

MANUFACTURING TOLERANCES

General	
Number of cylinders	2
Type	4-cycle, 45°V ² , air-cooled
Torque	85 ft-lbs (115.2 Nm) @ 3000 rpm
Bore	3.75 in. (95.25 mm)
Stroke	4.00 in. (101.6 mm)
Piston displacement (approx.)	88 cu. in. (1450 cc)
Compression ratio	9.0:1
Combustion chamber	5.187 cu. in. (85 cc) bathtub
Cam system	Twin cams, chain driven with spring loaded tensioners
Max. sustained engine speed	5500 rpm
Idle speed	1000 rpm +/- 50
Weight	165 lbs (74.8 kg)

Ignition System	
Type	Sequential, non waste spark, MAP-N control
Ignition timing: 1050 rpm (Hot Idle)	20°-30°
Spark plug size	12 mm
Spark plug type	Harley-Davidson 6R12
Spark plug gap	0.038-0.043 in. (0.97-1.09 mm)
Spark plug torque	12-18 ft-lbs (16-24 Nm)

Oiling System	
Pump	Twin gerotor, dual scavenge, crank mounted and driven, internal oil pump, dry sump
Pressure	30-38 psi (207-262 kN/m ²) at 2000 rpm and normal operating temperature of 230° F (110° C)
Filtration	5 micron media, filtered between pump and engine

Rocker Arm	IN.	MM
Shaft fit in bushing (loose)	0.0005-0.0020	0.013-0.051
End clearance	0.003-0.013	0.08-0.33
Bushing fit in rocker arm (tight)	0.002-0.004	0.051-0.102

Rocker Arm Shaft	IN.	MM
Shaft fit in rocker arm support plate (loose)	0.0007-0.0022	0.018-0.056

Hydraulic Lifter	IN.	MM
Fit in crankcase (loose)	0.0008-0.0020	0.02-0.05

Cylinder Head	IN.	MM
Valve guide in head (tight)	0.0020-0.0033	0.051-0.084
Valve seat in head (tight)	0.003-0.0045	0.076-0.114
Head gasket surface (flatness)	0-0.006	0-0.0152

Valve	IN.	MM
Fit in guide: exhaust	0.001-0.003	0.0254-0.0762
Fit in guide: intake	0.001-0.003	0.0254-0.0762
Seat width	0.040-0.062	1.02-1.58
Stem protrusion from cylinder head boss	2.012-2.032	51.10-51.61

Valve Spring	IN.	MM
Closed	135 lbs @ 1.850 in.	61.2 kg @ 47.0 mm
Open	312 lbs @ 1.300 in.	141.5 kg @ 33.0 mm
Free length	2.325 in.	59.1 mm

Piston	IN.	MM
Fit in cylinder: Early Style Piston Late Style Piston	0.0006-0.0017 0.0014-0.0025	0.015-0.043 0.036-0.064
Ring end gap: Top compression ring	0.010-0.020	0.25-0.51
2nd compression ring	0.014-0.024	0.36-0.61
Oil control ring	0.010-0.050	0.25-1.27
Ring side clearance: Top compression ring	0.0012-0.0037	0.030-0.094
2nd compression ring	0.0012-0.0037	0.030-0.094
Oil control ring	0.0031-0.0091	0.079-0.23
Piston pin fit (loose)	0.0002-0.0005	0.005- 0.013

Connecting Rod	IN.	MM
Piston pin fit (loose)	0.0007-0.0012	0.018-0.030
Side play between flywheels	0.005-0.015	0.13-0.38
Connecting rod to crankpin (loose)	0.0004-0.0017	0.0102-0.0432

MANUFACTURING TOLERANCES (CONT.)

Flywheel	IN.	MM
Runout (flywheels at rim)	0.000-0.010	0.000-0.254
Runout (shaft at flywheel)	0.000-0.002	0.000-0.051
End play	0.003-0.010	0.076-0.254

Crankshaft/Sprocket Shaft Bearings	IN.	MM
Bearing fit (loose)	0.0002-0.0015	0.005-0.038
Crankshaft runout	0.0-0.003	0.0-0.076
Bearing fit in crankcase (tight)	0.0038-0.0054	0.097-0.137
Bearing inner race on crankshaft (tight)	0.0004-0.0014	0.010-0.036

TORQUE VALUES

Item	ft/in-lbs	NM
Breather assembly bolts	90-120 in-lbs	10-14 Nm
Cam cover screws	125-155 in-lbs	14-18 Nm
Cam cover plate screws	20-30 in-lbs	2.3-3.4 Nm
Cam support plate screws	90-120 in-lbs	10-14 Nm
Bearing retainer plate screws	20-30 in-lbs	2-3 Nm
Crank sprocket flange bolt	15 ft-lbs, loosen one full turn, 24 ft-lbs	20.3 Nm, loosen one full turn, 32.5 Nm
Primary cam sprocket flange bolt	15 ft-lbs, loosen one full turn, 34 ft-lbs	20.3 Nm, loosen one full turn, 46.1 Nm
Crank position sensor screw	90-120 in-lbs	10.2-13.6 Nm
Piston jet screws	25-35 in-lbs	2.8-4.0 Nm
Transmission housing to crankcase bolts	15 ft-lbs, 30-35 ft-lbs	20 Nm, 41-48 Nm
Crankcase to front engine mounting bracket bolts	33-38 ft-lbs	45-52 Nm
Crankcase bolts	10 ft-lbs, 15-19 ft-lbs	14 Nm, 20-26 Nm
Cylinder head bolts	120-144 in-lbs , 15-17 ft-lbs + 90° turn	13.6-16.3 Nm, 20.3-23.1 Nm + 90° turn
Cylinder studs	10-20 ft-lbs	14-27 Nm
Engine oil drain plug	14-21 ft-lbs	19-28 Nm
Lifter cover screws	90-120 in-lbs	10-14 Nm
Oil pan screws	84-132 in-lbs	9.5-14.9 Nm
Oil filter	1/2-3/4 turn after gasket contact	
Oil filter mount	12-16 ft-lbs	16-22 Nm
Crankcase oil fittings/plugs	120-168 in-lbs	13.6-18.9 Nm
Oil hose cover screws	84-108 in-lbs	10-12 Nm
Oil pressure switch/sender	96-120 in-lbs	11-14 Nm
Rocker arm support plate bolts	18-22 ft-lbs	24-30 Nm
Rocker cover bolts	15-18 ft-lbs	20-24 Nm
Rocker housing bolts	120-168 in-lbs	13.6-18.9 Nm
Spark plugs	12-18 ft-lbs	16-24 Nm
Stator screws	55-75 in-lbs	6.2-8.5 Nm
Upper engine mounting bracket:		
To cylinder heads	35-40 ft-lbs	48-54 Nm
To top stabilizer link	18-22 ft-lbs	24-30 Nm
ET sensor	120-180 in-lbs	13.6-20.3 Nm
Intake flange adapter screws	96-144 in-lbs	10.9-16.3 Nm
Exhaust flange adapter nuts	100-120 in-lbs	11.3-13.6 Nm

GENERAL

Wear limits can be used as a guide when deciding whether to reuse engine parts. Replace used parts whenever the following wear limits are exceeded.

Rocker Arm/ Rocker Arm Shaft	REPLACE IF	
	IN.	MM
Shaft fit in bushing (loose)	More than 0.0035	More than 0.089
End clearance	More than 0.025	More than 0.635
Shaft fit in rocker arm support plate (loose)	More than 0.0035	More than 0.089

Hydraulic Lifter	REPLACE IF	
	IN.	MM
Fit in crankcase	More than 0.003	More than 0.08
Roller fit	More than 0.0015	More than 0.038
Roller end clearance	More than 0.015	More than 0.38

Cam Support Plate	REPLACE IF	
	IN.	MM
Cam chain tensioner shoe wear	More than 0.090	More than 2.29
	1/2 thickness of shoe	
Crankshaft bushing fit in cam support plate	Less than 0.0008	Less than 0.0203
Crankshaft bushing maximum ID	More than 0.8545	More than 21.704

Cylinder Head	REPLACE IF	
	IN.	MM
Valve guide in head (tight)	Less than 0.002	Less than 0.051
Valve seat in head (tight)	Less than 0.002	Less than 0.051
Head warp	More than 0.006	More than 0.152

Cylinder	REPLACE IF	
	IN.	MM
Taper	More than 0.002	More than 0.051
Out of round	More than 0.002	More than 0.051
Warp of gasket or O-ring surfaces: top	More than 0.006	More than 0.152
Warp of gasket or O-ring surfaces: base	More than 0.004	More than 0.102

Cylinder Bore	REPLACE IF	
	IN.	MM
Standard	More than 3.752	More than 95.301
0.005 in. oversize	More than 3.757	More than 95.428
0.010 in. oversize	More than 3.762	More than 95.555

Piston	REPLACE IF	
	IN.	MM
Fit in cylinder (loose)	More than 0.003	More than 0.076
Piston pin fit (loose)	More than 0.0008	More than 0.020
Ring end gap		
Top compression	More than 0.030	More than 0.76
2nd compression	More than 0.034	More than 0.86
Oil control ring rails	More than 0.050	More than 1.27
Ring side clearance		
Top compression	More than 0.0045	More than 0.11
2nd compression	More than 0.0045	More than 0.11
Oil control ring rails	More than 0.010	More than 0.25

Connecting Rod	REPLACE IF	
	IN.	MM
Piston pin fit (loose)	More than 0.002	More than 0.051
Side play between flywheels	More than 0.020	More than 0.508
Fit on crankpin (loose)	More than 0.002	More than 0.051

Flywheel	REPLACE IF	
	IN.	MM
Runout (flywheels at rim)	More than 0.015	More than 0.381
Runout (shaft at flywheel)	More than 0.005	More than 0.127
End play	More than 0.010	More than 0.254

Crankshaft/Sprocket Shaft Bearings	REPLACE IF	
	IN.	MM
Bearing to shaft clearance	More than 0.0015	More than 0.038
Shaft runout	More than 0.003	More than 0.076
Bearing fit in crankcase (tight)	Less than 0.0038	Less than 0.097
Bearing inner race on shaft (tight)	Less than 0.0004	Less than 0.010

SERVICE WEAR LIMITS (CONT.)

Breather Assembly	REPLACE IF	
	IN.	MM
Breather cover warpage	More than 0.005	More than 0.13
Breather baffle warpage	More than 0.005	More than 0.13

Valve Stem to Guide Clearance	REPLACE IF	
	IN.	MM
Intake	More than 0.0038	More than 0.0965
Exhaust	More than 0.0038	More than 0.0965

FUEL

Use a good quality leaded or unleaded gasoline (91 pump octane or higher). Octane rating is usually posted on the pump.

CAUTION

Using gasolines with alcohol additives (such as methanol) can cause rubber components within the fuel system to fail or result in engine damage.

GASOLINE/ALCOHOL BLENDS

Harley-Davidson motorcycles were designed to give the best performance using unleaded gasoline. Some fuel suppliers sell gasoline/alcohol blends as a fuel. The type and amount of alcohol added to the fuel is important.

- DO NOT USE GASOLINES CONTAINING METHANOL. Using gasoline/methanol blends will result in starting and driveability deterioration and damage to critical fuel system components.
- ETHANOL is a mixture of 10% ethanol (Grain alcohol) and 90% unleaded gasoline. Gasoline/ethanol blends can be used in your motorcycle if the ethanol content does not exceed 10%.
- REFORMULATED OR OXYGENATED GASOLINES (RFG): "Reformulated gasoline" is a term used to describe gasoline blends that are specifically designed to burn cleaner than other types of gasoline. Your motorcycle will run normally using this type of gas.

You may find that some gasoline blends adversely affect the starting, driveability or fuel efficiency of your bike. If you experience one or more of these problems, we recommend you try a different brand of gasoline or gasoline with a higher octane rating.

LUBRICATION

CHECKING ENGINE OIL LEVEL

CAUTION

Oil level cannot be accurately measured on a cold engine. For pre-ride inspection, with motorcycle leaning on jiffy stand on level ground, oil should register on dipstick between arrows when engine is cold. Do NOT add oil to bring the level to the FULL mark on a COLD engine.

1. Perform engine oil level **COLD CHECK** as follows:
 - a. With the vehicle resting on the jiffy stand on level ground, wipe off the dipstick and insert it back into the oil pan with the plug pushed completely into the fill spout.
 - b. Remove the dipstick and note the level of the oil. Oil level should register between the two arrows on the dipstick. See [Figure 3-1](#). If oil level is at or below the lower arrow, add only enough oil to bring the level between the two arrows on the dipstick.
2. Perform engine oil level **HOT CHECK** as follows:
 - a. Ride vehicle until engine is at normal operating temperature.
 - b. With the vehicle resting on the jiffy stand on level ground, allow engine to idle for 1-2 minutes. Turn engine off.
 - c. Wipe off the dipstick and insert it back into the oil pan with the plug pushed completely into the fill spout.
 - d. Remove the dipstick and note the level of the oil. Add only enough oil to bring the level to the FULL mark on the dipstick. See [Figure 3-1](#). Do not overfill.

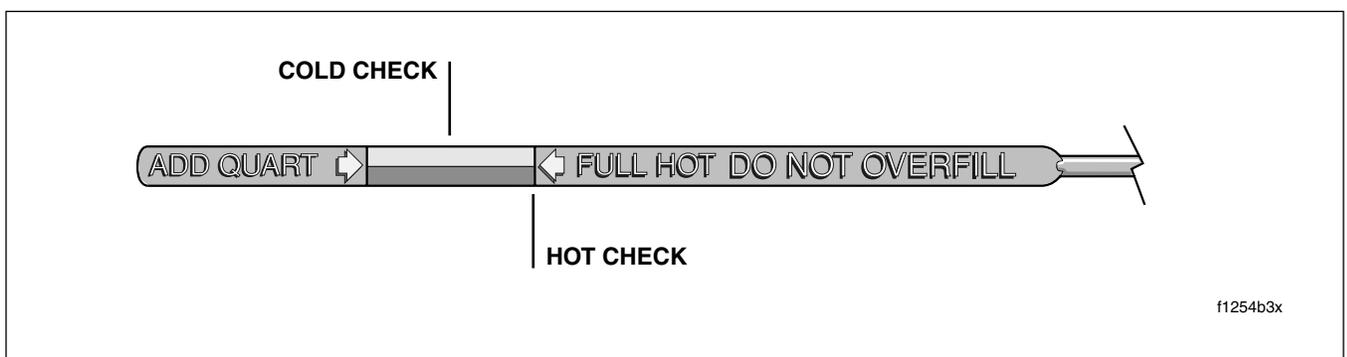


Figure 3-1. Engine Oil Dipstick

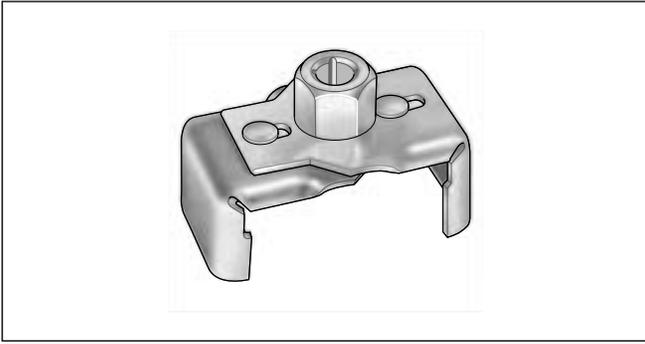


Figure 3-2. Oil Filter Wrench (Part No. HD-42311)

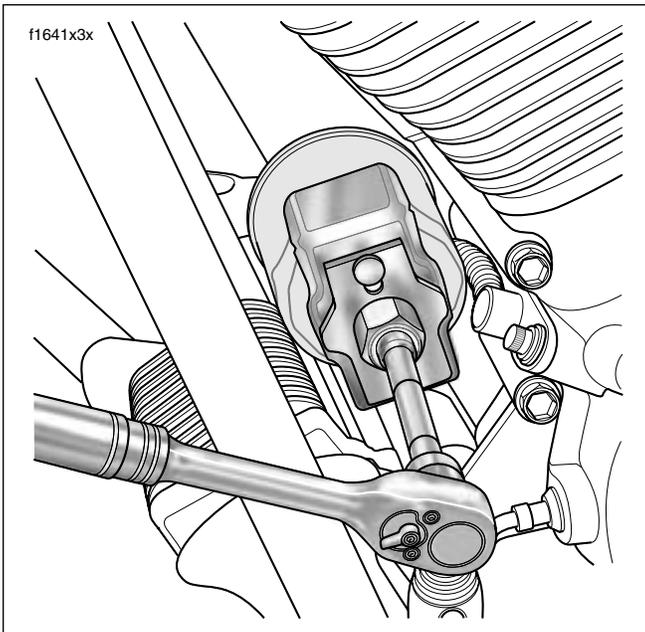


Figure 3-3. Remove Engine Oil Filter

CHANGING ENGINE OIL AND FILTER

NOTE

At the 1000 mile (1600 km) service interval, and at every 5000 mile (8000 km) service interval thereafter, change the engine oil and engine oil filter. If motorcycle is ridden hard, under dusty conditions or in cold weather, change engine oil and filter more often.

1. Ride vehicle until engine is at normal operating temperature.
2. Locate oil filler plug/dipstick on right side of vehicle at top of transmission case. To remove the oil filler plug, pull steadily while moving plug back and forth.
3. Locate oil drain plug at front left side of the oil pan. Remove the oil drain plug and allow oil to drain completely.
4. Inspect the oil drain plug O-ring for cuts, tears or signs of deterioration. Replace as necessary.

5. Remove the oil filter as follows:
 - a. Obtain the OIL FILTER WRENCH (HD-42311). The tool allows easy removal of the oil filter without risk of damage to the CKP sensor or cable.
 - b. Place the jaws of the wrench over the oil filter with the tool oriented vertically. See Figure 3-3.
 - c. Using a 3/8 inch drive with a 4 inch extension, turn wrench in a counterclockwise direction. Do not use with air tools.

NOTE

Use OIL FILTER WRENCH (HD-44067) if HD-42311 is not available.

6. Clean the oil filter mount flange of any old gasket material.
7. Lubricate gasket with clean engine oil and install **new** oil filter on filter mount. Hand tighten oil filter 1/2-3/4 turn after gasket first contacts filter mounting surface. Do **NOT** use OIL FILTER WRENCH for oil filter installation.

NOTE

Use of the Premium 5 micron synthetic media oil filter is highly recommended, Part No. 63798-99A (Chrome) or 63731-99A (Black).

8. Install engine oil drain plug with O-ring. Tighten plug to 14-21 ft-lbs (19-28 Nm).
9. With vehicle resting on jiffy stand, add 3-1/2 quarts (3.3 liters) engine oil as specified in Table 3-1. Use the proper grade of oil for the lowest temperature expected before the next oil change.

Table 3-1. Recommended Engine Oils

Harley-Davidson Type	Viscosity	Harley-Davidson Rating	Lowest Ambient Temperature	Cold Weather Starts Below 50°F (10°C)
HD Multi-grade	SAE 10W40	HD 360	Below 40°F (4°C)	Excellent
HD Multi-grade	SAE 20W50	HD 360	Above 40°F (4°C)	Good
HD Regular Heavy	SAE 50	HD 360	Above 60°F (16°C)	Poor
HD Extra Heavy	SAE 60	HD 360	Above 80°F (27°C)	Poor

CAUTION

Oil level cannot be accurately measured on a cold engine. For pre-ride inspection, with motorcycle leaning on jiffy stand on level ground, oil should register on dipstick between arrows when engine is cold. Do **NOT** add oil to bring the level to the **FULL** mark on a **COLD** engine.

10. Perform engine oil level **COLD CHECK** as follows:

- a. With the vehicle resting on the jiffy stand on level ground, wipe off the dipstick and insert it back into the oil pan with the plug pushed completely into the fill spout.
 - b. Remove the dipstick and note the level of the oil. Oil level should register between the two arrows on the dipstick. See [Figure 3-1](#). If oil level is at or below the lower arrow, add only enough oil to bring the level between the two arrows on the dipstick.
11. Perform engine oil level **HOT CHECK** as follows:
- a. Ride vehicle until engine is at normal operating temperature.
 - b. With the vehicle resting on the jiffy stand on level ground, allow engine to idle for 1-2 minutes. Turn engine off.
 - c. Wipe off the dipstick and insert it back into the oil pan with the plug pushed completely into the fill spout.
 - d. Remove the dipstick and note the level of the oil. Add only enough oil to bring the level to the FULL mark on the dipstick. See [Figure 3-1](#). Do not overfill.
12. Start engine and carefully check for oil leaks around drain plug and oil filter.

WINTER LUBRICATION

Combustion in an engine produces water vapor. During starting and warm-up in cold weather, especially in freezing temperatures, the vapor condenses to water before the crankcase is hot enough to exhaust it through the breather system. If the engine is run long enough for the crankcase to become thoroughly heated, the water returns to vapor and is then exhausted.

An engine used for only short trips, and seldom allowed to thoroughly warm up, accumulates increasing amounts of water in the oil pan. Water mixed with oil forms a sludge that causes accelerated engine wear. In freezing temperatures, the water becomes slush or ice, which may clog oil lines and result in engine failure.

Always change the engine oil more often in winter. If the engine is used for short runs, change the oil even more frequently. The farther below freezing the temperature drops the more often the oil should be changed.

OIL PRESSURE INDICATOR LAMP

The **red** OIL PRESSURE indicator lamp illuminates to indicate improper circulation of the engine oil. The lamp illuminates when the ignition is first turned on (before the engine is started), but should be extinguished once the engine is running.

CAUTION

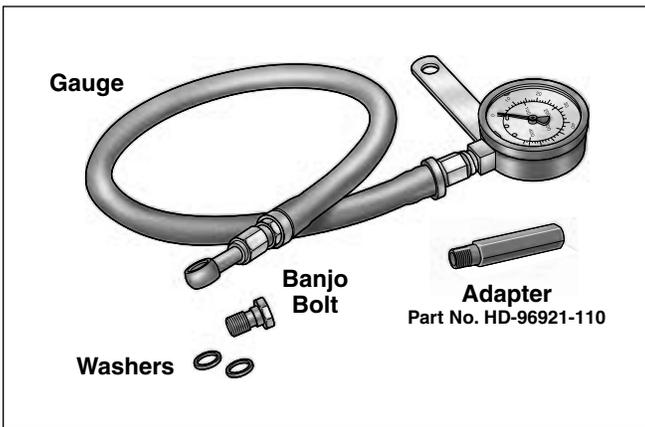
Check the engine oil level if the oil pressure indicator lamp remains illuminated. If the oil level is normal, stop the engine immediately. Do not ride the vehicle until the problem is located and corrected.

If the indicator lamp is not extinguished, it may be the result of a low oil level or diluted oil supply. In freezing weather, the oil feed and return lines can clog with ice or sludge. A defect in the lamp wiring, faulty oil pressure switch/sender, damaged oil pump, plugged oil filter element, incorrect oil viscosity, broken or weak spring in the oil pressure relief valve and/or damaged or incorrectly installed O-rings in the engine may also cause the indicator lamp to remain on.

To troubleshoot the problem, always check the engine oil level first. If the oil level is OK, determine if oil returns to the pan from the oil return hose. If oil does not return, shut off the engine until the problem is located and corrected.

To check the engine oil pressure, proceed as follows:

1. Verify engine oil level. See [CHECKING ENGINE OIL LEVEL](#) in this section.
2. Locate the oil pressure switch/sender at the front right side of the crankcase.
3. On FLHR/C/S models, pull elbow from post of oil pressure switch. On FLHX, FLHT/C/U and FLTR models, pull external latch outward and use rocking motion to remove Delphi connector from oil pressure sender.
4. On FLHR/C/S models, use a 15/16 inch Open End Crow Foot (Snap-On FC30B) to remove oil pressure switch from crankcase. On FLHX, FLHT/C/U and FLTR models, use 1-1/16 inch Open End Crow Foot (Snap-On FC34A) to remove oil pressure sender.
5. Start OIL PRESSURE GAUGE ADAPTER (HD-96921-110) into crankcase bore. Using a 5/8 inch open end/box wrench, turn adapter until snug. See [Figure 3-4](#).
6. Moving to left side of vehicle, route banjo fitting and hose of OIL PRESSURE GAUGE (HD-96921-52B) over shifter lever and oil filter to right side of engine. See [Figure 3-5](#).
7. Slide washer on banjo bolt and insert through banjo fitting on gauge. Install second washer on bolt and thread into adapter until snug.
8. Run vehicle or simulate road running until engine is at normal operating temperature, approximately 230° F. (110° C.). Gauge reading will not be accurate if engine is not completely warmed.
9. Verify that oil pressure is 30-38 psi (207-262 kN/m²) at 2000 rpm.
10. Remove banjo bolt (and washers) from adapter. Remove gauge from vehicle and then remove adapter from crankcase.



**Figure 3-4. Oil Pressure Gauge
(Part No. HD-96921-52B)**

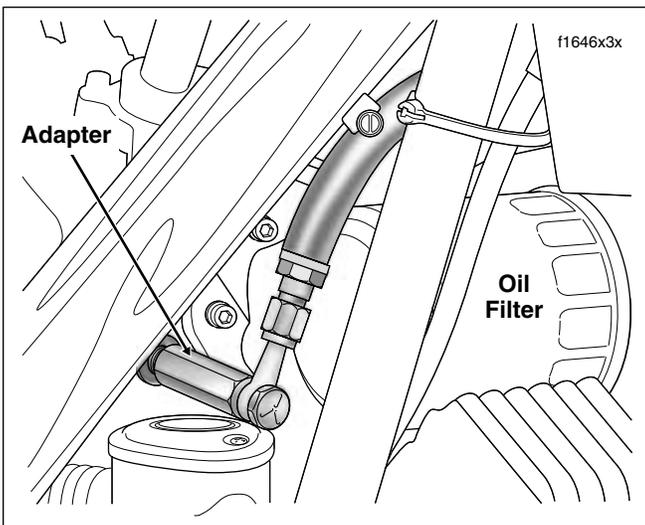


Figure 3-5. Install Adapter and Oil Pressure Gauge

NOTE

If reusing oil pressure switch/sender, apply Loctite Pipe Sealant with Teflon 565 to threads.

11. Start oil pressure switch/sender into crankcase bore.
12. On FLHR/C/S models, use a 15/16 inch Open End Crow Foot (Snap-On FC30B) to tighten oil pressure switch to 96-120 **in-lbs** (11-14 Nm). On FLHX, FLHT/C/U and FLTR models, use 1-1/16 inch Open End Crow Foot (Snap-On FC34A) to tighten oil pressure sender to same torque.
13. On FLHR/C/S models, install elbow on post of oil pressure switch. On FLHX, FLHT/C/U and FLTR models, install Delphi connector to oil pressure sender.

NOTE

If wire socket terminal requires replacement, see APPENDIX B.6 SEALED BUTT SPLICE CONNECTORS.

14. Test oil pressure switch/sender for proper operation.

ENGINE OIL FLOW

CAUTION

The oiling system is carefully designed for optimum efficiency. All oil holes and passageways are specially sized. Exercise caution to avoid enlarging oil holes during cleaning. Any modification of the oiling system will adversely affect oil pressure or cooling and lubrication efficiency.

Oil Feed (Figures 3-6, 3-7)

Oil flows from the oil pan through a passageway at the front of the transmission housing into a flexible hose clamped to the lower fitting (A1) at the rear right side of the crankcase.

Running through a passageway in the crankcase, the oil exits a hole in the crankcase flange (B2) and enters a hole on the inboard side of the cam support plate. Passing through a channel in the cam support plate (A3), the oil enters the feed side of the oil pump. See OIL PUMP OPERATION. The feed gerotors of the pump direct the flow up a second channel in the cam support plate (A4).

A drilling in this channel connects to a pressure relief valve mounted in the bypass port of the cam support plate (A5). When the oil pressure exceeds the setting of the valve spring (35 psi), the orifice opens to bypass excess oil back to the feed side of the pump (A3).

Oil not returned to the feed side exits a hole on the inboard side of the cam support plate and passes through a hole in the crankcase flange (B6). Flowing through a passageway in the crankcase, where a reading is taken by the oil pressure sender (B7), the oil exits the lower hole in the oil filter mount (D8).

After circulating through the oil filter, the flow of oil is directed back into the crankcase through the upper hole in the oil filter mount (D9). Exiting a passageway in the crankcase through a hole in the crankcase flange (B10), the flow of oil reenters the cam support plate.

Filtered oil is then routed to the top and bottom ends of the engine, as described below.

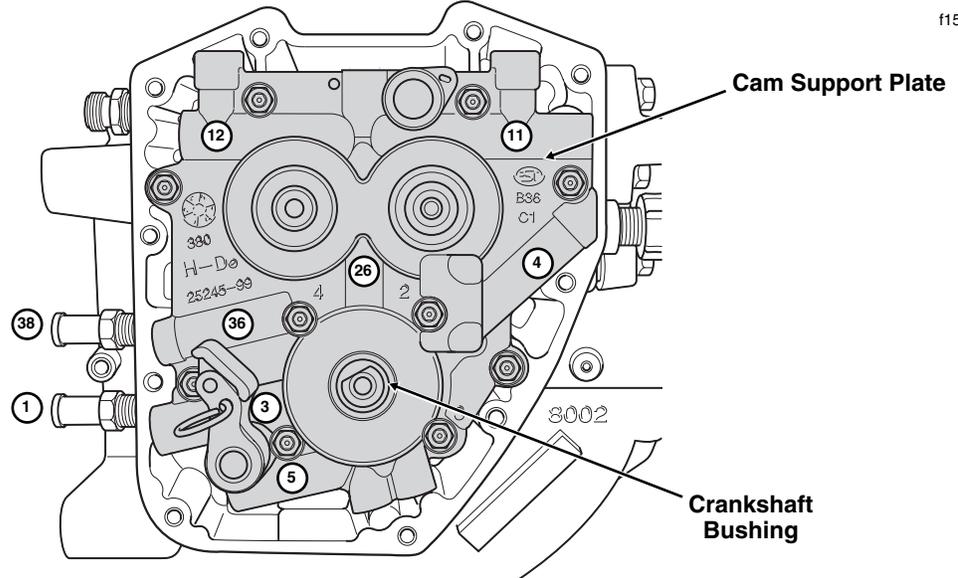
Top End (Figures 3-6, 3-7)

Oil passes through a channel in the cam support plate exiting the inboard side through two holes near the top (A11, A12). Entering two holes in the crankcase flange (B13, B14), one leading to the front cylinder and the other to the rear, the oil travels through passageways in the crankcase to the hydraulic lifter bores (D15).

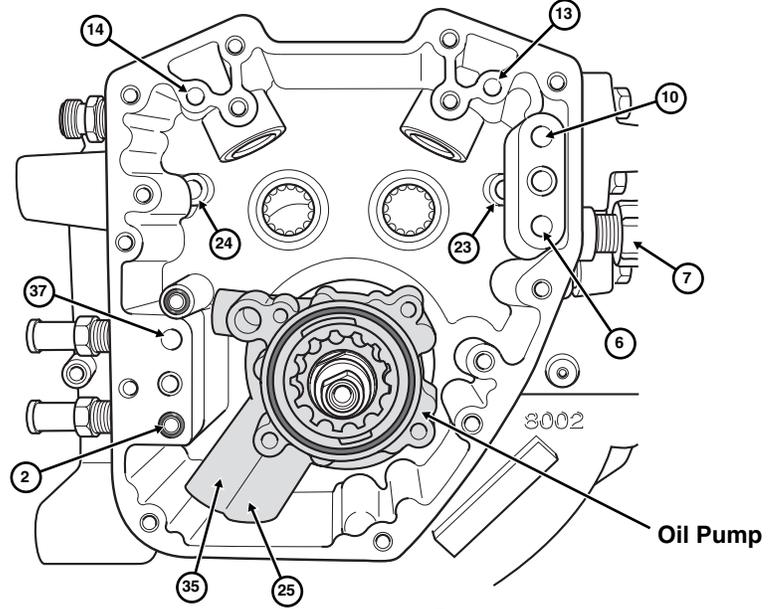
Exiting a hole in each lifter bore (E16), the oil flows around the lifter and enters a hole at the side of the lifter body. As the chamber inside the lifter body is filled, the push rod socket rises to achieve the no-lash fit of the valve train components. The flow of oil then exits a hole centered in the lifter socket and runs up the hollow push rods.

f1581c3x

A

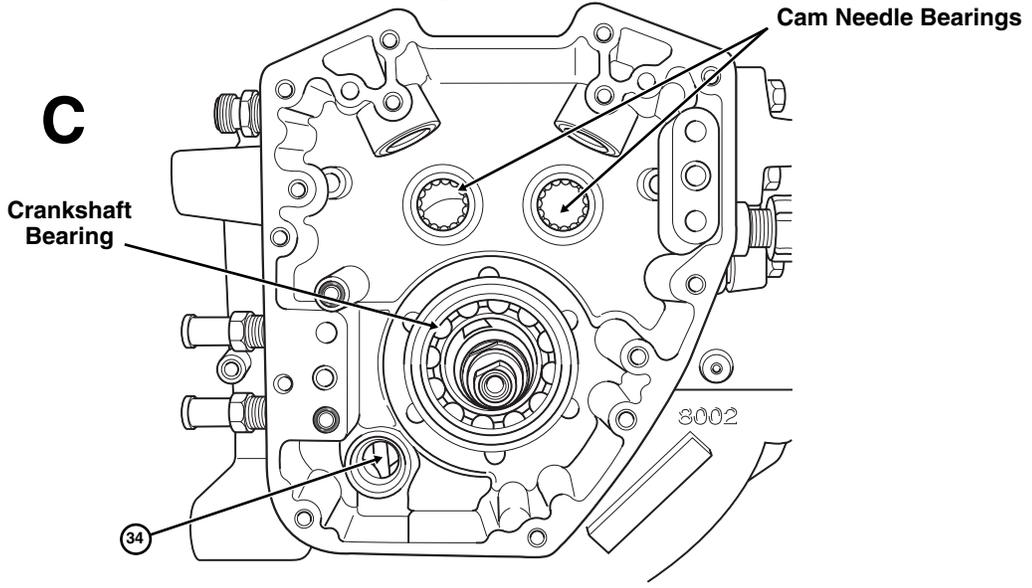


B



f1573b3x

C



f1580b3x

Figure 3-6. Engine Oil Flow - Cam Support Plate/Right Crankcase Half

NOTE

Note that there is one additional hole drilled into the inside lifter bores- while the oblong hole circulates oil around the lifter body as described, the round hole (E17) feeds oil to the piston jets in the flywheel compartment.

Exiting holes at the top of the hollow push rods, oil enters a hole at the bottom of the intake and exhaust rocker arms. Lubricating the rocker arm bushings, oil flows down the rocker arm shafts and exits a pin hole in the outboard side of each rocker arm housing (F18) where it sprays the valve springs and the top of the valve stem.

Oil runs down to the low side of the rocker housing and enters the exhaust valve spring pocket where a drain hole (G19) leads to a passageway in the cylinder head casting.

Oil exits the bottom of the cylinder head and passes through a ring dowel (H20) on the “down side” of the cylinder flange. The oil runs through a vertical passageway in the cylinder, passes through a second ring dowel on the “down side” of the cylinder deck (I21) and enters the left crankcase half.

Flowing through a horizontal passageway in the left crankcase half (J22), oil runs through a third ring dowel (K23) to the right crankcase half where it travels through another passageway before emptying into the cam compartment (B23, B24).

Oil collecting in the cam compartment is picked up by one of two scavenge lobes on the oil pump (B25).

Bottom End (Figures 3-6, 3-7, 3-8)

Oil travels down the center passage of the cam support plate (A26) and sprays out through pin holes on each side of the casting to lubricate both the primary and secondary cam chains. Oil also passes through a hole in the crankshaft bushing where the flow enters a drilling in the crankshaft (L27).

Oil runs down the center of the crankshaft and then up a cross drilling into the right side of the flywheel. The flow exits a drilling in the crank pin bore, enters the crank pin and then sprays out through three holes to lubricate the lower rod bearing set.

The oil splash and mist created by the action of the flywheel lubricates the crankshaft bearing and the camshaft needle bearings in the right crankcase half. This same action serves to lubricate the sprocket shaft bearing in the left crankcase half (M28).

Since the oil mist also lubricates the cylinder walls, three holes on each side of the piston (in the area of the third ring land) evacuate excess oil scraped from the walls on the piston downstroke.

The piston jets (N29), which receive a supply of oil from the intake lifter bores, spray the underside of the piston for cooling of the piston crown and skirt area. A check valve in each jet opens only when the oil pressure reaches 12-15 psi, at which point the engine is operating above idle speed. At idle speeds (9-12 psi), the valve remains closed to prevent over oiling and to ensure proper system operating pressure.

Oil spray from each piston jet also enters a hole at the bottom of each pin boss (O30) for lubrication of the piston pin. Another hole at the top of the connecting rod (D31) allows a portion of the oil to reach the upper rod bushing.

Surplus oil falls back to the bottom of the flywheel compartment where it collects in the sump area (P32). Oil in the sump is drawn to the cam compartment through an internal channel (P33, C34) that connects with the second scavenge lobe of the oil pump (B35).

Oil Return (Figures 3-6, 3-8)

The “dual kidney” designation given to the oil pump refers to its two scavenging functions, whereby it simultaneously draws oil from both the cam and flywheel compartments.

Oil sucked up by the scavenge lobes passes through the scavenge gerotors of the oil pump and is directed through a return channel in the cam support plate (A36). See OIL PUMP OPERATION.

Exiting a hole on the inboard side of the cam support plate, the oil enters a hole in the crankcase flange (B37).

The oil flows through a passageway in the crankcase and exits the upper fitting at the rear right side of the crankcase (A38). Passing through a flexible hose connection, the flow of oil runs through a passageway at the front of the transmission housing (Q39) before emptying into the oil pan at the front of the baffle (R40).

The oil flows to the rear of the oil pan along each side of the baffle. Spring tension holds the unit tight against the bottom of the pan to prevent oil from entering or escaping around the perimeter of the baffle. At the back of the oil pan, the oil enters the open side of the baffle where it is redirected forward. The baffle plates slow the circulation of the oil through the pan to enhance cooling.

Oil pickup occurs in the front compartment of the baffle where a passageway in the casting (S41) directs the flow upward. Passing through a second passageway in the transmission housing (Q42), the flow of oil enters the flexible hose connection (A1) to repeat the circuit.

Also note that a third flexible hose clamped to a fitting behind the rear lifter cover connects the cam compartment with the oil filler spout. This crankcase breather connection provides the pressure balance necessary for oil circulation.

Oil Pump Operation

The oil pump consists of a housing containing two gerotor gear sets, one feed and the other scavenge. Driven by the crankshaft, the feed gerotor set distributes oil to the engine, while the scavenge gerotor set draws oil from the cam and flywheel compartments and returns it to the oil pan.

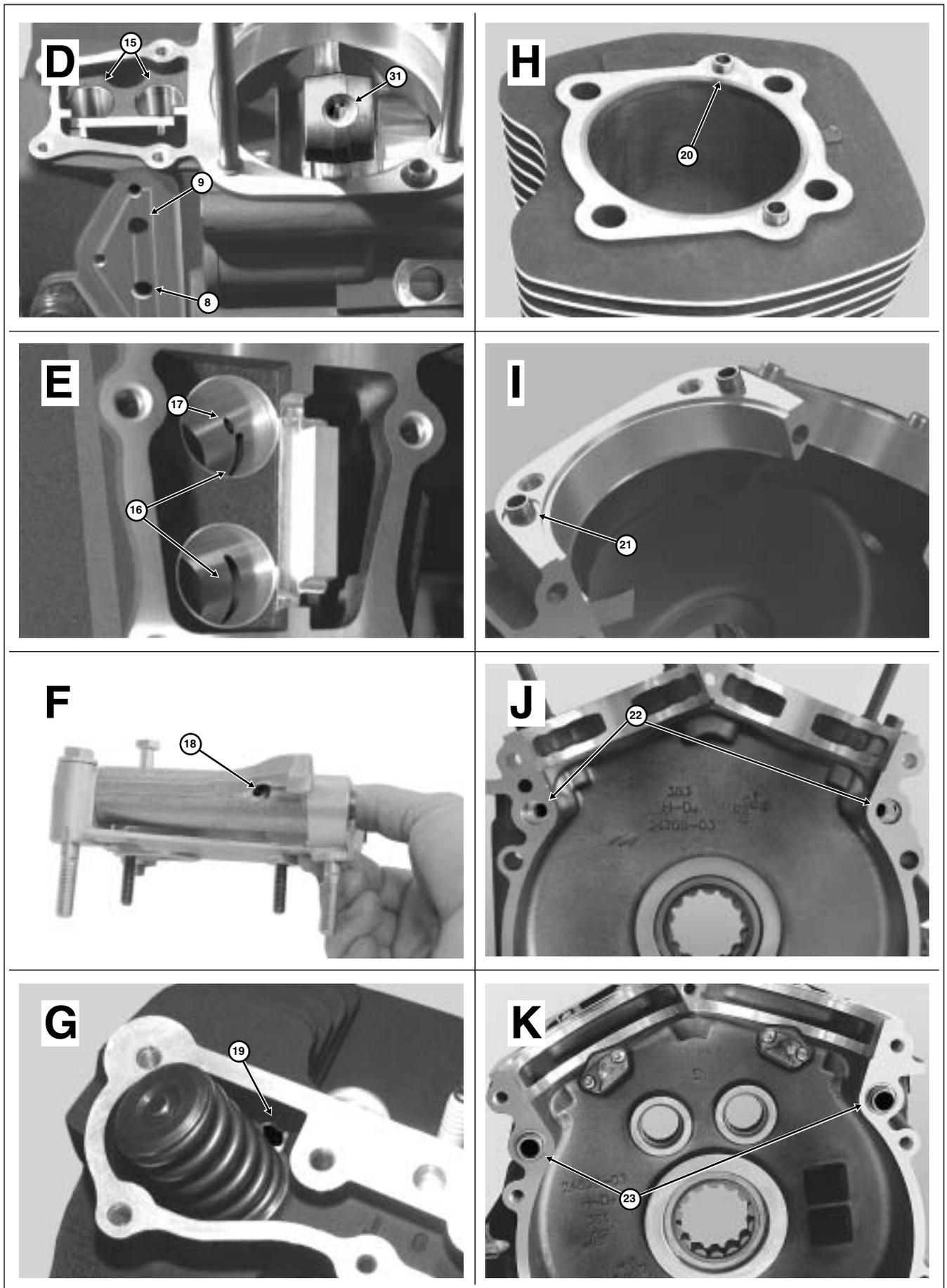


Figure 3-7. Engine Oil Flow - Top End

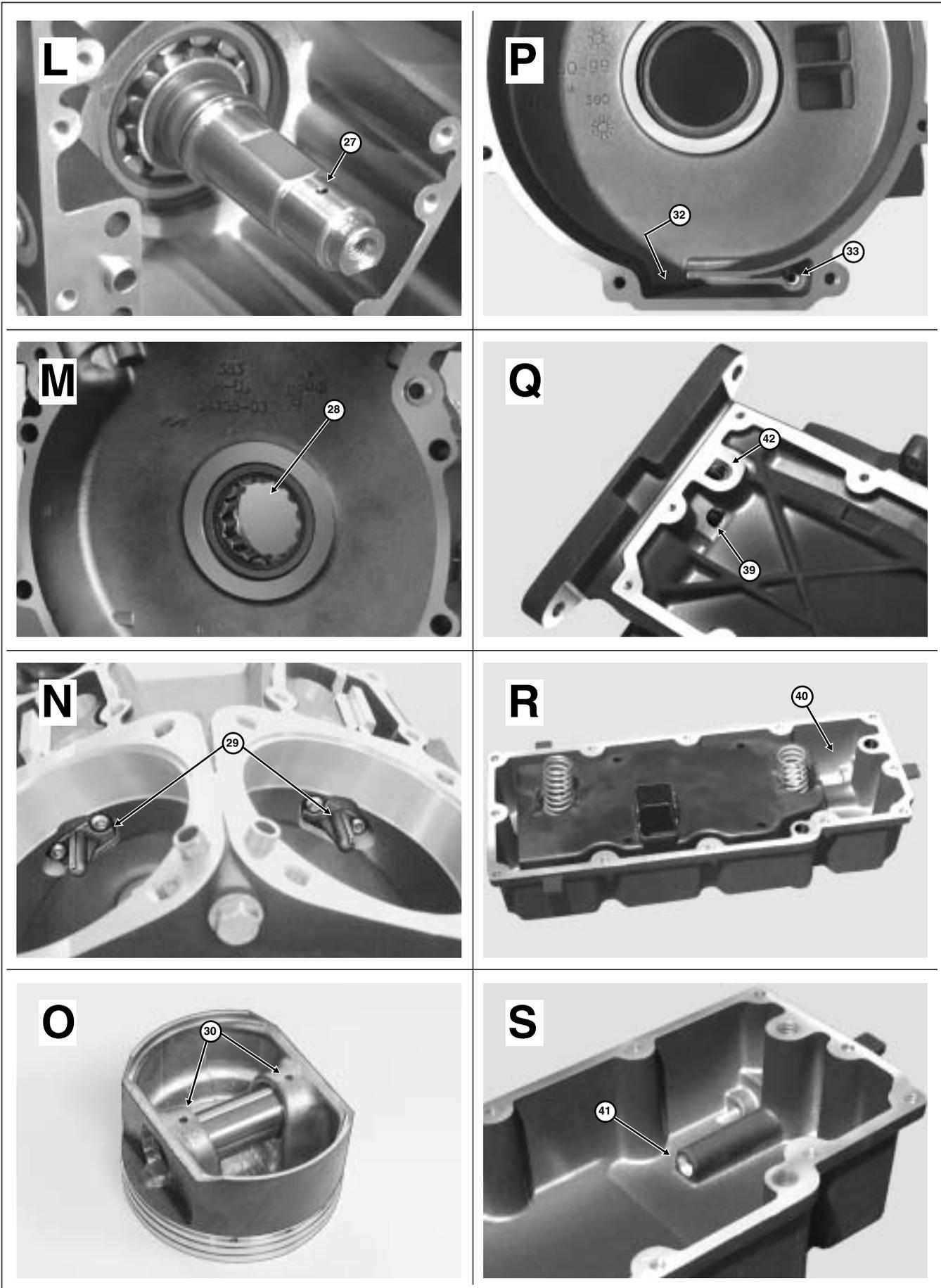


Figure 3-8. Engine Oil Flow - Bottom End

Each gerotor gear set has two parts, an inner and outer gerotor. The inner and outer gerotors have fixed centers that are slightly offset to one another. Also, the inner gerotor has one less tooth.

As the crankshaft rotates, the cavity between the inner and outer gerotors on the inlet side of the pump increases in volume. This creates a vacuum causing oil to be drawn in. The cavity continues to increase until the volume is equivalent to that of the missing tooth on the inner gerotor. Also note that the inlet and outlet sides of the pump are sealed by the tips and lobes of the inner and outer gerotors. See A of Figure 3-9.

Continued rotation moves the pocket of oil to the outlet side of the pump. In this area, the cavity decreases in volume as the gerotor teeth mesh causing the oil to be squeezed out the discharge port. As the cavity on the outlet side is emptied, a second seal formed by the tips and lobes of the inner and outer gerotors prevents oil on the outlet side (high pressure) from being transferred to the inlet side (low pressure). See B of Figure 3-9.

In operation, the gerotors provide a continuous flow of oil. See C of Figure 3-9.

Breather Operation

NOTE

The crankcase breather system relieves crankcase pressure produced by the downstroke of the pistons and allows crankcase vapors vacated from each cylinder to be directed into the air filter element. Through effective recirculation of crankcase vapors, the system serves to eliminate the pollutants normally discharged from the crankcase.

As each piston pushes downward on its power and intake stroke, displaced air in the flywheel compartment is vented through the crankshaft bearing into the cam compartment and then up the push rod covers into the rocker housing.

Air rushes under the rocker arm support plate, which is elevated slightly, and passes through an opening at the bottom of the plate to enter the breather baffle compartment.

In the baffle compartment, the flow of air passes upward through the oil filter gauze, where the oil is removed from the air. Two pin holes in the rocker arm support plate act as drain holes to rid the baffle compartment of the oil separated from the air.

Passing through the oil filter gauze, the flow of air passes through the umbrella valve into the breather compartment. The flaps of the umbrella valve only allow air to be vented one way, rising to allow the passage of air, but then falling back into place to seal the vent holes as the flow of air stops.

In the breather compartment, the flow of air reverses direction passing downward through holes aligned in the breather baffle, rocker arm support plate and rocker housing. Exiting the rocker housing, the air enters a passageway cast into the top of the cylinder head. Proper orientation of the rocker housing gasket is critical for effective sealing of this passageway.

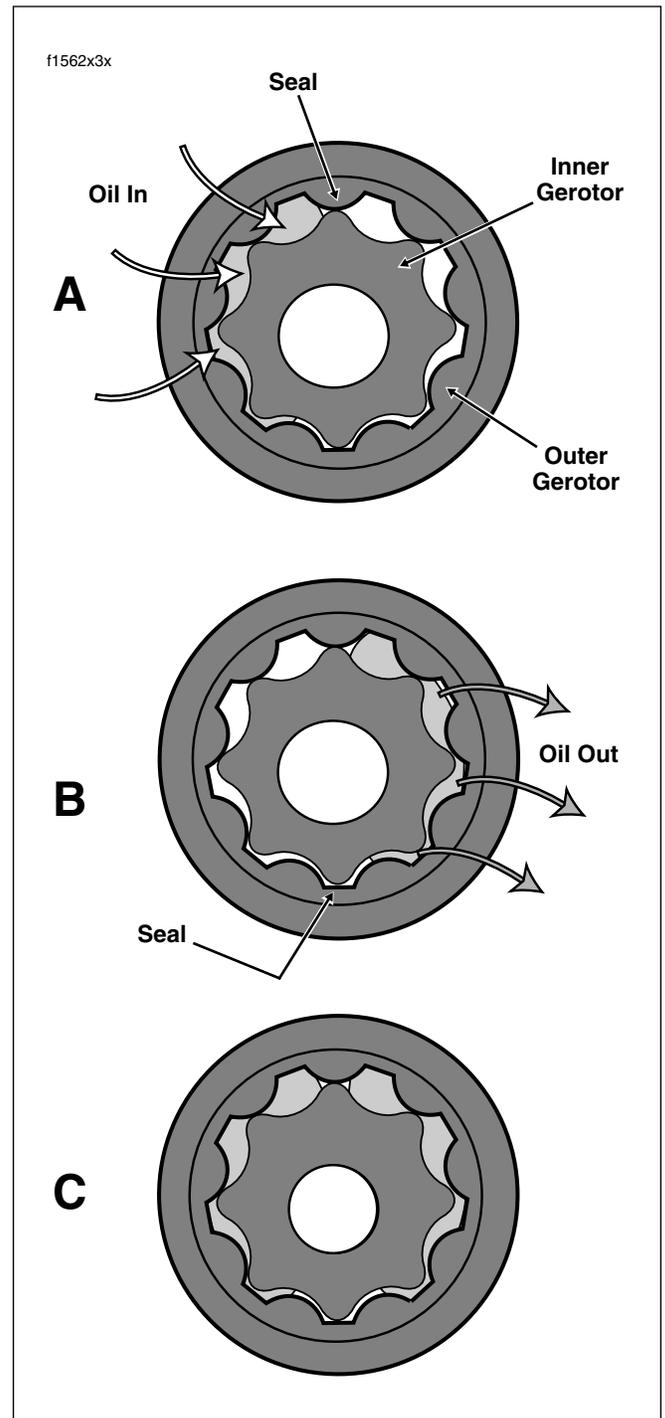


Figure 3-9. Gerotor Operation

Flowing through the cylinder head passageway, the air passes through a drilling in the air cleaner backplate bolt and then through a breather tube into the air filter element.

NOTE

Air cleaner mounting without installation of the breather tubes allows crankcase vapors to be vented into the atmosphere in violation of legal emissions standards.

GENERAL

Three basic levels of service are presented in this section: top end overhaul, bottom end overhaul and subassembly service and repair. The manner in which these instructions are used depends upon the level of disassembly required.

Top End Overhaul

If servicing only cylinder head components, pistons, cylinders and/or upper rod bushings, see Section 3.5 [STRIPPING MOTORCYCLE FOR SERVICE](#), and then proceed to Section 3.9 [TOP END OVERHAUL, DISASSEMBLY](#). During top end disassembly, the engine may be left in the chassis for service.

NOTE

If the engine is to be removed from the chassis, see Section 3.7 [REMOVING ENGINE FROM CHASSIS](#) in lieu of Section 3.5 [STRIPPING MOTORCYCLE FOR SERVICE](#).

In the top end disassembly instructions, references are made to Section 3.11 [SUBASSEMBLY SERVICE AND REPAIR](#) for service of all top end subassemblies.

To rebuild the engine after a top end overhaul is complete, perform the steps under Section 3.9 [TOP END OVERHAUL, ASSEMBLY](#), immediately following the disassembly instructions. Then, refer to Section 3.6 [ASSEMBLING MOTORCYCLE AFTER STRIPPING](#) to complete the project.

NOTE

For clarity, all artwork in this section shows the engine removed from the chassis for service.

Bottom End Overhaul

Bottom end service may require either partial or complete disassembly of the engine. Servicing components in the cam compartment requires only partial disassembly, while servicing those in the flywheel compartment requires complete disassembly. An easy rule to remember is that any time the crankcase halves must be split, complete disassembly needs to occur. The cam compartment can be accessed through removal of the cam cover making complete engine disassembly unnecessary.

During bottom end service that requires complete disassembly, the engine must be removed from the chassis and placed in an engine stand. To begin, see Section 3.7 [REMOVING ENGINE FROM CHASSIS](#).

After the motorcycle has been stripped and the engine removed, follow all of the steps under Section 3.9 [TOP END OVERHAUL, DISASSEMBLY](#). When finished, continue with disassembly of the bottom half by performing those steps listed under Section 3.10 [BOTTOM END OVERHAUL, DISASSEMBLY](#).

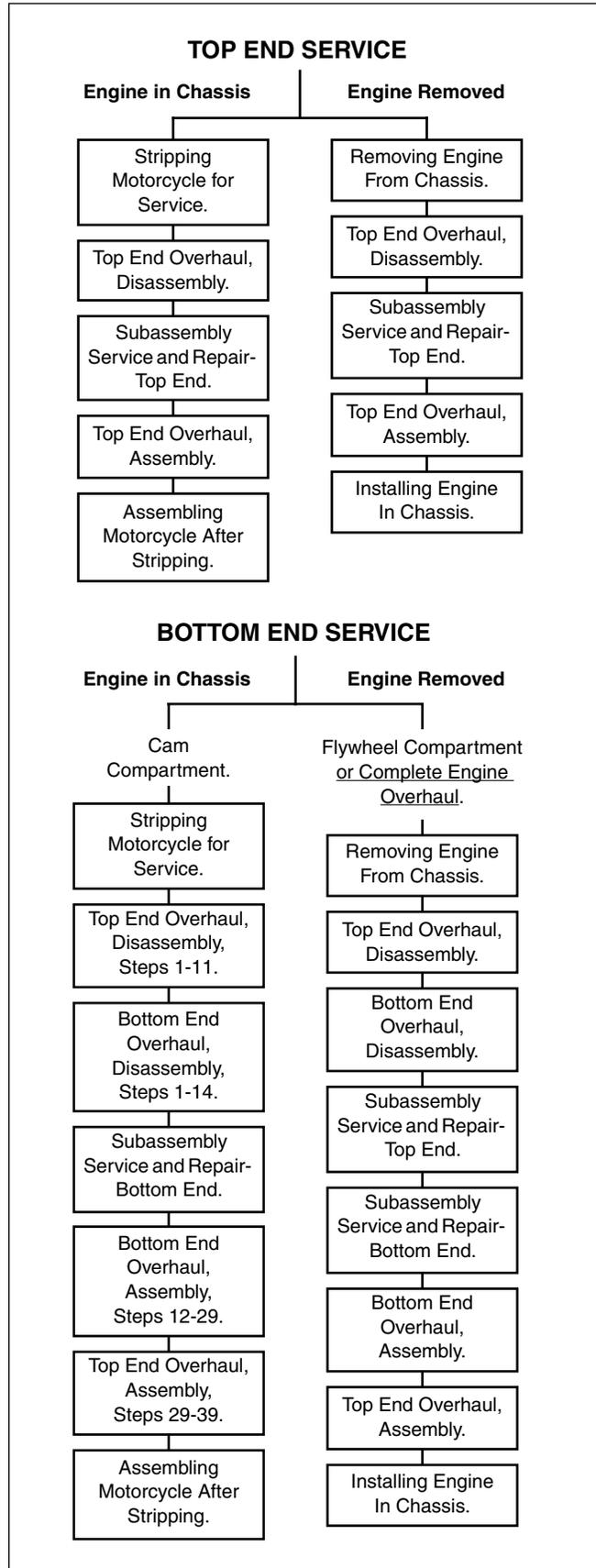


Figure 3-10. Top/Bottom End Service

As with the top end disassembly instructions, references are made to Section [3.11 SUBASSEMBLY SERVICE AND REPAIR](#) for service of bottom end subassemblies.

Since it is standard practice to inspect and clean all oil passages when the engine is completely disassembled, a detailed explanation of the engine oil circuit is presented under Section [3.3 GENERAL INFORMATION, ENGINE OIL FLOW](#).

To rebuild the engine after a bottom end overhaul is complete, perform the steps under Section [3.10 BOTTOM END OVERHAUL, ASSEMBLY](#), and then proceed to Section [3.9 TOP END OVERHAUL, ASSEMBLY](#), to rebuild the upper end.

Once the engine is assembled, refer to Section [3.8 INSTALLING ENGINE IN CHASSIS](#) to complete the project.

The flow charts on the preceding page show how the same subsections are used for various levels of service.

Subassembly Service and Repair

Finally, if the task entails servicing of only one particular sub-assembly, then move directly to Section [3.11 SUBASSEMBLY SERVICE AND REPAIR](#) for all service instructions.

For example, if just installing new cams, then refer to Section [3.11 SUBASSEMBLY SERVICE AND REPAIR, CAM SUPPORT PLATE](#).

The steps under Section [3.9 TOP END OVERHAUL](#) and Section [3.10 BOTTOM END OVERHAUL](#) that need to be followed for the removal and installation of the cam support plate are given.

Furthermore, detailed instructions for disassembling, cleaning, inspecting, replacing and assembling cam support plate components are provided.

PROCEDURE

NOTE

If performing top end service (or both cam compartment and top end), follow steps 1-16. If servicing cam compartment components only, perform steps 1-7.

1. Remove the exhaust system in two sections. See Section 2.38 EXHAUST SYSTEM, REMOVAL.
2. Remove the air cleaner and backplate. See Section 4.5 AIR CLEANER, REMOVAL.
3. Drain and remove fuel tank. Proceed as follows:

Carbureted: See Section 4.7 FUEL TANK (CARBURETED), COMPLETE REMOVAL, FLHX, FLHT, or FLHR/S.

Fuel Injected: See Section 9.4 FUEL TANK (FUEL INJECTED), COMPLETE REMOVAL, FLHXI, FLHT/C/U/I, FLTRI, or FLHR/C/S/I.
4. Moving to left side of motorcycle, pull boots on spark plug cables to release from spark plug and ignition coil towers. Release cables from three cable clips at bottom of frame backbone.
5. Remove spark plugs.
6. Disconnect ignition coil connector [83] from left side of ignition coil.
7. Pull sides of ignition coil bracket outward to remove from bosses of front fuel tank mount.
8. Remove connections to carburetor or induction module. Proceed as follows:

Carbureted:

- a. Standing on left side of motorcycle, remove MAP sensor connector [80] at top of intake manifold.
- b. Locate the fuel enricher knob under the left side of the fuel tank, and loosen hex nut at backside of mounting bracket. Slide cable assembly free of slot in mounting bracket.

Fuel Injected:

- a. Standing on right side of motorcycle, remove IAC connector [87] and MAP sensor connector [80].
- b. Remove front fuel injector connector [84] and rear fuel injector connector [85].
- c. Remove TP sensor connector [88] and IAT sensor connector [89].
- d. Moving to left side of motorcycle, pull back boot at back of front cylinder and remove ET sensor connector [90]. Cut cable strap to release conduit from horn bracket.

- e. Tape free ends of wire harness to top of wire harness trough on frame backbone to keep conduit and connectors out of the way.

9. Remove idle and throttle control cables as follows:

Carbureted: Using a needle nose pliers, carefully pull idle cable barrel from upper inboard hole in throttle wheel. Pull throttle cable barrel from remaining hole. Release idle and throttle cables from guides in throttle cable bracket.

Fuel Injected: Using a needle nose pliers, carefully pull idle cable barrel from upper hole in throttle wheel. Pull throttle cable barrel from lower hole. Using slots, release idle and throttle cables from guides in throttle cable bracket.

10. Free idle and throttle control cables from J-clamp fastened to right side of frame backbone. Move cables up and out of the way.
11. If equipped with cruise control, remove E-clip from sleeve at end of cruise cable housing. Using slot, remove cable housing from cable guide in throttle cable bracket. Push the plastic end fitting on the cruise cable to the outboard side to release from wheel pin. Move cable up and out of the way.
12. Remove intake manifold/carburetor or induction module. Proceed as follows:
 - a. Remove right side allen head socket screws from front and rear cylinder head flange adapters. For best results, use the INTAKE MANIFOLD WRENCH (HD-47250), or a long 1/4 inch ball allen head socket with end driver 4 inches long.
 - b. Moving to opposite side of motorcycle, just loosen left side allen head socket screws from flange adapters. Slots in flanges make removal of left side screws unnecessary.
 - c. Remove intake manifold/carburetor or induction module from right side of motorcycle.
13. Standing on left side of motorcycle, remove two hex head bolts (with flat washers) to release top engine mounting bracket from cylinder heads.
14. Leaving ground wire ring terminal in place, detach socket terminal of yellow lead from spade contact at back of horn. Release wire conduit from J-clamp.
15. Moving to right side of motorcycle, turn hex head bolt to release stabilizer link from frame weldment.
16. Remove horn, top engine mounting bracket and stabilizer link as an assembly.

PROCEDURE

NOTE

If top end service was performed (or both cam compartment and top end), follow steps 1-13. If only cam compartment components were serviced, perform steps 8-12.

1. Install intake manifold/carburetor or induction module. Proceed as follows:
 - a. With the counterbore facing outward, slide cylinder head flange adapters onto outlet ports of intake manifold/induction module. The flange adapters are not interchangeable. Look next to the slotted bolt hole for a stamp that indicates F(front) and R(ear) cylinder.
 - b. Place a **new** seal in each flange adapter with the beveled side in against the counterbore.
 - c. Standing on right side of engine, slide intake manifold/induction module toward installed position so that open-ended slots on flange adapters begin to engage allen head socket screws loosely installed on left side.
 - d. Align fixed holes in flange adapters with those in cylinder heads and start allen head socket screws. For best results, use the INTAKE MANIFOLD WRENCH (HD-47250), or a long 1/4 inch ball allen head socket with end driver 4 inches long.
 - e. Use the air cleaner backplate to properly locate carburetor/induction module. Install two breather bolts to fasten backplate to front and rear cylinder heads. Install three T27 TORX screws to secure backplate to face of carburetor/induction module.
 - f. Tighten allen head socket screw in fixed holes of flange adapters until snug. Moving to left side of engine, tighten screws in slotted holes to 96-144 **in-lbs** (10.9-16.3 Nm).
 - g. Remove breather bolts and T27 TORX screws to remove backplate.
 - h. Tighten allen head socket screws in fixed holes of flange adapters to 96-144 **in-lbs** (10.9-16.3 Nm).
2. Install horn, top engine mounting bracket and stabilizer link as an assembly. Proceed as follows:
 - a. Moving to right side of motorcycle, turn hex head bolt to secure stabilizer link to frame weldment. Tighten bolt to 18-22 ft-lbs (24-30 Nm).
 - b. Attach socket terminal of yellow lead to spade contact at back of horn. Capture wire conduit in J-clamp.
 - c. Standing on left side of motorcycle, install two hex head bolts (with flat washers) to secure top engine mounting bracket to front and rear cylinder heads. Alternately tighten bolts to 35-40 ft-lbs (48-54 Nm).
3. If equipped with cruise control, slide groove in cruise cable end fitting over cap of wheel pin. Push on end fitting until it snaps in place. Using slot, slip cruise cable housing into cable guide in throttle cable bracket. Install **new** E-clip on sleeve at end of cruise cable housing.
4. Route idle and throttle control cables through J-clamp fastened to right side of frame backbone.
5. Install idle and throttle control cables as follows:

Carbureted: Install sleeve on throttle cable housing into shorter cable guide in throttle cable bracket. Drawing throttle cable downward, fit barrel end into lower outboard hole in throttle wheel. Install sleeve and spring on idle cable housing into longer cable guide inserting barrel end into upper inboard hole in throttle wheel.

Induction Module: Install sleeve on throttle cable housing into shorter cable guide at top of throttle cable bracket. Drawing throttle cable downward, fit barrel end into lower hole in throttle wheel. Install sleeve and spring on idle cable housing into longer cable guide at bottom of throttle cable bracket inserting barrel end into upper hole in throttle wheel.
6. Adjust cables as necessary to keep barrel ends from dislodging. Verify that cables are seated in channel of throttle wheel. Verify operation by turning throttle grip and observing cable action.
7. Install connections to carburetor or induction module. Standing on left side of motorcycle, proceed as follows:

Carbureted:

 - a. Moving to left side of motorcycle, install MAP sensor connector [80] at top of intake manifold.
 - b. Slide threaded portion of enrichener cable into slot of mounting bracket. Flat on threads must face rear of motorcycle for script on enrichener knob to be right side up. With the external tooth lockwasher and hex nut positioned on the inboard side of the mounting bracket, tighten hex nut to 20-35 **in-lbs** (2.3-4.0 Nm).

Fuel Injected:

 - a. Install rear fuel injector connector [85] and front fuel injector connector [84].
 - b. Install MAP sensor connector [80] and IAC connector [87].

- c. Install IAT sensor connector [89] and TP sensor connector [88].
 - d. Moving to left side of motorcycle, install ET sensor connector [90] at back of front cylinder. Pull boot over sensor to keep out dirt and debris. Install **new** cable strap to secure connector conduit to horn bracket.
8. Install spark plugs in front and rear cylinder heads. Install the plugs finger tight and then tighten to 12-18 ft-lbs (16-24 Nm).
 9. Install ignition coil and spark plug cables as follows:
 - a. With the coil towers facing rear of vehicle, hold ignition coil and bracket at bottom of frame backbone. Pull sides of bracket outward and install on bosses of front fuel tank mount. See [Figure 3-11](#).
 - b. Connect ignition coil connector [83] to left side of ignition coil.
 - c. Install spark plug cable to front cylinder onto left side coil tower. Verify that spark plug cable is captured in double-sided cable clip at bottom left side of frame backbone. Install **new** cable clip on T-stud if damaged or missing.
 - d. Install spark plug cable to rear cylinder onto right side coil tower. Verify that spark plug cable is captured in two single-sided cable clips at bottom left side of frame backbone. Install **new** cable clips on T-studs if damaged or missing.
 10. Install the fuel tank. Proceed as follows:

Carbureted: See [Section 4.7 FUEL TANK \(CARBURETED\), INSTALLATION \(AFTER COMPLETE REMOVAL\)](#), FLHX, FLHT, or FLHR/S.

Fuel Injected: See [Section 9.4 FUEL TANK \(FUEL INJECTED\), INSTALLATION \(AFTER COMPLETE REMOVAL\)](#), FLHXI, FLHT/C/U/I, FLTRI, or FLHR/C/S/I.
 11. Install the backplate and air cleaner. See [Section 4.5 AIR CLEANER, INSTALLATION](#).
 12. Install the exhaust system. See [Section 2.38 EXHAUST SYSTEM, INSTALLATION](#).
 13. Adjust idle and throttle control cables as follows:

Non-Cruise: See [Section 2.21 THROTTLE CABLES \(NON-CRUISE\), ADJUSTMENT](#).

Cruise Equipped: See [Section 8.31 CRUISE CONTROL \(FLHRC, FLHTCU, FLTR\), CABLE ADJUSTMENT](#).

PROCEDURE

1. Remove the exhaust system in two sections. See Section 2.38 EXHAUST SYSTEM, REMOVAL.
2. Remove the air cleaner and backplate. See Section 4.5 AIR CLEANER, REMOVAL.
3. Drain and remove fuel tank. Proceed as follows:

Carbureted: See Section 4.7 FUEL TANK (CARBURETED), COMPLETE REMOVAL, FLHX, FLHT, or FLHR/S.

Fuel Injected: See Section 9.4 FUEL TANK (FUEL INJECTED), COMPLETE REMOVAL, FLHXI, FLHT/C/U/I, FLTRI, or FLHR/C/S/I.
4. Remove the primary chaincase. See Section 6.5 PRIMARY CHAINCASE, REMOVAL.
5. Remove connections to carburetor or induction module. Proceed as follows:

Carbureted:

- a. Moving to left side of motorcycle, remove MAP sensor connector [80] at top of intake manifold.
- b. Locate the fuel enricher knob under the left side of the fuel tank, and loosen hex nut at backside of mounting bracket. Slide cable assembly free of slot in mounting bracket.

Fuel Injected:

- a. Standing on right side of motorcycle, remove IAC connector [87] and MAP sensor connector [80].
 - b. Remove front fuel injector connector [84] and rear fuel injector connector [85].
 - c. Remove TP sensor connector [88] and IAT sensor connector [89].
 - d. Moving to left side of motorcycle, pull back boot at back of front cylinder and remove ET sensor connector [90]. Cut cable strap to release conduit from horn bracket.
 - e. Tape free ends of wire harness to top of wire harness trough on frame backbone to keep conduit and connectors out of the way.
6. Remove idle and throttle control cables as follows:

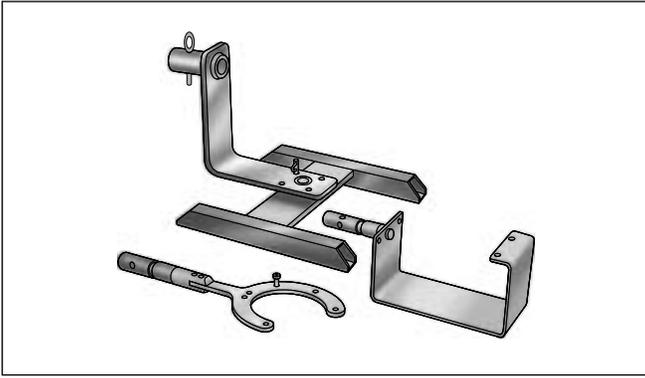
Carbureted: Using a needle nose pliers, carefully pull idle cable barrel from upper inboard hole in throttle wheel. Pull throttle cable barrel from remaining hole. Release idle and throttle cables from guides in throttle cable bracket.



Figure 3-11. Remove Ignition Coil Bracket

Fuel Injected: Using a needle nose pliers, carefully pull idle cable barrel from upper hole in throttle wheel. Pull throttle cable barrel from lower hole. Using slots, release idle and throttle cables from guides in throttle cable bracket.

7. Free idle and throttle control cables from J-clamp fastened to right side of frame backbone. Move cables up and out of the way.
8. If equipped with cruise control, remove E-clip from sleeve at end of cruise cable housing. Using slot, remove cable housing from cable guide in throttle cable bracket. Push the plastic end fitting on the cruise cable to the outboard side to release from wheel pin. Move cable up and out of the way.
9. Moving to left side of motorcycle, pull boots on spark plug cables to release from spark plug and ignition coil towers. Release cables from three cable clips at bottom of frame backbone.
10. Remove spark plugs.
11. Disconnect ignition coil connector [83] from left side of ignition coil.
12. Pull sides of ignition coil bracket outward to remove from bosses of front fuel tank mount. See Figure 3-11.
13. Moving to right side of motorcycle, remove two allen head socket screws to release oil hose cover.
14. Using a side cutters, cut and remove clamps on engine side of oil hoses. Pull hoses from crankcase fittings.
15. Cut and remove clamp on breather hose behind rear lifter cover. Pull hose from crankcase fitting and tuck behind transmission to engine flange to keep out of the way.



**Figure 3-12. Engine/Transmission Bench Stand
(Part No. HD-42310)**

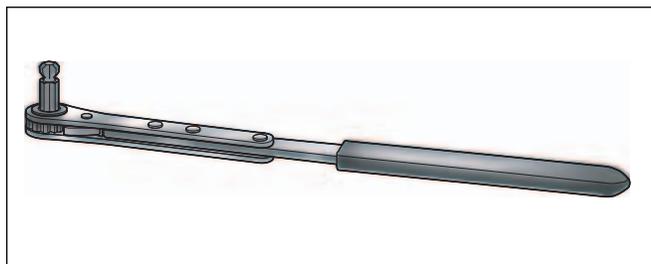
16. Remove the voltage regulator. See Section 8.9 VOLTAGE REGULATOR, REMOVAL.
17. Draw cables and socket of stator connector [46], 3-place Lyall, to rear of front engine stabilizer link and then up to area in front of primary chaincase.
18. Remove CKP sensor and oil pressure switch/sender as follows:
 - a. Locate CKP sensor connector [79], 2-place Deutsch, next to oil filter mount. Depress button on socket terminal side and pull apart pin and socket halves.
 - b. Remove allen head socket screw to free crank position sensor mount from crankcase. Pull sensor from bore. Remove O-ring from groove on sensor body. Discard O-ring.
 - c. Locate the oil pressure switch/sender at the front right side of the crankcase. On FLHR/C/S models, pull elbow from post of oil pressure switch. On FLHX, FLHT/C/U and FLTR models, pull external latch outward and use rocking motion to remove Delphi connector from oil pressure sender.
 - d. On FLHR/C/S models, use a 15/16 inch Open End Crow Foot (Snap-On FC30B) to remove oil pressure switch from crankcase. On FLHX, FLHT/C/U and FLTR models, use 1-1/16 inch Open End Crow Foot (Snap-On FC34A) to remove oil pressure sender.
19. Coil main harness conduit and allow to hang below lower frame tube at front of motorcycle. If harness is not moved out of the way, it may be damaged during engine removal.
20. Place jack under oil pan at rear of motorcycle. Using a block of wood to distribute pressure across the length of the casting, raise the jack until firm contact is made with the bottom of the oil pan.
21. Standing on left side of motorcycle, remove two hex head bolts (with flat washers) to release top engine mounting bracket from cylinder heads.

22. Remove elbow terminals from spade contacts at back of horn. Release wire harness conduit from J-clamp.
23. Moving to right side of motorcycle, turn hex head bolt to release stabilizer link from frame weldment.
24. Remove horn, top engine mounting bracket and stabilizer link as an assembly.
25. Remove four bolts (with flat washers) to free rear of crankcase from transmission housing. Loosen and remove bolts in a crosswise pattern.
26. Remove two bolts (with flat washers) to free front of crankcase from front engine mounting bracket.
27. Wrap rear master cylinder reservoir with foam padding or bubble pack.
28. Cover lower frame tubes (both left and right side) with foam padding or bubble pack. Split loom conduit or a half shell of PVC tubing will also produce good results. Protection is necessary to prevent nicks or paint damage to left frame tube and chafing, cutting or kinking of the brake line, wire cables and conduit at the top of the right frame tube.
29. Cover rocker covers of front and rear cylinders with foam padding or bubble pack.

CAUTION

The engine weighs approximately 165 pounds (74.8 kg). Use a suitable lifting device, if necessary. Exercise caution to avoid personal injury.

30. Move engine forward far enough to clear two ring dowels in lower flange of transmission housing. Raise engine and remove from right side of motorcycle. Exercise caution to avoid contact with rear brake master cylinder reservoir and brake line, wire cables and conduit at top of lower frame tube.
31. Using the TWIN CAM 88 CRADLE (HD-42310-2), install engine in BENCH STAND (HD-42310) or ROLLING STAND (HD-43646A). See Figure 3-12.
32. Remove intake manifold/carburetor or induction module. Proceed as follows:



**Figure 3-13. Intake Manifold Wrench
(Part No. HD-47250)**

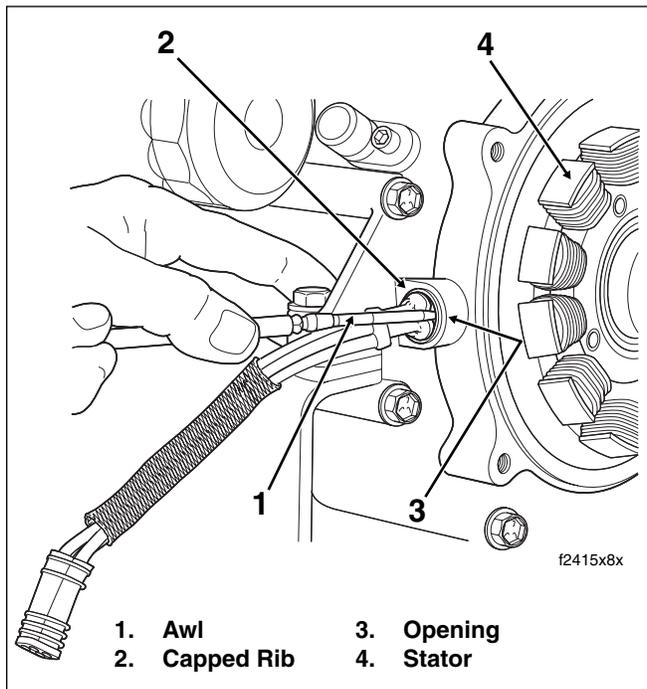


Figure 3-14. Remove Grommet From Crankcase

- a. Remove right side allen head socket screws from front and rear cylinder head flange adapters. For best results, use the INTAKE MANIFOLD WRENCH (HD-47250), or a long 1/4 inch ball allen head socket with end driver 4 inches long. See [Figure 3-13](#).
- b. Moving to opposite side of motorcycle, just loosen left side allen head socket screws from flange adapters. Slots in flanges make removal of left side screws unnecessary.
- c. Remove intake manifold/carburetor or induction module from right side of motorcycle.

33. Remove the rotor as follows:

CAUTION

The high-output rotor contains powerful magnets. Use the ROTOR REMOVER/INSTALLER and SHAFT PROTECTOR SLEEVE (HD-41771) to prevent parts damage and possible hand injury during removal and installation.

- a. Verify that threads of engine sprocket shaft are clean, especially of old Loctite material. Thread the Shaft Protector Sleeve onto the shaft.
- b. Turn thumbscrews of Rotor Remover/Installer into threaded holes in rotor face.
- c. Rotate handle of forcing screw in a clockwise direction to remove rotor from shaft.

34. Remove stator as follows:

- a. Remove four T27 TORX screws to free stator from crankcase. Discard screws.
- b. Using point of awl, carefully lift capped rib on grommet away from crankcase and then insert into bore between grommet and casting. See [Figure 3-14](#). Tilt awl slightly squirting isopropyl alcohol or glass cleaner into opening. Repeat this step at one or two other locations around grommet.
- c. While pushing on capped rib from outside of crankcase, draw grommet through bore by pulling on cable stop with needle nose pliers. Rock grommet back and forth to facilitate removal, if necessary. Exercise caution to avoid damaging ribs on grommet if stator is to be reused.
- d. Draw stator cables and socket through crankcase bore.

35. Remove the oil filter as follows:

- a. Obtain the OIL FILTER WRENCH (HD-42311). The tool allows easy removal of the oil filter without risk of damage to the CKP sensor or cable.
- b. Place the jaws of the wrench over the oil filter with the tool oriented vertically.
- c. Using a 3/8 inch drive with a 4 inch extension, turn wrench in a counterclockwise direction until loose. Do not use with air tools.

NOTE

Use OIL FILTER WRENCH (HD-44067) if HD-42311 is not available.

36. Remove oil filter mount as follows:

- a. Carefully bend corners on lockplate away from heads of top and bottom bolts in oil filter mount. Remove top and bottom bolts, lockplate and flat washers. Discard lockplate.
- b. Remove middle bolt with flat washer to free filter mount from crankcase.
- c. Remove two O-rings from inboard side of filter mount. Discard O-rings.

NOTES

Remove and clean the oil pan under any of the following conditions:

- *Metal debris is found in the engine or crankcase.*
- *Oil contamination is suspected.*
- *A complete engine overhaul is being performed as a result of a major engine failure.*
- *The engine is being replaced with a new one.*

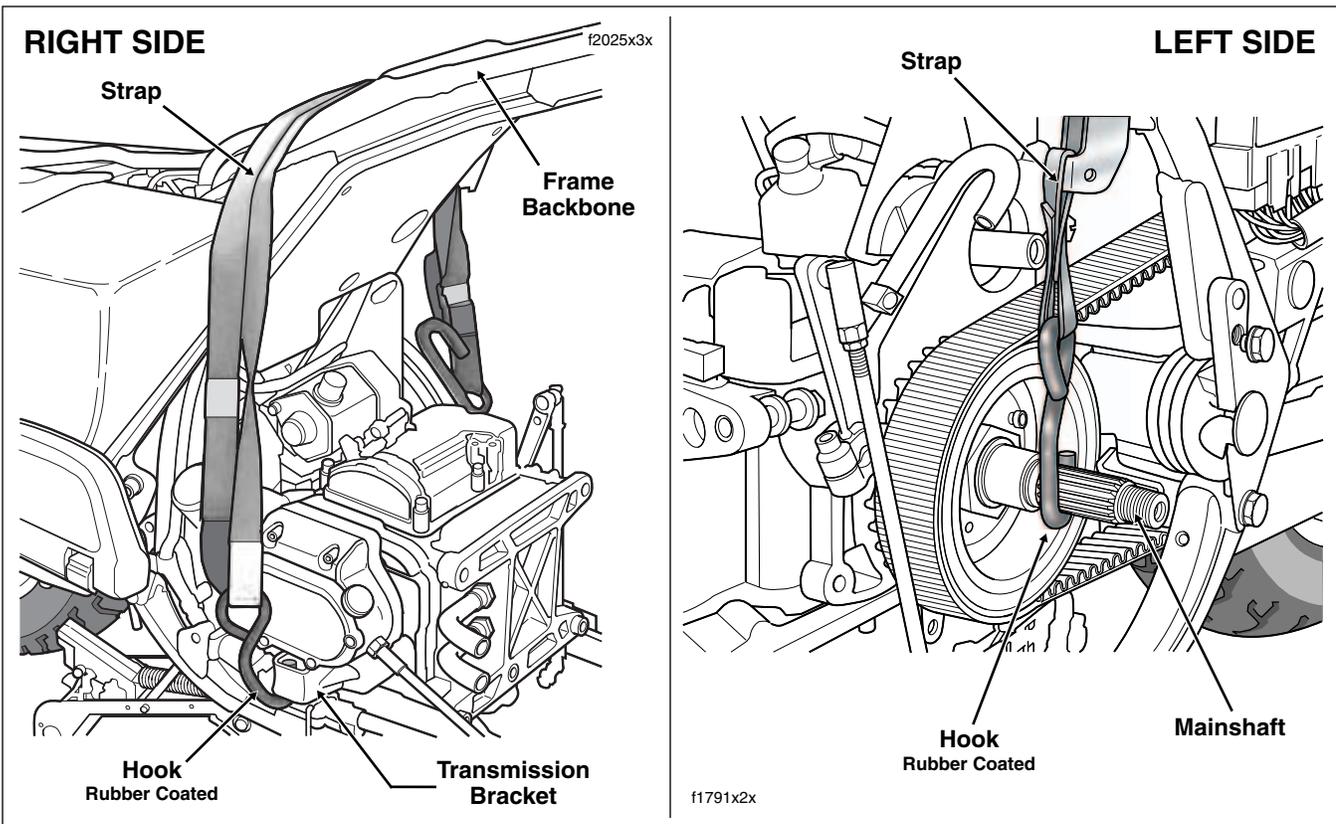


Figure 3-15. Secure Transmission Using Transmission Exhaust Bracket and Mainshaft

37. To remove the oil pan, proceed as follows:

- a. Use a tie down strap to hold the transmission. Lay strap over frame backbone placing one rubber coated hook through the transmission exhaust bracket on the right side of the motorcycle and the other around the mainshaft on the left. Using buckle, tighten strap until taut. See [Figure 3-15](#).
- b. Lower and remove jack under oil pan.
- c. Locate oil drain plug at front of the oil pan. See [Figure 3-16](#). Remove the plug and allow oil to drain completely.
- d. Locate transmission drain plug on right side of the oil pan. See [Figure 3-16](#). Remove the plug and drain the transmission lubricant into a suitable container.
- e. Alternately loosen and then remove the twelve allen head socket screws to release the oil pan from the transmission housing. Follow the pattern shown in [Figure 3-16](#).
- f. Remove gasket from oil pan and discard.

PROCEDURE

NOTE

If oil pan was drained and removed, start at step 1. If oil pan was neither drained nor removed, move to step 13.

1. Coat gasket surface of oil pan with a thin coat of HYLO-MAR® gasket sealer.
2. Place gasket on oil pan and allow sealer to dry until tacky.
3. Position oil pan under transmission housing and start the twelve allen head socket screws. Tighten each screw about two turns after initial thread engagement.
4. Inspect the oil pan gasket to verify that it is properly positioned.
5. Alternately tighten oil pan screws to 84-132 **in-lbs** (9.5-14.9 Nm) following the pattern shown in Figure 3-16.
6. Remove any foreign material from magnet of oil drain plug. Also check the O-ring for tears, cuts or general deterioration. Replace as necessary.
7. Install the engine oil drain plug in front of the oil pan. Tighten plug to 14-21 **ft-lbs** (19-28 Nm).
8. Remove the transmission filler plug from the clutch release cover on the right side of the transmission case. Check the O-ring for tears, cuts or general deterioration. Replace as necessary.
9. Remove any foreign material from magnet of transmission drain plug. Also check the O-ring for tears, cuts or general deterioration. Replace as necessary.
10. Install the transmission lubricant drain plug in right side of the oil pan and tighten to 14-21 **ft-lbs** (19-28 Nm).

 **WARNING**

When draining or adding lubricant, do not allow dirt, debris or other contaminants to enter the transmission case. Exercise caution so that lubricant does not contact rear wheel, tire and brake components. Such contact can adversely affect traction and may lead to loss of vehicle control, which could result in death or serious injury.

11. Fill the transmission with 20-24 oz. (590-710 ml) of transmission lubricant or until the lubricant level on the dipstick of the filler plug is at the F(ULL) mark with the motorcycle in a level, upright position and the filler plug resting on the threads.

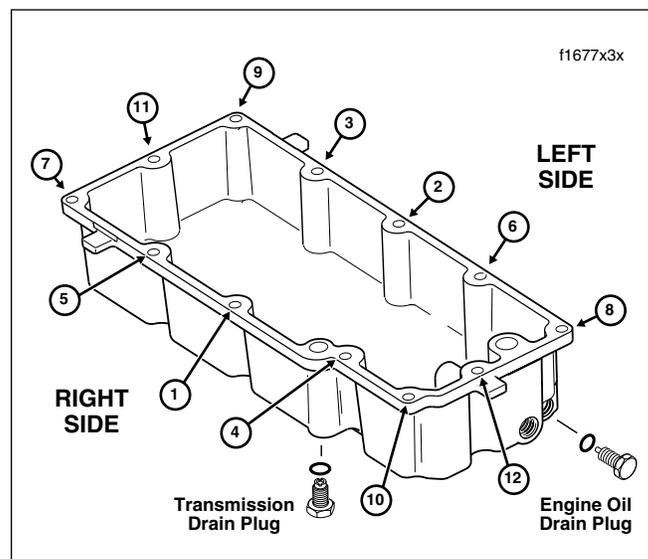


Figure 3-16. Oil Pan Torque Sequence

Use only Harley-Davidson FORMULA+ TRANSMISSION AND PRIMARY CHAINCASE LUBRICANT, Part No. 99851-05 (quart).

12. Install the transmission filler plug/dipstick in the clutch release cover. Tighten the plug to 25-75 **in-lbs** (2.8-8.5 Nm).
13. Place jack under oil pan at rear of motorcycle. Using a block of wood to distribute pressure across the length of the casting, raise the jack until firm contact is made with the bottom of the oil pan.
14. Remove strap from frame backbone disengaging hooks from mainshaft and transmission exhaust bracket.
15. Install spark plugs in front and rear cylinder heads. Install the plugs finger tight and then tighten to 12-18 **ft-lbs** (16-24 Nm).
16. Install oil filter mount as follows:
 - a. Install two **new** O-rings on inboard side of filter mount.
 - b. Place flat washers in recessed bolt holes at top and bottom of filter mount flange.
 - c. Align holes in lockplate with holes in flat washers.
 - d. Slide two hex head bolts through lockplate, flat washers and filter mount flange. Apply Loctite Medium Strength Threadlocker 243 (blue) to threads of installed bolts.

CAUTION

To avoid cross threading tapped holes, exercise care when starting hex head bolts in crankcase.

- e. Align holes in filter mount flange with holes in crankcase and tighten bolts until snug.
 - f. Install flat washer on remaining bolt, apply Loctite Medium Strength Threadlocker 243 (blue) to threads, and install in middle hole of filter mount flange.
 - g. Starting at the top, alternately tighten three hex head bolts to 12-16 ft-lbs (16-22 Nm). Re-tighten middle bolt when done.
 - h. To prevent rotation, carefully bend outside corners of lockplate against heads of top and bottom bolts.
17. Clean oil filter mount flange of any old gasket material. Lubricate gasket of **new** oil filter with clean engine oil and install on filter mount. Hand tighten oil filter 1/2-3/4 turn after gasket first contacts filter mounting surface. Do **NOT** use OIL FILTER WRENCH for oil filter installation.

NOTE

Use of the Premium 5 micron synthetic media oil filter is highly recommended, Part No. 63798-99A (Chrome) or 63731-99A (Black).

18. Install stator as follows:
- a. From inside crankcase, feed socket and stator cables through hole in crankcase.
 - b. Thoroughly lubricate grommet with isopropyl alcohol or glass cleaner. To avoid leakage, ribs of grommet must be free of dirt and oily residue.
 - c. Carefully grasp cable stop behind grommet with a needle nose pliers. Push grommet into crankcase bore while carefully pulling on outside cable. Installation is complete when cable stop contacts casting and capped rib of grommet exits crankcase bore.
 - d. If necessary, carefully run awl around edge of capped rib so that it rests flat against seating surface on crankcase.
 - e. Feed socket and cables forward under front engine stabilizer link.

CAUTION

Do not reuse T27 TORX screws. The threads of the screws contain a locking compound in pellet form. When the screw is started, the pellet breaks releasing the compound.

- f. Install four **new** T27 TORX screws to fasten stator to crankcase. Alternately tighten screws to 55-75 **in-lbs** (6.2-8.5 Nm).
19. Install rotor as follows:

CAUTION

The high-output rotor contains powerful magnets. Use the ROTOR REMOVER/INSTALLER and SHAFT PROTECTOR SLEEVE (HD-41771) to prevent parts damage and possible hand injury during removal and installation.

- a. Install the Shaft Protector Sleeve and Rotor Remover/Installer, if removed.

NOTE

The Shaft Protector Sleeve not only protects the threads from the splines of the rotor, but acts as a guide to ensure that the rotor is properly centered.

- b. Center ball on forcing screw in recess at end of engine sprocket shaft. Rotate the handle of the tool in a counterclockwise direction to ease rotor into position over stator.
 - c. Loosen thumbscrews and remove Rotor Remover/Installer. Remove Shaft Protector Sleeve.
 - d. Install the shaft extension on the engine sprocket shaft.
20. Install intake manifold/carburetor or induction module. Proceed as follows:
- a. With the counterbore facing outward, slide cylinder head flange adapters onto outlet ports of intake manifold/induction module. The flange adapters are not interchangeable. Look next to the slotted bolt hole for a stamp that indicates F(ront) and R(ear) cylinder.
 - b. Place a **new** seal in each flange adapter with the beveled side in against the counterbore.
 - c. Standing on right side of engine, slide intake manifold/induction module toward installed position so that open-ended slots on flange adapters begin to engage allen head socket screws loosely installed on left side.
 - d. Align fixed holes in flange adapters with those in cylinder heads and start allen head socket screws. For best results, use the INTAKE MANIFOLD WRENCH (HD-47250), or a long 1/4 inch ball allen head socket with end driver 4 inches long.
 - e. Use the air cleaner backplate to properly locate carburetor/induction module. Install two breather bolts to fasten backplate to front and rear cylinder heads. Install three T27 TORX screws to secure backplate to face of carburetor/induction module.
 - f. Tighten allen head socket screw in fixed holes of flange adapters until snug. Moving to left side of engine, tighten screws in slotted holes to 96-144 **in-lbs** (10.9-16.3 Nm).
 - g. Remove breather bolts and T27 TORX screws to remove backplate.

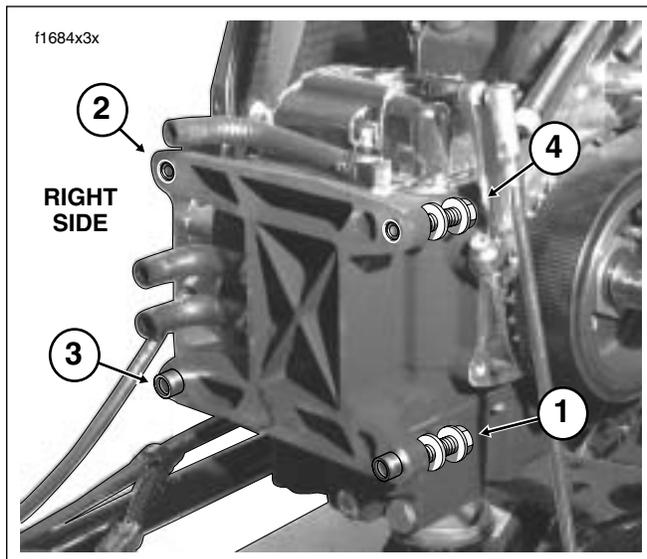


Figure 3-17. Transmission Housing to Crankcase Torque Sequence

- h. Tighten allen head socket screws in fixed holes of flange adapters to 96-144 **in-lbs** (10.9-16.3 Nm).
21. Cover rocker covers of front and rear cylinders with foam padding or bubble pack.
 22. Cover lower frame tubes (both left and right side) with foam padding or bubble pack. Split loom conduit or a half shell of PVC tubing will also produce good results. Protection is necessary to prevent nicks or paint damage to left frame tube and chafing, cutting or kinking of the brake line, wire cables and conduit at the top of the right frame tube.
 23. Wrap rear master cylinder reservoir with foam padding or bubble pack.
 24. Remove engine from BENCH STAND (HD-42310) or ROLLING STAND (HD-43646A) and set on floor on right side of chassis.

CAUTION

The engine weighs approximately 165 pounds (74.8 kg). Use a suitable lifting device, if necessary. Exercise caution to avoid personal injury.

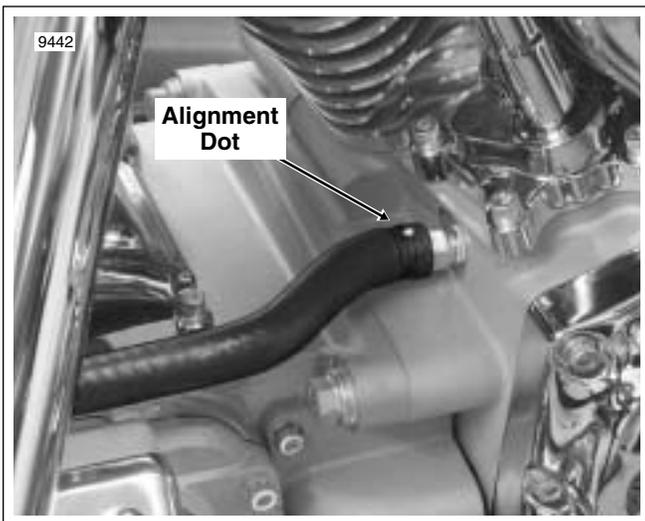
25. Raise engine and install in chassis from right side of motorcycle setting front of crankcase onto front engine mounting bracket. Engine must be set forward far enough to clear two ring dowels in lower flange of transmission housing. Exercise caution to avoid contact with rear brake master cylinder reservoir and brake line, wire cables and conduit at top of lower right frame tube.
26. Move engine rearward to fully engage two ring dowels in lower flange of transmission housing.

27. Secure the engine as follows:
 - a. Hand tighten four bolts (with flat washers) to secure transmission housing to rear of crankcase.
 - b. Hand tighten two bolts (with flat washers) to secure front of crankcase to front engine mounting bracket.
 - c. Tighten the four transmission housing to crankcase bolts to 15 ft-lbs (20.3 Nm) in the sequence shown in Figure 3-17.

NOTE

For best results, use Open End Crowfoot (Snap-On FC018) on upper left and upper right transmission housing to crankcase bolts.

- d. Following the same sequence, final tighten the four transmission housing to crankcase bolts to 30-35 ft-lbs (40.7-47.5 Nm).
 - e. Tighten the two crankcase to front engine mounting bracket bolts to 33-38 ft-lbs (44.8-51.5 Nm).
28. Install horn, top engine mounting bracket and stabilizer link as an assembly. Proceed as follows:
 - a. Moving to right side of motorcycle, turn hex head bolt to secure stabilizer link to frame weldment. Tighten bolt to 18-22 ft-lbs (24-30 Nm).
 - b. Install elbow terminals onto spade contacts at back of horn. Capture wire harness conduit in J-clamp.
 - c. Standing on left side of motorcycle, install two hex head bolts (with flat washers) to secure top engine mounting bracket to front and rear cylinder heads. Alternately tighten bolts to 35-40 ft-lbs (48-54 Nm).
 29. Lower and remove jack under oil pan.
 30. Uncoil main harness conduit and allow to hang below lower frame tube at front of motorcycle.
 31. Install oil pressure switch/sender and CKP sensor as follows:
 - a. Start oil pressure switch/sender into crankcase bore at the front right side of the crankcase. On FLHR/C/S models, use a 15/16 inch Open End Crow Foot (Snap-On FC30B) to tighten oil pressure switch to 96-120 **in-lbs** (11-14 Nm). On FLHX, FLHT/C/U and FLTR models, use 1-1/16 inch Open End Crow Foot (Snap-On FC34A) to tighten oil pressure sender to same torque.
 - b. On FLHR/C/S models, install elbow on post of oil pressure switch. On FLHX, FLHT/C/U and FLTR models, install Delphi connector to oil pressure sender .
 - c. Install **new** O-ring in groove on crank position sensor body. Apply a very thin film of clean H-D 20W50 engine oil to O-ring before installation.
 - d. Push sensor into bore aligning hole in sensor mount with hole in spot face. Install allen head socket screw (1/4 x 1 inch) and tighten to 90-120 **in-lbs** (10.2-13.6 Nm).



**Figure 3-18. Install Breather Hose
(Hose Clamp Not Shown for Illustration Purposes)**

- e. Mate pin and socket halves of CKP sensor connector [79], 2-place Deutsch.

32. Install voltage regulator. See Section [8.9 VOLTAGE REGULATOR, INSTALLATION](#).

33. Slide **new** clamp onto free end of breather hose behind rear lifter cover. Install hose onto crankcase fitting. Crimp clamp using HOSE CLAMP PLIERS (HD-97087-65B).

NOTE

*If installing **new** breather hose or if hose was completely removed, be sure that end with white alignment dot is connected to crankcase fitting and that dot is topside after installation of hose. See [Figure 3-18](#). Improper orientation can result in chaffing of the transmission top cover.*

- 34. Slide **new** clamps onto free ends of oil hoses. Install hoses onto crankcase fittings. Crimp clamps.
- 35. Install two allen head socket screws to secure oil hose cover to transmission and engine housings. Longer screw goes to engine housing. Alternately tighten screws to 84-108 **in-lbs** (10-12 Nm).
- 36. Install ignition coil and spark plug cables as follows:
 - a. With the coil towers facing rear of motorcycle, hold ignition coil and bracket at bottom of frame backbone. Pull sides of bracket outward and install on bosses of front fuel tank mount. See [Figure 3-11](#).
 - b. Connect ignition coil connector [83] to left side of ignition coil.
 - c. Install spark plug cable to front cylinder onto left side coil tower. Verify that spark plug cable is captured in double-sided cable clip at bottom left side of frame backbone. Install **new** cable clip on T-stud if damaged or missing.

- d. Install spark plug cable to rear cylinder onto right side coil tower. Verify that spark plug cable is captured in two single-sided cable clips at bottom left side of frame backbone. Install **new** cable clips on T-studs if damaged or missing.

37. If equipped with cruise control, slide groove in cruise cable end fitting over cap of wheel pin. Push on end fitting until it snaps in place. Using slot, slip cruise cable housing into cable guide in throttle cable bracket. Install **new** E-clip on sleeve at end of cruise cable housing.

38. Route idle and throttle control cables through J-clamp fastened to right side of frame backbone.

39. Install idle and throttle control cables as follows:

Carbureted: Install sleeve on throttle cable housing into shorter cable guide in throttle cable bracket. Drawing throttle cable downward, fit barrel end into lower outboard hole in throttle wheel. Install sleeve and spring on idle cable housing into longer cable guide inserting barrel end into upper inboard hole in throttle wheel.

Induction Module: Install sleeve on throttle cable housing into shorter cable guide at top of throttle cable bracket. Drawing throttle cable downward, fit barrel end into lower hole in throttle wheel. Install sleeve and spring on idle cable housing into longer cable guide at bottom of throttle cable bracket inserting barrel end into upper hole in throttle wheel.

40. Tighten cables as necessary to keep barrel ends from dislodging. Verify that cables are seated in channel of throttle wheel. Verify operation by turning throttle grip and observing cable action.

41. Install connections to carburetor or induction module. Standing on left side of motorcycle, proceed as follows:

Carbureted:

- a. Moving to left side of motorcycle, install MAP sensor connector [80] at top of intake manifold.
- b. Slide threaded portion of enrichener cable into slot of mounting bracket. Flat on threads must face rear of motorcycle for script on enrichener knob to be right side up. With the external tooth lockwasher and hex nut positioned on the inboard side of the mounting bracket, tighten hex nut to 20-35 **in-lbs** (2.3-4.0 Nm).

Fuel Injected:

- a. Install rear fuel injector connector [85] and front fuel injector connector [84].
- b. Install MAP sensor connector [80] and IAC connector [87].
- c. Install IAT sensor connector [89] and TP sensor connector [88].

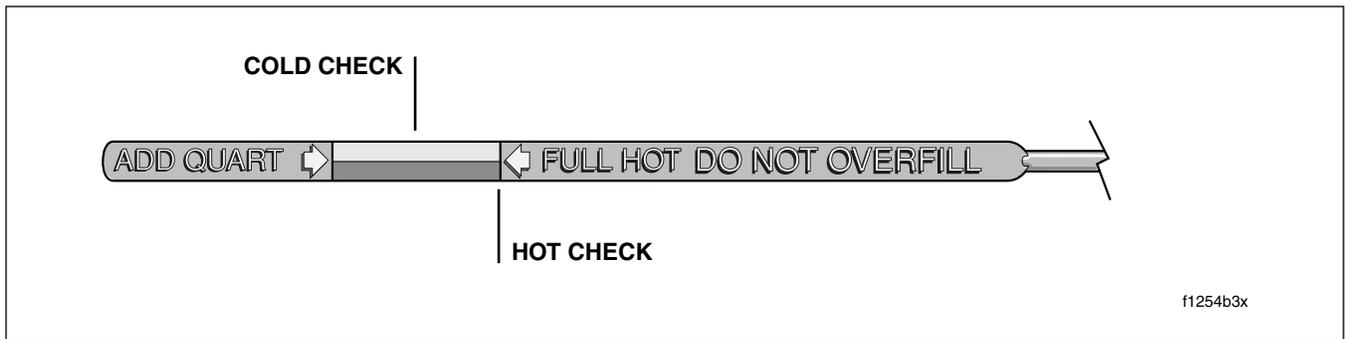


Figure 3-19. Engine Oil Dipstick

- d. Moving to left side of motorcycle, install ET sensor connector [90] at back of front cylinder. Pull boot over sensor to keep out dirt and debris. Install **new** cable strap to secure connector conduit to horn bracket.
42. Install the primary chaincase. See Section 6.5 PRIMARY CHAINCASE, INSTALLATION.
43. Install the fuel tank. Proceed as follows:
- Carbureted:** See Section 4.7 FUEL TANK (CARBURETED), INSTALLATION (AFTER COMPLETE REMOVAL), FLHX, FLHT, or FLHR/S.
- Fuel Injected:** See Section 9.4 FUEL TANK (FUEL INJECTED), INSTALLATION (AFTER COMPLETE REMOVAL), FLHXI, FLHT/C/U/I, FLTRI, or FLHR/C/S/I.
44. Adjust idle and throttle control cables as follows:
- Non-Cruise:** See Section 2.21 THROTTLE CABLES (NON-CRUISE), ADJUSTMENT.
- Cruise Equipped:** See Section 8.31 CRUISE CONTROL (FLHRC, FLHTCU, FLTR), CABLE ADJUSTMENT.
45. Install the backplate and air cleaner. See Section 4.5 AIR CLEANER, INSTALLATION.
46. Install the exhaust system. See Section 2.38 EXHAUST SYSTEM, INSTALLATION.

NOTE

If oil pan was **not** drained, move to step 48.

47. With motorcycle resting on jiffy stand, add 3-1/2 quarts (3.3 liters) engine oil as specified in Table 3-2. Use the proper grade of oil for the lowest temperature expected before the next oil change.

Table 3-2. Recommended Engine Oils

Harley-Davidson Type	Viscosity	Harley-Davidson Rating	Lowest Ambient Temperature	Cold Weather Starts Below 50°F (10°C)
HD Multi-grade	SAE 10W40	HD 360	Below 40°F (4°C)	Excellent
HD Multi-grade	SAE 20W50	HD 360	Above 40°F (4°C)	Good
HD Regular Heavy	SAE 50	HD 360	Above 60°F (16°C)	Poor
HD Extra Heavy	SAE 60	HD 360	Above 80°F (27°C)	Poor

CAUTION

Oil level cannot be accurately measured on a cold engine. For preride inspection, with motorcycle leaning on jiffy stand on level ground, oil should register on dipstick between arrows when engine is cold. Do NOT add oil to bring the level to the FULL mark on a **COLD** engine.

48. Perform engine oil level **COLD CHECK** as follows:
- With the motorcycle resting on the jiffy stand on level ground, wipe off the dipstick and insert it back into the oil pan with the plug pushed completely into the fill spout.
 - Remove the dipstick and note the level of the oil. Oil level should register between the two arrows on the dipstick. See Figure 3-19. If oil level is at or below the lower arrow, add only enough oil to bring the level between the two arrows on the dipstick.
49. Perform engine oil level **HOT CHECK** as follows:
- Ride motorcycle until engine is at normal operating temperature.
 - With the motorcycle resting on the jiffy stand on level ground, allow engine to idle for 1-2 minutes. Turn engine off.
 - Wipe off the dipstick and insert it back into the oil pan with the plug pushed completely into the fill spout.
 - Remove the dipstick and note the level of the oil. Add only enough oil to bring the level to the FULL mark on the dipstick. See Figure 3-19. Do not overfill.
50. Start engine and carefully check for oil leaks around drain plug and oil filter.

NOTES
