit. ● Wire harness and connectors loose, damaged or corroded. ● Pin circuit wiring or connectors at Black 10, 11 and 16.
Testing	See Temperature/Manifold Absolute Pressure (TMAP) Sensor to right. **Preferred Method:** Use Rehlko Diagnostic System to confirm sensor function

Fault Code	SPN	FMI
Code P0108	**102**	**3**

Component:	Manifold Absolute Pressure (TMAP)
Function:	Measures intake manifold pressure and transmits data to ECU
Fault:	MAP Circuit High Voltage
Condition:	Intake manifold leak, shorted connection or faulty sensor.
Possible Causes:	TMAP Sensor Related ● Sensor malfunction. ● Vacuum leaks from loose manifold or sensor. Wire Harness Related ● Poor grounding. ● Pin circuit wiring or connectors at Black 11.
Testing	See Temperature/Manifold Absolute Pressure (TMAP) Sensor to right. **Preferred Method:** Use Rehlko Diagnostic System to confirm sensor function.

Temperature/Manifold Absolute Pressure (TMAP) Sensor

A sealed non-serviceable integrated sensor that checks both intake air temperature and manifold absolute pressure. Complete replacement is required if it is faulty. Sensor and wiring harness can be checked as follows.

If troubleshooting indicates a problem with Intake Air Temperature (TMAP) Sensor Circuit (P0112 or P0113), it can be tested as follows:

1. Remove TMAP sensor from intake manifold.
2. Allow it to reach room temperature (20°C, 68°F).
3. Unplug Black connector from ECU.
4. With sensor still connected, check temperature sensor circuit resistance between Black pin 10 and 8 pin terminals. Value should be 1850-2450 Ω.
5. Unplug sensor from wire harness and check sensor resistance separately across pin. Resistance value should again be 1850-2450 Ω.
   a. If resistance is out of specifications, check local temperature. Sensor resistance will go down as temperature is higher. Replace TMAP sensor if determined to be faulty.
   b. If it is within specifications, proceed to Step 6.
6. Check circuits (input, ground), from main harness connector to sensor plug for continuity, damage, etc. Connect one ohmmeter lead to Black pin 8 in main harness connector (as in step 4). Connect other lead to terminal #3 in sensor plug. Continuity should be indicated. Repeat test between Black pin 10 and terminal #4 in sensor plug.
7. Reinstall sensor.

Fault Code	SPN	FMI
Code P0112	**105**	**4**

Component:	Intake Air Temperature (TMAP)
Function:	Measures intake air temperature and transmits data to ECU
Fault:	Intake Air Temperature Sensor Circuit Low Voltage
Condition:	Shorted connection, faulty sensor or shorted wire.
Possible Causes:	TMAP Sensor Related ● Sensor wiring or connection. Engine Wiring Harness Related ● Pin circuits ECU Black pin 10 and Black 8 may be damaged or routed near noisy signal (coils, stator, etc.). ● ECU-to-harness connection problem.
Testing:	See Temperature/Manifold Absolute Pressure (TMAP) Sensor to right. **Preferred Method:** Use Rehlko Diagnostic System to confirm sensor function.

Fault Code	SPN	FMI
Code P0113	**105**	**3**

Component:	Intake Air Temperature (TMAP)
Function:	Measures intake air temperature and transmits data to ECU
Fault:	Intake Air Temperature Sensor Circuit High Voltage or Open
Condition:	Shorted connection, faulty sensor, broken wire or connection.
Possible Causes:	TMAP Sensor Related ● Sensor wiring or connection. Engine Wiring Harness Related ● Pin circuits ECU Black pin 10 and 8 may be damaged. ● ECU-to-harness connection problem or broken wire.
Testing:	See Temperature/Manifold Absolute Pressure (TMAP) Sensor to right. **Preferred Method:** Use Rehlko Diagnostic System to confirm sensor function.

Temperature/Manifold Absolute Pressure (TMAP) Sensor

If troubleshooting indicates a problem with Manifold Absolute Pressure (TMAP) Sensor Circuit (P0107 or P0108), it can be tested as follows:

1. Make sure all connections are making proper contact and are free of dirt and debris. Slide locking tab out and pull off TMAP connector. Turn key switch to ON and check with a volt meter by contacting red lead to pin 1 and black lead to pin 2. There should be 5 volts present, indicating ECU and wiring harness are functioning.
2. Check continuity in wire harness. Ohms between Pin 3 at sensor connector and Black pin 11 connector at ECU should be near zero ohms. If no continuity is measured or very high resistance, replace wire harness.
3. Check to make sure intake manifold is not loose and TMAP sensor is not loose. Loose parts would allow a vacuum leak, making TMAP sensor report misleading information to ECU.
   a. Tighten all hardware and perform an ECU Reset Procedure to see if MIL will display a fault with sensor again. If MIL finds a fault with TMAP sensor, replace it.

Fault Code	SPN	FMI
Code P0117	**110**	**4**

Component:	Engine Temperature Sensor
Function:	Continuously measures engine temperature and transmits data to ECU
Fault:	Engine Temperature Sensor Circuit Low Voltage
Condition:	Shorted connection, faulty sensor or shorted wire.
Possible Causes:	Temperature Sensor Related ● Sensor wiring or connection. Engine Wiring Harness Related ● Pin circuits ECU Black pin 10 and Black 14 may be damaged or routed near noisy signal (coils, stator, etc.). ● ECU-to-harness connection problem.
Testing:	See Engine Temperature Sensor (Lead). **Preferred Method:** Use Rehlko Diagnostic System to confirm sensor function.

Fault Code	SPN	FMI
Code P0118	**110**	**3**

Component:	Engine Temperature Sensor
Function:	Continuously measures engine temperature and transmits data to ECU
Fault:	Engine Temperature Sensor Circuit High Voltage or Open
Condition:	Shorted connection, faulty sensor, open connection or broken wire.
Possible Causes:	Temperature Sensor Related ● Sensor wiring or connection. Engine Wiring Harness Related ● Pin circuits ECU Black pin 10 and 14 may be damaged. ● ECU-to-harness connection problem or broken wire. System Related ● Engine is operating above 176°C (350°F) temperature sensor limit.
Testing:	See Engine Temperature Sensor (Lead). **Preferred Method:** Use Rehlko Diagnostic System to confirm sensor function.

Engine Temperature Sensor (Lead)

A sealed, non-serviceable assembly. A faulty sensor must be replaced. If a troubleshooting indicates a problem with temperature sensor, it can be tested as follows:

1. Remove temperature sensor from crankcase next to breather cover and cap or block sensor hole.
2. Wipe sensor clean and allow it to reach room temperature (25°C, 77°F).
3. Unplug Black connector from ECU
.4. With sensor still connected, check temperature sensor circuit resistance between Black pin 10 and 14 terminals. Value should be 9000-11000 Ω.
5. Unplug sensor from wire harness and check sensor resistance separately across two pins. Resistance value should again be 9000-11000 Ω.
   a. If resistance is out of specifications, replace temperature sensor.
   b. If it is within specifications, proceed to Step 6.
6. Check circuits (input, ground), from wire harness connector to sensor plug for continuity, damage, etc. Connect one ohmmeter lead to Black pin 14 in wire harness connector (as in step 4). Connect other lead to terminal #1 in sensor plug. Continuity should be indicated. Repeat test between Black pin 10 and terminal #2 in sensor plug.

Fault Code	SPN	FMI
Code P0122	**51**	**4**

Component:	Throttle Position Sensor (TPS)
Function:	Monitors throttle plate angle and transmits data to ECU
Fault:	TPS Circuit Low Voltage or Open
Condition:	Open connection, broken wire or faulty sensor.
Possible Causes:	TPS Related ● TPS bad or worn internally. Engine Wiring Harness Related ● Broken or shorted wire in harness. ECU Black pin 10 to TPS pin 1. ECU Black pin 12 to TPS pin 3. ECU Black pin 16 to TPS pin 2. Throttle Body Related ● Throttle shaft inside TPS worn, broken, or damaged. ● Throttle plate loose or misaligned. ● Throttle plate bent or damaged allowing extra airflow past, or restricting movement. ECU Related ● Circuit providing voltage or ground to TPS damaged. ● TPS signal input circuit damaged.
Testing:	See Throttle Position Sensor (TPS) troubleshooting. **Preferred Method:** Use Rehlko Diagnostic System to confirm sensor function.

Fault Code	SPN	FMI
Code P0123	**51**	**3**

Component:	Throttle Position Sensor (TPS)
Function:	Monitors throttle plate angle and transmits data to ECU
Fault:	TPS Circuit High Voltage
Condition:	Shorted connection or faulty sensor.
Possible Causes:	TPS Sensor Related ● Sensor connector or wiring. Throttle Body Related ● Throttle shaft or bearings worn/damaged. Engine Wiring Harness Related ● ECU pins Black 10, 12 and 16 damaged (wiring, connectors). ● ECU pins Black 10, 12 and 16 routed near noisy electrical signal (coils, stator). ● Intermittent 5 volt source from ECU (pin Black 16). ● ECU-to-harness connection problem.
Testing:	See Throttle Position Sensor (TPS) troubleshooting. **Preferred Method:** Use Rehlko Diagnostic System to confirm sensor function.

Throttle Position Sensor (TPS) Troubleshooting

TPS is a sealed, non-serviceable internal part of electronic throttle body assembly. If diagnosis indicates a bad sensor, complete electronic throttle body replacement is necessary. Throttle body is serviced as an assembly, with throttle shaft, TPS, throttle plate, and idle speed adjusting screw installed. Throttle shaft rotates on needle bearings (non-serviceable), capped with seals to prevent air leaks. If a troubleshooting indicates a problem with TPS, it can be tested as follows:

Diagnostics of sensor: ECU will still have electrical faults captured in fault codes: P0122 & P0123. These electrical faults still have same meaning as with prior sensor, P0122 detecting low voltage, open circuit, and P0123 for high voltage conditions between ECU, wire harness, and sensor. Tip: when working with any electrical connection, remember to keep connections clean & dry. This is best accomplished by cleaning connection thoroughly prior to disassembly. Contaminated sensor connections can cause premature engine faults. Functionally testing sensor can no longer be done with simple resistance checks. If either of these two faults is present or a TPS fault is suspected, recommended diagnostic test is as follows:

NOTE: ECU Reset is required if throttle body is replaced.

If Rehlko Diagnostic System (KDS) Gen 2 is available (see Tools and Aids) Refer to page 19.

Observe throttle percent and raw TPS values through diagnostic tool. With diagnostic tool communicating to ECU and key ON engine not running, these values can be observed using Throttle Position test within tool test options. Select Throttle Position Test, (see instructions within help (?) area of test.) Select desired percent of throttle opening. (For example, 50% requested opening will yield 50% TPS opening +/- 5%.) It is recommended to perform multiple tests in different throttle opening positions. (For example, 10%, 50%, and 100%.) If any of these tests are found to be outside of specified range, it is recommended to power engine down, wait 15 seconds, turn engine key switch power to ON position, and using diagnostic tool, repeat Throttle Opening Test. If values again are found to be outside of specified range, it is recommended to replace electronic throttle body assembly. If no results are found while performing this test, a small load or gentle back and forth motion can be applied to connectors or wires just outside connectors to detect a faulty connection.

Fault Code	SPN	FMI
Code P0131	**3056**	**4**

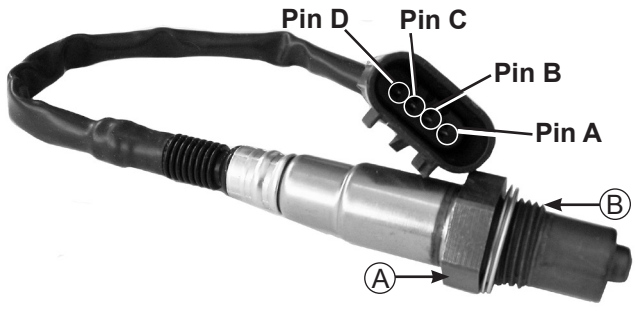
Component:	Oxygen Sensor
Function:	Measure exhaust oxygen content
Fault:	O2S 1 Circuit Low Voltage
Condition:	Open connection, broken wire or faulty sensor.
Possible Causes:	Oxygen Sensor Related ● Sensor connector or wiring problem. ● Sensor contaminated, corroded or damaged. ● Poor ground path. ● Pin circuit wiring or connectors. ECU Black pin 10 or 17. TPS Auto-Learn Incorrect ● Lean condition (check oxygen sensor signal with VOA and see Oxygen Sensor). Engine wiring harness related such as a cut wire, broken or pinched.
Testing:	See troubleshooting starting on page 44.

Fault Code	SPN	FMI
Code P0132	**3056**	**3**

Component:	Oxygen Sensor
Function:	Measure exhaust oxygen content
Fault:	O2S 1 Circuit High Voltage
Condition:	Shorted connection or faulty sensor.
Possible Causes:	Oxygen Sensor Related ● Sensor connector or wiring problem. ● Sensor contaminated or damaged. ● Poor ground path. ● Pin circuit wiring or connectors. ECU Black pin 10 or Black pin 17. Engine Wiring Harness Related ● Difference in voltage between sensed voltage and actual sensor voltage. ● Short in wire harness.
Testing:	See troubleshooting starting on page 44.

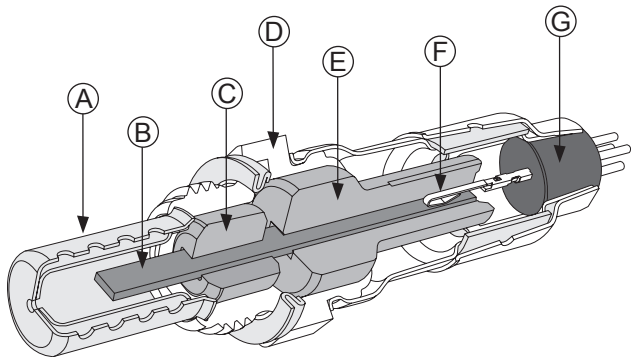
Oxygen Sensor (O2)

Design Detail



Pin A	Heater +	**Pin B**	Heater -
Pin C	Sensor Output	**Pin D**	Sensor Ground
A	22 mm or 7/8 in. Wrench Size	**B**	18 mm x 1.5 Thread Size
Installation Torque 50.1 N·m (37 ft. lb.)			

Cutaway Oxygen Sensor Components (O2)



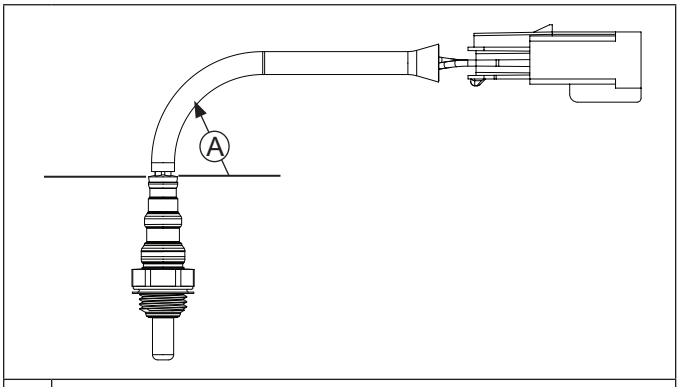
A	Protection Shield	**B**	Planar Element and Heater
C	Lower Insulator	**D**	Stainless Steel Housing
E	Upper Insulator	**F**	Terminal Connection to Element
G	High Temp Water Seal		

Absolute accuracy requires lab equipment, and intermittent faults remain difficult to pinpoint. However, solid system knowledge enables reliable diagnosis of most common faults.

Using Rehlko Diagnostic System (KDS) Gen 2, (see Tools and Aids), connected to ECU is a useful technique for observing sensor performance. However, user must understand that such software reads a signal generated by ECU. If there is an ECU or wiring problem, readings could be misinterpreted as a sensor problem. Digital nature of signal to diagnostic tool means that it is not reading continuous output of sensor. A voltmeter can also be used as an effective tool in diagnosing sensors.

Using "Adjust Injector Time" test within the diagnostic tool software will aid in testing operation of O2 sensor. See instructions within help (?) area of test.

Visual Inspection
Sensor Wire Detail



A	Keep a minimum of 25 mm (1.0 in.) radius at grommet.

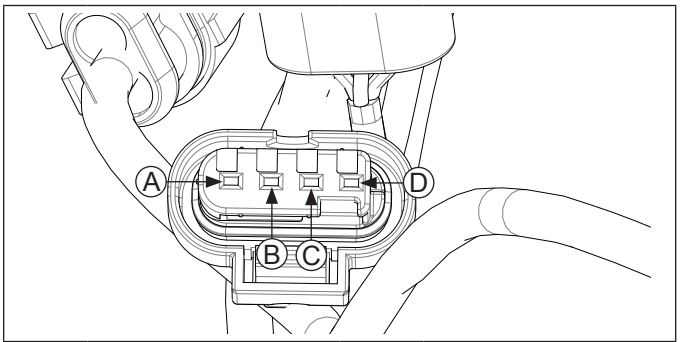
NOTE: Always route harness away from hot exhaust and away from moving parts.

NOTE: **Do not attempt to clean sensor.** Replace as needed.

1. Look for a damaged or disconnected sensor-to-engine harness connection.
2. Look for damage to sensor lead wire or associated engine wiring due to cutting, chaffing or melting on a hot surface.
3. Disconnect sensor connector and look for corrosion in connector.
4. Try reconnecting sensor and observe if problem has cleared.
5. Correct any problems found during visual check.
6. Inspect for any exhaust system leaks upstream or downstream of oxygen sensor. Confirm oxygen sensor is secured to 50.1 N·m (37 ft. lb.).

   All leaks must be repaired and an ECU reset must be performed before proceeding with sensor testing.
7. Using diagnostic tool, document any trouble codes. Determine if historic trouble codes are logically related to current fault experienced. If uncertain, clear codes and retest.

Sensor Signal Observation
Engine Harness O2 Sensor Connector Plug Detail



A	Red w/Black Stripe	**B**	Dark Green
C	Purple	**D**	Black

NOTE: **Do not cut into or pierce sensor or engine wiring to make this connection.** Sensor produces a very small signal. Corrosion or damage to wiring could lead to an incorrect signal because of repairs or contamination to sensor.

1. With sensor connected and using Rehlko Diagnostic System (KDS) Gen 2, see Tools and Aids, start engine to observe O2 sensor activity. Run engine at sufficient speed to bring sensor and engine up to operating temperature (engine temperature of 150°F (66°C) or more displayed by Diagnostic tool).

   Maintained throttle openings of less than 20% typically display closed loop operation where sensor output voltage should cycle between 0.05 to 0.95 Volts.

   Maintained throttle openings of 30-40% and above typically display open loop operation where sensor should have above 0.500 Volt. Occasional spikes outside these values is normal. Lack of continuous fluctuation is not an indication of a defective sensor.
2. With key ON and engine OFF, sensor connected, using diagnostic software, O2 volts displayed should be more than 1.0 volt. This voltage is generated by ECU. If not present, there may be a power and/or ground supply fault to engine harness or ECU, a fault of engine harness itself (refer to Visual Inspection), or a fault of ECU.

   It is advisable to use an electronic meter such as a digital voltmeter. Simple mechanical meters may place a heavy electrical load on sensor and cause inaccurate readings. Since resistance of sensor is highest at low temperatures, such meters will cause largest inaccuracies when sensor is in a cool exhaust.

   With key ON and sensor unplugged, using a digital voltmeter, observe voltage between Pin socket C and Pin socket D of engine wiring harness (refer to engine harness connector plug detail on page). Voltage should read approximately 5.0 volts.
3. Using a digital voltmeter, observe system sensor voltage between Pin socket A and negative (-) battery ground. Battery voltage should be seen. If battery voltage is not seen, inspect engine wiring, fuses, and/or electrical connections.

Sensor Removal Inspection

NOTE: Apply anti-seize compound only to threads. **Anti-seize compound will affect sensor performance if it gets into lower shield of sensor.**

1. If sensor has heavy deposits on lower shield, engine, oil, or fuel may be source.
2. If heavy carbon deposits are observed, incorrect engine fuel control may be occurring.
3. With sensor at room temperature measure heater circuit resistance, Heater + (Pin A) and Heater - (Pin B), resistance should be 8.1-11.1 Ω.
4. If a damaged sensor is found, identify root cause, which may be elsewhere in application. Refer to Troubleshooting-Oxygen (O2) Sensor table.
5. A special "dry to touch" anti-seize compound is applied to all new oxygen sensors at factory. If recommended mounting thread sizes are used, this material provides excellent anti-seize capabilities and no additional anti-seize is needed. If sensor is removed from engine and reinstalled, anti-seize compound should be reapplied. Use an oxygen sensor safe type anti-seize compound. It should be applied according to directions on label. Torque sensor to 50.1 N·m (37 ft. lb.).

Troubleshooting-Oxygen (O2) Sensor

Condition	Possible Cause	Conclusion
Continuous low voltage output (less than 400mV) observed with throttle openings of 40% or more (lean biased condition). Fault codes P0131, P0171, or P0174 may set.	Shorted sensor or sensor circuit. Shorted lead wire. Wiring shorted to ground.	Replace sensor or replace and properly route wiring.
	Upstream or downstream exhaust leaks observed. Air leak at sensor.	Repair all exhaust leaks and torque sensor to 50.1 N·m (37 ft. lb.).
	Restricted fuel supply.	Resolve fuel supply issues from tank to engine. Test fuel pressure. Perform repairs necessary.
	Misfire	A misfire causing incomplete combustion will result in lean (low voltage) values.
	Lean biased sensor failure.	Replace sensor.
Continuous high voltage output (600mV or more) observed with throttle openings of 40% or less (rich biased condition). Fault codes P0172 or P0132 may set.	Silica poisoning.	Replace sensor. Identify and resolve root cause.
	Contaminated gasoline.	Purge fuel system and retest.
	Wiring shorted to voltage.	Replace damaged harness.
	Overly rich condition due to unmetered fuel entering combustion chamber.	Test fuel pressure. Inspect fuel pump vent and evaporative emissions hoses for raw fuel flow. Inspect engine oil for fuel contamination; drain and refill if suspect. Perform repairs as necessary.
	Cold engine. Engine temperature below 150°F (66°C) as displayed by Rehlko® Diagnostic System (KDS) Gen 2, see Tools and Aids.	Normal operation, or engine operated in an excessively cold environment.
	Rich biased sensor failure.	Replace sensor.
No activity from sensor. KDS tool displays 1.015 Volts continuously. Fault codes P0031 or P0032 may set.	Heater circuit open or shorted.	Replace sensor.
	Engine keyed ON with sensor disconnected. Historic codes.	Secure and/or confirm sensor connection and clear codes.
	Contaminated gasoline.	Purge fuel system and retest.

Fault Code	SPN	FMI
Code P0171	**4237**	**0**

Component:	Fuel System
Function:	Fuel Delivery
Fault:	Maximum adaptation limit exceeded
Condition:	Fuel inlet screen/filter plugged, low pressure at high pressure fuel line, TPS malfunction, shorted connection, faulty O2 sensor, low fuel or wrong fuel type.
Possible Causes:	Oxygen Sensor Related ● Corrosion or poor connection. ● Sensor contaminated or damaged. ● Air leak into exhaust. ● Poor ground path. ● Pin circuit wiring or connectors. ECU Black pin 10 or Black pin 17. TPS Sensor Related ● Throttle plate position incorrect during Auto-Learn. ● TPS problem or malfunction. Engine Wiring Harness Related ● Difference in voltage between sensed voltage and actual sensor voltage. ● Problem in wiring harness. ● ECU-to-harness connection problem. Systems Related ● Ignition (spark plug, plug wire, ignition coil). ● Fuel (fuel type/quality, injector, fuel pressure too low, fuel pump module or lift pump). ● Combustion air (air cleaner dirty/ restricted, intake leak, throttle bore). ● Base engine problem (rings, valves). ● Exhaust system leak (muffler, flange, oxygen sensor mounting boss, etc.). ● Fuel in crankcase oil. NOTE: ECU reset required to clear this code. See page 34.
Testing:	See troubleshooting starting on page 46.

Fault Code	SPN	FMI
Code P0172	**4237**	**1**

Component:	Fuel System
Function:	Fuel Delivery
Fault:	Minimum adaptation limit exceeded
Condition:	Too high pressure at high pressure fuel line, TPS malfunction, shorted connection, faulty O2 sensor or fuel pump module failure.
Possible Causes:	Oxygen Sensor Related ● Sensor connector or wiring. ● Sensor contaminated or damaged. ● Poor ground path. ● Pin circuit wiring or connectors. ECU Black pin 10 or Black pin 17. TPS Sensor Related ● Throttle plate position incorrect during Auto-Learn. ● TPS problem or malfunction. Engine Wiring Harness Related ● Difference in voltage between sensed voltage and actual sensor voltage. ● Problem in wiring harness. ● ECU-to-harness connection problem. Systems Related ● Ignition (spark plug, plug wire, ignition coil). ● Fuel (fuel type/quality, injector, fuel pressure too high, fuel pump module or lift pump). ● Combustion air (air cleaner dirty/ restricted). ● Base engine problem (rings, valves). ● Fuel in crankcase oil. ● Fuel pump module is over filled. ● Lift pump diaphragm is ruptured. NOTE: ECU reset required to clear this code. See page 34.
Testing:	See troubleshooting starting on page 46.

Fault Code	SPN	FMI
Code P0174	**4237**	**31**

Component:	Fuel System
Function:	Fuel Delivery
Fault:	Lean fuel condition
Condition:	Fuel inlet screen/filter plugged, low pressure at high pressure fuel line, TPS malfunction, shorted connection or faulty sensor.
Possible Causes::	TPS Auto-Learn Incorrect ● Lean condition (check oxygen sensor signal with VOA and see Oxygen Sensor). Engine Wiring Harness Related ● Pin circuit wiring or connectors. ECU pin Black 10, 12, 16 and 17. Low Fuel Pressure ● Plugged filters. ● Bad lift pump. ● Vapor lock. Oxygen Sensor Related ● Sensor connector or wiring problem. ● Exhaust leak. ● Poor ground. ● Contaminated sensor. Poor system ground from ECU to engine, causing rich running while indicating lean. Fuel pump module connection. See Fuel Components.
Testing:	See troubleshooting starting on page 46.

Fault Code	SPN	FMI
Code P0201	**651**	**31**

Component:	Fuel Injector
Function:	ECU controlled valve that injects fuel into cylinder
Fault:	Injector 1 Circuit Malfunction
Condition:	Injector damaged or faulty, shorted or open connection.
Possible Causes:	Injector Related ● Injector coil shorted or opened. Engine Wiring Harness Related ● Broken or shorted wire in harness. ECU pin Black 5. ● Wiring from Ignition. ECU Related ● Circuit controlling injector #1 damaged.
Testing:	See troubleshooting on page 51.

Fault Code	SPN	FMI
Code P0202	**652**	**31**

Component:	Fuel Injector
Function:	ECU controlled valve that injects fuel into cylinder
Fault:	Injector 2 Circuit Malfunction
Condition:	Injector damaged or faulty, shorted or open connection.
Possible Causes:	Injector Related ● Injector coil shorted or opened. Engine Wiring Harness Related ● Broken or shorted wire in harness. ECU pin Black 6. ● Wiring from Ignition. ECU Related ● Circuit controlling injector #2 damaged.
Testing:	See troubleshooting on page 49.

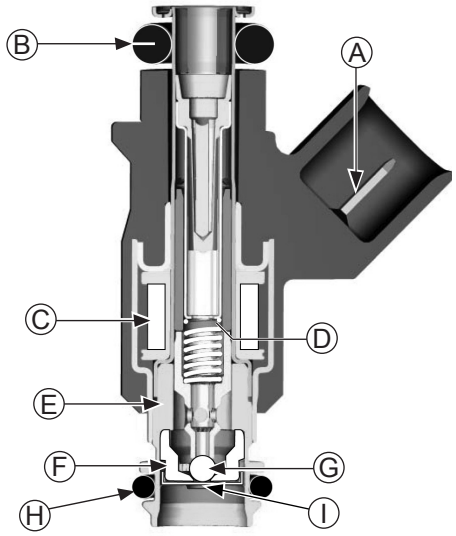
Fuel Injectors

⚠ WARNING

Explosive Fuel can cause fires and severe burns.

Fuel system ALWAYS remains under HIGH PRESSURE.

Wrap a shop towel completely around fuel pump module connector. Press release button(s) and slowly pull connector away from fuel pump module allowing shop towel to absorb any residual fuel in high pressure fuel line. Any spilled fuel must be completely wiped up immediately.



A	Electrical Connection	**B**	Upper O-ring
C	Solenoid Winding	**D**	Armature
E	Valve Housing	**F**	Valve Seat
G	Valve End	**H**	Lower O-ring
I	Director Plate		

NOTE: Do not apply voltage to fuel injector(s). Excessive voltage will burn out injector(s). Do not ground injector(s) with ignition ON.

NOTE: When cranking engine with injectors disconnected, fault codes will be registered in ECU and will need to be cleared using software fault clear or an ECU Reset Procedure.

Injector problems typically fall into three general categories: electrical, dirty/clogged, or leakage. An electrical problem usually causes one or both of injectors to stop functioning. Several methods may be used to check if injectors are operating.

1. With engine running at idle, listen for a buzzing or clicking sound.
2. Disconnect electrical connector from an injector and listen for a change in idle performance (only running on one cylinder) or a change in injector noise or vibration.
3. Using Rehlko Diagnostic System (KDS) Gen 2, see Tools and Aids, perform Adjust Injector Timing test or Injector #1 or #2 test as found in test section of tool. See instructions within help (?) area of each test.

If an injector is not operating, it can indicate either a bad injector, or a wiring/electrical connection problem. Check as follows:

1. Disconnect electrical connector from both injectors. Plug a 12 volt noid light into one connector.
2. Make sure all safety switch requirements are met. Crank engine and check for flashing of test light. Turn key OFF for at least 10 seconds between tests to allow ECU to go to sleep and reawake. Repeat test at other connector.
   a. If flashing occurs, use an ohmmeter (Rx1 scale) and check resistance of each injector across two terminals. Proper resistance is 11-13 Ω. If injector resistance is correct, check whether connector and injector terminals are making a good connection. If resistance is not correct, replace injector.

Check all electrical connections, connectors, and wiring harness leads if resistance is incorrect.

Injector leakage is very unlikely, but in those rare instances it can be internal (past tip of valve needle), or external (weeping around injector O-rings). Loss of system pressure from leakage can cause hot restart problems and longer cranking times. To check for leakage it will be necessary to loosen or remove blower housing which may involve removing engine from unit. Refer to Disassembly for removal of injector.

1. Remove manifold mounting bolts and separate throttle body/manifold from engine leaving TPS, high pressure fuel line, injectors and fuel line connections intact. Discard old gaskets.
2. Position manifold assembly over an appropriate container to capture fuel and turn key switch ON to activate fuel pump and pressurize system. Do not turn switch to START position.
3. If either injector exhibits leakage of more than two to four drops per minute from tip, or shows any sign of leakage around outer shell, turn ignition switch OFF and replace injector as follows.
4. Depressurize fuel system.
5. Clean any dirt accumulation from sealing/mounting area of faulty injector(s) and disconnect electrical connector(s).
6. Pull retaining clip off top of injector(s). Remove screw holding injector(s) from manifold.
7. Reverse appropriate procedures to install new injector(s) and reassemble engine. Use new O-rings and retaining clips any time an injector is removed (new replacement injectors include new O-rings and retaining clips). Lubricate O-rings lightly with clean engine oil. Use installation tool provided with O-rings to install new upper O-ring. Place tool into fuel injector inlet. Place one side of O-ring into O-ring groove and roll O-ring over tool onto fuel injector. Torque screw securing fuel injector caps and blower housing mounting screws to 7.3 N·m (65 in. lb.), and intake manifold and air cleaner mounting screws to 10.5 N·m (93 in. lb.). An ECU Reset will need to be completed.

Fault Code	SPN	FMI
Code P0217	**110**	**0**

Component:	Engine Overheat Warning
Fault:	Overheat
Condition:	Engine operating at or above recommended temperature limit.
Possible Causes:	Throttle opening is limited, value varies by engine model. ● Ramps in and out of limit. Provides an alert to operator of a condition that may cause damage to engine. ● Typically this is remedied by clearing debris blocking engine cooling air flow.
Testing:	Perform visual inspection to ensure engine cooling system is clean and clear of debris.

Fault Code	SPN	FMI
Code P0230	**1347**	**5**

Component:	Electric Fuel Pump
Function:	Increases Fuel Pressure
Fault:	Circuit Low Voltage or Open
Condition:	Shorted or open connection.
Possible Causes:	Fuel Pump Related ● Fuel pump module open or shorted internally. Engine Wiring Harness related ● Broken or shorted wire in harness. ECU pin Black 9 or Grey 17. ECU Related ● ECU is damaged.
Testing:	See possible causes and additional troubleshooting starting on page 50.

Fault Code	SPN	FMI
Code P0232	**1347**	**6**

Component:	Electric Fuel Pump
Function:	Increases Fuel Pressure
Fault:	Circuit High Voltage
Condition:	Shorted Connection
Possible Causes:	Fuel Pump Related ● Fuel pump module damaged internally Charging System Output Too High
Testing:	See possible causes and additional troubleshooting starting on page 50.

Electric Fuel Pump Function Test

⚠ WARNING

High Pressure Fluids can puncture skin and cause severe injury or death.

Do not work on fuel system without proper training or safety equipment.

Fluid puncture injuries are highly toxic and hazardous. If an injury occurs, seek immediate medical attention.

Function of fuel system is to provide sufficient delivery of fuel at system operating pressure of 39 psi ± 3. If an engine starts hard, or turns over but will not start, it may indicate a problem with EFI fuel system. A quick test will verify if system is operating.

1. Disconnect and ground spark plug leads.
2. Complete all safety interlock requirements and crank engine for approximately 3 seconds.
3. Remove spark plugs and check for fuel at tips.
   a. If there is fuel at tips of spark plugs fuel pump and injectors are operating.
   b. If there is no fuel at tips of spark plugs, check following:
      1. Make sure fuel tank contains clean, fresh, proper fuel.
      2. Make sure that vent in fuel tank is open.
      3. Make sure fuel tank valve (if equipped) is fully opened.
      4. Make sure battery is supplying proper voltage.
      5. Check that fuses are good, and that no electrical or fuel line connections are damaged or broken.
      6. Test fuel pump module operation as described earlier under Fuel Pump Module in following section.

High Pressure Fuel Line

High pressure fuel line is mounted to intake manifold. No specific servicing is required unless operating conditions indicate that it needs replacement. Thoroughly clean area around all joints and relieve any pressure before starting any disassembly. Detach by removing two mounting screws, wire ties, and injector retaining clips.

Purge Port and Vent Hose Assembly

No specific servicing is required for vent hose assembly or purge port unless operating conditions indicate replacement is required. All components are serviced individually. Abrasion sleeves on hoses should be reused or replaced when servicing vent hoses. Please note vent hose routing and replicate after service or component replacement to prevent pinching or abrasion of vent hoses. Only Rehlko replacement parts can be used because fitting is specific to system and must be maintained. Visit Engines.rehlko.com for recommended Rehlko replacement parts.

⚠ WARNING

Explosive Fuel can cause fires and severe burns.

Fuel system ALWAYS remains under HIGH PRESSURE.

Wrap a shop towel completely around fuel pump module connector. Press release button(s) and slowly pull connector away from fuel pump module allowing shop towel to absorb any residual fuel in high pressure fuel line. Any spilled fuel must be completely wiped up immediately.

Fuel Pump Module (FPM)

FPM is not serviceable and must be replaced if determined to be faulty. If a FPM problem is suspected, make certain pump is being activated, all electrical connections are properly secured, fuses are good. If required, testing of fuel pump may be conducted.

FPM can be tested using Rehlko® Diagnostic System (KDS) Gen 2, see Tools and Aids. Select Engine>Tests>Fuel Pump Test and follow instructions in help (?) area of test.

NOTE: Fuel pump module pins are coated with a thin layer of electrical grease to prevent fretting and corrosion. Do not attempt to remove electrical grease from fuel pump module pins.

1. Relieve fuel pressure at FPM. FPM may need to be loosened or pulled away from engine. Press release button(s) and slowly pull connector away from FPM allowing shop towel to absorb any residual fuel in high pressure fuel line. Insert pressure test jumper (from Rehlko EFI Service Kit) between high pressure fuel line and FPM.
2. Connect black hose of Pressure Tester. Route clear hose into a portable gasoline container or equipment fuel tank.
3. Turn on key switch to activate pump and check system pressure on gauge. It may take several key/power down cycles to compress air introduced into system and reach regulated pressure. System pressure of 39 psi ± 3 should be present. Turn key switch OFF and depress valve button on tester to relieve system pressure.
   a. If pressure is too high or too low, proceed to troubleshooting.
4. If pump did not activate (step 3), confirm that safety system on equipment is not active. One potential cause of unnecessary FPM replacement may involve measuring voltage at FPM electrical connector. Using a Digital Volt Ohm Meter (DVOM) will provide a reading near battery voltage, even when ECU is not grounding FPM circuit.
   a. Connect a DVOM across terminals in plug, turn on key switch and confirm battery voltage is present during six second prime process.
   b. Test light confirmation: Turn key off. Disconnect DVOM. Connect 12 volt test light across terminals in plug. Key needs to remain off for a minimum of 30 seconds before proceeding. Turn key on. Confirm test light illuminates for approximately 6 seconds. After approximately 6 seconds, test light will remain off unless another prime cycle is initiated.
5. If battery voltage is not present and/or test light does not illuminate, connect red lead of DVOM to red wire of plug and black lead to a battery ground while key is still ON.
6. If battery voltage is present, turn key switch OFF and connect an ohmmeter between terminals on FPM to check or continuity. If battery voltage at plug was confi rmed, and there was continuity across FPM terminals, reconnect plug to FPM, making sure you have a good connection. Turn on key switch and listen for FPM to activate.
   a. If FPM starts, repeat steps 2 and 3 to verify correct pressure.
   b. If FPM still does not operate, replace it.
7. If battery voltage was not present at connector inspect fuse and wiring harness

Fault Code	SPN	FMI
Code P0336	**636**	**2**

NOTE: P0336 can be caused by an incorrect sensor air gap or debris on the sensor face disrupting the magnetic signal. Visually confirm that sensor is clean and gapped correctly.

Component:	Crankshaft Position Sensor
Function:	Monitors rotation and speed (RPM) of crankshaft.
Fault:	Crankshaft Position Sensor Noisy Signal
Condition:	Loose sensor, faulty/bad battery, shorted or faulty connection, faulty sensor or faulty sensor grounding.
Possible Causes:	Crankshaft Position Sensor Related ● Sensor connector or wiring. ● Sensor loose. Crankshaft Position Sensor Wheel Related ● Damaged teeth. ● Gap section not registering. Engine Wiring Harness Related ● Pin circuit wiring or connectors. ECU pin Black 4 and Black 13 may be routed near noisy signal (coils, stator, etc.). ● ECU-to-harness connection problem. Ignition System Related ● Non-resistor spark plug(s) used. ● Faulty or disconnected ignition coil or secondary lead.
Testing:	Perform visual inspection and check for loose sensor, faulty/bad battery, shorted or faulty connection, faulty sensor or faulty sensor grounding.

Fault Code	SPN	FMI
Code P0337	**636**	**8**

NOTE: If P0337 is present and engine operates, clear codes and retest. If Fault Code diagnosis indicates a problem within this area, proceed with testing.

Component:	Crankshaft Position Sensor
Function:	Monitors rotation and speed (RPM) of crankshaft.
Fault:	Crankshaft Position Sensor No Signal
Condition:	Loose sensor, open or shorted connection (sensor connector or battery connections) or faulty sensor.
Possible Causes:	Crankshaft Position Sensor Related ● A false fault code P0337 is triggered by a voltage drop with key ON and engine off. Voltage drop may be caused by a poor/inadequate battery connection, battery charger connected or disconnected, or any event that may interrupt voltage signal to ECU like a power interruption or heavy load from equipment that results in a recordable voltage drop. ● Sensor connector or wiring. ● Sensor loose. Crankshaft Position Sensor Wheel Related ● Damaged teeth. Engine Wiring Harness Related ● Pin circuit wiring or connectors. ECU pin Black 4 or Black 13. ● ECU-to-harness connection problem. If code is stored in fault history and starts normally. Clear code, no other service required.
Testing:	1. Check mounting and air gap of crankshaft position sensor. 2. Inspect wiring and connections for damage or problems. 3. Make sure engine has resistor type spark plugs. 4. Disconnect Black connector from ECU. 5. Connect an ohmmeter between #4 and #13 pin terminals. A resistance value of 325-395 Ω at room temperature (20°C, 68°F) should be obtained. If resistance is correct, check mounting, air gap, flywheel teeth (damage, run-out, etc.), and flywheel key. 6. Disconnect crankshaft position sensor connector from wiring harness. Test resistance between terminals. A reading of 325-395 Ω should again be obtained. a. If resistance is incorrect, remove screws securing sensor to mounting bracket and replace sensor. b. If resistance in step 5 was incorrect, but resistance of sensor alone was correct, test wire harness circuits between sensor connector terminals and corresponding pin terminals (#4 and #13) in main connector. Correct any observed problem, reconnect sensor, and perform step 5 again. 7. When fault is corrected and engine starts, clear fault codes following ECU Reset procedure. **Using the Rehlko diagnostic system Gen 2 (software must be registered-see details earlier in this section):** 1. Confirm battery voltage is above 12.4 Volts. 2. Connect Diagnostic System to engine and observe 3. Select engine>live data>main data display 4. While cranking engine, observe RPM display. If the scan tool registers any RPM above 0 during cranking, the sensor is functioning properly.

Fault Code	SPN	FMI
Code P0351	**1268**	**31**

Component:	Ignition Coil
Function:	Transforms low battery voltage into a high-voltage pulse that generates spark needed for combustion
Fault:	Cylinder 1 Ignition Coil Malfunction
Condition:	Broken/shorted wire in harness (may not be visible), shorted connection or faulty sensor.
Possible Causes:	Engine Wiring Harness Related ● Connection to ignition or fuse. ● Pin circuit wiring or connectors. ● ECU pin Black 1. ● ECU-to-harness connection problem. Ignition System Related ● Incorrect spark plug(s) used. ● Poor connection to spark plug.
Testing:	See Ignition Coil Troubleshooting Chart

Fault Code	SPN	FMI
Code P0352	**1269**	**31**

Component:	Ignition Coil
Function:	Transforms low battery voltage into a high-voltage pulse that generates spark needed for combustion
Fault:	Cylinder 2 Ignition Coil Malfunction
Condition:	Broken/shorted wire in harness (may not be visible), shorted connection or faulty sensor.
Testing:	See troubleshooting chart
Possible Causes:	Engine Wiring Harness Related ● Connection to ignition or fuse. ● Pin circuit wiring or connectors. ● ECU pin Black 1. ● ECU-to-harness connection problem. Ignition System Related ● Incorrect spark plug(s) used. ● Poor connection to spark plug.
Conclusion:	Engine Wiring Harness Related ● Connection to ignition or fuse. ● Pin circuit wiring or connectors. ECU pin Grey 10. ● ECU-to-harness connection problem. Ignition System Related ● Incorrect spark plug(s) used. ● Poor connection to spark plug.
Testing:	See Ignition Coil Troubleshooting Chart

Ignition Coil Troubleshooting

An ohmmeter may be used to test wiring and coil windings.

NOTE: Do not ground primary coil with ignition ON as they may overheat or spark.

NOTE: Always disconnect spark plug lead from spark plug before performing following tests.

NOTE: **If ignition coil(s) are disabled and an ignition fault is registered, system will automatically disable corresponding fuel injector drive signal.** Fault must be corrected to ignition coil and ECU power (switch) must be turned OFF for 10 seconds for injector signal to return. This is a safety measure to prevent bore washing and oil dilution.

Testing

Using an ohmmeter set on Rx1 scale, check resistance in circuits as follows:

1. To check cylinder coil 1 (starter side), disconnect Black connector from ECU and test between Black pins 1 and 15. To check cylinder coil 2 (oil filter side), disconnect Grey connector from ECU and test between Grey pins 10 and 17. Wiring and coil primary circuits are OK if readings are 0.5-0.8 Ω.
2. If reading(s) are not within specified range, check and clean connections and retest.
3. If reading(s) are still not within specified range, test coils separately from main harness as follows:
   a. Remove screw retaining coil to housing and disconnect primary leads connector.
   b. Connect an ohmmeter set on Rx1 scale to primary terminals of coil. Primary resistance should be 0.5-0.8 Ω.
   c. Connect an ohmmeter set on Rx10K scale between spark plug boot terminal and B+ primary terminal. Secondary resistance should be 8000-18000 Ω.
   d. If secondary resistance is not within specified range, coil is faulty and needs to be replaced.

Using the Rehlko diagnostic system Gen 2 (software must be registered-see details earlier in this section):

1. Confirm battery voltage is above 12.4 Volts.
2. Connect Diagnostic System to engine and observe
3. Select engine>tests.
4. See instructions within help (?) area of each test.

Fault Code	SPN	FMI
Code P0562	**168**	**4**

Component:	System Voltage
Fault:	System Voltage Low
Condition:	Faulty voltage regulator, bad fuse or shorted connection.
Conclusion:	Corroded Connections Bad Stator Bad Battery ● Low output charging system. ● Poor magnet in flywheel. ● Bad or missing fuse.
Testing:	See electrical troubleshooting starting on page 62.

Fault Code	SPN	FMI
Code P0563	**168**	**3**

Component:	System Voltage
Fault:	System Voltage High
Condition:	Faulty voltage regulator or shorted connection.
Conclusion:	Faulty Rectifier-Regulator Bad Stator. Bad Battery.
Testing:	See electrical troubleshooting starting on page 62.

Fault Code	SPN	FMI
Code P2100	**5419**	**5**

Component:	Throttle Actuator Control Motor Circuit Open
Fault:	Low Current
Condition:	Throttle drive motor open circuit.
Conclusion:	Engine will only run at fixed low speed.
Testing:	See Throttle Actuator Troubleshooting

Fault Code	SPN	FMI
Code P2119	**5419**	**7**

Component:	Throttle Actuator
Fault:	Sticking/sticky/binding
Condition:	Throttle performance-binding
Conclusion:	Movement of throttle blade is restricted.
Testing:	See Throttle Actuator Troubleshooting

Throttle Actuator Troubleshooting

Using the Rehlko diagnostic system Gen 2 (software must be registered-see details earlier in this section):

1. Confirm battery voltage is above 12.4 Volts.
2. Connect Diagnostic System to engine and observe
3. Select engine>tests>Throttle Position Test.
4. See instructions within help (?) area of each test.

NOTE: ECU Reset is required if electronic throttle body is replaced. See page 34.

Electronic throttle body (ETB) is serviced as an assembly, with throttle shaft, TPS, and throttle plate installed. Throttle shaft rotates on needle bearings (non-serviceable), capped with seals to prevent air leaks.

Troubleshooting Flow Chart

Following flow chart provides an alternative method of troubleshooting EFI system. Chart will enable you to review entire system in about 10-15 minutes. Using chart, accompanying diagnostic aids (listed after chart), and any signaled fault codes, you should be able to quickly locate any problems within system.

NOTE: Either incandescent or LED type bulbs can be used for MIL as long as they do not draw more than 0.1 amps. Bulb needs to be rated at 1.4 Watts or less, or needs to have a total resistance of 140 Ω or more. LEDs typically draw less than 0.03 amps. All current fault codes will turn on MIL when engine is running.

Flow Chart Diagnostic Aids

Diagnostic Aid #1 SYSTEM POWER	
(MIL does not illuminate when key is turned ON) NOTE: MIL is installed by vehicle OEM. If no MIL is present, see note above. Twelve volt supply to bulb will be part of vehicle wire harness. Rehlko key switch model will have MIL on engine with 12V supply to bulb. *All current fault codes will turn on MIL when engine is running.	
Conclusion	• Battery • Main system fuse • MIL light bulb burned out • MIL electrical circuit problem Pin circuits Grey 3. • Ignition switch • Permanent ECU power circuit problem Pin circuit Black 18. • Switched ECU power circuit problem Pin circuit Black 15. • ECU grounds • ECU

Diagnostic Aid #2 FAULT CODES
Refer to Diagnostic Fault Code Summary.

Diagnostic Aid #3 CRANKSHAFT POSITION SENSOR	
(MIL does not turn off during cranking)	
Condition	• Crankshaft position sensor • Crankshaft position sensor circuit problem, pin circuits Black 4 and Black 13. • Crankshaft position sensor/toothed wheel air gap • Toothed wheel • Flywheel key sheared • ECU

Diagnostic Aid #4 FUEL PUMP	
(fuel pump not turning on	
Condition	• Main fuse • Fuel pump circuit problem, pin circuits Black 9 and Grey 17. • Fuel pump module

Diagnostic Aid #5 IGNITION SYSTEM	
(no spark)	
Condition	• Spark plug • Plug wire • Coil • Coil circuit(s), pin circuits Grey 10 and Black 1. • ECU grounds • ECU • Vehicle safety interlocks, ground signal on safety wire.

Diagnostic Aid #6 FUEL SYSTEM ELECTRICAL	
(no fuel delivery)	
Condition	• No fuel • Air in high pressure fuel line • Fuel valve shut OFF • Fuel filter/line plugged • Injector circuit(s), pin circuits Black 5 and Black 6 • Injector • ECU grounds • ECU • Lift pump not working

Diagnostic Aid #7 FUEL SYSTEM	
(fuel pressure)	
Low Fuel Pressure-Condition	• Fuel filter plugged • Fuel supply line plugged • Lift fuel pump - insufficient fuel supply • Fuel pump (lift or module) - internally plugged • Pressure regulator not functioning properly inside fuel pump module.

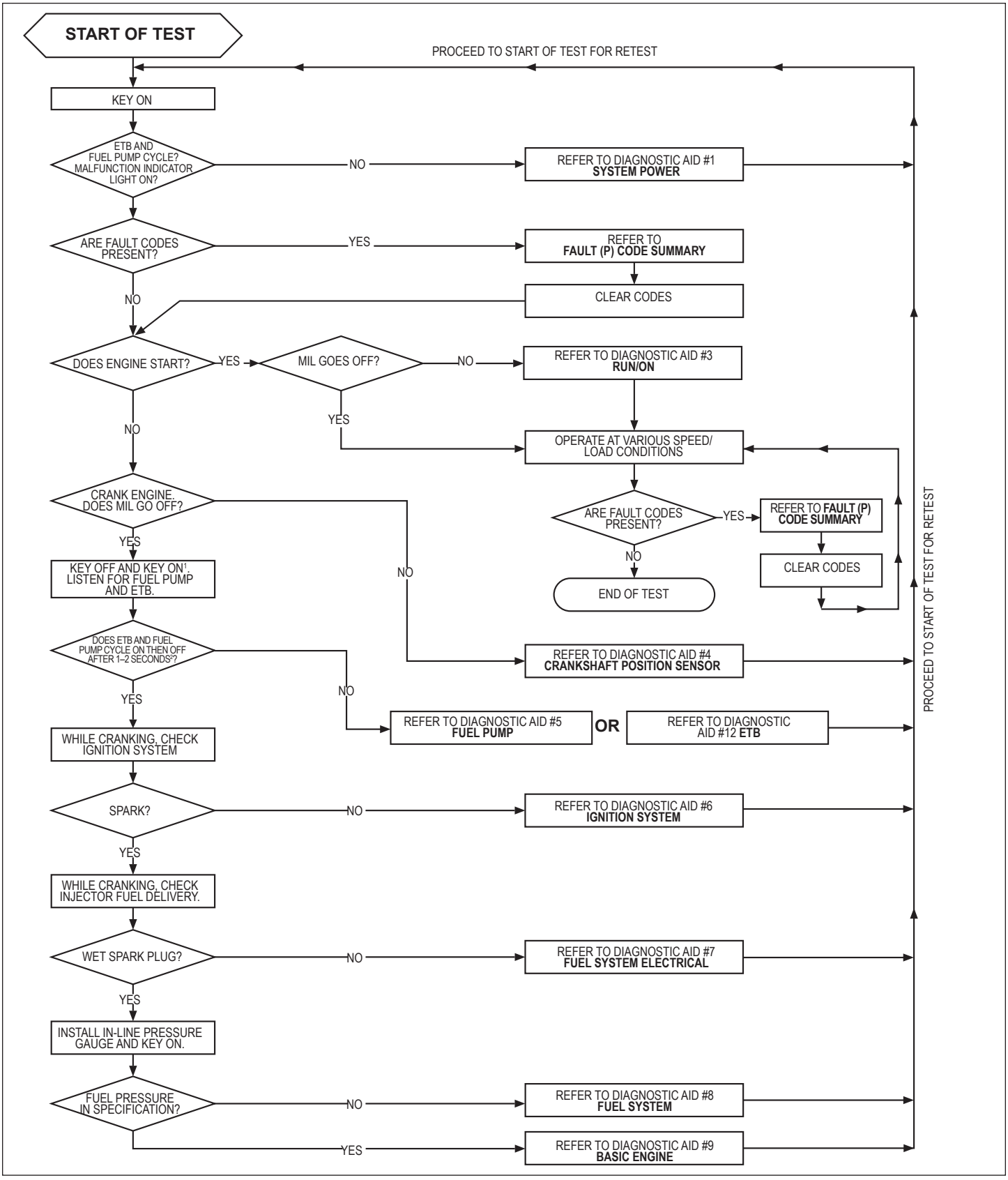
Diagnostic Aid #8 BASIC ENGINE	
(cranks but will not run)	
Condition	• Refer to basic engine troubleshooting charts within Troubleshooting.

Diagnostic Aid #9 SPEED CONTROL-Analog (0-5V input)	
(engine speed does not change when requested)	
Condition	● Speed request voltage from OEM controller is not being received by engine. Consult OEM service information for OEM diagnostics. ● Bad connection in speed input circuit (terminal G in engine connector, red w/ yellow tracer). ● Bad connection in engine connectors (ETB/equipment connector). ● Stuck/damaged ETB assembly.

Diagnostic Aid #10 SPEED CONTROL-CAN Communications	
(engine speed does not change when requested)	
Condition	● Speed request from OEM CAN controller is not being received by engine. Consult OEM service information for OEM diagnostics. ● Bad connection in engine connectors (ETB/equipment connector). ● Stuck/damaged ETB assembly.

Diagnostic Aid #11 ETB	
(ETB does not cycle when key is switched from off to on)	
Condition	● Blown power fuse ● Bad electrical connection ● Stuck throttle plate ● Defective throttle

EFI Diagnostic Flow Diagram



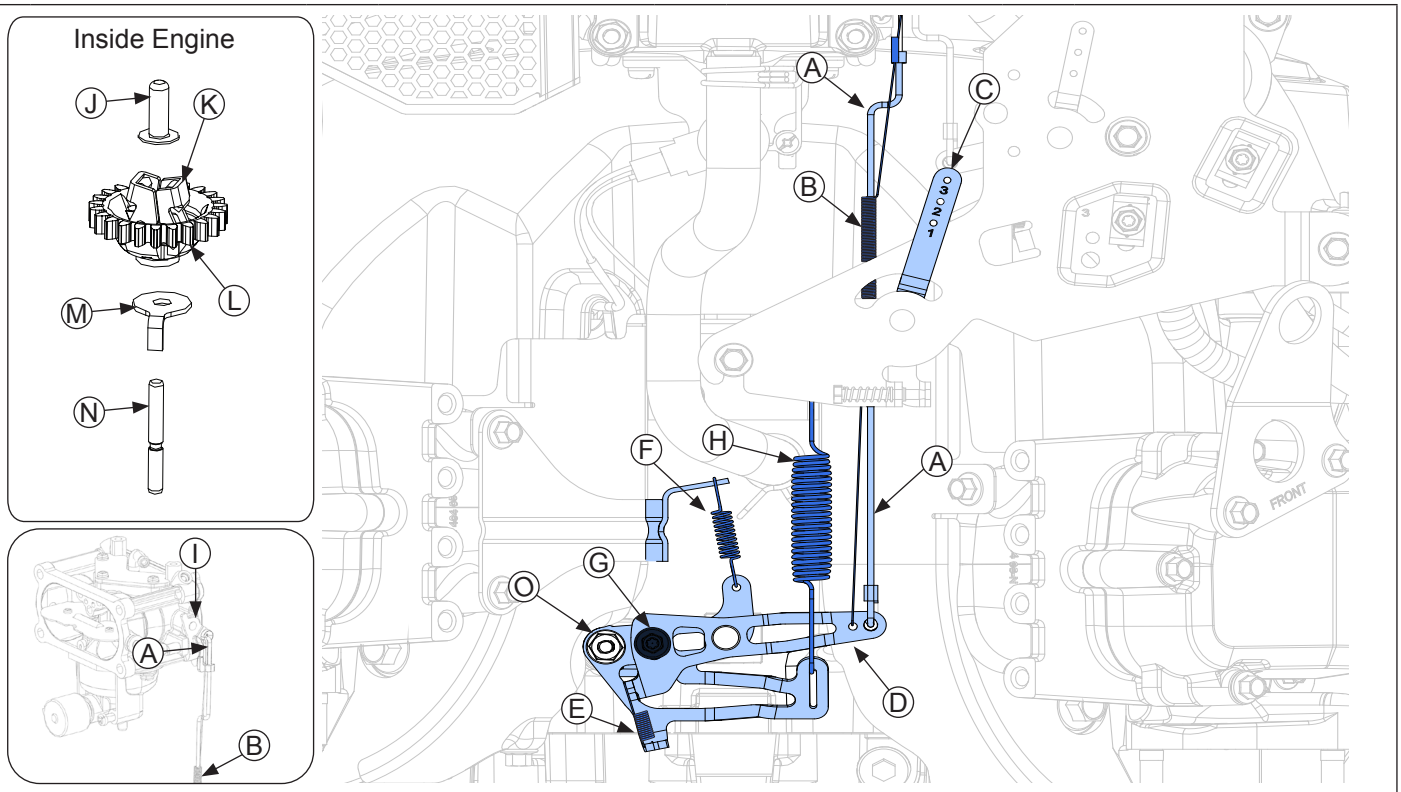
1. After turning key to OFF, wait 10 seconds before turning to ON to allow ECU to go to sleep.
2. Fuel pump module can be heard or a vibration can be felt to establish pump cycle. Fuel pump module will run for one 4-6 second cycle when ECU wakes up after being asleep.

MECHANICAL 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. Governor gear/flyweight mechanism is mounted inside oil pan and is driven off gear on camshaft.

Components



A	Throttle Linkage	**B**	Linkage Spring	**C**	Speed Control Linkage	**D**	Governor Lever Assembly
E	Governor Lever Assembly Spring	**F**	Governed Idle Spring	**G**	Left Hand Threaded Screw	**H**	Governor Spring
I	Throttle Lever	**J**	Regulating Pin	**K**	Flyweight	L	Governor Gear
M	Locking Tab Thrust Washer	**N**	Governor Gear Shaft	**O**	Governor Cross Shaft Nut		

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 throttle body through external linkage.
- When engine is at rest, and throttle is in FAST position, tension of governor spring holds throttle plate open. When engine is operating, governor gear assembly is rotating. Force applied by regulating pin against cross shaft tends to close throttle plate. Governor spring tension and force applied by regulating pin balance each other during operation, to maintain engine speed.
- When load is applied and engine speed and governor gear speed decreases, governor spring tension moves governor lever 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.

NOTE: If any governor linkage components have been removed/replaced, refer to page 65 in Reassembly before completing adjustment procedure.

NOTE: Governor adjustment is recommended if oil pan assembly has been replaced.

Adjustment Procedure
Make this adjustment whenever governor arm is loosened or removed from cross shaft or governor gear is replaced. Adjust as follows:

1. Confirm the following:

- All linkage and springs are in good condition and properly installed onto governor lever assembly.
- Governor cross shaft nut (O) is secure and torqued to 10.7 N·m (95 in. lb.)
- Throttle linkage (A) and linkage spring (B) are properly attached to governor lever and throttle at carburetor.

2. Loosen **left hand screw** (G) that secures governor lever assembly (D).
3. Move the throttle linkage at reference point (D) toward the carburetor to position the throttle butterfly at wide open throttle (WOT). Maintain the linkage in this position.

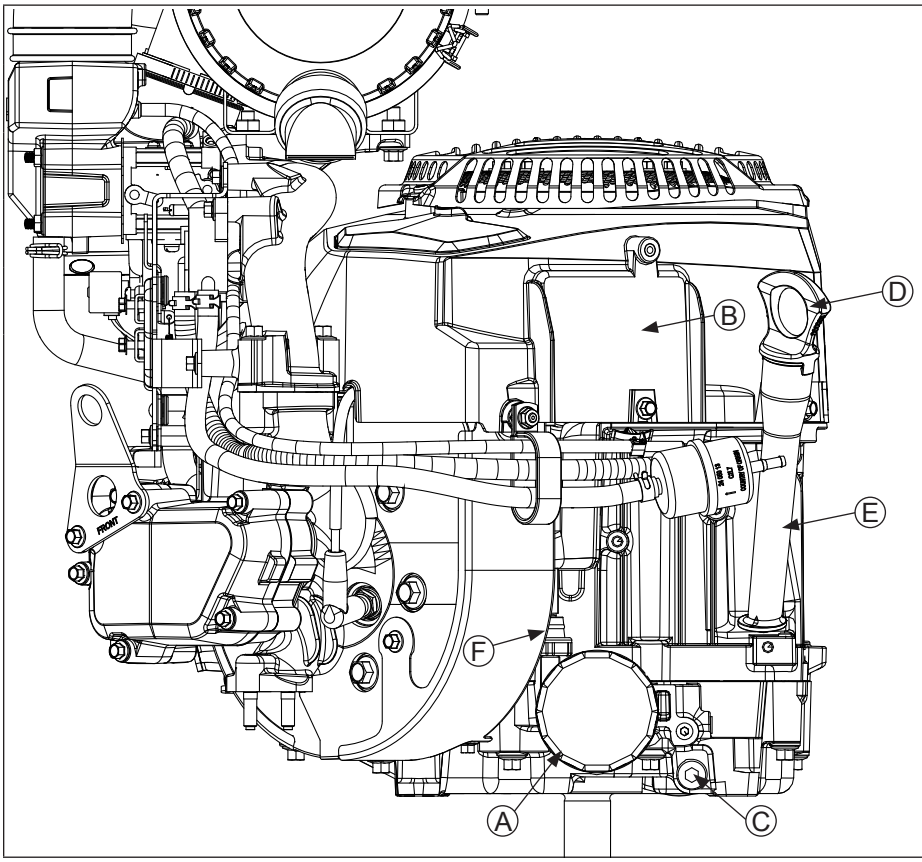
Idle Speed (RPM) Adjustment (carbureted)

1. Start engine and allow to warm up 5-10 minutes to stabilize speeds. Hold governor lever away from carburetor so throttle lever is against idle speed (RPM) adjustment screw of carburetor, then adjust screw to set approximately 1450 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. Obtain equipment manufacturer's recommended idle speed (1800 RPM). All 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 350 RPM (approximate) higher than low idle speed.
3. Move throttle lever to wide-open/full throttle position and hold in this position. Obtain equipment manufacturer's recommended high speed setting. Turn high speed screw to obtain intended high speed no-load RPM (estimated 3640 rpm). Governed idle speed must be set before making this adjustment.

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

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. Oil pan must be removed to service oil governor gear and oil pump. For ETB engines Oil pan must be removed to service oil pickup, pressure relief valve, and oil pump.

Lubrication Components



A	Oil Filter
B	Oil Cooler (if equipped)
C	Oil Drain Plug
D	Oil Fill/Dipstick
E	Oil Fill Tube
F	Pressure Switch

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 and drain plug. Remove drain plug and oil fill cap/dipstick. Allow oil to drain completely.
2. Clean area around oil filter; remove filter; wipe off mounting surface. Reinstall drain plug and torque to 13.6 N·m (10.0 ft. lb.).
3. Place new filter in shallow pan with open end up. Fill with new oil until oil reaches bottom of threads. Allow 2 minutes for oil to be absorbed by filter material.
4. Apply a thin film of clean oil to rubber gasket on new filter.
5. Refer to instructions on oil filter for proper installation.
6. Fill crankcase with new oil. Level should be at top of indicator on dipstick.
7. Reinstall oil fill cap/dipstick and tighten securely.
8. Start engine; check for oil leaks. Stop engine; correct leaks. Recheck oil level.
9. Dispose of used oil and filter in accordance with local ordinances.

OIL COOLER (if equipped)

1. Clean fins with a brush or compressed air.
2. Remove screws securing oil cooler and tilt to clean back side.
3. Reinstall oil cooler and torque top screw to 3.3 N·m (30 in. lb.) and bottom screw (M6) to 4.8 N·m (42 in. lb.).

OIL PRESSURE SWITCH (if equipped)

Oil Pressure switch is installed in oil pan pressure port.

Installation

1. Apply pipe sealant with Teflon® (Loctite® PST® 592™ Thread Sealant or equivalent) to threads of switch.
2. Install switch into tapped hole in oil pan.
3. Torque switch to 9 N·m (80 in. lb.).

Testing

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

Normally Open Switch

1. Connect continuity tester across blade terminal and metal case of switch. With 0 psi pressure applied to switch, tester should indicate no continuity (switch open).
2. Gradually increase pressure to switch. As pressure increases through range of 2.0/5.0 psi, tester should indicate a change to continuity (switch closed). Switch should remain closed as pressure is increased to 90 psi maximum.
3. Gradually decrease pressure through range of 2.0/5.0 psi. Tester should indicate a change to no continuity (switch open) down to 0 psi.
4. Replace switch if it does not operate as specified.

Normally Closed 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 2.0/5.0 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 2.0/5.0 psi. Tester should indicate a change to continuity (switch closed) down to 0 psi.
4. Replace switch if it does not operate as specified.

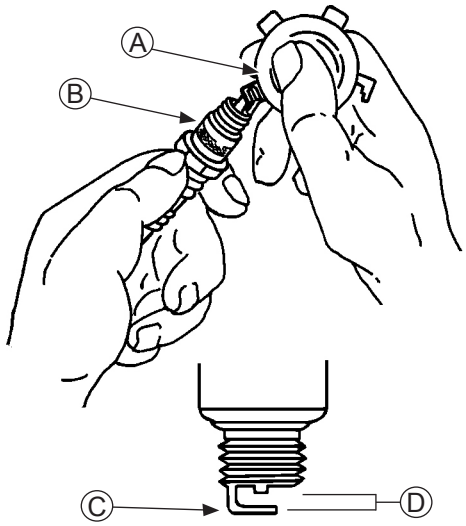
SPARK PLUGS

⚠ CAUTION

Electrical Shock can cause injury.

Do not touch wires while engine is running.

Spark Plug Component and Details



A	Wire Gauge	**B**	Spark Plug
C	Ground Electrode	**D**	Gap

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

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

Engine is equipped with following spark plugs:

Gap	0.76 mm (0.030 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.

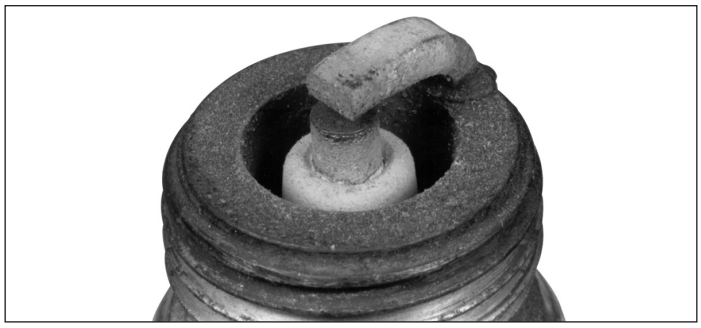
1. Check gap using wire feeler gauge. Adjust gap to 0.76 mm (0.030 in.).
2. Install plug into cylinder head.
3. Torque plug to 27 N·m (20 ft. lb.).

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.

Carbon Fouled

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

Overheated

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

BATTERY

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

Battery Size Recommendations

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

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

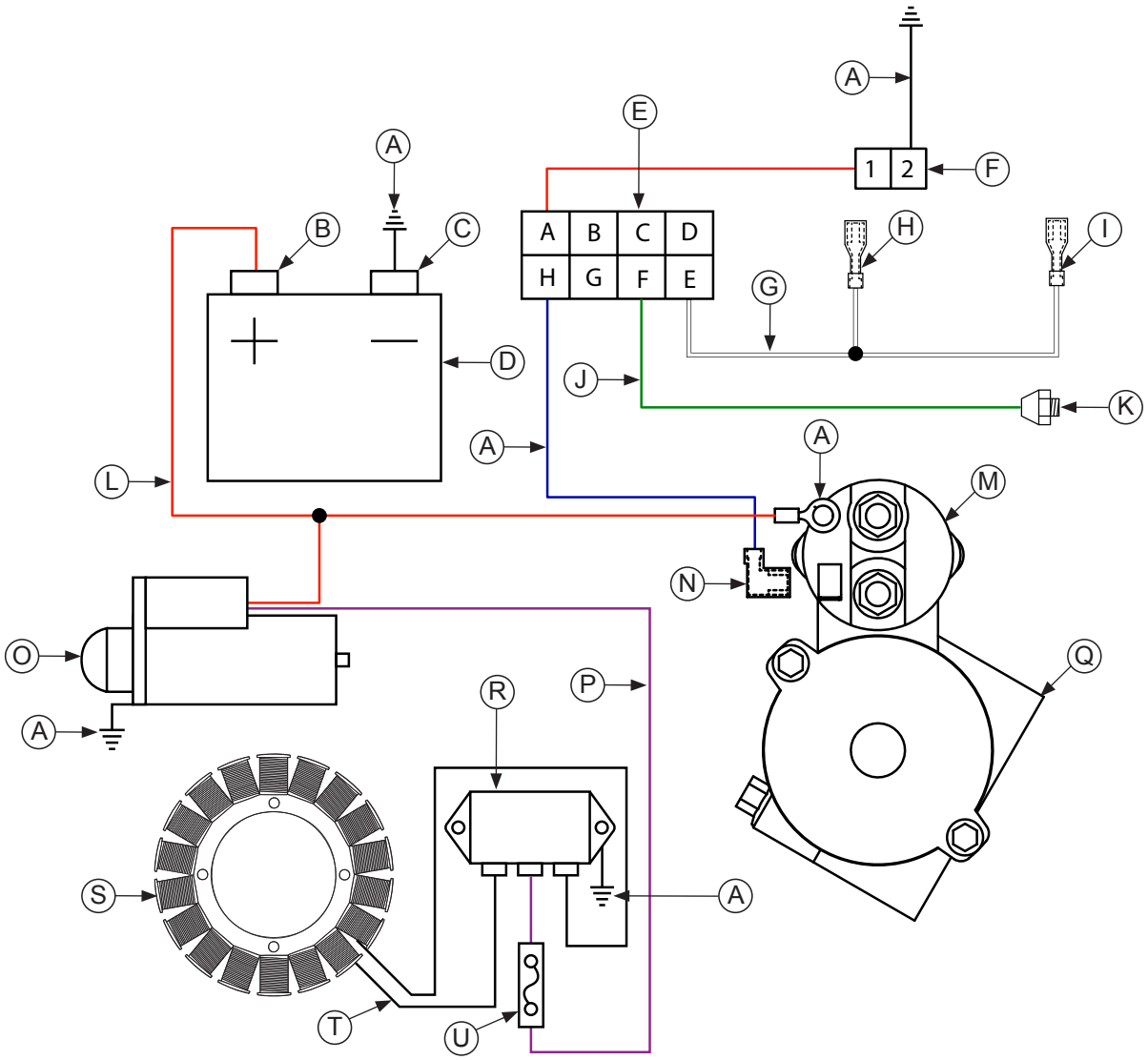
Battery Maintenance

Regular maintenance is necessary to prolong battery life.

Battery Test

To test battery, follow manufacturer's instructions.

CV829 & CV832 Wiring Diagram-15/20/25 Amp Regulated Battery Charging System



A	Ground	**B**	Battery Positive	**C**	Battery Negative	**D**	Battery
E	8-Pin Connector	**F**	Fuel shutoff solenoid	**G**	White	**H**	Kill #1
I	Kill #2	**J**	Green	**K**	Oil Pressure Switch	**L**	Red
M	Starter Solenoid	**N**	Starter Solenoid Tang	**O**	Starter Motor	**P**	Purple
Q	Solenoid Shift Starter Assembly	**R**	Rectifier-Regulator	**S**	Stator	**T**	Black
U	Fuse						

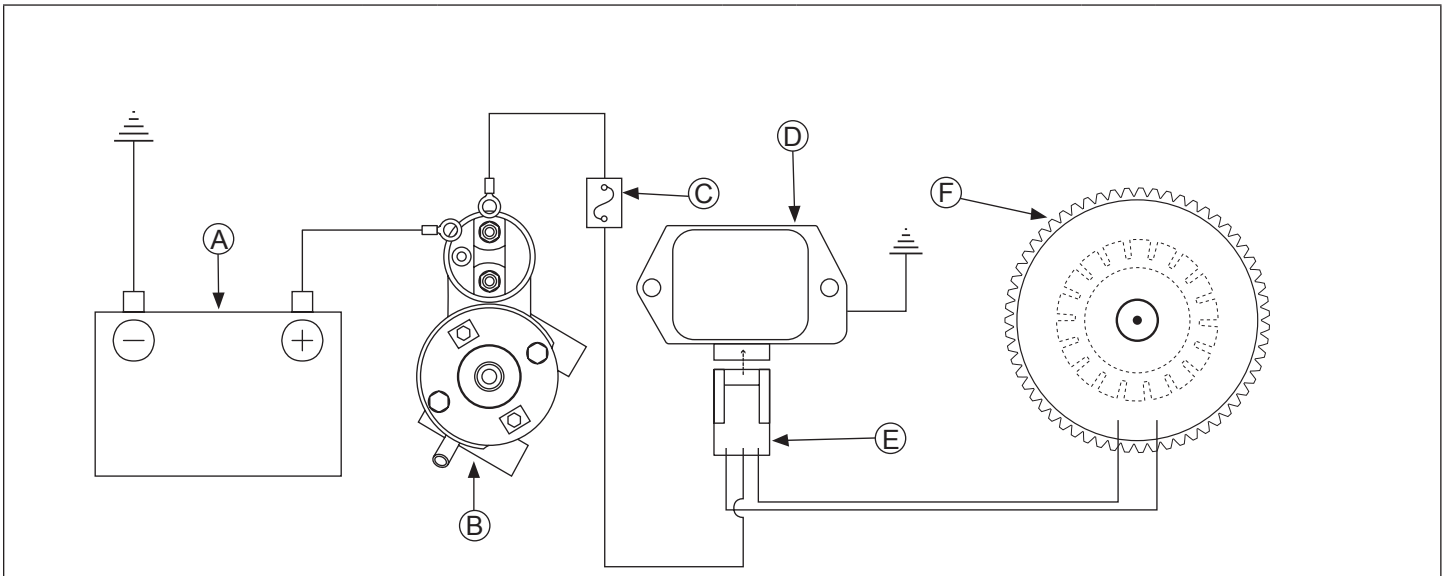
BATTERY CHARGING SYSTEM

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. Also, 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.

These engines are equipped with a 20 or 25 amp regulated charging system.

20/25 Amp Regulated Charging System



A	Battery	**B**	Starter	**C**	Fuse	**D**	Rectifier-Regulator
E	Connector Block	**F**	Flywheel Stator Assembly				

Stator

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

Rectifier-Regulator

NOTE: When installing rectifier-regulator, take note of terminal markings and install plug(s) accordingly.

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

Rectifier-regulator is mounted on blower housing. To replace, disconnect plug(s), remove mounting screws, and ground wire or metal grounding strap.

Troubleshooting Guide

20/25 Amp Battery Charging System

NOTE: Always zero digital volt-ohm meter (DVOM) on each scale before testing to ensure accurate readings. Voltage test should be made with engine running at specific test condition noted. Battery state of charge should be checked before testing. Battery voltage reading of 12.5 VDC or lower should be charged or replaced.

When problems occur in keeping a battery fully charged or a battery charges at too high a rate, battery or charging system may be cause of fault. Before performing any testing, battery must be fully charged.

To test charging system:

1. Inspect charging system fuse. If damaged, replace before continuing..
2. Visually inspect system components and wiring. Look for damaged or loose wire connections, including battery cables.
3. Set DVOM to DC volts, place one lead of tester on rectifier-regulator body and other lead to battery negative (-) terminal. Run engine and observe volt reading on meter. If voltage is 0.5 VDC or less continue with testing. If voltage is higher than 0.5 VDC, inspect and repair wiring/connections as needed (insufficient ground).

4. Perform these output tests for charging system using DVOM set to DC volts.

   a. With engine off and key switch in OFF position, measure voltage at battery. If less than 12.4 VDC, recharge battery and retest. If 12.5 VDC continue with tests.

   b. Start and run engine at high speed no load (greater than 3000 RPM). After running 1 minute, measure voltage at battery.

      i. If voltage increases to between 13-15 VDC, system is working correctly.

      ii. If voltage increases to 15.5 VDC or higher,system is overcharging. Replace rectifier regulator.

      iii. If voltage stays at 12.5 VDC or decreases, charging system is NOT operating, proceed to step 5.

5. With engine off, unplug rectifier-regulator connector and inspect connector terminals within connector body and rectifier-regulator for corrosion/arcing/damage. Repair/replace as needed. If OK, proceed to next test.

6. Set DVOM to AC volts, place test leads to each white stator wire. Run engine at 1200 RPM or greater and monitor voltage.

Condition	Conclusion
Voltage is 13 volts or more.	Stator is OK. .
Voltage is less than 13 volts AC.	Stator is faulty; Continue with steps 7 and 8.

7. With engine off and stator unplugged from rectifier-regulator, check for resistance/continuity across both stator leads.

Note: Resistance testing across the stator wire leads may yield values too low to reliably measure, leading to misdiagnosis. If the stator passes output testing, it should be considered functional. .

Condition	Conclusion
Resistance is 0.1/0.2 ohms.	Stator is OK.
Resistance is 0 ohms.	Stator is shorted; replace.
Resistance is infinity ohms/ no continuity.	Stator is open; replace.

8. With engine off and stator unplugged from rectifier-regulator, check for resistance/continuity from stator leads to ground.

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.

9. If stator tests good (steps 5-8), but system was identified in step 4 as not working, failure is likely with rectifier-regulator. Replace rectifier-regulator, retest system to confirm repairs (step 4).

FUSES

This engine has blade type automotive fuse. Replacement fuse must have same rating as blown fuse. Use fuse chart below to determine correct fuse.

Wire Color	Fuse Rating
2 Purple Wires	30-amp Fuse

Fuse Replacement

1. Shut engine off and remove key.
2. Locate fuse holders.
3. Remove fuse cover and pull out fuse.
4. Inspect fuse for a solid fusible link or a broken fusible link. Replace fuse if fusible link is broken. If you are not sure if fusible link is broken, replace fuse.
5. Insert fuse into fuse holder until it is seated properly. Install fuse cover.
6. If replacement fuse fails, there is a problem within this circuit. Diagnostics are required. Identify which circuit is affected (see electrical schematic) by identifying failed fuse/circuit. Perform troubleshooting procedures appropriate for circuit fuse that failed.
7. Install fuse holder into fuse cover.

Typical carbureted fuel system and related components include:

- Fuel tank and valve.
- 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 Rehlko engines to maintain EPA and CARB regulatory compliance.

FUEL PUMP

These engines use a pulse style fuel pump. Pumping action of pulse style pumps is created by oscillation of positive and negative pressures within crankcase. This pressure is transmitted to pulse pump through rubber hose connected between pump and crankcase. Pumping action causes diaphragm on inside of pump to pull fuel in on its downward stroke and to push it into carburetor on its upward stroke. Two check valves prevent fuel from going backward through pump.

Performance

Minimum fuel delivery rate must be 7.5 L/hr. (2 gal./hr.) with a pressure at 0.3 psi and a fuel lift of 24 in. A 1.3 L/hr. (0.34 gal./hr.) fuel rate must be maintained at 5 Hz.

Fuel Pump Replacement

NOTE: Make sure orientation of new pump is consistent with removed pump. Internal damage may occur if installed incorrectly.

To replace pulse pump follow these steps. Note orientation of pump before removing.

1. Disconnect fuel lines from inlet, outlet, and pulse fittings on fuel pump.
2. Remove screws and take off pump.
3. Connect pulse line to new fuel pump and make sure opposite end is properly connected to fitting on crankcase.
4. Attach new fuel pump using screws. Torque screws to 2.3 N·m (73 in. lb.).
5. Reconnect fuel lines to inlet and outlet fittings and secure with clamps.

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

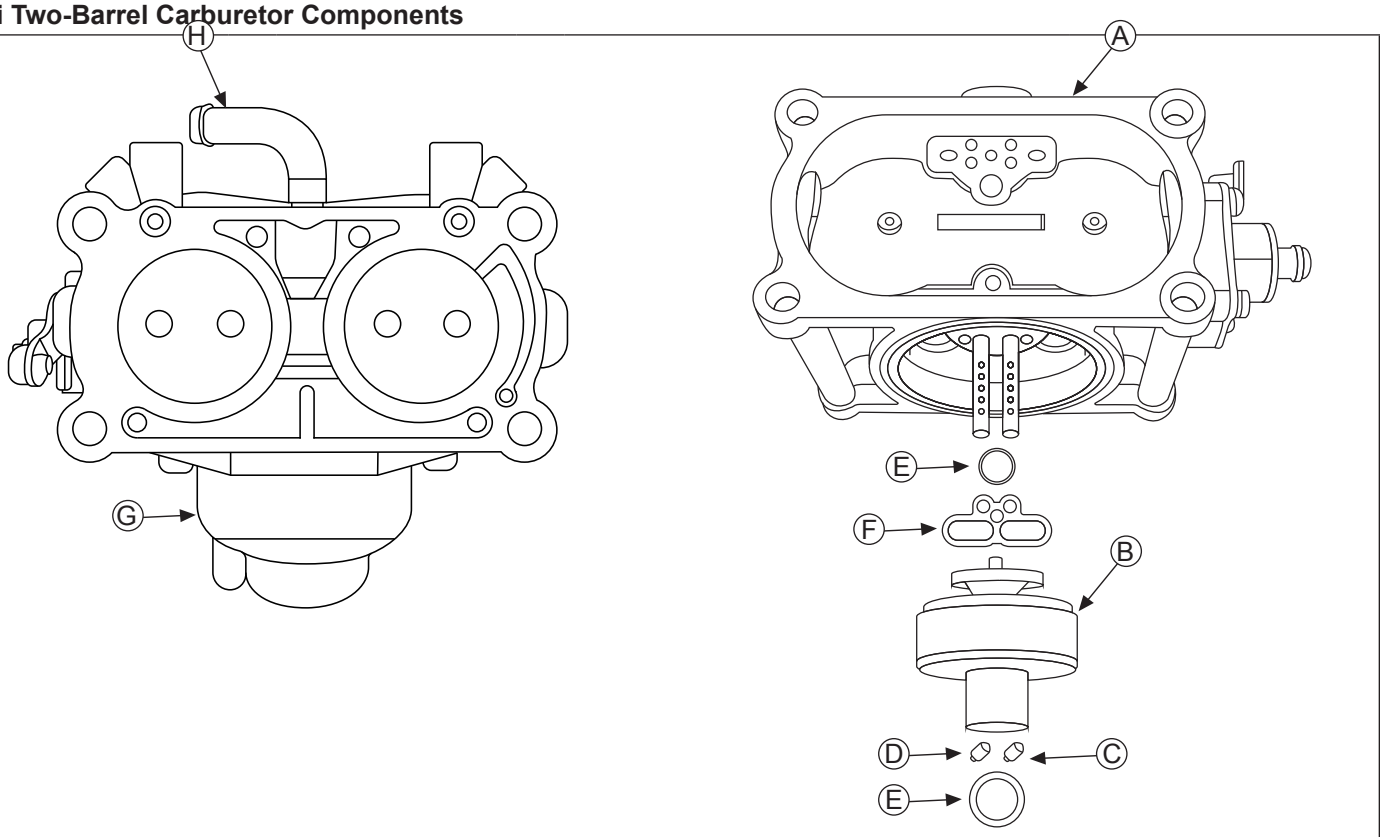
Condition	Conclusion
Fuel at tip of spark plug.	Fuel is reaching combustion chamber.
No fuel at tip of spark plug.	Check fuel flow from fuel tank (step 2).
Fuel flows from fuel line.	Check for faulty fuel pump (step 3). If fuel pump is working, check for faulty carburetor. Refer to Carburetor.
No fuel 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

Engines in this series are equipped with a two-barrel side-draft carburetor with fixed main jets on a matching intake manifold. Carburetor features a choke, serviceable main jets, and a fuel shutdown solenoid. .

	**⚠ 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 Two-Barrel Carburetor Components



Main Jets are side specific, note when disassembling.

A	Carburetor Body Subassembly	**B**	Float	**C**	Right Main Jet	**D**	Left Main Jet	**E**	O-Ring
F	Float Chamber Gasket	**G**	Float Bowl	**H**	Fuel Inlet Line				

Troubleshooting Checklist

When engine starts hard, runs roughly or stalls at low idle speed, check following 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 that it 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 speed improperly adjusted.	Adjust idle speed/governed idle tab.
Engine runs rich (indicated by black, sooty exhaust smoke, misfiring, loss of speed and power, governor hunting, or excessive throttle opening).	Clogged air cleaner.	Clean or replace air cleaner.
	Choke partially closed during operation.	Check choke lever/linkage to ensure choke is operating properly.
	Float level is set too high.	Adjust float according to Float Replacement Procedure.
	Dirt under fuel inlet needle.	Remove needle; clean needle and seat and blow with compressed air.
	Bowl vent or air bleeds plugged.	Remove low idle fuel adjusting needle. Clean vent, ports, and air bleeds. Blow out all passages with compressed air.
Engine runs lean (indicated by misfiring, loss of speed and power, governor hunting, or excessive throttle opening).	Float level is set too low.	Adjust float according to Float Replacement Procedure.
	Idle holes plugged; dirt in fuel delivery channels.	Remove low idle fuel adjusting needle. Clean main fuel jet and all passages; blow out with compressed air.
Fuel leaks from carburetor.	Float level is set too high.	Adjust float according to Float Replacement Procedure.
	Dirt under fuel inlet needle.	Remove needle; clean needle and seat and blow with compressed air.
	Bowl vents plugged.	Blow out with compressed air.
	Carburetor bowl gasket leaks.	Replace gasket.
Poor load acceptance/throttle response.	Mechanical engine problem	Refer to Troubleshooting section
	Mechanical governor problem	Refer to Governor section

Fuel Shut-Off Solenoid

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, disconnect lead 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 battery and jumpers.
3. Connect jumper lead to battery B+and to one solenoid terminal. Connect jumper lead to other solenoid terminal. Touch jumper lead to negative battery terminal and observe solenoid pin.
4. Pin should retract with jumper lead touching negative battery terminal. Pin should return to its original position when jumper lead is removed. Test several times to verify operation. Replace solenoid if pin does not move

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 2 main jets and further metered through slow jets. Air and fuel are mixed in body of slow jet and exit to transfer port. From transfer port, air fuel mixture is delivered to idle progression chamber. From idle progression chamber, air fuel mixture is metered through idle port passages. At low idle when vacuum signal is weak, 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 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 4 air jets, fuel is drawn through main jets. 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. Allow to warm up 5-10 minutes to stabilize speeds.

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.

Idle Speed (RPM) Adjustment

1. Start engine and allow to warm up 5-10 minutes to stabilize speeds. Hold governor lever away from carburetor so throttle lever is against idle speed (RPM) adjustment screw of carburetor, then adjust screw to set approximately 1450 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. Obtain equipment manufacturer's recommended idle speed (1800 RPM). All 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 350 RPM (approximate) higher than low idle speed.

3. Move throttle lever to wide-open/full throttle position and hold in this position. Obtain equipment manufacturer's recommended high speed setting. Turn high speed screw to obtain intended high speed no-load RPM (estimated 3640 rpm). Governed idle speed must be set before making this adjustment.

High Speed (RPM) Adjustment

1. With engine running, move throttle control to fast.
2. Turn adjustment screw inward to decrease, or outward to increase RPM speed.
3. Stop when desired RPM speed is obtained.

Carburetor Servicing

WARNING

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.

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

NOTE: Keep solvent away from plastic or rubber parts if non-compatible or damage may occur.

- 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.

Float Replacement/Overhaul/Choke Repair

NOTE: Main and slow jets are size and side specific. Fixed jets for high altitudes are available.

NOTE: If symptoms described in Troubleshooting-Carburetor Related Causes indicate float level problems, remove carburetor from engine to check and/or replace float. Use a float kit to complete repair.

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. Disconnect Fuel Shutoff Solenoid and remove float bowl screws. (Before removing float bowl, note its position on carburetor) Carefully separate fuel bowl from carburetor Transfer any remaining fuel into an approved container. Save all parts.
4. Carefully remove float assembly noting o-ring/s placement. Main jets are located in carburetor float assembly and may differ by size or side, mark accordingly before removal. Slow jets cannot be removed from carburetor assembly and are non serviceable. Save parts for cleaning and reuse.

NOTE: Fuel inlet and needle are part of float assembly.

6. Remove slow passage cover and fuel shut-off solenoid from float bowl. Solenoid can be removed using a thin 1/2" wrench.
7. Carburetor is now disassembled for appropriate cleaning and installation of parts in overhaul kit. Further disassembly is not necessary. Throttle shaft assembly and slow jets are non-serviceable items and should not be removed. Choke shaft assembly is serviceable, however it should not be removed unless a choke repair kit will be installed.

   To install choke repair kit go to step 7, otherwise go to step 14.
8. Clean areas around choke lever/shaft assembly thoroughly.
9. Note position of choke plate for correct reassembly later. Remove screws attaching choke plate to choke shaft. Carefully remove shaft from carburetor body.
10. Clean I.D. of both choke shaft bores as required.
11. Carefully install dust seal o-ring on shaft.
12. Slide choke shaft assembly into carburetor body.
13. Position and reinstall choke plate to flat side of choke shaft. Start screws. Close choke and check plate alignment within carburetor throat, then tighten screws securely. Do not overtighten.
14. Check for proper operation and free movement of parts.
15. Clean carburetor body, main jets, vent ports, seats, etc., using a good commercially available carburetor solvent. Keep solvent away from plastic or rubber parts if non-compatible or damage may occur. Use clean, dry compressed air to blow out internal channels and ports. Do not use metal tools or wire to clean orifices and jets. Inspect and thoroughly check carburetor for cracks, wear, or damage. Replace float if inlet seat is suspect.
16. Clean carburetor fuel bowl as required, including feed hole.
17. Install new O-rings onto the float assembly. To ensure proper O-ring seating during installation, position the float assembly with the O-rings facing upward and carefully install onto the carburetor body.
18. Float height is non-adjustable. If a problem is suspected, replace the entire float assembly.
19. Reinstall float bowl. Secure with new screws. Torque screws to 5.88 N·m (52 in. lb.).
20. Use new mounting gaskets for air cleaner and carburetor. Reinstall carburetor and disassembled components following Reassembly procedures.
21. Reconnect spark plug leads and negative battery cable. Start engine and perform Low Idle Speed Adjustment.

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 an authorized dealer, visit Engines.rehlko.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.

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 starter is engaged while flywheel is rotating, starter pinion and flywheel ring gear may clash and damage starter.

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

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

Engines in this series use solenoid shift starters.

Troubleshooting-Starting Difficulties

Condition	Possible Cause	Conclusion
Starter does not energize.	Battery	Check battery state of charge. If below 12.4 volts, recharge or replace battery as necessary.
	Wiring	Clean corroded connections and tighten loose connections. Replace wires in poor condition and with frayed or broken insulation.
	Starter Switch or Solenoid	By-pass switch or solenoid with a jumper wire. If starter cranks normally, replace faulty components. Remove and perform individual solenoid test procedure.
Starter energizes but turns slowly.	Battery	Check battery state of charge. If below 12.4 volts, recharge or replace battery as necessary.
	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.

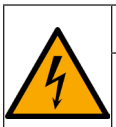
Starting System Voltage Test

⚠ WARNING

Explosive Fuel can cause fires and severe burns.

Do not fill the fuel tank while the 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. Do not fill the fuel tank while the engine is hot or running, since spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Do not start the engine near spilled fuel. Never use gasoline as a cleaning agent.



⚠ CAUTION

Electrical Shock can cause injury.

Do not touch wires while engine is running.

Never touch electrical wires or components while the engine is running. They can be sources of electrical shock.

Before Starting

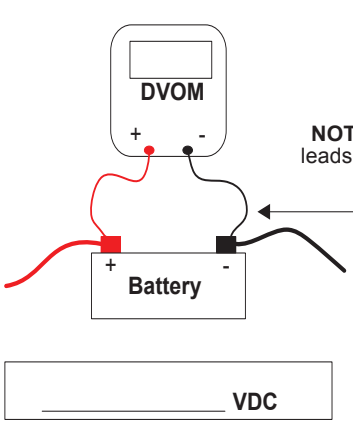
NOTE: Please perform the following testing as near to the conditions during failure (i.e. in the morning when cold, a hot restart, or as close to the description of failure provided by the customer).

NOTE: Voltage drop testing measures the voltage lost across portions of the starting circuit while the starter is under full load. Excessive voltage drop indicates unwanted resistance that restricts current flow and prevents the starter from receiving the voltage and amperage required for proper operation

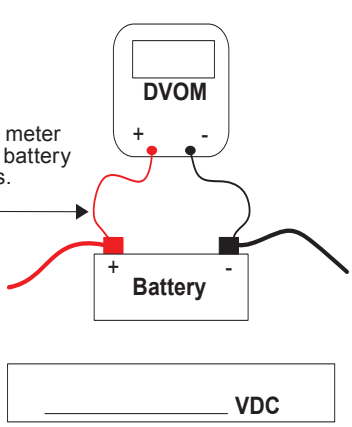
- Disable ignition system: disconnect the spark plug lead from the spark plug, then ground the spark plug lead to the engine block using mechanical means. Refer to the correct engine service manual if necessary.
- Battery voltage should be tested and must be at 12.4 VDC or higher. Do not proceed if battery voltage is less than 12.4 VDC as battery should be charged.
- Test meter leads before use. (Set meter to Ohms and check for resistance reading of less than 0.5 Ohm.)
- If available, use clamping meter leads to assist with testing.
- Set meter to next highest voltage scale that includes 12 VDC.
- When taking readings, allow the meter to stabilize before recording. The reading should stabilize after 3 to 5 seconds. **If reading continues to drop while cranking, stop the test and perform a battery load test.**

Procedure

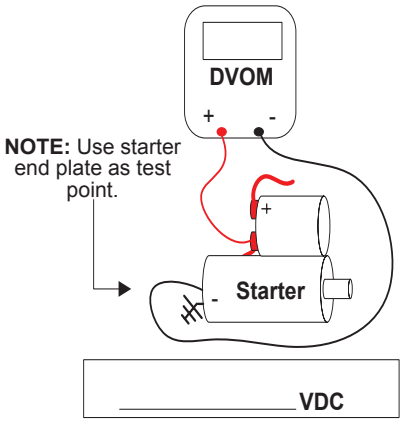
Test #1
Battery Voltage Test (Static)



Test #2
Voltage Drop Across Battery (Cranking)



Test #3
Voltage Drop Across Starter (Cranking)



Test 1 Conclusions

- If battery voltage is above 12.4 VDC continue to Test 2.
- If voltage is below 12.4 VDC, charge battery and retest.
- If battery will not hold a charge it should be replaced before continuing the test or replacing the starter.

Test 2 Conclusions

- If battery cranking voltage is above 9.0 VDC continue to Test 3.
- If battery cranking voltage is below 9.0 VDC you should check the battery by using a load tester. Also check for external engine load.

Test 3 Conclusions

- If the difference between test 2 and test 3 is greater than 1 VDC, a voltage drop test on the system will need to be performed to determine where the loss is occurring. Testing of the battery + and battery – circuit will need to be done independently.

SOLENOID SHIFT STARTERS

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

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

Solenoid Tests

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

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

To test solenoid pull-in coil/plunger:

Actuation

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

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

Continuity

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

To test solenoid hold-in coil:

Function

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

Continuity

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

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

	WARNING	
	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.

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

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

Disconnect Spark Plug Leads

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

1. Disconnect spark plug leads.
2. Shut off fuel supply.

Drain Oil from Crankcase and Remove Oil Filter

1. Clean oil filter and housing area.
2. Remove dipstick and 1 oil drain plug.
3. Allow ample time for oil to drain from crankcase.
4. Remove and discard oil filter.

Disconnect Fuel Lines

	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.	

NOTE: To prevent damage to hoses, use a hose removal tool.

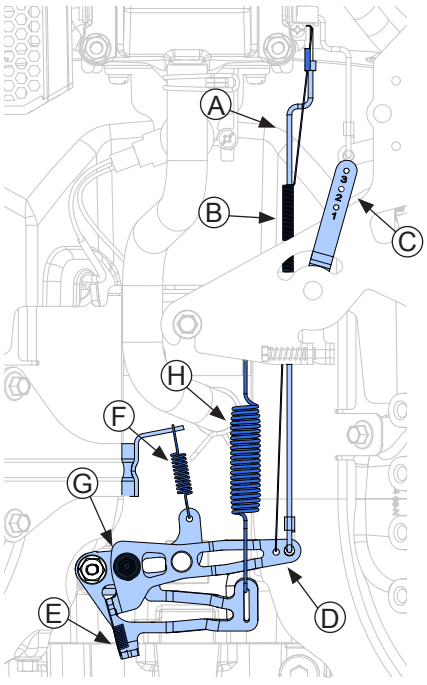
1. Wrap a shop towel completely around fuel line hose, disconnect pulse line and low pressure fuel line (with fuel filter) from pulse pump.
2. Remove and slide hoses through clamp mounted on blower housing.
3. Remove clamp from blower housing.

Remove Starter Motor

1. Disconnect electrical leads from starter.
2. Unplug rectifier/regulator main connector and charge wire fuseholder. Secure harness safely aside.
3. If equipped with an ECU:
   1. Unplug ECU connectors (2).
   2. Remove ECU bolts (2) (if necessary).
4. Remove starter, fuseholder bracket and ground leads

Remove Governor Linkages, Spring, and Lever (Mechanical Governor)

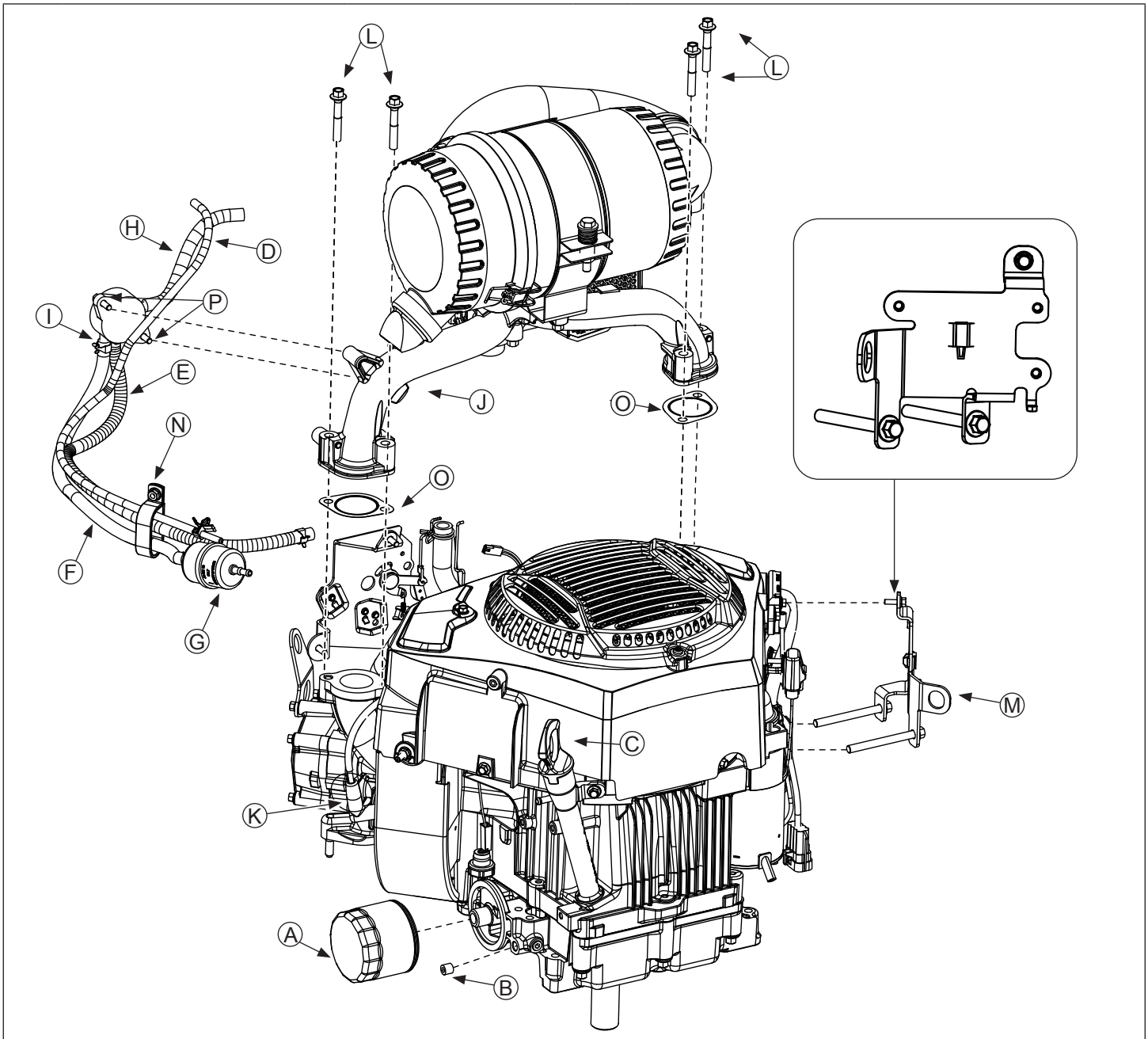
Mechanical Governor Components



A	Throttle Linkage	**B**	Linkage Spring
C	Speed Control Linkage	**D**	Governor Lever Assembly
E	Governor Lever Assembly Spring	**F**	Governed Idle Spring
G	Left Hand Threaded Screw	**H**	Governor Spring

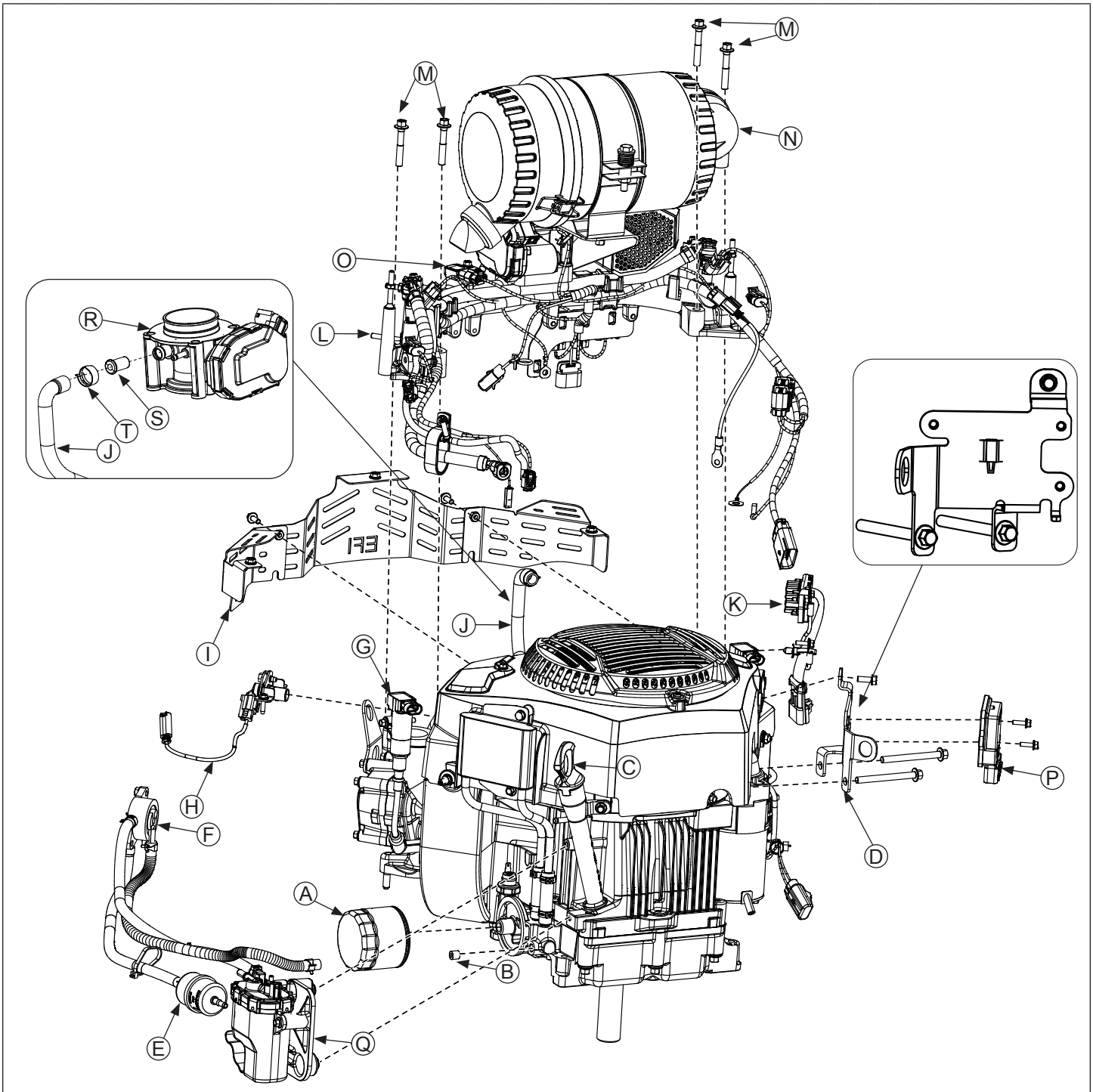
1. Unhook throttle linkage and linkage spring from carburetor. Note color, location, and position of each.
2. Disconnect speed control linkage from governor linkage lever. Note color, location, and position.
3. Loosen nut and remove governor lever from cross shaft; note hole location, then unhook governor spring from governor lever.
4. Remove fasteners securing Speed Control Assembly bracket.

CV829 & CV832 External Engine Components



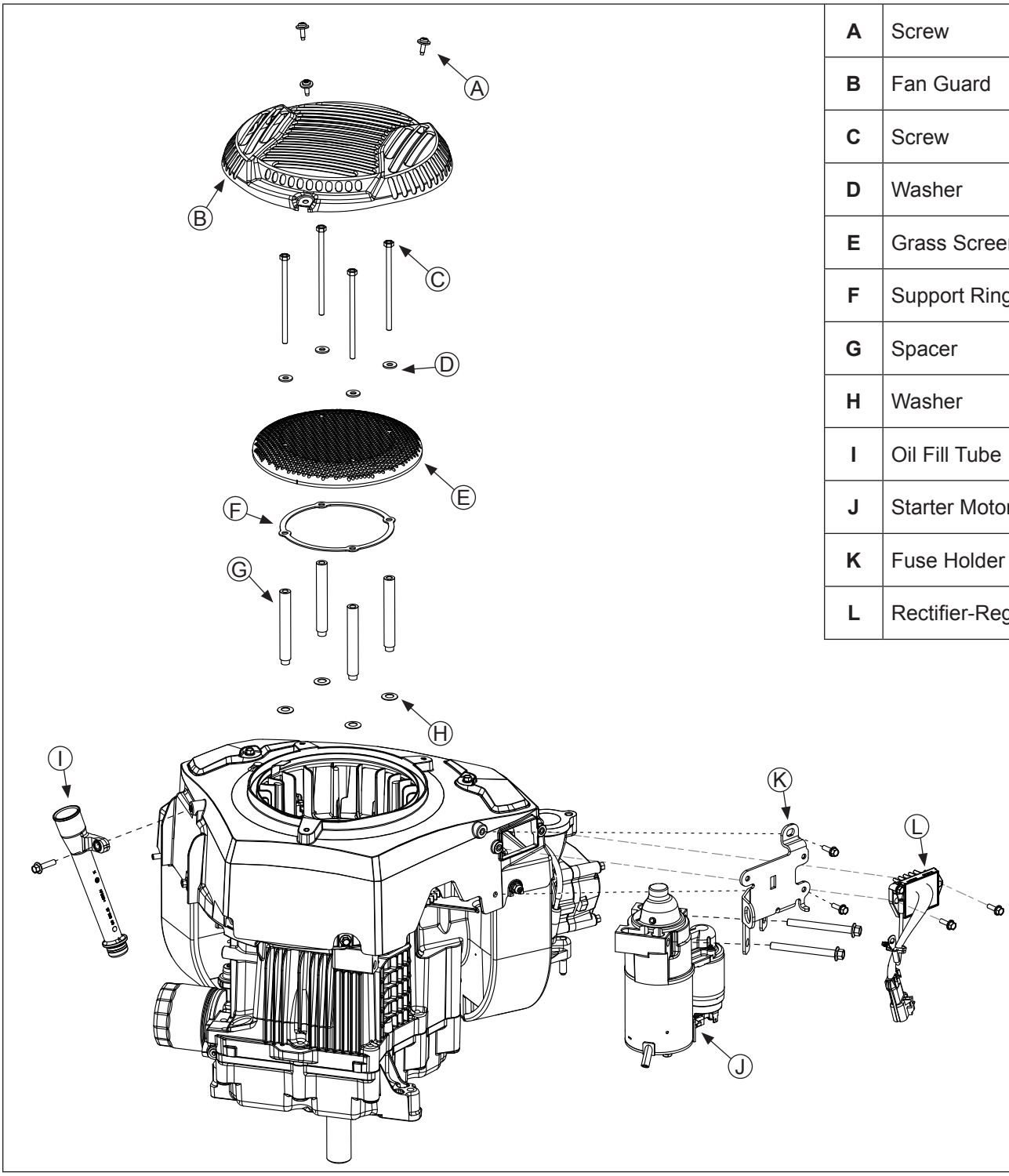
A	Oil Filter	**B**	Oil Drain Plug	**C**	Dipstick	**D**	Vent Hose
E	Pulse Line	**F**	Low Pressure Fuel Line	**G**	Fuel Filter	**H**	Fuel Line
I	Pulse Pump	**J**	Manifold Assembly	**K**	Spark Plug Lead	**L**	Manifold Screw
M	Fuse Holder Brackett	**N**	Clamp	**O**	Gasket	**P**	Pulse Pump Screw

ECV830 & ECV834 External Engine Components



A	Oil Filter	**B**	Oil Drain Plug	**C**	Dipstick	**D**	Fuse Holder Brackett
E	Fuel Filter	**F**	Pulse Pump	**G**	Spark Plug Lead	**H**	Speed Sensor
I	Manifold Guard	**J**	Breather Hose	**K**	Rectifier Regulator	**L**	Manifold Assembly
M	Manifold Screws	**N**	Heavy Duty Air Cleaner (HDAC)	**O**	TMAP Sensor	**P**	ECU
Q	Fuel Pump	**R**	Electronic Throttle Body	**S**	Breather Inlet Restrictor	**T**	Clamp

Blower Housing/Starter Motor Components



A	Screw
B	Fan Guard
C	Screw
D	Washer
E	Grass Screen
F	Support Ring
G	Spacer
H	Washer
I	Oil Fill Tube
J	Starter Motor Assembly
K	Fuse Holder Bracket
L	Rectifier-Regulator

Remove Manifold Guards (if equipped)

Remove screws securing the (3) piece manifold guard.

Remove Intake Manifold & Air Intake Filter Assembly

Note: Separate parts only if additional service is required. Refer to exploded view drawing.

Note: Harness clips are used to secure harness in place on manifold. Note their location and reinstall during reassembly.

1. Unplug Fuel shutoff solenoid harness connector. (if equipped)
2. Remove fuel, vent and breather hoses from intake assembly.
3. Unplug Fuel injectors, Fuel Pump Module, TMAP sensor, Electronic Throttle Body, Ignition Coils, Oil Pressure switch, O2 sensor, Engine Temp sensor and Rectifier regulator. (if equipped)
4. Remove harness ring terminal at starter.
5. Remove harness ground ring terminal under intake manifold.
6. Speed sensor connector (if equipped) is located under blower housing and will need to be unplugged before harness is removed from intake manifold. (Engines equipped with a blower housing clean out cover may allow limited access to this connector).
7. Remove four intake manifold screws from cylinder head.
8. Carefully lift and remove manifold assembly from engine.

Remove Fan Guard

Remove screws securing fixed guard and spacers; remove guard and spacers.

Remove Grass Screen

NOTE: Fan will be loose, but cannot be removed until after blower housing is removed.

1. Remove screws securing screen and remove screen.
2. Remove spacers, paying attention to curvature of spring washers between spacers and fan.
3. Remove mounting screw and oil fill tube.

Remove Blower Housing

1. Rectifier regulator assembly can remain installed on blower housing.
2. Loosen screws and nuts securing blower housing to crankcase.
3. Remove blower housing.

Remove Ignition Coils

1. Unplug connector from ignition coils.
2. Remove screws securing ignition coils to engine
3. Remove coils.

Remove Flywheel Assembly

NOTE: Always use a flywheel strap wrench or holding tool to hold flywheel when loosening or tightening flywheel screw. Do not use any type of bar or wedge to hold flywheel. Use of such tools could cause flywheel to become cracked or damaged.

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

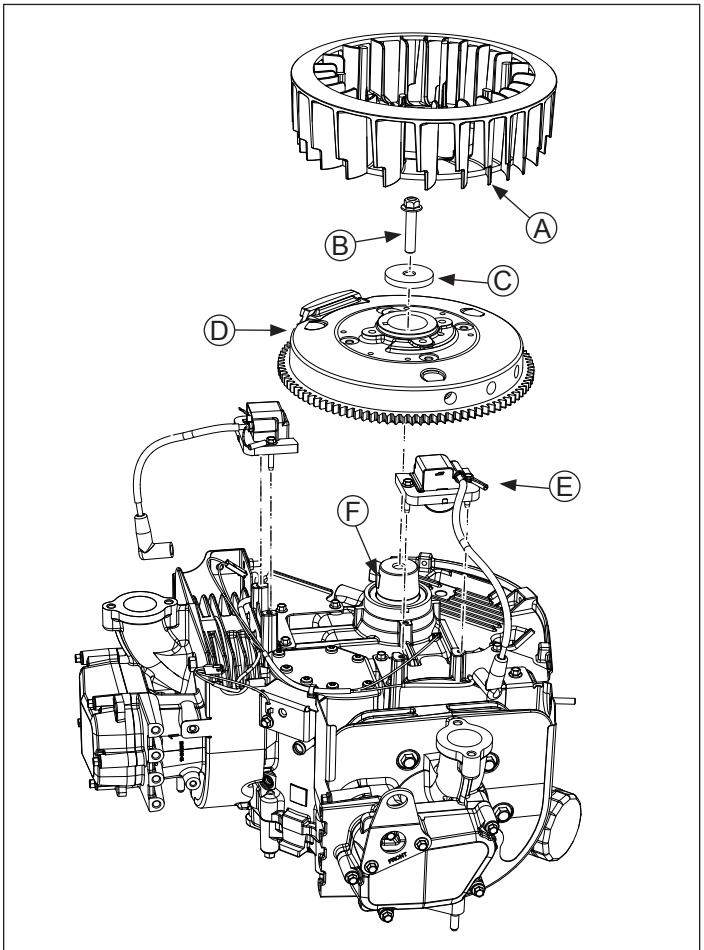
1. Remove flywheel fan and fan mounting hardware.
2. Use a flywheel strap wrench or holding tool to hold flywheel and loosen screw securing flywheel to crankshaft.
3. Remove screw and washer.
4. Use a puller to remove flywheel from crankshaft.
5. Remove woodruff key from crankshaft.

Inspection

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

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

Flywheel/Fan Components



A	Flywheel Fan	**B**	Flywheel Screw
C	Washer	**D**	Flywheel
E	Ignition Module	**F**	Woodruff Key

Remove Pulse Pump (if needed)

⚠ WARNING

Explosive Fuel can cause fires and severe burns.

Do not fill fuel tank while engine is hot or running.

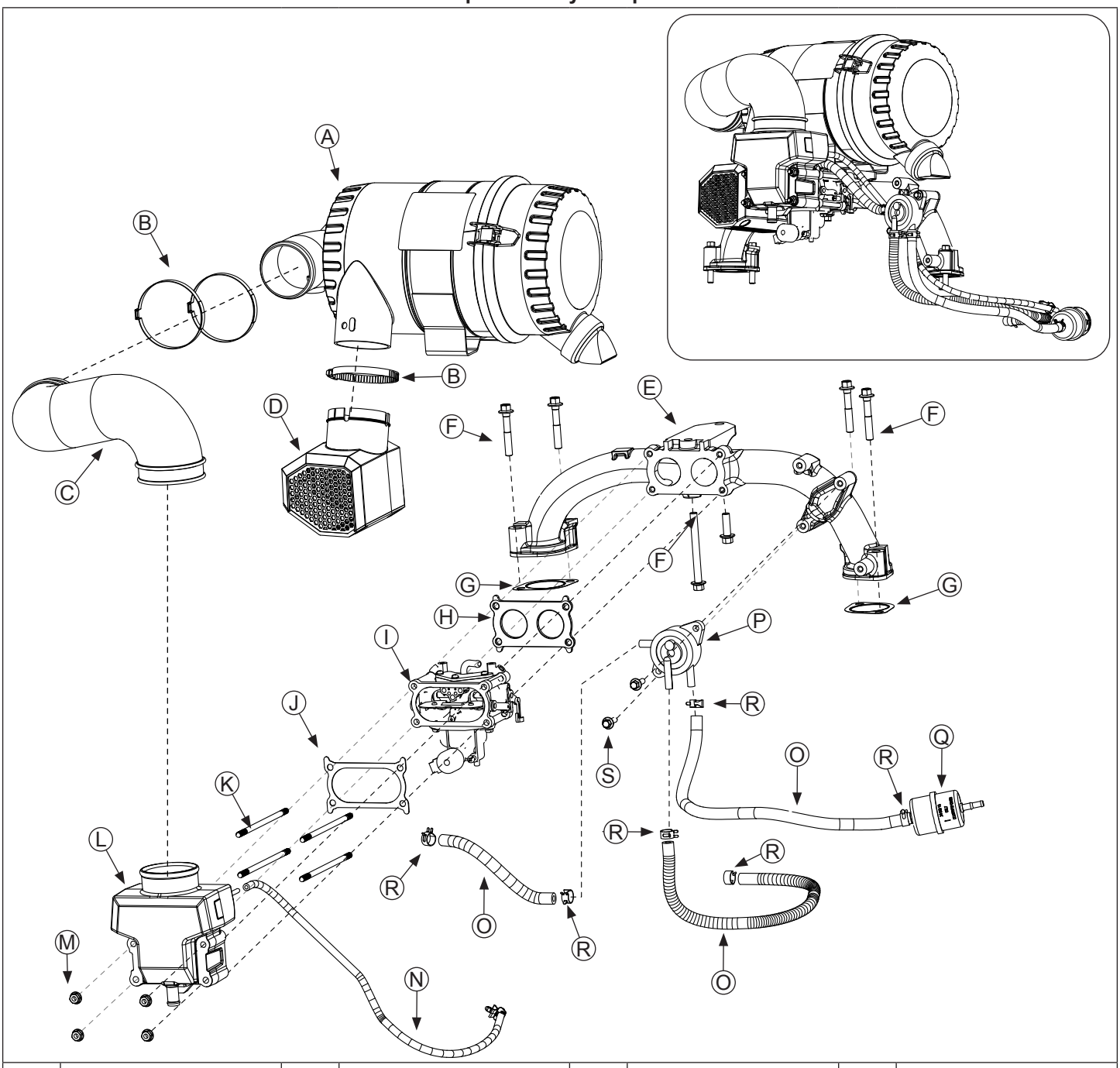
Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning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

Note: Pulse pump was removed as part of intake manifold assembly.

1. Disconnect outlet line, pulse line, and inlet line from fuel pump.

   Fuel filter may stay attached to inlet line.
2. Remove 2 screws securing fuel pump to bracket on intake manifold and remove fuel pump.
3. Remove screws securing bracket to intake manifold and remove bracket.
4. Reverse procedure to install. Torque screws to 8.2 N·m (73 in. lb.).

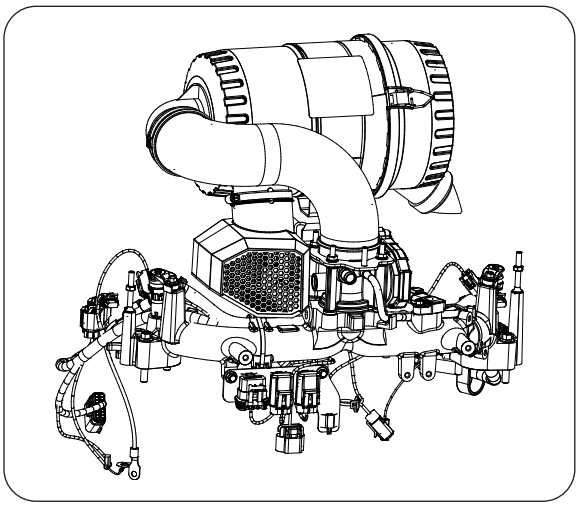
CV829 & CV832 Intake Manifold and Pulse Pump Assembly Components

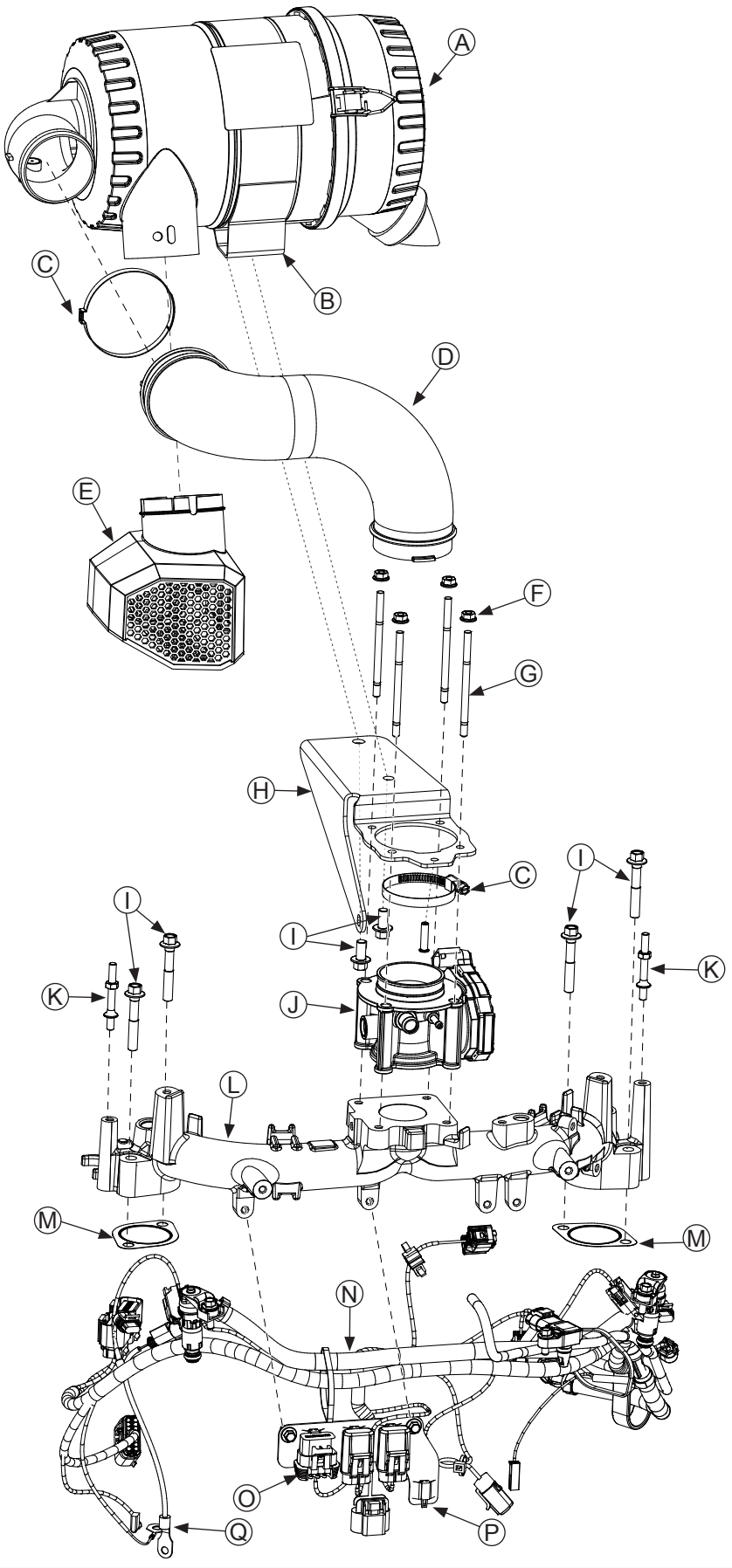


A	Air Cleaner	**B**	Clamp	**C**	Air Cleaner Hose	**D**	Intake Duct
E	Intake Manifold	**F**	Bolt	**G**	Gasket	**H**	Gasket
I	Carburetor	**J**	Gasket	**K**	Stud	**L**	Elbow
M	Nut	**N**	Evap Hose	**O**	Fuel Hose	**P**	Pulse Pump
Q	Fuel Filter	**R**	Hose Clamp	**S**	Bolt		

ECV830 & ECV834 Intake Manifold and Electronic Throttle Body Assembly Components

A	Air Cleaner
B	Hoop Bracket
C	Clamp
D	Air Cleaner Hose
E	Intake Duct
F	Nut
G	Stud
H	Throttle Body HDAC Bracket
I	Bolt
J	Throttle Body
K	Guard Stud
L	Intake Manifold
M	Gasket
N	Harness Fuel Rail Assembly
O	7-Pin Diagnostic Port
P	Fuse Bracket Assembly
Q	Harness Ground





Remove Stator

Remove screws and stator. Wire harness may stay connected to stator.

Remove Valley Baffle

Remove two lower screws on side, remove harness ground screw in valley area and remaining bolt and stud. Remove valley baffle.

Remove Cylinder Baffles

Remove screws and cylinder baffles.

Remove Crankcase Baffles

Remove screws and crankcase baffles.

Remove Ground Wire and Wire Harness

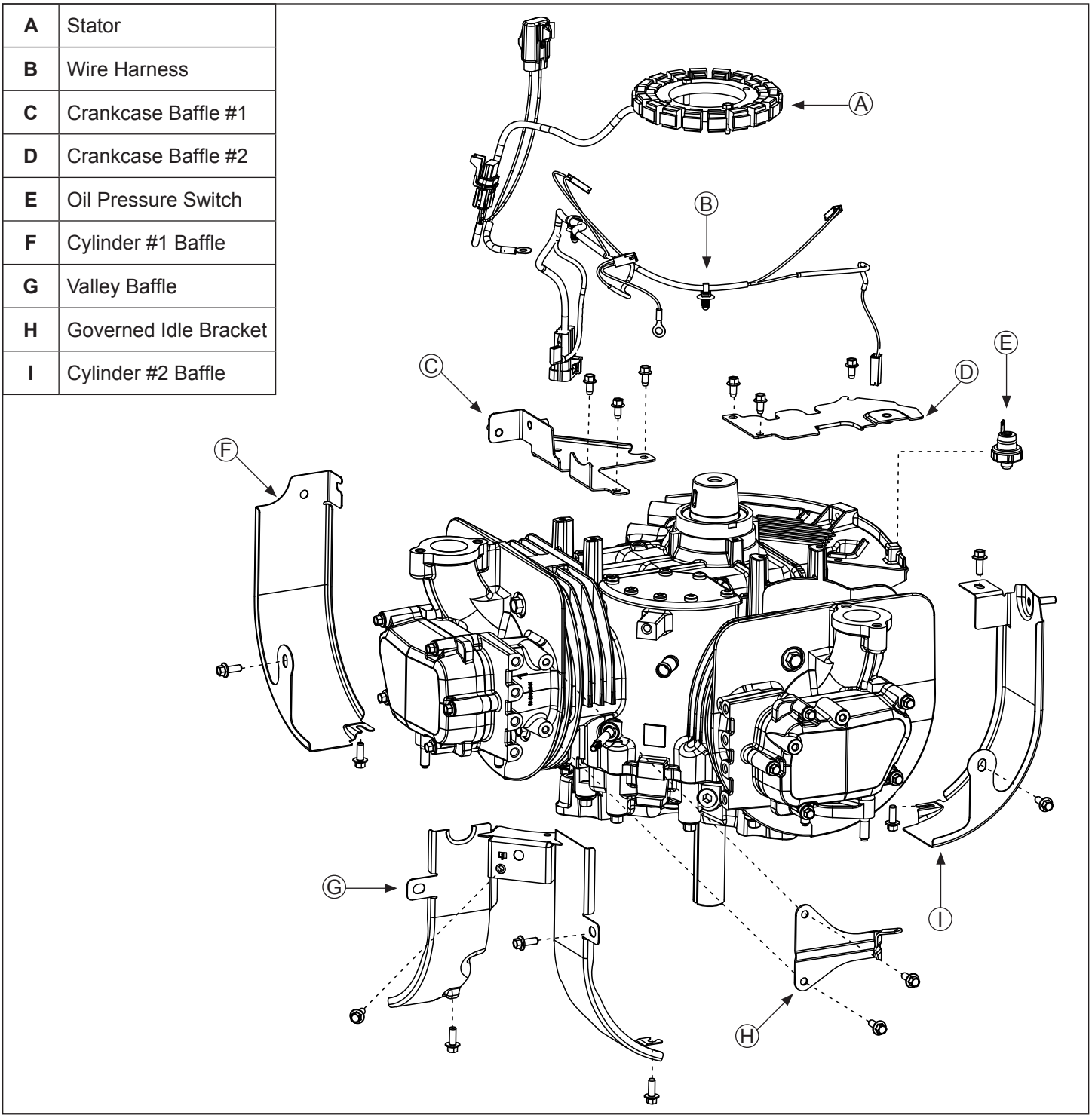
1. Disconnect oil temperature sensor connector and oil pressure switch lead.

   Note: Remove oil pressure switch from oil pan only if replacing.

2. Remove any remaining wire harnesses from engine. Stator and harness can remain attached during removal.

Baffles/Wire Harness/Stator Components

A	Stator
B	Wire Harness
C	Crankcase Baffle #1
D	Crankcase Baffle #2
E	Oil Pressure Switch
F	Cylinder #1 Baffle
G	Valley Baffle
H	Governed Idle Bracket
I	Cylinder #2 Baffle



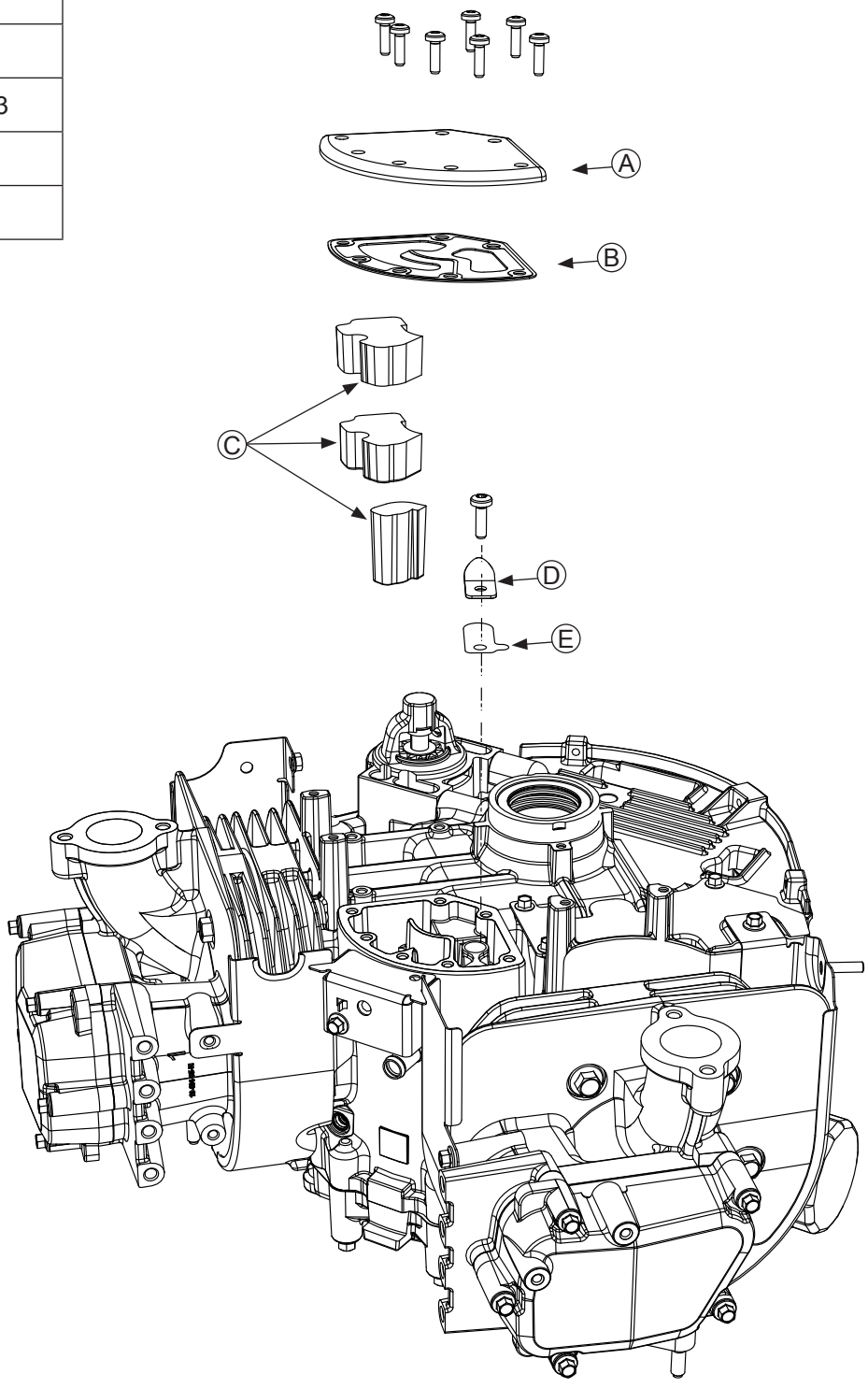
Remove Breather Assembly

NOTE: All breather components can be accessed without opening crankcase.

1. Remove fasteners securing breather cover to crankcase.
2. Carefully break gasket seal and remove cover, gasket, and filter. Do not pry on sealing surfaces as it could cause damage resulting in leaks. Note assembly and orientation of parts.
3. Remove screw, reed retainer, and reed.
4. Discard gasket.

Breather Assembly Components

A	Breather Cover
B	Gasket
C	Breather Filter x3
D	Reed Retainer
E	Reed



Remove Valve Covers

1. Remove screw securing each valve cover.
2. Remove valve cover and gasket from each cylinder head. Valve covers are cylinder specific. Note for reassembly.

Remove Spark Plugs

Remove spark plug from each cylinder head.

Remove Cylinder Heads

NOTE: Cylinder head number is embossed on outside of each cylinder head.

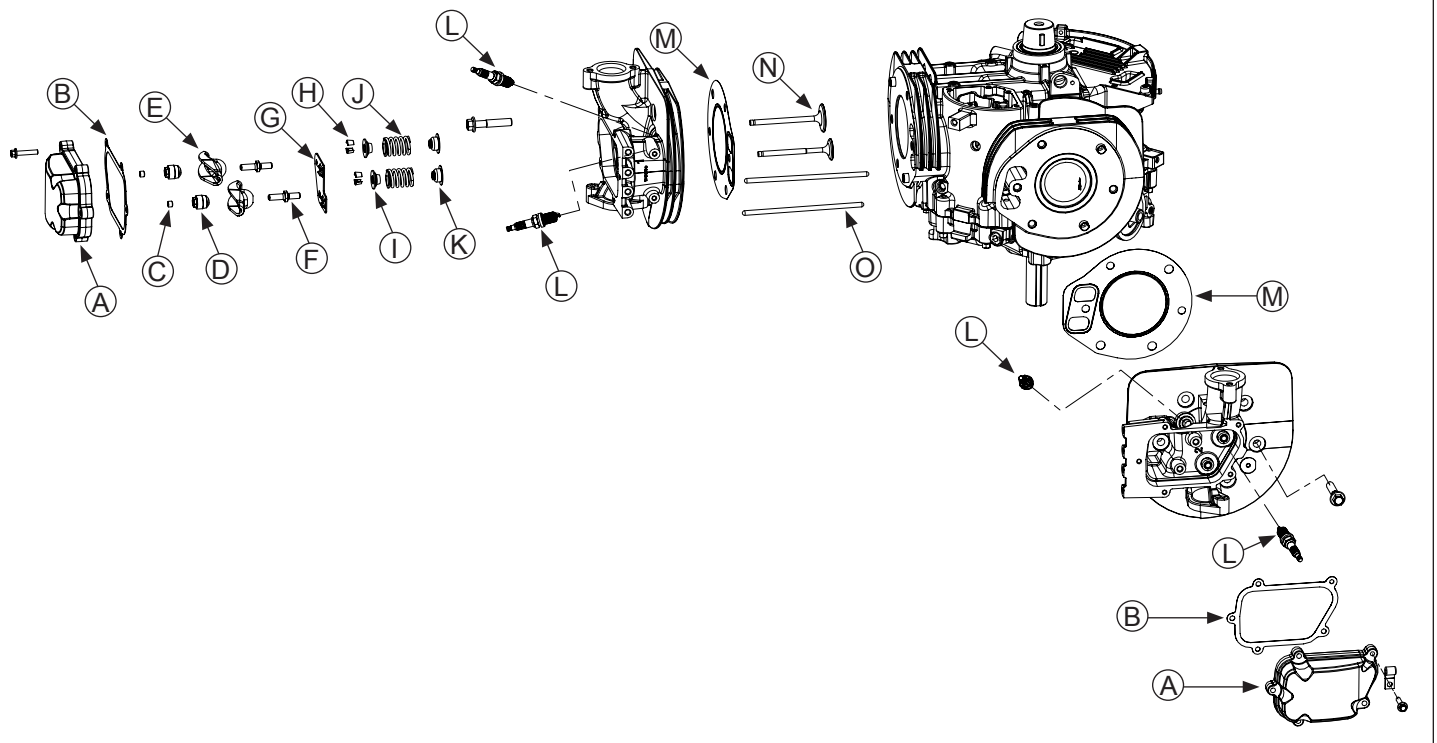
1. Loosen set screws and rocker arm pivots for each rocker arm enough to remove push rods.
2. Mark position of push rods as either intake or exhaust and cylinder #1 or #2. Push rods should always be reinstalled in same positions.
3. Remove set screws, rocker arm pivots, rocker arms, and push rods from cylinder head.
4. Remove screws securing cylinder head.
5. Carefully remove cylinder head and head gasket.
6. Repeat procedure for other cylinder head.

Disassemble Cylinder Heads

NOTE: These engines use valve stem seals on intake and exhaust valves. Use a new seal whenever valves are removed, or if seal is deteriorated in any way. Never reuse an old seal.

1. Remove set screws, rocker arm pivots, rocker arms, and push rods from cylinder head. Remove pivot studs and guide plate as required.
2. Compress valve springs using a valve spring compressor.
3. Once valve spring is compressed, remove following items:
   - Valve spring keepers.
   - Valve springs.
   - Valve spring caps.
   - Intake and exhaust valves (mark position).
   - Valve stem seals.
4. Repeat above procedure for other cylinder head. Do not interchange parts from one cylinder head to another.

Cylinder Head Components



A	Valve Cover	**B**	Gasket	**C**	Set Screw	**D**	Rocker Arm Pivot
E	Rocker Arm	**F**	Rocker Arm Stud	**G**	Push Rod Guide Plate	**H**	Valve Spring Keepers
I	Valve Spring Cap	**J**	Valve Spring	**K**	Valve Stem Seal	**L**	Spark Plug
M	Head Gasket	**N**	Valve	**O**	Push Rod		

Inspection and Service
After cleaning, check flatness of cylinder head and corresponding top surface of crankcase using a surface plate or precision straight edge and feeler gauge. Maximum allowable out of flatness is 0.076 mm (0.003 in.).If cylinder head is out of flatness, then replace cylinder head.

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

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

Then, carefully inspect each valve, valve seat, and cylinder head assembly for excessive corrosion or a worn components. If any component has visual wear, replacement is recommended.

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

See valve guide-to-valve stem clearance in Specification section. If visual wear or valve guide-to-valve stem clearance is questionable, cylinder head replacement is recommended.

Valve Seat Inserts
Hardened steel alloy intake and exhaust valve seat inserts are press fitted into cylinder head. Inserts are not replaceable. If found to be too badly pitted, distorted, cracked or badly warped, cylinder head should be replaced.

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

Remove Oil Pan Assembly

1. Remove screws securing oil pan to crankcase.
2. Locate protruding tabs on oil pan. Carefully tap to break gasket seal. Do not pry on sealing surfaces as this could cause leaks. Separate oil pan from crankcase. Remove old gasket.

Inspection
Inspect oil seal in oil pan and remove it if it is worn or damaged.

Inspect crankshaft bearing surface for wear or damage (refer to Specifications). Replace oil pan assembly if required.

Oil Pump Assembly

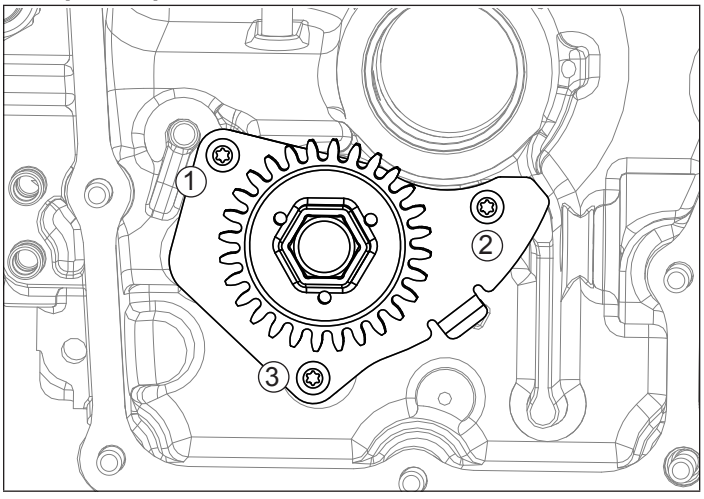
Oil pump is mounted inside oil pan. If service is required, continue with Disassembly, Inspection, and Reassembly.

Disassembly
1. Remove screws securing oil pump housing.
2. Lift oil pump assembly from oil pan. Remove outer gerotor gear and pickup screen from oil pan.
3. Ensure ball and spring remain installed in pressure relief hole of oil pan. If ball and spring fall out of pressure relief hole, see reassembly for correct installation.

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

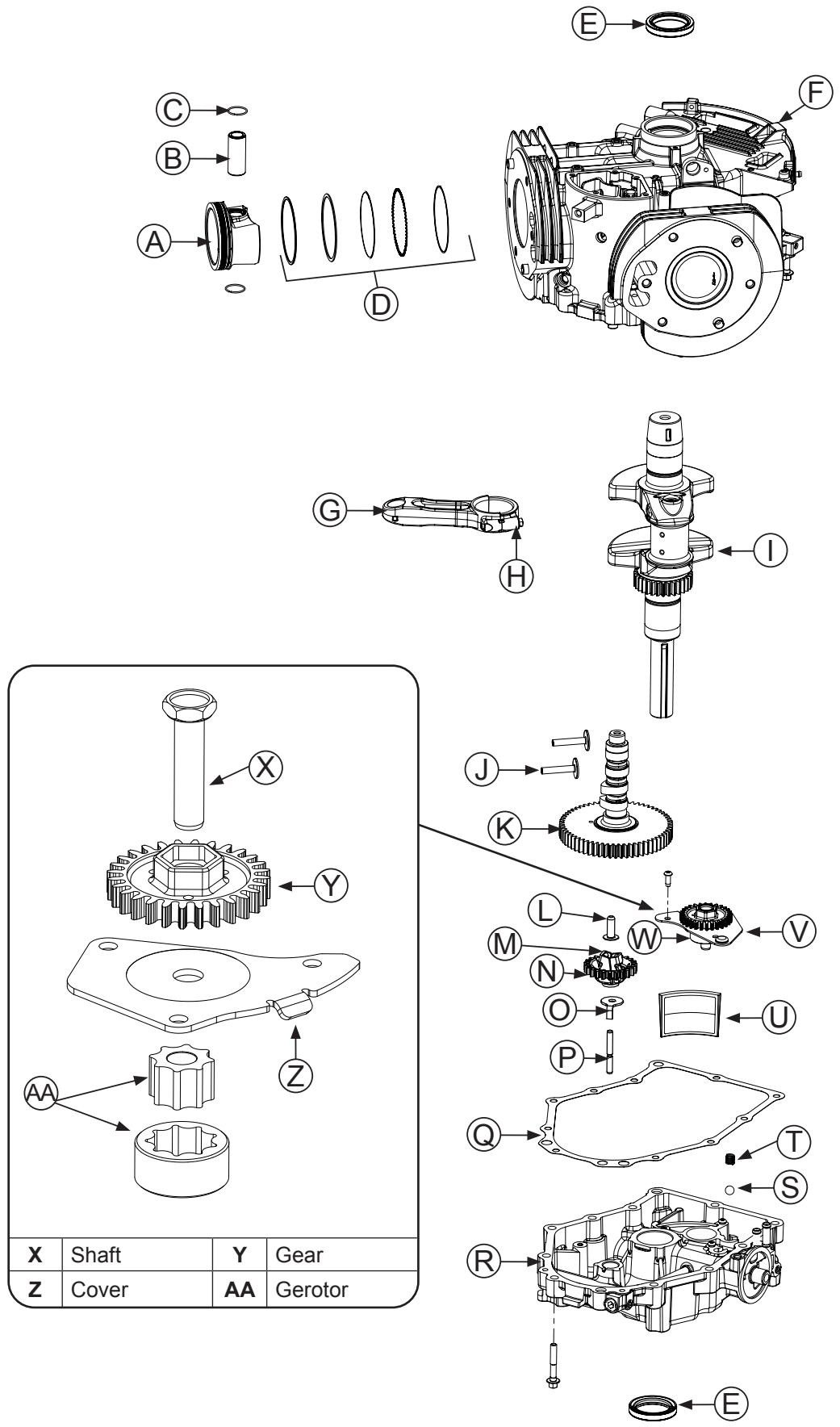
Reassembly
1. Lubricate outer gerotor gear with oil. Install outer gerotor gear through shaft of oil pump, around inner gerotor gear. Matching molding dots on inner and outer gerotor gears is not necessary and will not affect oil pump efficiency.
2. Reinstall ball, then spring into pressure relief hole in oil pan.
3. Install oil pump inserting center shaft into corresponding recess in oil pan. Apply consistent downward pressure to oil pump cover, compressing oil pressure relief spring and start screws. Secure oil pump by torquing screws to 9.6 N·m (85 in. lb.) into new holes, or 6.0 N·m (53 in. lb.) into used holes.
4. After torquing, rotate gear and check for freedom of movement. Make sure there is no binding. If binding occurs, loosen screws, reposition pump, retorque screws and recheck movement.

Torque Sequence



Crankcase Components

A	Piston
B	Piston Pin
C	Piston Pin Retainer Clip
D	Piston Ring
E	Oil Seal
F	Crankcase
G	Connecting Rod
H	Connecting Rod End Cap
I	Crankshaft
J	Tappet
K	Camshaft
L	Regulating Pin*
M	Flyweight*
N	Governor Gear*
O	Locking Tab Thrust Washer*
P	Governor Gear Shaft
Q	Gasket
R	Oil Pan
S	Relief Ball
T	Spring
U	Oil Screen
V	Oil Pump
W	Gerotor Gear

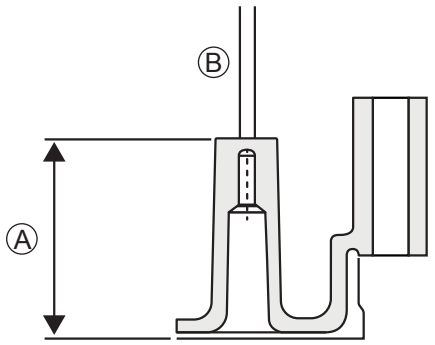


X	Shaft	**Y**	Gear
Z	Cover	**AA**	Gerotor

*Carbureted engine only

Governor Gear Assembly (Mechanical Governor)

Governor Shaft Press Depth Detail



A	60.0 mm (2.3622 in.) 58.95 mm (2.3029 in.)	**B**	Gear Shaft

Governor gear assembly is located inside oil pan. If service is required, continue with Inspection, Disassembly, and Reassembly.

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

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

Governor gear must be replaced once it is removed from oil pan.

1. Use 2 small screwdrivers and carefully pry upward to unseat governor gear assembly from governor gear shaft. Remove regulating pin and governor gear assembly.
2. Remove locking tab thrust washer and note orientation.
3. Carefully inspect governor gear shaft and replace it only if it is damaged. After removing damaged shaft, press or lightly tap replacement shaft into oil pan to depth shown.

Reassembly
1. Install locking tab thrust washer on governor gear shaft with tab down.
2. Position regulating pin within governor gear/flyweights assembly and slide both onto governor shaft until assembly locks into place.

Remove Camshaft and Valve Tappets

1. Remove camshaft.
2. Remove valve tappets from crankcase and mark them by their location, as either intake or exhaust and cylinder 1 or 2. Tappets should always be reinstalled in same position.

Camshaft Inspection and Service
Check lobes of camshaft for wear or damage. Inspect cam gear for badly worn, chipped, or missing teeth. Replacement of camshaft will be necessary if any of these conditions exist.

Valve Tappet Inspection
Check base surface of valve tappet(s) for wear or damage. Replace tappets(s) if condition is questionable in any way. Corresponding camshaft lobe(s) should also be checked for wear or damage. Whenever tappets are replaced, apply a liberal coating of lubricant to base of each new tappet before it is installed.

Governor Cross Shaft (Mechanical Governor)

Governor Cross Shaft is not a serviceable part.

Inspect cross shaft for abnormalities. If during visual inspection cross shaft, supporting structure or bearings show excessive wear marks or are worn, replace engine.

Remove Governor Cross Shaft Oil Seal (Mechanical Governor)

Carefully remove governor cross shaft seal from shaft bore in crankcase. Do not scratch or damage seal bore.

Remove Connecting Rods with Pistons and Rings

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

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

1. Remove screws securing closest connecting rod end cap. Remove end cap.
2. Carefully remove connecting rod and piston assembly from cylinder bore.
3. Repeat above procedures for other connecting rod and piston assembly.

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

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

Service replacement connecting rods are available in STD crankpin size. Always refer to appropriate parts information to ensure that correct replacements are used.

Piston and Rings

Inspection And Service

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

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

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

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

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

Detonation damage occurs when a portion of fuel charge ignites spontaneously from heat and pressure shortly after ignition. This creates 2 flame fronts which meet and explode to create extreme hammering pressures on a specific area of piston. Detonation generally occurs from using low octane fuels.

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

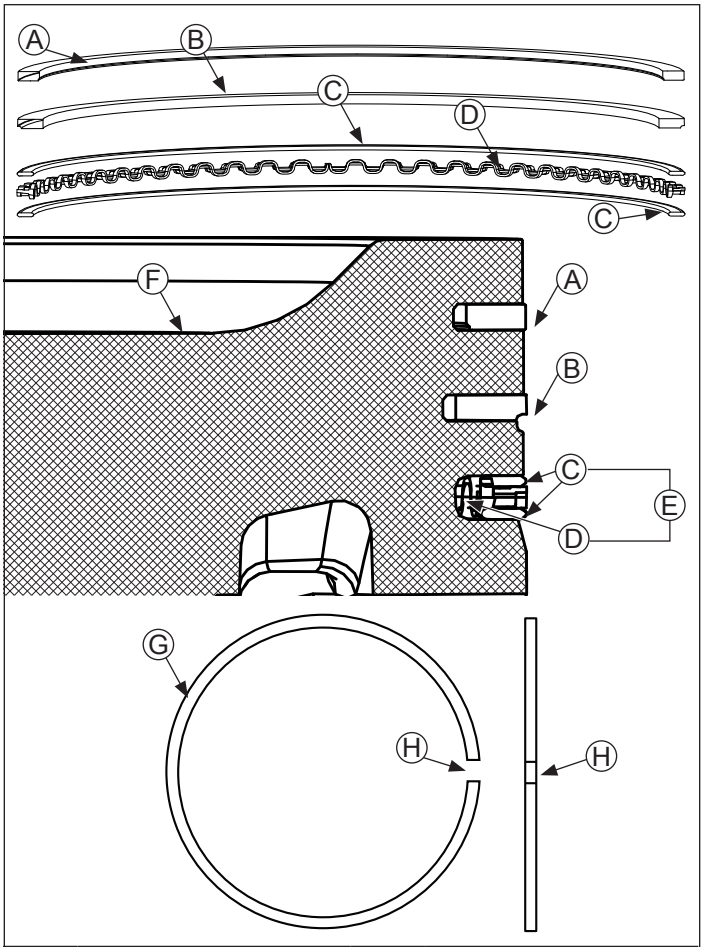
Replacement pistons are available in STD bore size and include new piston ring sets and new piston pins.

Replacement ring sets are also available separately for STD pistons. Always use new piston rings when installing pistons. Never reuse old rings.

Some important points to remember when servicing piston rings:

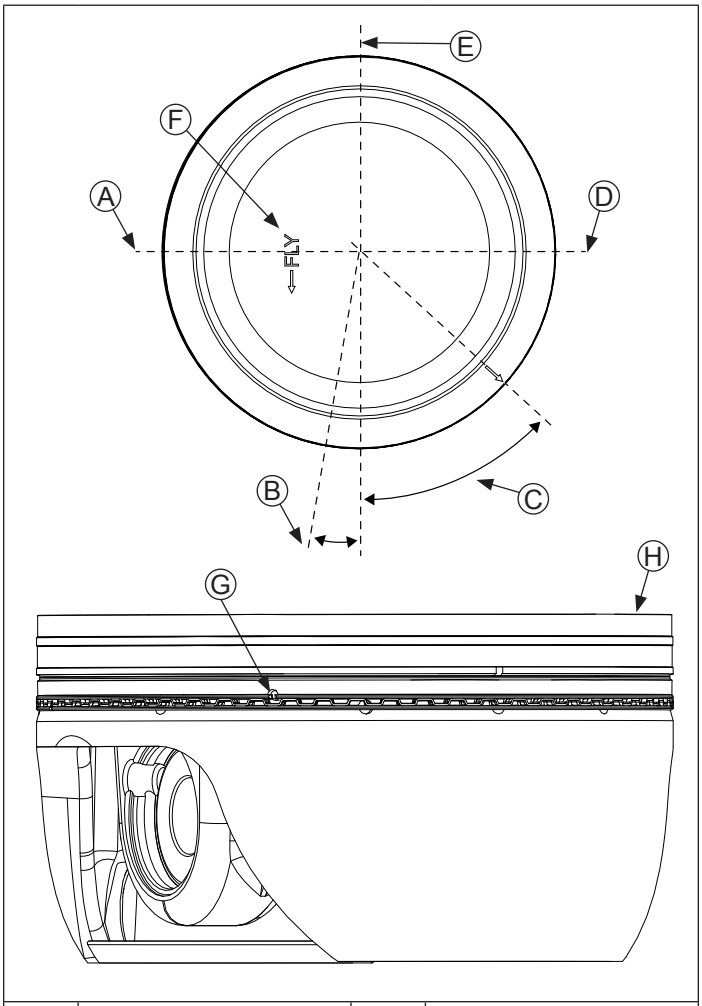
1. If cylinder bore is worn, and/or crosshatch is no longer visible engine replacement is recommended.
1. Cylinder bore must be deglazed before service ring sets are used.
2. If cylinder bore does not need reboring and if old piston is within wear limits and free of score or scuff marks, old piston may be reused.
3. Remove old rings and clean up grooves. Never reuse old rings.
4. Before installing new rings on piston, place top 2 rings, each in turn, in its running area in cylinder bore and check end gap. Compare ring gap to tolerance listed in Specifications.
5. After installing new compression (top and middle) rings on piston, check piston-to-ring side clearance. Compare clearance to tolerance listed in Specifications. If side clearance is greater than specified, a new piston must be used.

Install New Piston Rings
Piston and Rings Components and Details



A	Top Compression Ring	**B**	Middle Compression Ring
C	Oil Ring Rails	**D**	Oil Ring Expander
E	Oil Control Ring (3 Piece)	**F**	Piston
G	Piston Ring	**H**	End Gap

Piston Ring Orientation



A	Top Compression Ring Gap	**B**	Bottom Oil Ring Rail Gap — 10°
C	Top Oil Ring Rail Gap — 48°	**D**	Middle Compression Ring Gap
E	Oil Ring Expander Gap	**F**	FLY Stamp
G	Pin	**H**	Piston

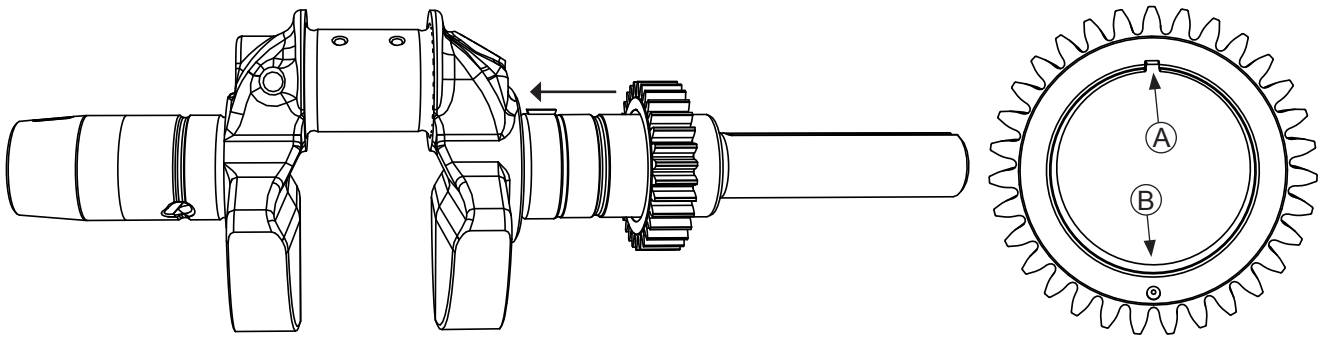
NOTE: Rings must be installed correctly. Ring installation instructions are usually included with new ring sets. Follow instructions carefully. Use a piston ring expander to install rings. Install bottom (oil control) ring first and top compression ring last.

To install new piston rings, proceed as follows:

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

Crankshaft Inspection

Crankshaft Detail



A	Keyway Notch	**B**	Top Dead Center Mark

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

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

NOTE: Due to pre-established wear patterns, both the camshaft and crankshaft gear assembly should always be replaced as a set, even when damage may not be visible.

Inspect crankshaft bearing surfaces for scoring, grooving, etc. Measure running clearance between crankshaft journals and their respective bearing bores. Use an inside micrometer or telescoping gauge to measure inside diameter of both bearing bores in vertical and horizontal planes. Use an outside micrometer to measure outside diameter of crankshaft main bearing journals. Subtract journal diameters from their respective bore diameters to get running clearances. Check results against values in Specifications. If running clearances are within specification, and there is no evidence of scoring, grooving, etc., no further reconditioning is necessary. If bearing surfaces are worn or damaged, crankcase, crankshaft and/or oil pan will need to be replaced.

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

Inspect crankpin for score marks or metallic pickup. Slight score marks can be cleaned with crocus cloth soaked in oil. If wear limits, as stated in Clearance Specifications, are exceeded, it will be necessary to replace crankshaft. Measure crankpin for size, taper, and out-of-round.

Clearance Specifications-Connecting Rod Journal

O.D. - New	43.98/44.00 mm (1.7316/1.7323 in.)
O.D. - Max. Wear Limit	43.971 mm (1.7311 in.)
Max. Taper	0.018 mm (0.0007 in.)
Max. Out-of-Round	0.025 mm (0.0010 in.)
Width	53.000/53.150 mm (2.0866/2.0923 in.)

Remove Flywheel End Oil Seal

Remove oil seal from crankcase using a seal puller.

Crankcase

Inspection and Service
Check all gasket surfaces to make sure they are free of gasket fragments. Gasket surfaces must also be free of deep scratches or nicks. The use of sharp gasket removal tools can cause damage to aluminum surface. Take precaution to use proper gasket removal tools and procedures.

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

If cylinder bore is badly scored, excessively worn, tapered, or out-of-round, engine replacement is recommended.

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.

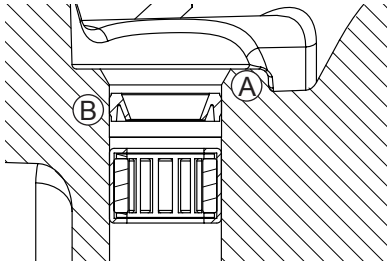
Check oil pan, crankcase, cylinder heads, and valve covers to be certain all old gasket material has been removed. Use gasket remover, lacquer thinner, or paint remover to remove any remaining traces. Clean surfaces with isopropyl alcohol, acetone, lacquer thinner, or electrical contact cleaner.

Install Flywheel End Oil Seal

1. Make sure seal bore of crankcase is clean and free of any nicks or burrs.
2. Apply a light coat of P80 Emulsion Lubricant (refer to Tools and Aids) to outside diameter of oil seal.
3. Install oil seal into crankcase using a seal driver. Make sure oil seal is installed straight and true in bore and tool bottoms against crankcase.

Install Governor Cross Shaft Oil Seal (Mechanical Governor)

Lightly coat outer diameter of governor cross shaft seal with P80 Emulsion Lubricant (refer to Tools and Aids). Use a seal installer and install new seal into bore until top of seal is slightly below bottom of bore hole chamfer.



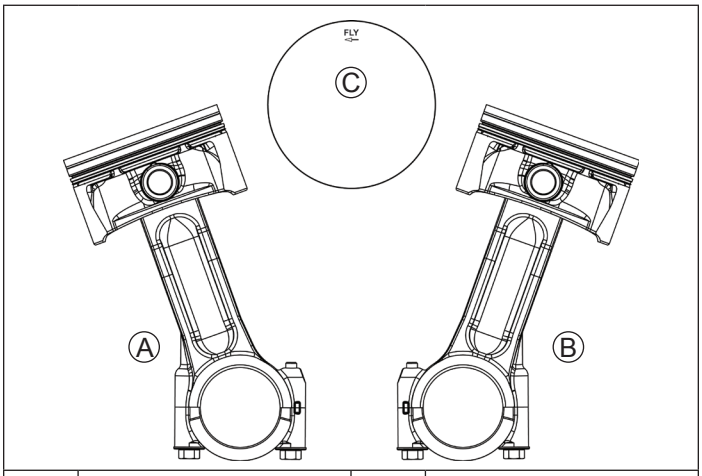
A	Top of Seal Below Bottom of Chamfer	**B**	Oil Seal

Install Crankshaft

Carefully slide flywheel end of crankshaft through oil seal in crankcase.

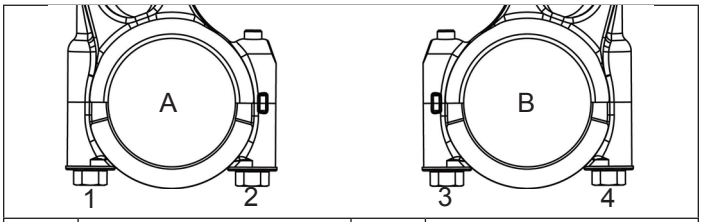
Install Connecting Rods with Pistons and Rings

Piston Details



A	Side 1	**B**	Side 2
C	Top of Piston		

Connecting Rod Torque Sequence



A	Cylinder 1	**B**	Cylinder 2

NOTE: Cylinders are numbered on the crankcase. Install the piston, rod, and end cap in their original bore as marked during disassembly. Do not mix rods and caps.

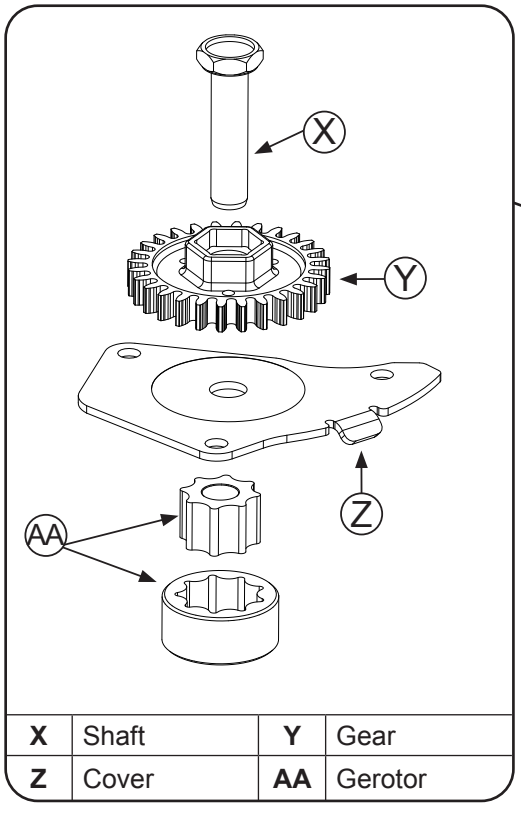
NOTE: Proper piston/rod orientation is critical. Incorrect assembly can cause severe wear/damage. Ensure pistons and rods are installed exactly as shown.

1. If piston rings were removed, refer to Disassembly/ Inspection and Service procedure to install new rings.
2. Lubricate cylinder bore, piston, and piston rings with engine oil. Compress rings of piston side 1 using a piston ring compressor.
3. Lubricate crankshaft journals and connecting rod bearing surfaces with engine oil.
4. Make sure FLY stamping on piston is facing toward flywheel side of engine. Use a hammer with a rubber grip and gently tap piston into cylinder. Be careful oil ring rails do not spring free between bottom of ring compressor and top of cylinder.
5. Install inner rod cap to connecting rod using screws. Torque screws in 2 stages, first to 5.7 N·m (50 in. lb.) finally to 12.4 N m (110 in. lb.) following sequence shown. Illustrated instructions are provided in service rod package.

   Align chamfer of connecting rod with chamfer of its mating end cap. When installed, flat faces of connecting rods should face each other. Faces with raised rib should be toward outside.
6. Repeat this procedure for other connecting rod and piston assembly.

Crankcase Components

A	Piston
B	Piston Pin
C	Piston Pin Retainer Clip
D	Piston Ring
E	Oil Seal
F	Crankcase
G	Connecting Rod
H	Connecting Rod End Cap
I	Crankshaft
J	Tappet
K	Camshaft
L	Regulating Pin*
M	Flyweight*
N	Governor Gear*
O	Locking Tab Thrust Washer*
P	Governor Gear Shaft
Q	Gasket
R	Oil Pan
S	Relief Ball
T	Spring
U	Oil Screen
V	Oil Pump
W	Geroter Gear



X	Shaft	**Y**	Gear
Z	Cover	**AA**	Gerotor

*Carbureted engine only

Install Valve Tappets and Camshaft

NOTE: Exhaust valve tappets are located on output shaft side of engine, while intake valve tappets are located on fan side of engine. Cylinder number is embossed on outside of each cylinder on crankcase. Valve tappets should always be installed in same position as before disassembly.

1. Apply camshaft lubricant to contact surface of valve tappets. Note mark or tag identifying tappets and install them in their appropriate crankcase locations. A small amount of grease applied to stems will hold valve tappets up until camshaft is installed.
2. Liberally apply camshaft lubricant to lobes of camshaft. Lubricate camshaft bearing surfaces of crankcase and camshaft with engine oil.
3. Position timing mark of crankshaft gear at 12 o'clock position.
4. Turn governor cross shaft clockwise until lower end (blade) is laying against bottom of cylinder. Make sure cross shaft remains in this position while installing camshaft.
5. Slide camshaft into bearing surface of crankcase, positioning timing mark of camshaft gear at 6 o'clock position. Make sure camshaft gear and crankshaft gear mesh with both timing marks aligned.

Determining Camshaft End Play

1. Place a new oil pan gasket into position on crankcase.
2. Position camshaft end play checking tool over camshaft. Use a feeler gauge to check end play between camshaft and end play checking tool. Camshaft end play should be between 0.200/0.548 mm (0.008/0.022 in.).
3. If camshaft end play is not within specified range, remove checking tool and replace camshaft.
4. Reinstall end play checking tool and recheck end play.

Oil Pump Assembly

Oil pump is mounted inside oil pan. If service was required and oil pump was removed, refer to Disassembly/Inspection and Service procedure.

Governor Assembly

Governor assembly is located inside oil pan. If service was required and governor was removed, refer to Disassembly/Inspection and Service procedure.

Install Oil Pan Seal

PTO Oil Seal Details

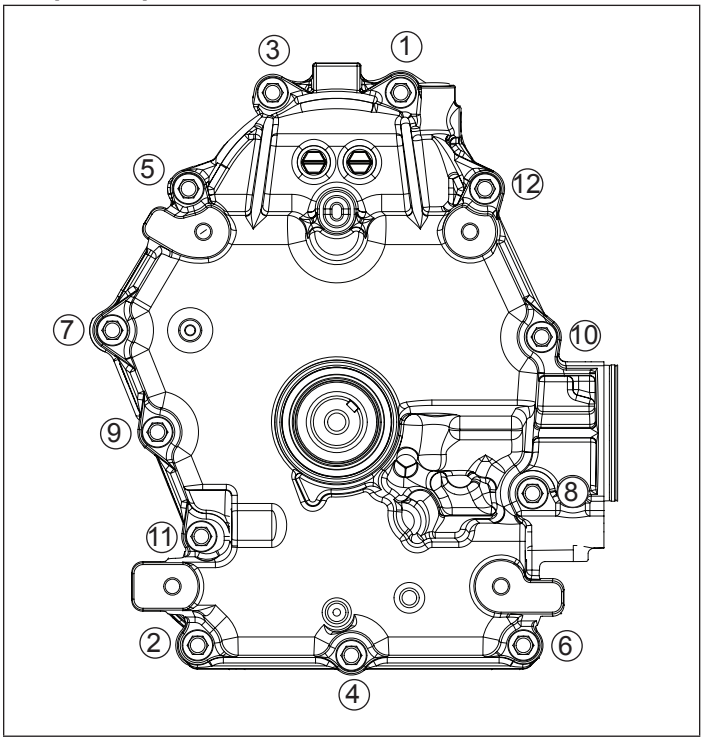
1. Check to make sure there are no nicks or burrs in crankshaft seal bore of oil pan.
2. Apply a light coat of P80 Emulsion Lubricant (refer to Tools and Aids) to outside diameter of oil seal.
3. Install oil seal into oil pan using a seal driver. Make sure oil seal is installed straight and true in bore to depth shown.

Install Oil Pan Assembly

1. Make sure sealing surfaces of oil pan and crankcase are clean, dry, and free of any nicks or burrs.
2. Install a new oil pan gasket onto crankcase and two O-rings on oil transfer passages.
3. Make sure oil pump is installed in oil pan.
4. Ensure end of locking tab washer on governor gear is positioned outward in 6 o’clock position inside crankcase.
5. Orient flat of oil pump gear to match position of flat on camshaft. Install oil pan to crankcase. Carefully seat camshaft and crankshaft into their mating bearings. Rotate crankshaft slightly to help oil pump and governor gears mesh.
6. Lightly oil threads and install screws securing oil pan to crankcase. Torque fasteners in sequence shown to 25.6 N·m (227 in. lb.).

NOTE: Governor adjustment is recommended if oil pan assembly has been replaced. Refer to process on page 65.

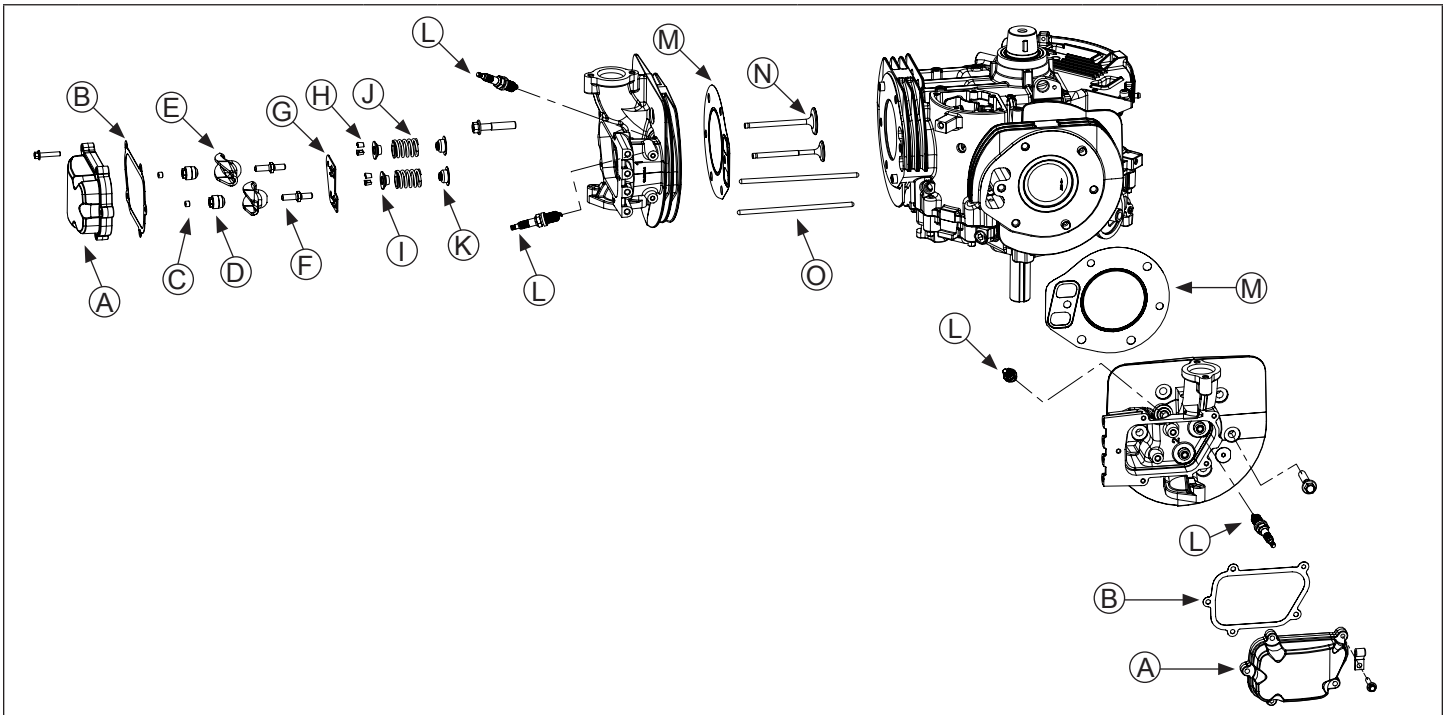
Torque Sequence



Check Crankshaft End Play

Set engine on base and use a dial indicator to check crankshaft end play. Crankshaft end play should be between 0.073/0.762 (0.0029/0.0300 in.).

Cylinder Head Components



A	Valve Cover	**B**	Gasket	**C**	Set Screw	**D**	Rocker Arm Pivot
E	Rocker Arm	**F**	Rocker Arm Stud	**G**	Push Rod Guide Plate	**H**	Valve Spring Keepers
I	Valve Spring Cap	**J**	Valve Spring	**K**	Valve Stem Seal	**L**	Spark Plug
M	Head Gasket	**N**	Valve	**O**	Push Rod		

Valve Stem Seals

These engines use valve stem seals on intake and exhaust valves. Always use new seals whenever valves are removed from cylinder head. Seals should also be replaced if worn or damaged. Never reuse an old seal.

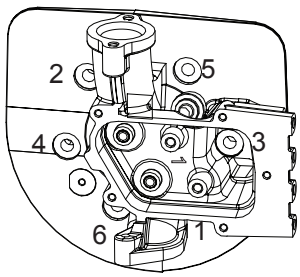
Assemble Cylinder Heads

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

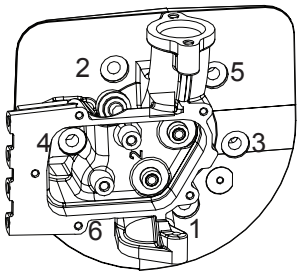
- Intake and exhaust valves
- Valve stem seals.
- Valve springs.
- Valve spring caps.
- Valve spring keepers.

Install Cylinder Heads

First Torque Sequence



Cylinder Head #1



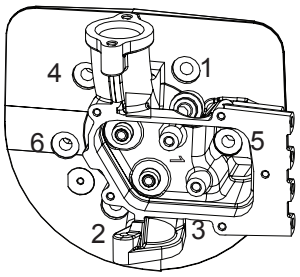
Cylinder Head #2

NOTE: Cylinder heads are side specific. Match embossed number on cylinder head with corresponding cylinder.

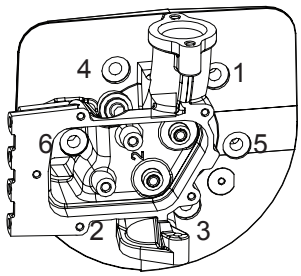
NOTE: First and second cylinder head torque sequence pattern is different between the two steps. See diagram.

1. Check to make sure there are no nicks or burrs on sealing surfaces of cylinder head or crankcase.
2. Check dowel pins are in place in 2 locations, and install a new cylinder head gasket. Confirm engine block mating surface is clean and free of debris.
3. Install cylinder head. Make sure head is flat on gasket and dowel pins. Start 6 screws.
4. Torque screws in 2 stages, first to 23.7 N·m (210 in. lb.), finally to 44.1 N·m (390 in. lb.) following sequence shown.
5. Repeat procedure for opposite cylinder.

Second Torque Sequence



Cylinder Head #1



Cylinder Head #2

Install Guide Plate, Rocker Arm Pivot, Push Rods and Rocker Arms

NOTE: Install rocker arm stud with coarse threads into head.

1. Install push rod guide plate and rocker arm studs onto cylinder heads if removed previously. Torque studs to 28.2 N·m (250 in. lb.).
2. Note mark or tag identifying push rod as either intake or exhaust and cylinder 1 or 2. Dip ends of push rods in engine oil and install, making sure each push rod ball seats in its socket.
3. Install rocker arms, rocker arm pivots, and set screws (loosely).

Adjust Valve Clearance

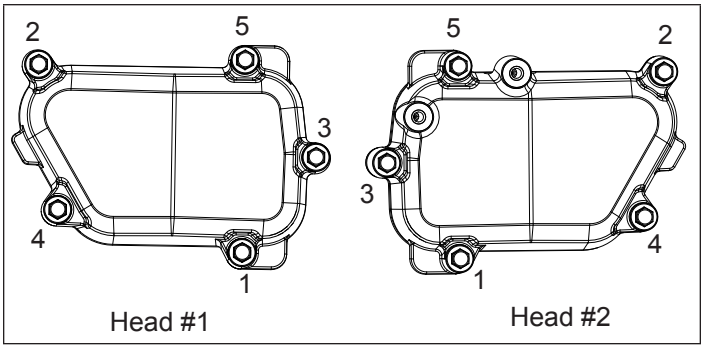
1. Turn rocker arm pivot in rocker arm by hand clockwise (down), only enough to capture push rods in recesses.
2. Rotate crankshaft to establish TDC on compression stroke for cylinder 1. Check for:
   a. Compression will be felt through spark plug hole.
   b. Keyway of crankshaft will be aligned with cylinder 1.
   c. No rocker arm/push rod movement if crankshaft is rotated slightly back and forth. If they are moving, rotate crankshaft one full revolution.
3. Insert a 0.127 mm (0.005 in.) feeler gauge between end of one valve and rocker arm.
4. Turn pivot until a slight drag is felt.
5. Hold in this position and tighten set screw securely. Torque set screw to 7.8 N·m (69 in. lb.), then recheck adjustment.
6. Proper clearance for all valves is 0.050/0.127 mm (0.0020/0.0050 in.).
7. Repeat procedure for other cylinder.
8. After proper clearance has been set, lubricate pivot and rocker arm contact points with engine oil.

Check Assembly

Rotate crankshaft a minimum of two revolutions to check assembly and overall proper operation.

Install Valve Covers

Torque Sequence



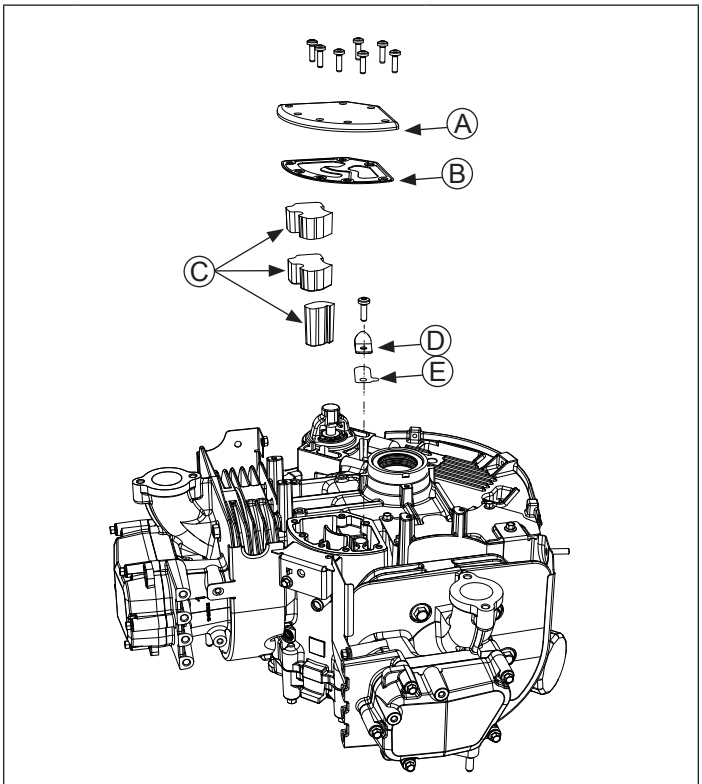
Head #1 Head #2

1. Make sure sealing surfaces are clean and free of any nicks or burrs.
2. Install valve covers on same side as they were originally installed using new gaskets.

   A J-Clip is mounted on screw closest to intake port.
3. Check position of each cover and gasket, then torque screws to 12.4 N·m (110 in. lb.) using sequence shown.

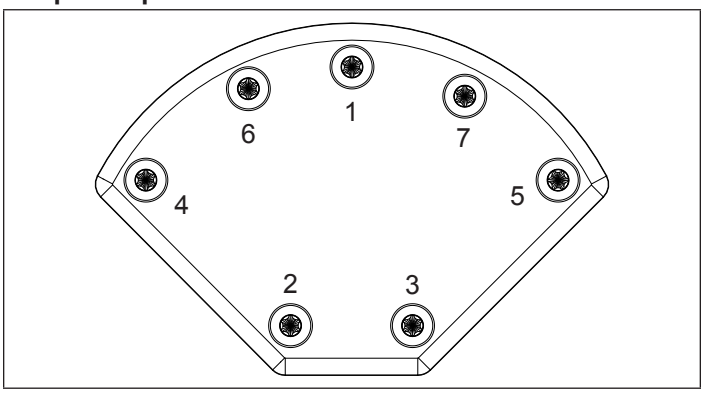
Install Breather Assembly

Breather Assembly Components



A	Breather Cover	**B**	Gasket
C	Filter x3	**D**	Reed Retainer
E	Reed		

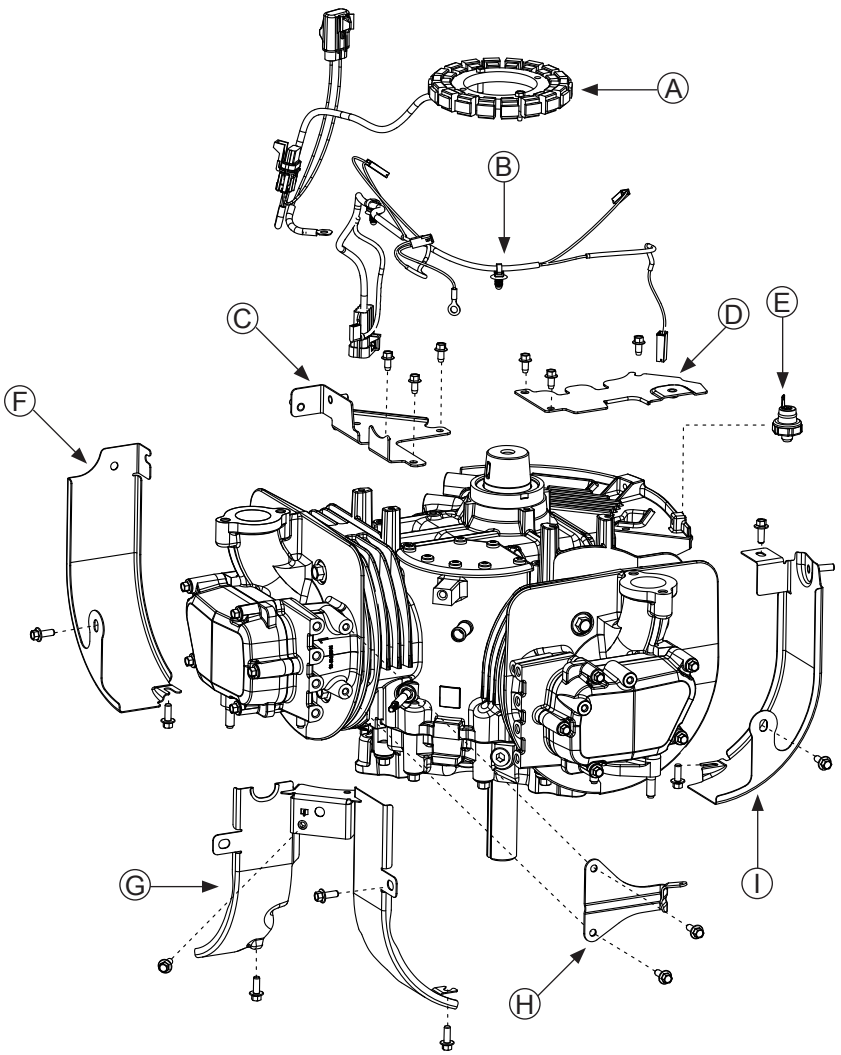
Torque Sequence



1. Make sure sealing surfaces of crankcase and breather cover are clean and free of any nicks or burrs. Do not scrape surfaces, as this could result in leakage.
2. Install reed and reed retainer. Torque screw to 11.3 N·m (100 in. lb.).
3. Install filter. Make sure filter does not extend above top surface.
4. Install breather gasket with sealant bead up (towards cover).
5. Install cover and screws. Torque screws in 2 stages, first to 4.5 N·m (40 in. lb.), finally to 11.3 N·m (100 in. lb.) following sequence shown.

Baffles/Wire Harness/Stator Components

A	Stator
B	Wire Harness
C	Crankcase Baffle #1
D	Crankcase Baffle #2
E	Oil Pressure Switch
F	Cylinder #1 Baffle
G	Valley Baffle
H	Governor Idle Bracket
I	Cylinder #2 Baffle



Install Valley, Crankcase, and Cylinder Baffles

1. Install crankcase baffles. Secure with screws. Torque M6 screws going into crankcase to 11.3 N·m (100 in. lb.) into new holes, or 7.7 N·m (68 in. lb.) into used holes.
2. Install valley baffle and secure with screws. Torque M6 screws to 8.2 N·m (73 in. lb.). Reinstall wire harness clip to baffle.
3. Install cylinder barrel baffles. Make sure spark plug lead is routed through corresponding opening in each baffle. Start each screw. Torque M6 screws to 8.2 N·m (73 in. lb.).

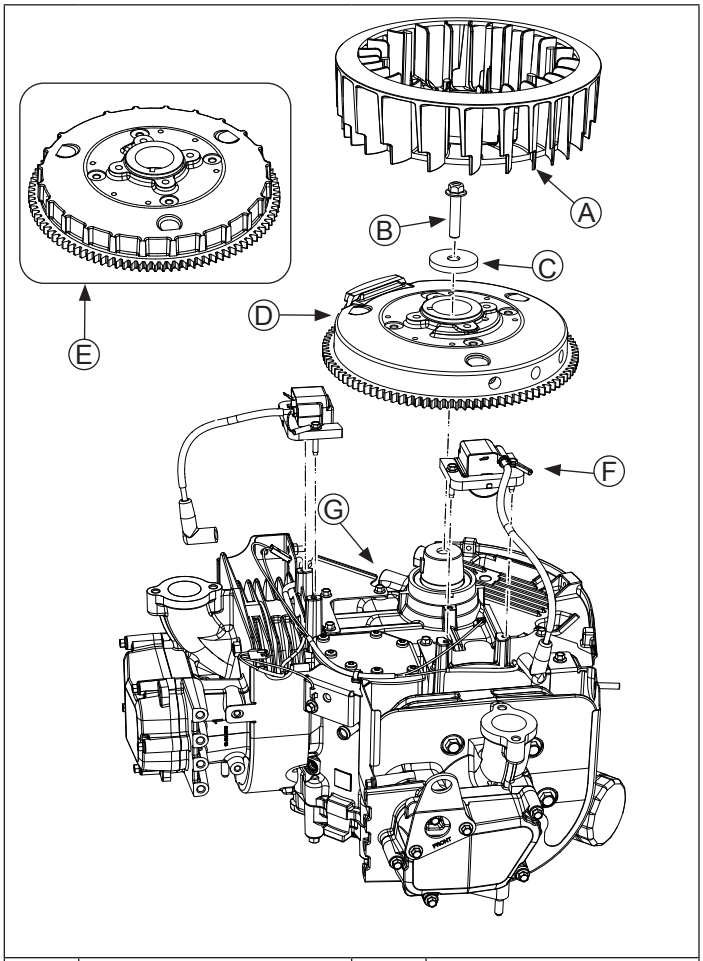
Install Stator

1. Position stator and wire harness on crankcase, aligning mounting holes, with stator lead toward cylinder #1 side. Route stator lead between electric starter boss, #1 crankcase baffle, and crankcase rib.
2. Apply pipe sealant with Teflon® (Loctite® PST® 592™ Thread Sealant or equivalent) to stator mounting holes and secure with two screws. Torque screws to 9.3 N·m (82 in. lb.) into new holes, or 4.0 N·m (35 in. lb.) into used holes.

   Install harness into baffle clips in a way that will not interfere with flywheel.

Install Flywheel/Fan

Flywheel/Fan Components



A	Flywheel Fan	**B**	Flywheel Screw
C	Washer	**D**	Carb Flywheel
E	ETB Flywheel	**F**	Ignition Modules
G	Woodruff Key		

⚠ CAUTION

Damaging Crankshaft and Flywheel can cause personal injury.

Using improper procedures can lead to broken fragments. Broken fragments could be thrown from engine. Always observe and use precautions and procedures when installing flywheel.

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

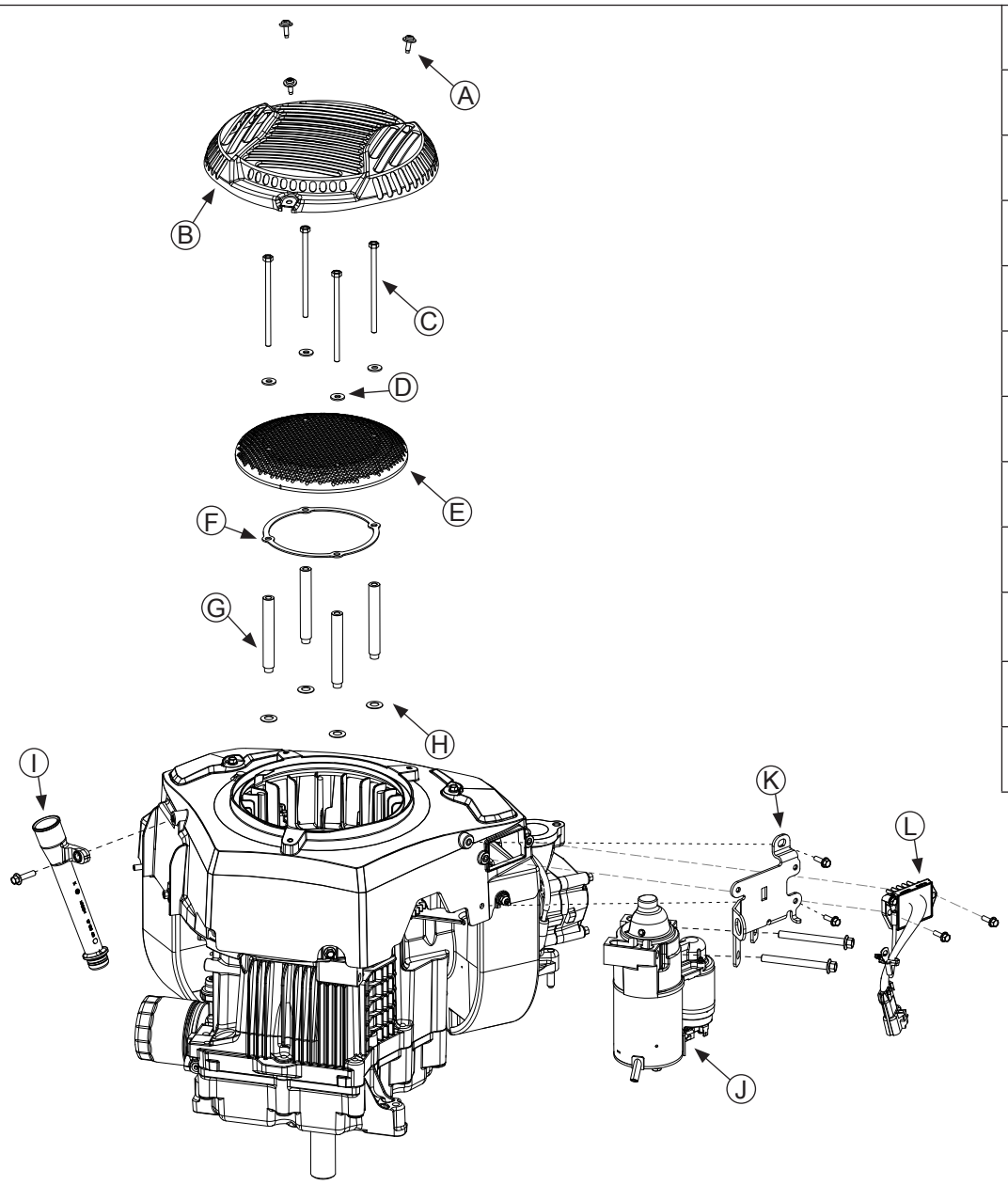
NOTE: Make sure flywheel key is installed properly in keyway. Flywheel can become cracked or damaged if key is not properly installed.

1. Install woodruff key into crankshaft keyway. Make sure key is properly seated and parallel with shaft taper.
2. Set flywheel onto crankshaft, being careful not to shift woodruff key.
3. Install screw and washer.
4. Use a flywheel strap wrench or holding tool to hold flywheel. Torque screw to 71.6 N·m (53 ft. lb.).

Install Fan

Set fan on flywheel with locating tabs on back of fan in locating holes of flywheel.

Blower Housing/Starter Motor



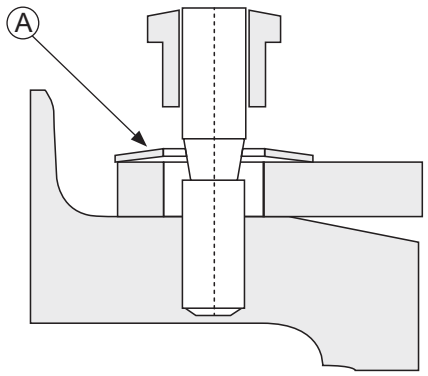
A	Screw
B	Fan Guard
C	Screw
D	Washer
E	Grass Screen
F	Support Ring
G	Spacer
H	Washer
I	Oil Fill Tube
J	Starter Motor Assembly
K	Fuse Holder Bracket
L	Rectifier-Regulator

Install Blower Housing

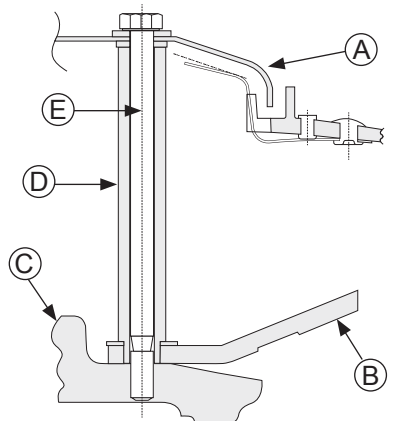
1. Install blower housing and secure with screws and nuts. Torque fasteners to 4.8 N·m (42 in. lb.).
2. If rectifier-regulator were removed from bracket/ blower housing, install them now. Torque screws to 1.7 N·m (12 in. lb.).
3. Plug Stator into rectifier-regulator.
4. Install oil fill tube into crankcase. Secure with mounting screw. Torque screw to 4.8 N·m (42 in. lb.).

Install Grass Screen

Spring Washer Details



A	Spring Washer



A	Grass Screen	**B**	Fan
C	Flywheel	**D**	Spacer
E	Hex Screw		

1. To assist assembly, find intake manifold studs with M6 thread at least 100 mm in length to be used as guide pins. Insert intake manifold studs through cooling fan mounting holes and thread them 4 or 5 turns into flywheel.
2. Install a spring washer on each stud with concave side down toward cooling fan.
3. Install a spacer on each stud with stepped end down. Smaller diameter should extend through spring washer and fan, so tip is resting on flywheel, and shoulder is resting on spring washer.
4. Install support rings on studs, so they are resting on spacers. Then install metal screen on top of support rings.
5. Install a plain washer on each screws. Apply Loctite® 242® to screw threads.
6. Carefully remove studs and replace with screws. Torque screws to 9.9 N·m (88 in. lb.). Repeat procedure for other studs and screws.

Install Fan Guard

Install spacers and fixed guard. Secure with three screws. Torque screws to 3.3 N·m (30 in. lb.).

Install Starter Motor

1. Install electric starter motor using screws.
2. Torque screws to 16.0 N·m (142 in. lb.).
3. Connect main power lead and solenoid lead. Attach harness wires.

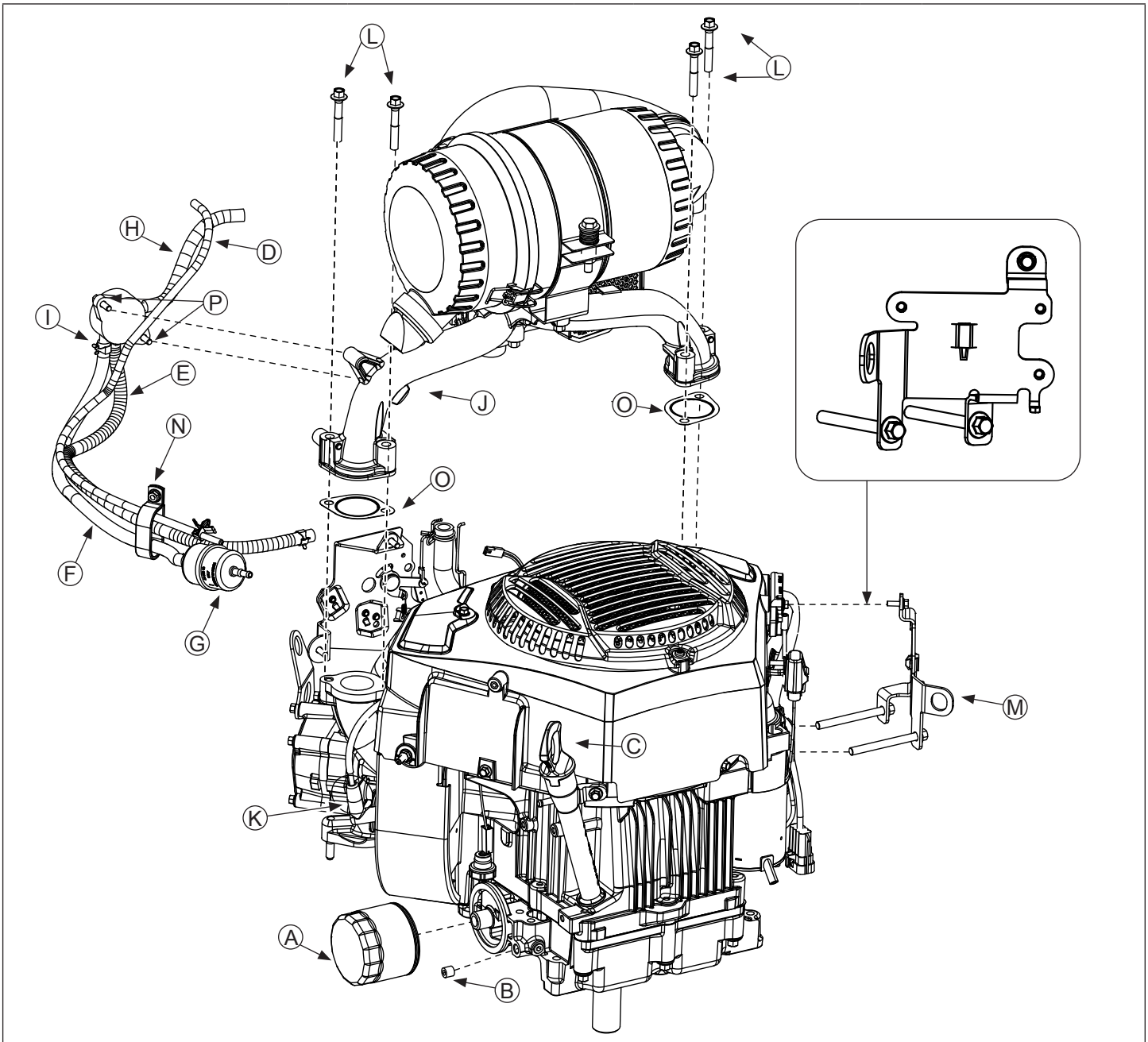
Install Oil Cooler (if equipped)

NOTE: New hose clamps are recommended for reassembly, or if clamps have been loosened (expanded) several times to avoid leakage.

NOTE: Following internal engine failure (e.g., bearing damage, piston seizure, or metallic debris), it is recommended to clean or replace the oil cooler. Residual debris trapped in the oil cooler can cause premature engine failure.

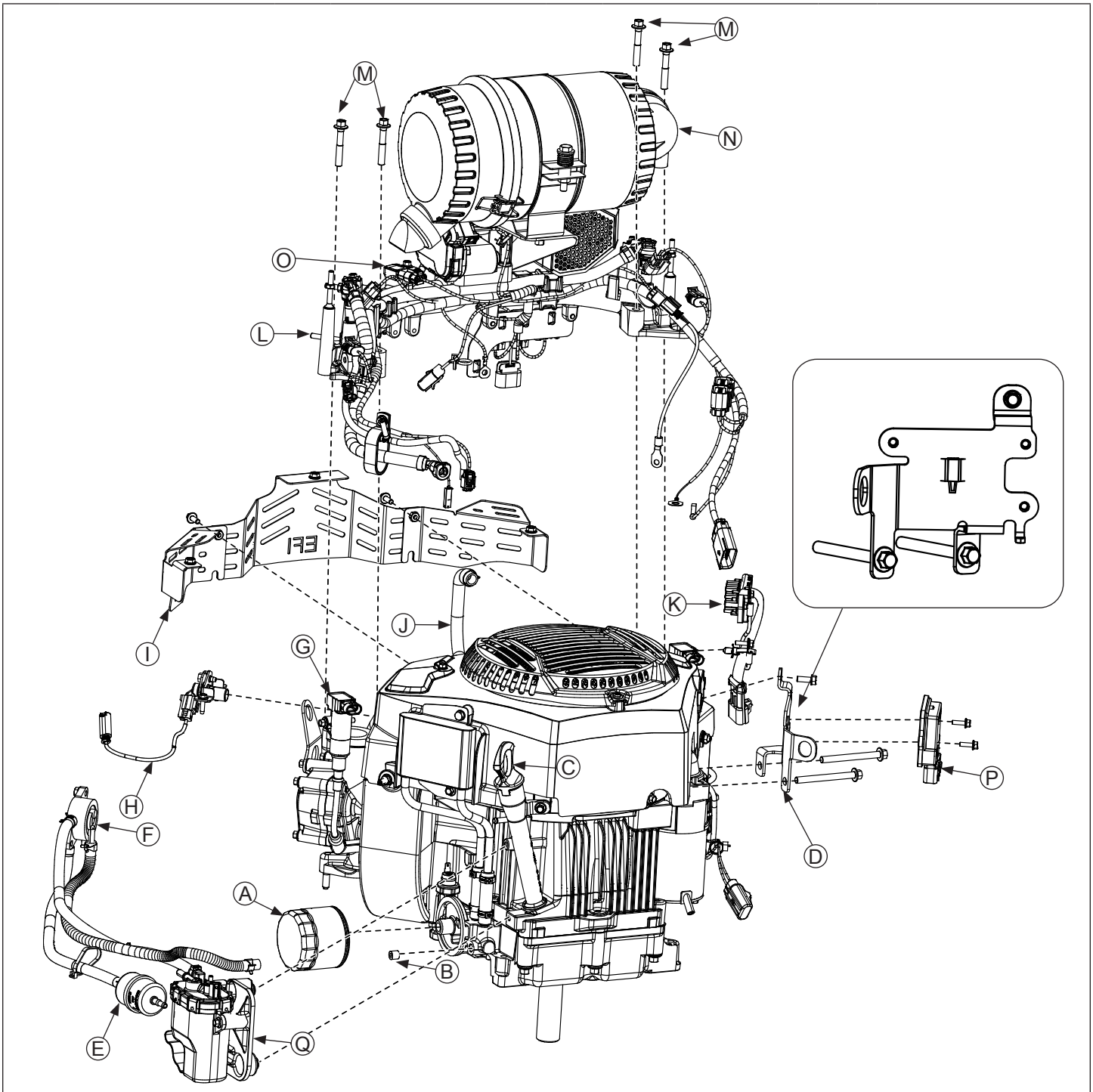
1. Connect hoses between oil cooler and oil pan. Secure with new clamps.
2. Orient new clamps as noted in disassembly.
3. Install screws to secure oil cooler to blower housing. Torque top screw (M5) to 3.3 N·m (30 in. lb.) and bottom screw (M6) to 4.7 N·m (42 in. lb.).

CV829 & CV832 External Engine Components



A	Oil Filter	**B**	Oil Drain Plug	**C**	Dipstick	**D**	Vent Hose
E	Pulse Line	**F**	Low Pressure Fuel Line	**G**	Fuel Filter	**H**	Fuel Line
I	Pulse Pump	**J**	Manifold Assembly	**K**	Spark Plug Lead	**L**	Manifold Screw
M	Fuse Holder Bracket	**N**	Clamp	**O**	Gasket	**P**	Pulse Pump Screw

ECV830 & ECV834 External Engine Components

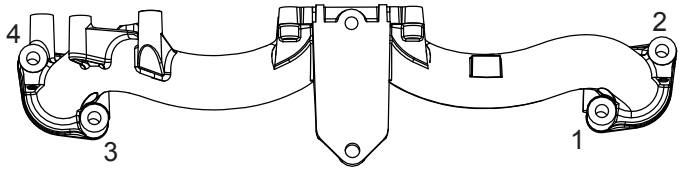


A	Oil Filter	**B**	Oil Drain Plug	**C**	Dipstick	**D**	Starter Bracket
E	Fuel Filter	**F**	Pulse Pump	**G**	Spark Plug Lead	**H**	Speed Sensor
I	Manifold Guard	**J**	Breather Hose	**K**	Rectifier Regulator	**L**	Manifold Assembly
M	Manifold Screws	**N**	Heavy Duty Air Cleaner (HDAC)	**O**	TMAP Sensor	**P**	ECU
Q	Fuel Pump						

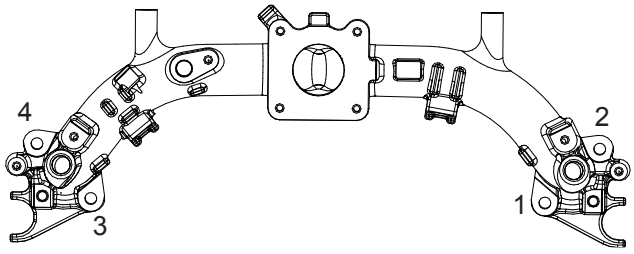
Install Intake Manifold

Torque Sequence

Carb Manifold



EFI Manifold



1. Carefully place intake manifold assembly onto engine.
2. Slide intake gaskets between intake ports and manifold. Torque intake manifold screws, using sequence shown, to 28.2 N·m (250 in. lb.).

Connect Wire Harness

Note: If Harness clips were removed during disassembly, resecure harness in place with clips.

1. If equipped, connect Fuel shutoff solenoid harness connector.
2. Connect fuel and vent hoses from intake assembly.
3. If equipped, connect Fuel injectors, Fuel Pump Module, TMAP sensor, Electronic Throttle Body, Ignition Coils, Oil Pressure switch, O2 sensor, Engine Temp sensor and Rectifier regulator.
4. Connect harness ring terminal at starter.
5. Connect harness ground ring terminal under intake manifold.
6. If equipped, speed sensor connector is located under blower housing and will need to be connected before manifold shield and blower housing is installed
7. Connect four intake manifold screws from cylinder head.

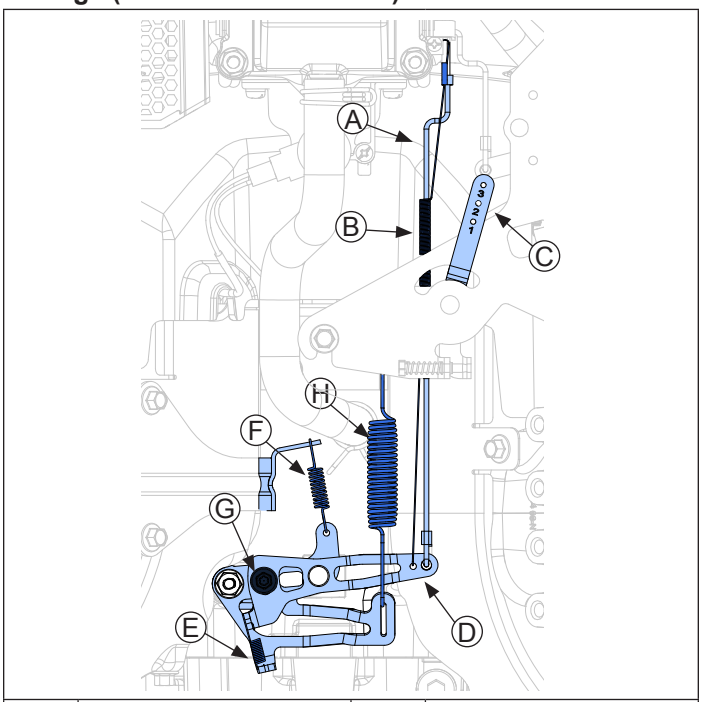
Install Breather Hose

Connect and clamp breather hose to intake elbow or throttle body (if equipped) and onto engine block fitting.

Install Manifold Guards (if equipped)

Install screws securing the (3) piece manifold guard.

Install Governor Lever, Governor Springs, and Linkage (Mechanical Governor)



A	Throttle Linkage	**B**	Linkage Spring
C	Speed Control Linkage	**D**	Governor Lever Assembly
E	Governor Lever Assembly Spring	**F**	Governed Idle Spring
G	Left Hand Threaded Screw	**H**	Governor Spring

1. Connect speed control linkage to governor linkage lever.
2. Connect governor linkage and linkage spring to throttle body and to governor lever.
3. Connect governor spring to governor lever and governor linkage lever.
4. Install the governor lever onto governor crossshaft, making sure it's aligned correctly on the threaded portion.

Governor Adjustment Procedure

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

Adjustment Procedure
Make this adjustment whenever governor arm is loosened or removed from cross shaft or governor gear is replaced. Adjust as follows:

1. Confirm the following:
   - All linkage and springs are in good condition and properly installed onto governor lever assembly.
   - Governor cross shaft nut (O) is secure and torqued to 7.1 N·m (70 in. lb.)
   - Throttle linkage (A) and linkage spring (B) are properly attached to governor lever and throttle at carburetor.
2. Loosen **left hand screw** (G) thats secures governor lever assembly (D).
3. Move throttle linkage side of governor lever toward throttle body (wide open throttle) and hold in this position.
4. While completing step 3, torque down **left hand screw** (G) to 5.1 N·m (45 in. lb.).

Install Fuel Lines

1. If it was removed, install fuel pump to intake manifold and secure with screws. Torque screws to 8.2 N·m (73 in. lb.).
2. Connect vent and fuel lines to fuel pump.
3. Place hoses into retaining bracket and mount to blower housing. Torque nut to 4.8 N·m (42 in. lb.).

Install Oil Filter and Add Oil to Crankcase

1. Install oil drain plugs. Torque plug to 14.9 N·m (11 ft. 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 and secure dipstick.

Install Spark Plugs

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.).

Connect Spark Plug Leads

Connect and secure leads to spark plugs.

Prepare Engine for Operation

Engine is now completely reassembled. Before starting or operating engine, follow proceeding steps.

1. Make sure all hardware is tightened securely.
2. Make sure oil drain plugs, Oil Sentry™ pressure switch, and a new oil filter are installed.
3. Verify crankcase has been filled with correct amount, weight, and type of oil. Refer to oil recommendations and procedures in Maintenance, Specifications, and Lubrication System sections.
4. Turn on fuel supply.

Testing Engine

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

1. Set engine up on a test stand. Install an oil pressure gauge. Start engine and check to be certain oil pressure (20 psi or more) is present. Run engine at idle for 2-3 minutes, then 5-6 minutes more between idle and midrange.

Idle Speed (RPM) Adjustment (carbureted)

1. Start engine and allow to warm up 5-10 minutes to stabilize speeds. Hold governor lever away from carburetor so throttle lever is against idle speed (RPM) adjustment screw of carburetor, then adjust screw to set approximately 1450 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. Obtain equipment manufacturer's recommended idle speed (1800 RPM). All 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 350 RPM (approximate) higher than low idle speed.

3. Move throttle lever to wide-open/full throttle position and hold in this position. Obtain equipment manufacturer's recommended high speed setting. Turn high speed screw to obtain intended high speed no-load RPM (estimated 3640 rpm). Governed idle speed must be set before making this adjustment.