SPECIFICATIONS 3.1

GENERAL		
Type	2 cylinder, air cooled, four-stroke 45 Degree V-twin	
Horsepower (ft-lbs)	101 @ 6200 RPM	
Torque (ft-lbs)	90 @ 5500 RPM	
Compression Ratio	10.0 to 1	
Bore	3.498 in.	88.849 mm
Stroke	3.8125 in.	96.838 mm
Engine Displacement	73.4 cu. in.	1203 cc
Oil Tank Capacity (with filter change)	2.5 quarts	2.37 liters

ENGINE IGNITION SPECIFICATIONS		
Type	Sequential, non waste spark	
Regular Idle	850-1050 RPM	
Spark Plug Size	12 mm	
Spark Plug Type	Harley-Davidson No. 10R12	
Spark Plug Gap	0.038-0.043 in.	0.97-1.09 mm
Spark Plug Torque	11-18 ft-lbs	15-24 Nm

NOTE

*Service wear limits are given as a guideline for measuring components that are not **new**. For measurement specifications not given under SERVICE WEAR LIMITS, see NEW COMPONENTS.*

CAMSHAFT SPECIFICATIONS	
Lift @ Valve (TDC) Intake/Exhaust	0.211 in./0.191 in.
Duration @ 0.053 lift Intake/Exhaust	256°/256°
Timing @ 0.053 lift Open/Close	Intake: 28° BTDC/48° ABDC Exhaust: 52° BBDC/24° ATDC

VALVE		NEW COMPONENTS		SERVICE WEAR LIMITS	
Fit in guide	Exhaust	0.0015-0.0033 in.	0.0381-0.0838 mm	0.0040 in.	0.1016 mm
	Intake	0.0008-0.0026 in.	0.0203-0.0660 mm	0.0035 in.	0.0889 mm
Seat width		0.040-0.062 in.	1.016-1.575 mm	0.090 in.	2.286 mm
Stem protrusion from cylinder valve pocket		1.975-2.011 in.	50.165-51.079 mm	2.031 in.	51.587 mm

OUTER VALVE SPRING		NEW COMPONENTS		SERVICE WEAR LIMITS	
Free length		2.105-2.177 in.	53.467-55.296 mm	2.105 in. (min)	53.467 mm (min)
Intake	1.751-1.848 in. (closed)	72-92 lbs	33-42 kg		
	1.286-1.383 in. (open)	183-207 lbs	83-94 kg		
Exhaust	1.751-1.848 in. (closed)	72-92 lbs	33-42 kg		
	1.332-1.429 in. (open)	171-195 lbs	78-88 kg		

INNER VALVE SPRING		NEW COMPONENTS		SERVICE WEAR LIMITS	
Free length		1.926-1.996 in.	48.920-50.698 mm	1.926 in. (min)	48.920 mm (min)
Intake	1.577-1.683 in. (closed)	38-49 lbs	17-22 kg		
	1.112-1.218 in. (open)	98-112 lbs	44-51 kg		
Exhaust	1.577-1.683 in. (closed)	38-49 lbs	17-22 kg		
	1.158-1.264 in. (open)	91-106 lbs	41-48 kg		

ROCKER ARM	NEW COMPONENTS		SERVICE WEAR LIMITS	
Shaft fit in bushing (loose)	0.0005-0.0020 in.	0.0127-0.0508 mm	0.0035 in.	0.0889 mm
End clearance	0.003-0.013 in.	0.076-0.330 mm	0.025 in	0.635 mm
Bushing fit in rocker arm (tight)	0.004-0.002 in.	0.102-0.0559 mm		
Rocker arm shaft fit in rocker cover (loose)	0.0007-0.0022 in.	0.018-0.056 mm	0.0035 in.	0.0889 mm

PISTON		NEW COMPONENTS		SERVICE WEAR LIMITS	
Compression ring gap (top and 2nd)		0.007-0.020 in.	0.178-0.508 mm	0.032 in.	0.813 mm
Oil control ring rail gap		0.009-0.052 in.	0.229-1.321 mm	0.065 in	1.651 mm
Compression ring side clearance	Top	0.0020-0.0045 in.	0.0508-0.1143 mm	0.0065 in.	0.1651 mm
	2nd	0.0016-0.0041 in.	0.0406-0.1041 mm	0.0065 in.	0.1651 mm
Oil control ring side clearance		0.0016-0.0076 in.	0.0406-0.1930 mm	0.0094 in.	0.2388 mm
Pin fit (loose, at room temperature)		0.00005-0.00045 in.	0.00127-0.01143 mm	0.00100 in.	0.02540 mm

CYLINDER HEAD	NEW COMPONENTS		SERVICE WEAR LIMITS	
Valve guide in head (tight)	0.0033-0.0020 in.	0.0838-0.0508 mm		
Valve seat in head (tight)	0.0035-0.0010 in.	0.0889-0.0254 mm		
Head gasket surface (flatness)	0.006 in. total	0.152 mm total	0.006 in. total	0.152 mm total

CYLINDER		NEW COMPONENTS		SERVICE WEAR LIMITS	
Taper				0.002 in.	0.051 mm
Out of round				0.003 in.	0.076 mm
Warpage (gasket surfaces)	Top			0.006 in.	0.152 mm
	Base			0.008 in.	0.203 mm
Bore diameter ± 0.0002 in. OS=over size	Standard	3.4978 in.	88.8441 mm	3.5008 in.	88.9203 mm
	0.005 OS	3.502 in.	88.951 mm	3.5050 in.	89.0270 mm
	0.010 OS	3.507 in.	89.078 mm	3.5100 in.	89.1540 mm
	0.020 OS	3.517 in.	89.332 mm	3.5200 in.	89.4080 mm
	0.030 OS	3.527 in.	89.586 mm	3.5300 in.	89.6620 mm

CONNECTING ROD	NEW COMPONENTS		SERVICE WEAR LIMITS	
Piston pin fit (loose)	0.00125-0.00175 in.	0.03175-0.04445 mm	0.00200 in.	0.05080 mm
Side play between flywheels	0.005-0.025 in.	0.127-0.635 mm	0.030 in.	0.762 mm
Fit on crankpin (loose)	0.0004-0.0017 in.	0.0102-0.0432 mm	0.0027 in.	0.0686 mm
Connecting rod race ID	1.6245-1.6250 in.	41.2623-41.2750 mm	1.6270 in.	41.3258 mm

HYDRAULIC LIFTER	NEW COMPONENTS		SERVICE WEAR LIMITS	
Fit in guide	0.0008-0.0020 in.	0.0203-0.0508 mm	0.0030 in.	0.0762 mm
Roller fit	0.0006-0.0010 in.	0.0152-0.0254 mm	0.0015 in.	0.0381 mm
Roller end clearance	0.008-0.022 in.	0.203-0.559 mm	0.026 in.	0.660 mm

OIL PUMP		NEW COMPONENTS		SERVICE WEAR LIMITS	
Oil pressure	1000 RPM	7-12 PSI	48-83 kN/m^2		
	2500 RPM	10-17 PSI	69-117 kN/m^2		
Shaft to pump clearance		0.0025 in.	0.0635 mm		
Feed/scavenge inner/outer gerotor clearance		0.003 in.	0.076 mm	0.004 in.	0.102 mm

GEARCASE	NEW COMPONENTS		SERVICE WEAR LIMITS	
Cam gear shaft in bushing (loose)	0.0007-0.0022 in.	0.0178-0.0559 mm	0.003 in.	0.076 mm
Cam gear shaft end play (min) (except rear intake)	0.005-0.024 in.	0.127-0.610 mm	0.025 in.	0.635 mm
Rear intake cam gear shaft end play (min)	0.006-0.024 in.	0.152-0.610 mm	0.040 in.	1.016 mm

FLYWHEEL		NEW COMPONENTS		SERVICE WEAR LIMITS	
Runout	Flywheels at rim	0.000-0.010 in.	0.000-0.254 mm	0.010 in.	0.254 mm
	Shaft at flywheel end	0.000-0.002 in.	0.000-0.051 mm	0.002 in.	0.051 mm
End play		0.001-0.005 in.	0.025-0.127 mm	0.005 in.	0.127 mm

SPROCKET SHAFT BEARING	NEW COMPONENTS		SERVICE WEAR LIMITS	
Outer race fit in crankcase (tight)	0.0004-0.0024 in.	0.0102-0.0610 mm		
Bearing inner race fit on shaft (tight)	0.0002-0.0015 in.	0.0051-0.0381 mm		

PINION SHAFT BEARINGS	NEW COMPONENTS		SERVICE WEAR LIMITS	
Pinion shaft jounal diameter	1.2496-1.2500 in.	31.7398-31.7500 mm	1.2496 in. (min)	31.7398 mm (min)
Outer race diameter in right crankcase	1.5646-1.5652 in.	39.7408-39.7561 mm	1.5672 in. (max)	39.8069 mm (max)
Bearing running clearance	0.00012-0.00088 in.	0.00305-0.02235 mm		
Fit in cover bushing (loose)	0.0023-0.0043 in.	0.0584-0.1092 mm	0.0050 in.	0.1270 mm

TORQUE VALUES

ITEM	TORQUE		NOTES
Anti-Rotation Screws (Lifter)	55-65 **in-lbs**	6-7 Nm	page 3-42
Crankcase 3/8 in. Screws	22-27 ft-lbs	30-37 Nm	page 3-61
Crankcase 5/16 in. Screws	15-19 ft-lbs	20-26 Nm	page 3-61
Cylinder Head Screws	7-9 ft-lbs then 13-15 ft-lbs then loosen and repeat torque sequence	10-12 Nm then 18-20 Nm then loosen and repeat torque sequence	special pattern to tighten and 3 step tightening procedure, page 3-21
Cylinder Studs	10-20 ft-lbs	14-27 Nm	special method to tighten, page 3-61
Front Isolator Mount Bolts	60 ft-lbs	81 Nm	LOCTITE THREADLOCKER 271 (red) engine oil on washers and under bolt heads, loosen one full turn and retighten to 60 ft-lbs, special procedure, page 3-20
Gearcase Cover Screws	80-110 **in-lbs**	9-12 Nm	special pattern to tighten, page 3-49
Isolator Bolt, Front	100-110 ft-lbs	136-149 Nm	page 3-10
Isolator TORX Bolts, Rear	63-70 ft-lbs	85-95 Nm	LOCTITE THREADLOCKER 262 (red) and ANTI-SEIZE under bolt heads, special procedure, page 3-10
Oil Filter Adapter	8-12 ft-lbs	11-16 Nm	LOCTITE THREADLOCKER 243 (blue) to mount side only, page 3-40
Oil Pressure Indicator Switch	50-70 **in-lbs**	6-8 Nm	page 3-40
Oil Pump Cover TORX Screws	70-80 **in-lbs**	8-9 Nm	page 3-39
Oil Pump Mounting Screws	125-150 **in-lbs**	14-17 Nm	page 3-39
Pinion Shaft Nut	35-45 ft-lbs	48-61 Nm	LOCTITE THREADLOCKER 262 (red), page 3-48
Push Rod Cover Retainer Screw	15-18 ft-lbs	20-24 Nm	page 3-42
Rocker Box Bolts	10-14 ft-lbs	14-19 Nm	page 3-22
Rocker Box Cover Screws	10-14 ft-lbs	14-19 Nm	page 3-22
Rocker Box Screws	135-155 **in-lbs**	15-18 Nm	page 3-22
Rocker Box to Head Bolts	18-22 ft-lbs	24-30 Nm	tighten in cross pattern, page 3-22
Swingarm Mount Block Bolts, Lower	68-75 ft-lbs	92-102 Nm	page 3-10
Swingarm Mount Block Bolts, Upper	41-45 ft-lbs	56-61 Nm	page 3-10
Tie Bar Bolts	30-33 ft-lbs	41-45 Nm	page 3-10

GENERAL

The Thunderstorm™ high performance engine is a two-cylinder, four-cycle, air-cooled, overhead-valve V-twin. It has three major component assemblies.

Cylinder

The cylinder assembly includes cylinder head, valves, rocker arm cover, rocker arms and piston. Cylinders mount on the crankcase in a 45 degree “V” with both connecting rods connected to a single crank pin.

Thunderstorm engines have modified cylinder heads with a black finish and unique pistons.

Crankcase

The up-and-down motion of the piston in the cylinder is converted to circular motion in the crankcase. The multi-piece crankshaft consists of a crank pin mounted between two counterweighted flywheels, which rotate on two end shaft bearings. The lower end of the rear cylinder connecting rod is forked to fit around the single-end front cylinder connecting rod, allowing a single connecting rod crank pin connection to the flywheel.

Gearcase

The gearcase is located on the right side of the crankcase. The gearcase houses the gear train, which operates and times the valves and ignition. The cam gear train, consisting of four cam shafts with one cam lobe on each shaft, is gear driven. The engine valves are opened and closed through the mechanical linkage of hydraulic lifters, push rods and rocker arms. Hydraulic lifters, located in the lifter bores, automatically compensate for heat expansion to maintain the no-lash fit of valve train components. Hydraulic lifters and pushrods transmit the cam action to the valve linkage. Valve timing is obtained by aligning timing marks when installing cam gears.

Ignition spark is produced by the operation of a microprocessor-controlled electronic control module (ECM), ignition coil and spark plugs. Spark timing is determined by a trigger rotor, magnetic sensing unit and the ECM.

The trigger rotor has six openings which time the cylinders and communicate engine speed to the ECM.

The spark plugs fire independently during the compression stroke on each cylinder (no waste spark).

FUEL

Gasoline/Alcohol Blends

Buell motorcycles were designed to obtain the best performance and efficiency using unleaded gasoline (91 pump octane or higher). 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%.
- Gasolines containing ETHER: Gasoline/ether blends are a mixture of gasoline and as much as 15% ether. Gasoline/ether blends can be used in your motorcycle if the ether content does not exceed 17%.
- 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, leaving fewer “tailpipe” emissions. They are also formulated to evaporate less when you are filling your tank. Reformulated gasolines use additives to “oxygenate” the gas. Your motorcycle will run normally using this type of gas. Buell recommends you use it when possible, as an aid to cleaner air in our environment.

Because of their generally higher volatility, these blends may adversely affect the starting, driveability and fuel efficiency of your motorcycle. If you experience these problems, Buell recommends you operate your motorcycle on straight, unleaded gasoline.

LUBRICATION

The engine has a force-feed (pressure) type oiling system, incorporating oil feed and return pumps in one pump body, with one check valve on the oil feed side. The feed pump forces oil to the engine, lubricating lower connecting rod bearings, rocker arm bushings, valve stems, valve springs, push rods and hydraulic lifters. Cylinder walls, pistons, piston pins, timing gears and bushings and main bearings are lubricated by oil spray thrown off connecting rods and crankshaft, and by oil draining from each rocker box through an internal drain passage in each cylinder and each lifter guide. A small amount of oil is sprayed through an oil galley jet onto the rear intake cam gear in the gearcase; oil is transferred to the teeth of all the cam gears by way of the gear meshing action. The oil-scavenging section of the pump returns oil to the tank from the engine. See 3.7 LUBRICATION SYSTEM for more information.

ADJUSTMENT/TESTING

General

When an engine needs repair, it is not always possible to determine definitely beforehand whether repair is possible with only cylinder heads, cylinders and pistons disassembled or whether complete engine disassembly is required for crankcase repair.

Most commonly, only cylinder head and cylinder repair is needed (valves, rings, piston, etc.) and it is recommended procedure to service these units first, allowing engine crankcase to remain in frame.

See 3.3 STRIPPING MOTORCYCLE FOR ENGINE REPAIR to strip motorcycle for removal of cylinder heads, cylinders, and pistons.

After disassembling “upper end” only, it may be found that crankcase repair is necessary. In this situation, remove the engine crankcase from the chassis. See 3.3 STRIPPING MOTORCYCLE FOR ENGINE REPAIR.

CAUTION

If engine is removed from chassis, do not lay engine on primary side. Placing engine on primary side will damage clutch cable end fitting. If fitting is damaged, clutch cable must be replaced.

Symptoms indicating a need for engine repair are often misleading, but generally, if more than one symptom is present, possible causes can be narrowed down to make at least a partial diagnosis. An above-normal consumption of oil, for example, could be caused by several mechanical faults. See 1.25 TROUBLESHOOTING. However, when accompanied by blue-gray exhaust smoke and low engine compression, it indicates the piston rings need replacing. Low compression by itself, however, may indicate improperly seated valves, in addition to or in lieu of worn piston rings.

Most frequently, valves, rings, pins, bushings, and bearings need attention at about the same time. If the possible causes can be narrowed down through the process of elimination to indicate any one of the above components is worn, it is best to give attention to all of the cylinder head and cylinder parts.

Compression Test Procedure

Combustion chamber leakage can result in unsatisfactory engine performance. A compression test can help determine the source of cylinder leakage. Use CYLINDER COMPRESSION GAUGE (Part No. HD-33223-1).

A proper compression test should be performed with the engine at normal operating temperature when possible. Proceed as follows:

CAUTION

After completing the compression test(s), make sure that the throttle plate is in the closed position before starting engine. Engine will start at an extremely high RPM if throttle plate is left open.

1. Disconnect spark plug wires. Clean around plug base and remove plugs.
2. Connect compression tester to front cylinder.
3. With throttle plates in wide open position, crank engine continuously through 5-7 full compression strokes.
4. Note gauge readings at the end of the first and last compression strokes. Record test results.
5. Connect compression tester to rear cylinder.
6. Repeat Steps 3 and 4 on rear cylinder.
7. Compression is normal if final readings are 120 psi (827 kN/m^2) or more and do not indicate more than a 10 psi (69 kN/m^2) variance between cylinders. See Table 3-1.
8. Inject approximately 1/2 oz. (15 ml) of SAE 30 oil into each cylinder and repeat the compression tests on both cylinders. Readings that are considerably higher during the second test indicate worn piston rings.

Table 3-1. Compression Test Results

DIAGNOSIS	TEST RESULTS
Ring trouble	Compression low on first stroke; tends to build up on the following strokes but does not reach normal; improves considerably when oil is added to cylinder.
Valve trouble	Compression low on first stroke; does not build up much on following strokes; does not improve considerably with the addition of oil.
Head gasket leak	Same reaction as valve trouble.

Cylinder Leakage Test

The cylinder leakage test pinpoints engine problems including leaking valves, worn, broken or stuck piston rings and blown head gaskets. The cylinder leakage tester applies compressed air to the cylinder at a controlled pressure and volume, and measures the percent of leakage from the cylinder.

Use a CYLINDER LEAKDOWN TESTER (Part No. HD-35667A) and follow the specific instructions supplied with the tester.

The following are some general instructions that apply to Buell motorcycle engines:

1. Run engine until it reaches normal operating temperature.
2. Stop engine. Clean dirt from around spark plugs and remove spark plugs.
3. Remove air cleaner cover. Set throttle in wide open position.
4. Remove timing inspection plug from crankcase.
5. The piston, in cylinder being tested, must be at top dead center of compression stroke during test.
6. To keep engine from turning over when air pressure is applied to cylinder, engage transmission in fifth gear and lock the rear brake.
7. Following the manufacturer's instructions, perform a cylinder leakage test on the front cylinder. Make a note of the percent leakdown. Any cylinder with 12% leakdown, or more, requires further attention.
8. Listen for air leaks at intake, exhaust, head gasket and timing inspection hole. See Table 3-2.

NOTE

If air is escaping through valves, check push rod length.

9. Repeat procedure on rear cylinder.

CAUTION

After completing the compression test(s), make sure that the throttle plate is in the closed position before starting engine. Engine will start at an extremely high RPM if throttle plate is left open.

Table 3-2. Air Leakage Test

AIR LEAK LOCATION	POSSIBLE CAUSES
Intake Manifold	Intake valve leaking.
Exhaust Pipe	Exhaust valve leaking.
Timing Inspection Hole	Piston rings leaking. Worn or broken piston. Worn cylinder.
Head Gasket	Leaking gasket.

Diagnosing Smoking Engine or High Oil Consumption

Perform COMPRESSION TEST PROCEDURE or CYLINDER LEAKAGE TEST as described previously. If further testing is needed, remove suspect head(s) and inspect the following:

- Valve guide seals.
- Valve guide-to-valve stem clearance.
- Gasket surface of both head and cylinder.
- Oil return passages for clogging.

DISASSEMBLING ENGINE FOR CYLINDER HEAD REPAIR

1. Lift and secure the motorcycle.
   a. Place vehicle on a lift and anchor front wheel in place. Raise lift so the top of the cylinder head is easy to access.
   b. Raise rear wheel off lift using REAR WHEEL SUPPORT STAND (Part No. B-41174).

⚠WARNING

To protect agsint shock and accidental start-up of vehicle, disconnect the negative battery cable before proceeding. Inadequate safety precautions could result in death or serious injury.

⚠WARNING

Always disconnect the negative battery cable first. If the positive battery cable should contact ground with the negative cable installed, the resulting sparks may cause a battery explosion which could result in death or serious injury.

2. Disconnect **both** battery cables, negative cable first and remove battery.

⚠WARNING

The gasoline in the fuel supply line downstream of the fuel pump is under high pressure (49 psi [338 kPa]). To avoid an uncontrolled discharge or spray of gasoline, always purge the system of high pressure gas before attaching fuel pressure gauge. Gasoline is extremely flammable and highly explosive. Inadequate safety precautions could result in death or serious injury.

3. Remove seat and fuel tank. See 4.37 FUEL TANK.
4. Remove air cleaner cover and backplate. See 4.42 AIR CLEANER.
5. Remove throttle body and manifold. See 4.41 THROTTLE BODY AND INTAKE MANIFOLD.
6. Remove support bracket on left side of cylinder heads.
7. Remove exhaust header and muffler. See 2.28 EXHAUST SYSTEM.
8. Disconnect spark plug cables. Remove spark plugs.
9. If removing front cylinder, remove ignition coil (4.31 IGNITION COIL) and horn (7.21 HORN).

NOTE

At this stage, the lower rocker boxes, cylinder heads and cylinders may be removed. See 3.5 CYLINDER HEAD.

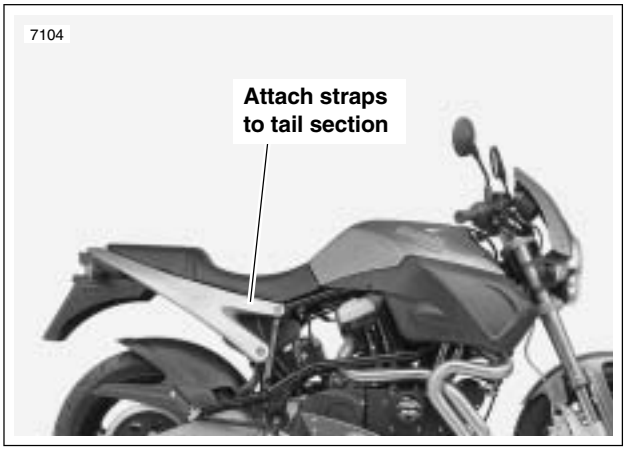


Figure 3-1. Floor Hoist

ENGINE CRANKCASE REPLACEMENT OR COMPLETE ENGINE REMOVAL

1. Perform the steps listed above. In addition, remove battery from frame.
2. See Figure 3-1. Place a floor hoist behind the lift. Attach straps to tail section and hoist. Raise hoist until straps tighten.
3. Detach clutch cable from handlebar lever.
4. Remove rear fender and lower belt guard. See 2.32 REAR FENDER.
5. Remove sprocket cover. See 2.30 SPROCKET COVER.
6. Detach rear brake caliper from caliper mount. See 2.14 REAR BRAKE CALIPER.
7. Detach belt from rear sprocket and remove rear wheel. See 2.6 REAR WHEEL.
8. Drain oil tank and remove oil filter. See 1.6 ENGINE LUBRICATION SYSTEM.
9. Detach hoses from oil tank fittings. See 3.9 OIL TANK.
10. Remove both rider footrest mounts from frame. See 2.29 FOOTRESTS.
11. Remove both rear shock mounting bolts (metric).
12. Disconnect wiring. See Section 7.
    a. Disconnect neutral switch wire from crankcase.
    b. Unplug cam position sensor from wiring harness.
    c. Remove solenoid wire, battery positive cable and circuit breaker charging wire from starter motor.
    d. Locate voltage regulator connector near the oil pump. Disconnect from alternator stator.
    e. Detach wire from oil pressure indicator switch. See 3.10 OIL PRESSURE INDICATOR SWITCH.
13. See Figure 3-2. Place a wooden cradle underneath the crankcase.

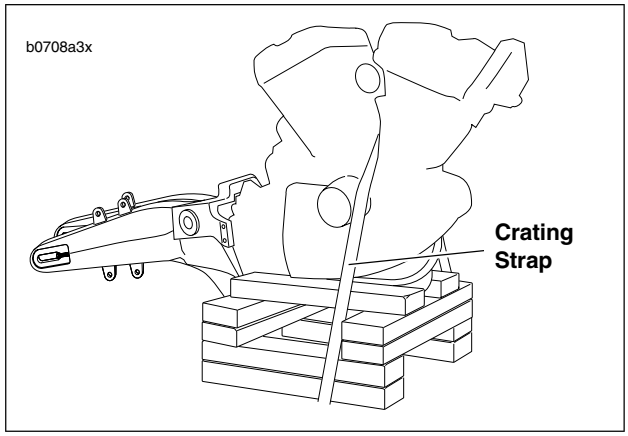


Figure 3-2. Supporting the Engine

14. Place a crating strap between the engine cylinders and around the lift. Tighten crating strap until snug.
15. See Figure 3-3. Remove engine ground strap (1) from swingarm mount block.
16. Detach remaining tie bars from frame.
    a. Remove rear tie bar using a swivel socket.
    b. See Figure 3-4. Detach front lower tie bar (1) and clutch cable clamp (3). Remove tie bar bolt (2), clutch cable clamp (3), washer (4) and locknut (5).
    c. Remove washer and nut to detach front upper tie bar (11) from isolator (8).
17. Detach front isolator (8). Remove front isolator bolt (6), nut (10), D-washer (9) and washer (7).
18. See Figure 3-3. Remove isolator bolt (7) and lockwasher (6) on each side.
19. Slowly raise floor hoist until rubber isolators (5) can be removed. Frame will rise while engine remains secured to lift by crating strap.

NOTE

Rubber isolators align with a frame mounted metal pin.

20. Raise frame and walk forward over and away from the engine.
21. If necessary, remove rear swingarm assembly. See 2.19 SWINGARM.
22. If necessary, detach swingarm mount block from powertrain by removing bolts (3, 4), washers and locknuts.

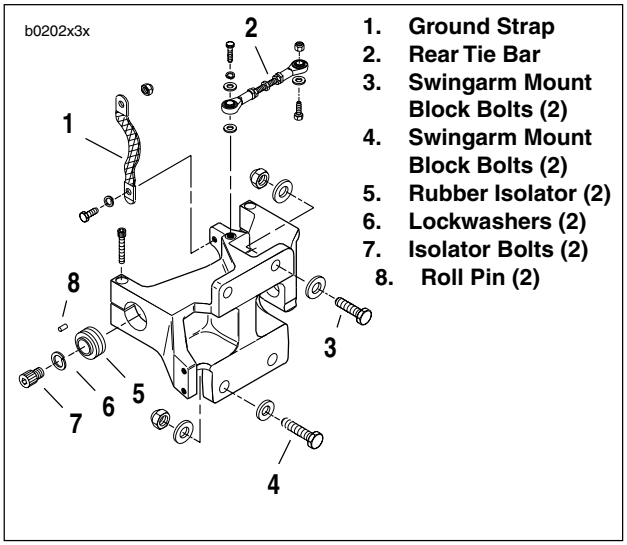


Figure 3-3. Rear Tie Bar Assembly

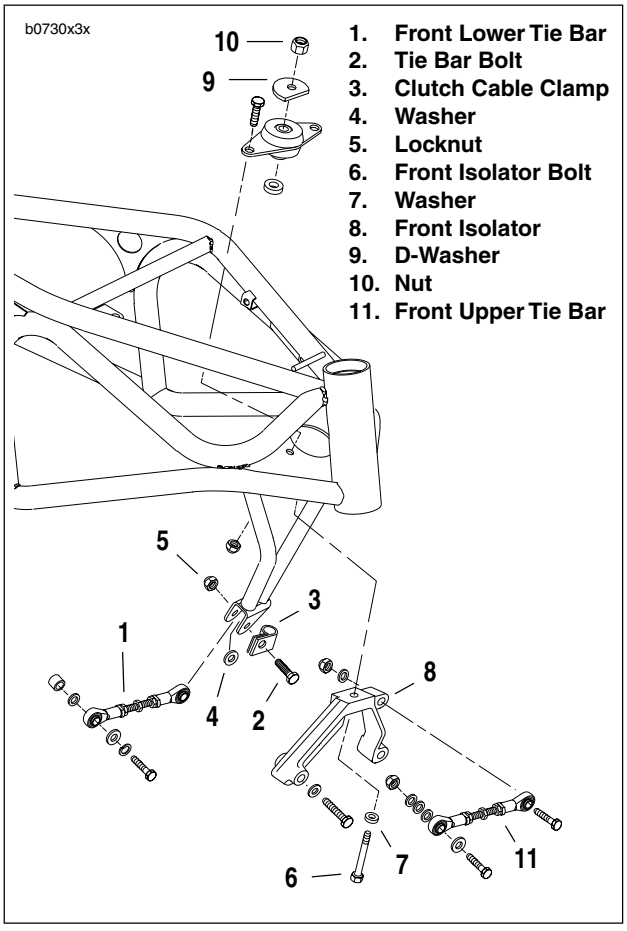


Figure 3-4. Front Tie Bar Assembly

ENGINE CRANKCASE INSTALLATION

1. See Figure 3-2. Place engine crankcase on supports so frame may be installed over the top of the engine.
2. See Figure 3-3. If removed, attach swingarm mount block to engine. Install upper bolts (3), washers and locknuts finger tight. Install lower bolts (4), washers and locknuts finger tight. Tighten upper bolts to 41-45 ft-lbs (56-61 Nm) and lower bolts to 68-75 ft-lbs (92-102 Nm).
3. If removed, install swingarm. Adjust swingarm bearing preload. See 2.19 SWINGARM.
4. If removed, install transmission mainshaft sprocket. See 6.13 TRANSMISSION INSTALLATION AND SHIFTER PAWL ADJUSTMENT.
5. Remove oil filter (if installed). Walk frame over powertrain.
6. See Figure 3-4. Attach front isolator (8). Install front isolator mount with bolt (6), washers (7), D-washer (9) and locknut (10). Flat on D-washer faces steering neck. Tighten bolt finger tight.

CAUTION

Isolator bolts must be tightened within 30 minutes of applying LOCTITE THREADLOCKER. Failure to tighten bolts within 30 minutes may cause LOCTITE to set.

7. See 2.20 REAR ISOLATORS for installation. Apply LOCTITE ANTI-SIEZE under two isolator bolt heads. Install rear isolators but do not tighten isolator bolts at this time.

CAUTION

Do not adjust tie bar assemblies. Tie bar tension is set at the factory. Any attempt at adjusting tension will cause damage to tie bars. Damaged tie bars must be replaced.

8. Rear tie bar must be horizontal and below frame tab. Insert bolt upwards through washer, tie bar and frame. Fasten with nut. Tighten bolt to 30-33 ft-lbs (41-45 Nm).

NOTE

See Figure 3-5. Route wire harness above rear tie bar, but below rear brake line.

9. See Figure 3-4. Place clutch cable clamp (3) on front tie bar bolt (2). Clamp should hold cable on primary cover side of motor. Insert bolt from front through frame and install washer (4). Continue through tie bar (1) and frame. Install locknut (5) and tighten to 30-33 ft-lbs (41-45 Nm).
10. Attach front upper tie bar (11). Insert bolt through tie bar front isolator, and frame. Secure with nut and washer. Tighten to 30-33 ft-lbs (41-45 Nm).

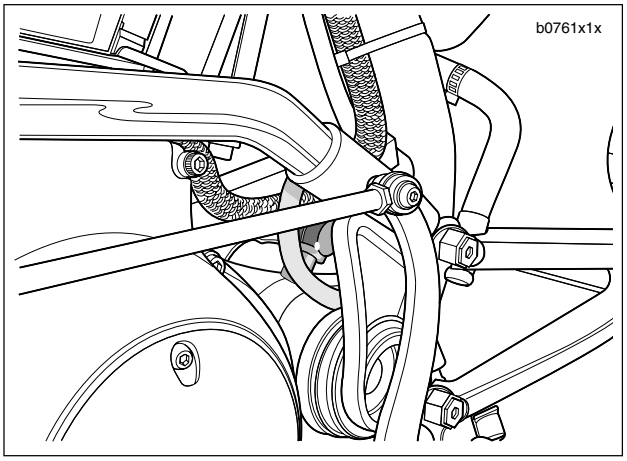


Figure 3-5. Wire Harness Routing

11. See Figure 3-3. Tighten the two rear isolator TORX bolts (7) to 63-70 ft-lbs (85-95 Nm). Make sure isolators do not twist during tightening. See 2.20 REAR ISOLATORS.
12. See Figure 3-4. Tighten front isolator bolt (6) to 100-110 ft-lbs (136-149 Nm).
13. Connect hoses to oil tank. See 3.8 OIL HOSE ROUTING. Use **new** hose clamps.
14. Attach battery ground strap to swingarm mount block.
15. Attach clutch cable to handlebar lever.
16. Remove strap from between engine cylinders. Using a floor hoist, lift motorcycle by the frame and remove the wooden cradle from underneath the crankcase.
17. Install rear shock. See 2.21 REAR SHOCK ABSORBER.
18. Install rear wheel and drive belt. See 2.6 REAR WHEEL. After rear wheel and belt are installed, remove floor hoist straps.
19. Install rear brake caliper. See 2.14 REAR BRAKE CALIPER.
20. Attach disconnected wires. See Section 7.
    a. Connect solenoid wire, circuit breaker charging wire and battery positive cable to starter.
    b. Connect voltage regulator connector to alternator stator wiring.
    c. Attach cam position sensor to wire harness.
    d. Connect neutral switch wire to crankcase.
    e. Attach oil pressure indicator switch wire.
21. Install rear fender and lower belt guard. See 2.32 REAR FENDER.
22. Install sprocket cover. See 2.30 SPROCKET COVER.
23. Install footrests. See 2.29 FOOTRESTS.
24. Continue with the steps listed under ENGINE INSTALLATION AFTER CYLINDER HEAD REPAIR.

ENGINE INSTALLATION AFTER CYLINDER HEAD REPAIR

1. Install **new** oil filter, engine oil and primary chaincase fluid as necessary. See Section 1.
2. Install throttle body and manifold and support bracket. See 4.41 THROTTLE BODY AND INTAKE MANIFOLD.
3. Install exhaust system. See 2.28 EXHAUST SYSTEM.
4. Install air cleaner assembly. See 4.42 AIR CLEANER.
5. If removed, install horn (7.21 HORN) and ignition coil (4.31 IGNITION COIL).
6. Install spark plugs and connect cables. See 1.18 SPARK PLUGS.

⚠WARNING

Always connect positive battery cable first. If the positive cable should contact ground with the negative cable installed, the resulting sparks may cause a battery explosion which could result in death or serious injury.

7. Install battery. Connect both battery cables, positive cable first.

⚠WARNING

After installing seat, pull upward on front of seat to be sure it is locked in position. If seat is loose, it could shift during vehicle operation and startle the rider, causing loss of control which could result in death or serious injury.

8. Install fuel tank, fuel tank cover and seat. See 4.37 FUEL TANK.
9. If engine crankcase installation was performed:
   a. Adjust rear belt deflection. See 1.11 DRIVE BELT DEFLECTION.
   b. Adjust rear shock spring preload. See 1.14 PRELOAD ADJUSTMENT.
   c. Adjust clutch lever. See 1.10 CLUTCH.
   d. Check rear brake pedal height. See 1.7 BRAKES.
10. Check all electrical components for proper operation.
11. Calibrate (re-zero) TPS. See 4.36 THROTTLE POSITION SENSOR.

REMOVAL

Before removing the cylinder head assembly, see DISASSEMBLING ENGINE FOR CYLINDER HEAD REPAIR. The rocker arm covers and internal components must be removed before removing cylinder heads.

1. See Figure 3-6. Remove screws with washers (1) and fiber seals (2). Discard fiber seals.

CAUTION

All washers and fasteners used in the V^2_{TM} engine are hardened. Do not mix or replace hardened washers and fasteners with unhardened parts. Do not reuse fiber cover seals. These actions may result in accelerated wear and increased noise.

2. Remove upper (4) and middle (5) sections of rocker cover. Remove and discard gaskets (6, 7 and 8).
3. Rotate crankshaft until piston on head being repaired reaches top dead center of compression stroke.

NOTE

Both valves in the cylinder head will be closed when viewed through the spark plug hole.

4. Remove remaining hardware holding lower rocker cover to cylinder head in the following order.
   a. Remove two screws and washers (14).
   b. Remove three bolts and washers (15).
   c. Remove the two rocker arm retaining bolts (12) near the push rods.
   d. Remove the remaining two rocker arm retaining bolts (13).
5. Remove lower rocker cover (18).

NOTE

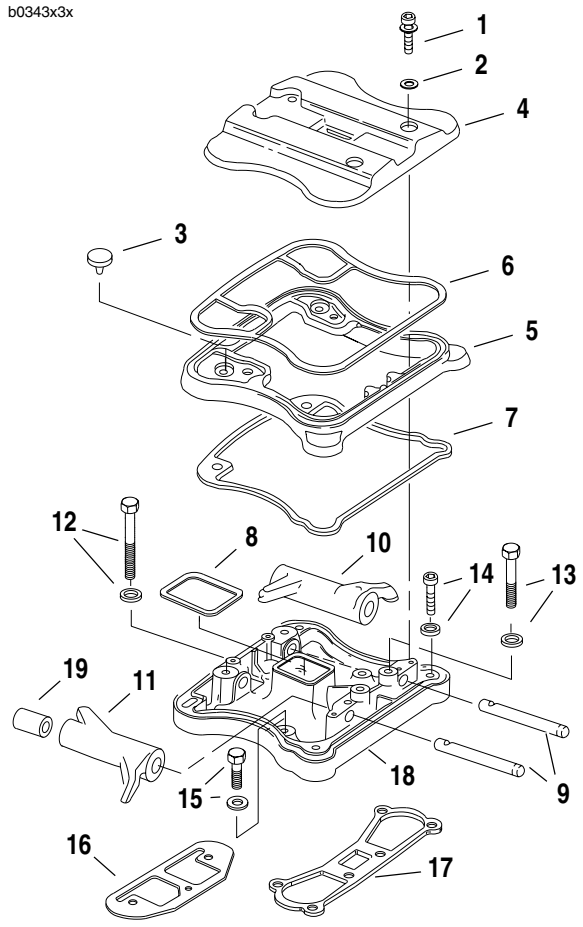
Remove lower rocker boxes as an assembly; then disassemble as required.

6. Mark the location and orientation (top/bottom) of each push rod. Remove push rods.

CAUTION

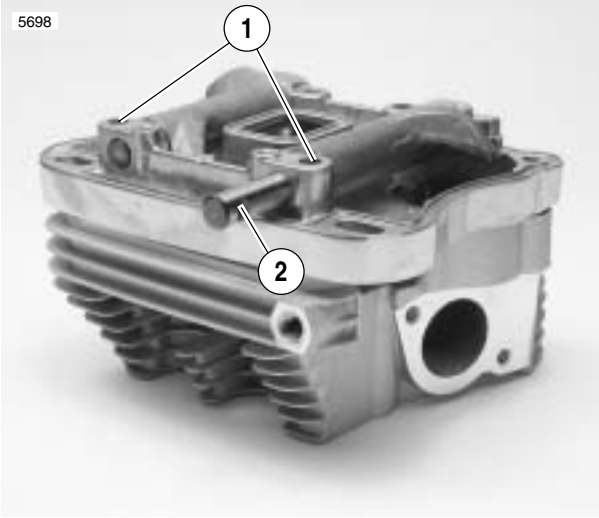
Mark rocker arm shafts for reassembly in their original positions. Valve train components must be reinstalled in their original positions to prevent accelerated wear and increased valve train noise.

7. See Figure 3-7. Remove rocker arm shafts by tapping them out using a hammer and a soft metal punch.
8. See Figure 3-6. Remove rocker arms (10, 11); mark them for reassembly in their original locations.



1. **Screws with Washers (4)**
2. **Fiber Seal (4)**
3. **Umbrella Valve (2)**
4. **Upper Rocker Cover**
5. **Middle Rocker Cover**
6. **Gasket**
7. **Gasket**
8. **Gasket**
9. **Rocker Arm Shafts**
10. **Rocker Arm**
11. **Rocker Arm**
12. **Bolt and Washer (2) (long)**
13. **Bolt and Washer (2) (short)**
14. **Screw and Washer (2)**
15. **Bolt and Washer (3)**
16. **Gasket**
17. **Gasket**
18. **Lower Rocker Cover**
19. **Rocker Arm Bushing (8)**

Figure 3-6. Rocker Arm Cover



1. **Position of Rocker Arm Retaining Bolts**
2. **Retaining Notch**

Figure 3-7. Removing Rocker Arm Shafts

CAUTION

Distortion to the head, cylinder and crankcase studs may result if head screws are not loosened (or tightened) gradually in the sequence shown in Figure 3-8.

9. See Figure 3-8. Loosen each head screw 1/8-turn following the sequence shown.

CAUTION

See Figure 3-9. Do not attempt to remove the front isolator mount from front cylinder head. Isolator mount is an integral component and is not meant to be removed unless absolutely necessary. Repeated removals and installations will damage cylinder head threads.

10. Support motorcycle under front header mount. Do not allow engine to drop when performing the next steps.
11. Remove nut, washer and bolt to detach front upper tie bar from isolator and frame.
12. Continue loosening in 1/8-turn increments until screws are loose. Remove head screws.
13. See Figure 3-10. Remove cylinder head (18), head gasket (4), and O-rings (14).

NOTE

Front cylinder head must be removed through upper triangular frame members with front isolator mount attached.

14. Remove both push rod covers and hydraulic lifters. See 3.15 HYDRAULIC LIFTERS.
15. Repeat the above procedure for the other cylinder head.

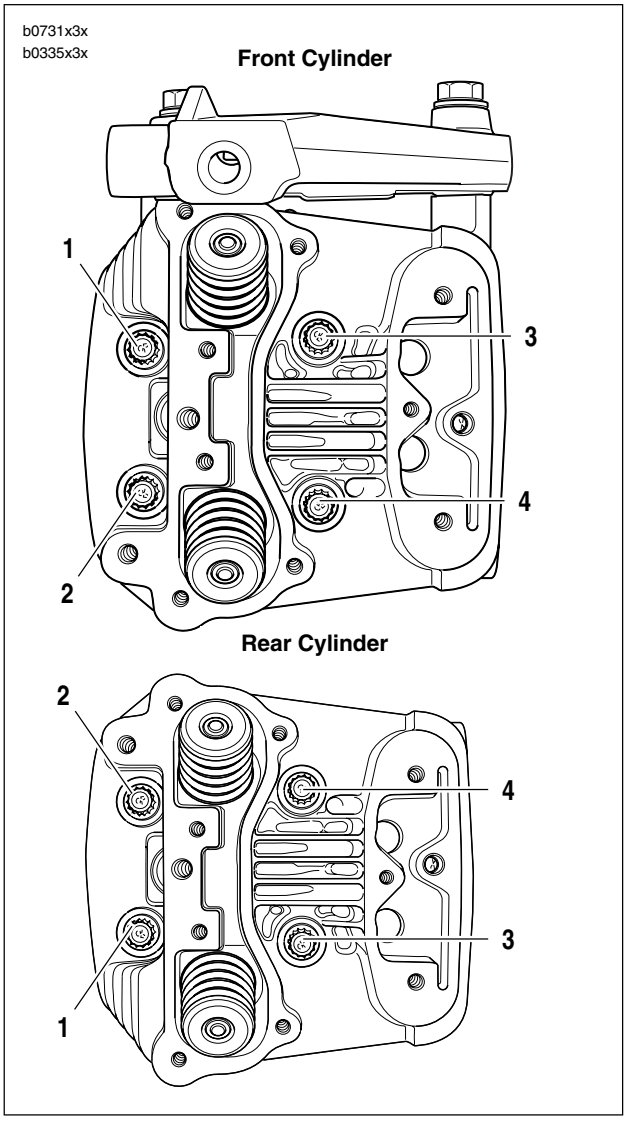


Figure 3-8. Head Screw Loosening/Tightening Sequence

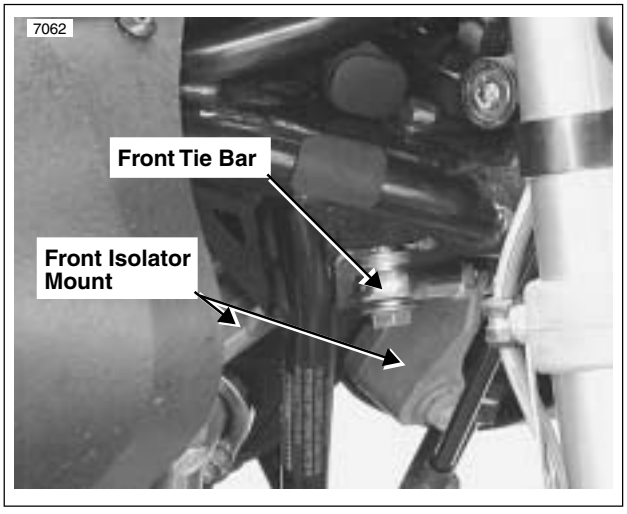


Figure 3-9. Front Isolator Mount and Tie Bar

1. Head Screw, Long (2)
2. Head Screw, Short (2)
3. Arrow, Piston Direction
4. Head Gasket
5. Inner Valve Spring (2)
6. Outer Valve Spring (2)
7. Valve Keeper (4)
8. Upper Collar (2)
9. Lower Collar (2)
10. Valve (1 Intake, 1 Exhaust)
11. Valve Stem Seal (2)
12. Cylinder Stud (4)
13. Base Gasket
14. O-Ring (2)
15. Insert/Dowel (2)
16. Valve Guide (2)
17. Valve Seat (2)
18. Cylinder Head
19. Cylinder
20. Piston

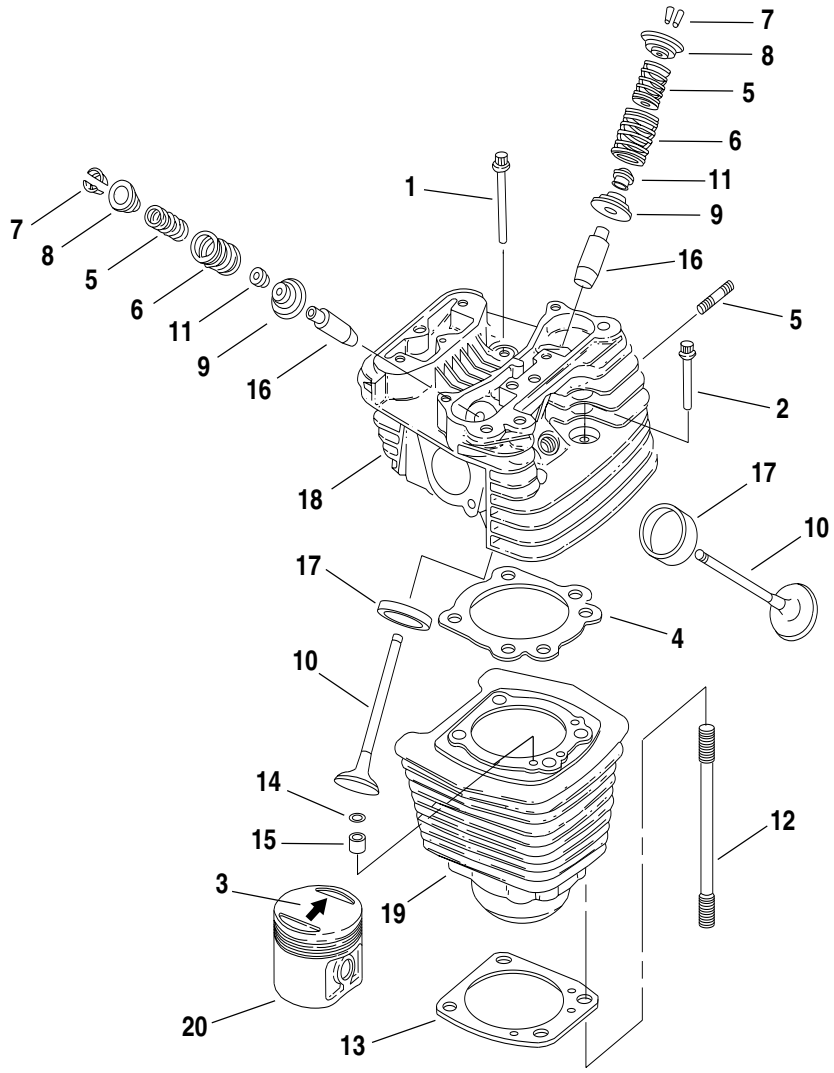


Figure 3-10. Cylinder Head, Cylinder and Piston

DISASSEMBLY

NOTE

Disassembly of front cylinder exhaust valve components requires front isolator mount removal.

1. See Figure 3-11. Compress valve springs with VALVE SPRING COMPRESSOR (Part No. HD-34736B).
2. See Figure 3-10. Remove valve keepers (7), upper collar (8) and valve springs (5, 6). Mark valve keepers for reassembly in their original locations.
3. Use a fine tooth file to remove any burrs on the valve stem at the keeper groove.
4. Mark valve to ensure that it will be reassembled in the same head. Remove valve (10), valve stem seal (11) and lower collar (9).
5. Repeat the above procedure for the other valve.
6. Disassemble the other head using the same procedure.

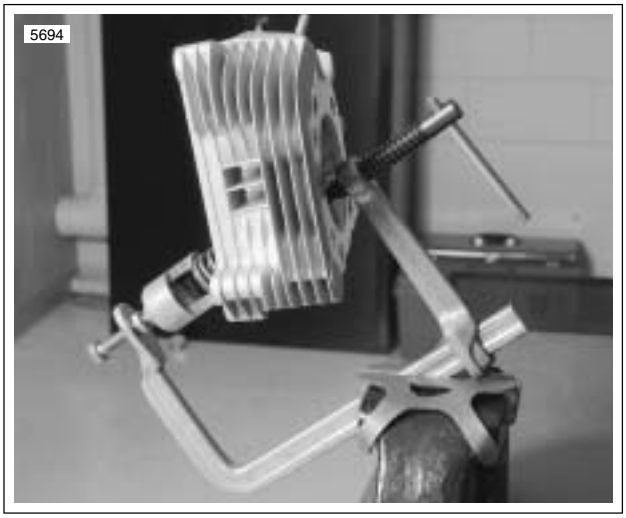


Figure 3-11. Valve Spring Compressor (Part No. HD-34736B)

CLEANING AND INSPECTION

1. Bead blast or scrape carbon from head, top of cylinder and valve ports. Be careful to avoid scratching or nicking cylinder head and cylinder joint faces. Blow off loosened carbon or dirt with compressed air.
2. Soak cylinder head in an aluminum-compatible cleaner/ solvent to loosen carbon deposits.
3. Wash all parts in non-flammable solvent, followed by a thorough washing with hot, soapy water. Blow out oil passages in head. Be sure they are free of sludge and carbon particles. Remove loosened carbon from valve head and stem using a wire wheel. Never use a file or other hardened tool which could scratch or nick valve. Polish valve stem with very fine emery cloth or steel wool.
4. Check each rocker arm, at pad end and push rod end, for uneven wear or pitting. Replace rocker arm if either condition exists.

Figure 3-12. Measuring Rocker Arm Shaft Diameter (Rocker Cover Position)

5. Measure and record rocker arm shaft diameter.
   a. See Figure 3-12. Measure where shaft fits in lower rocker arm cover.
   b. See Figure 3-13. Measure where rocker arm bushings ride.
6. Measure and record rocker arm shaft bore diameter.
   a. See Figure 3-14. Measure bore of lower rocker cover.
   b. See Figure 3-15. Measure rocker arm bushing inner diameter.
7. Check the measurements obtained in Steps 5-6 against the SERVICE WEAR LIMITS. Repair or replace parts exceeding limits.
8. Assemble rocker arms and rocker arm shafts into lower rocker cover.
9. Check end play of rocker arm with feeler gauge.
10. Replace rocker arm or lower cover or both if end play exceeds 0.025 in. (0.635 mm).

Figure 3-13. Measuring Rocker Arm Shaft Diameter (Rocker Arm Bushing Position)

Figure 3-14. Measuring Rocker Arm Shaft Bore Diameter in Lower Rocker Cover

Figure 3-15. Measuring Rocker Arm Bushing Inner Diameter

11. Valve heads should have a seating surface width of 0.040-0.062 in. (1.016-1.575 mm), and should be free of pit marks and burn spots. The color of carbon on exhaust valves should be black or dark brown. White or light buff carbon indicates excessive heat and burning.
12. Valve seats are also subject to wear, pitting, and burning. Resurface valve seats whenever valves are refinished.
13. Clean valve guides by lightly honing with VALVE GUIDE HONE (Part No. HD-34723).
14. Scrub guides with VALVE GUIDE BRUSH (Part No. HD-34751) and hot soapy water. Measure valve stem outer diameter and valve guide inner diameter. Check measurements against SERVICE WEAR LIMITS.
15. Inspect spark plug threads for damage. If threads in head are damaged, a special plug type insert can be installed using a 12 mm spark plug repair kit.
16. Inspect valve springs for broken or discolored coils.

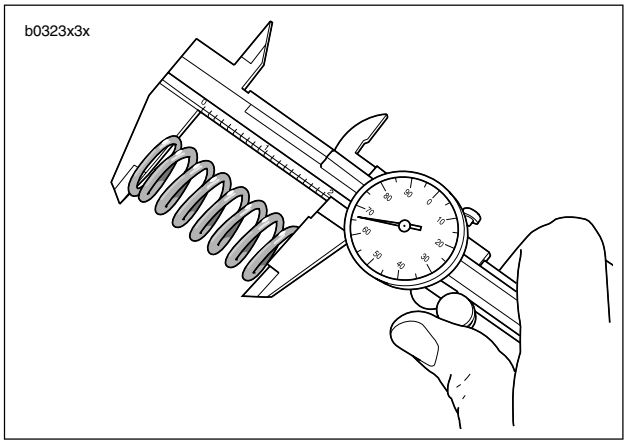


Figure 3-16. Checking Spring Free Length

17. See Figure 3-16. Check free length and compression force of each spring. Compare with SERVICE WEAR LIMITS. If spring length is shorter than specification or if spring compression force is below specification, replace spring.
18. Examine push rods, particularly the ball ends. Replace any rods that are bent, worn, discolored or broken.
19. See Figure 3-17. Check head gasket surface on head for flatness. Machine or replace any head which exceeds SERVICE WEAR LIMIT of 0.006 in. (0.152 mm).

Rocker Arms and Bushings

1. See Figure 3-18. To replace worn bushings, press or drive them from the rocker arm. If bushing is difficult to remove, turn a 9/16-18 tap into bushing. From opposite side of rocker arm, press out bushing and tap.
2. Press replacement bushing into rocker arm, flush with arm end, and split portion of bushing towards top of arm.
3. Using remaining old bushing as a pilot, line ream new bushing with ROCKER ARM BUSHING REAMER (Part No. HD-94804-57).
4. Repeat for other end of rocker arm.

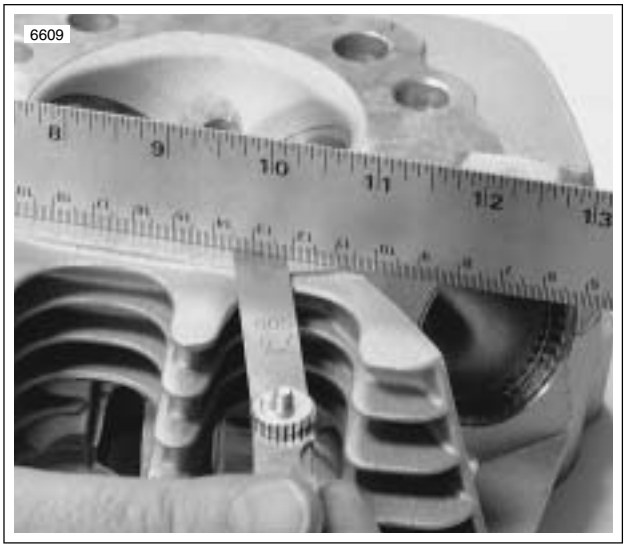


Figure 3-17. Checking Gasket Surface

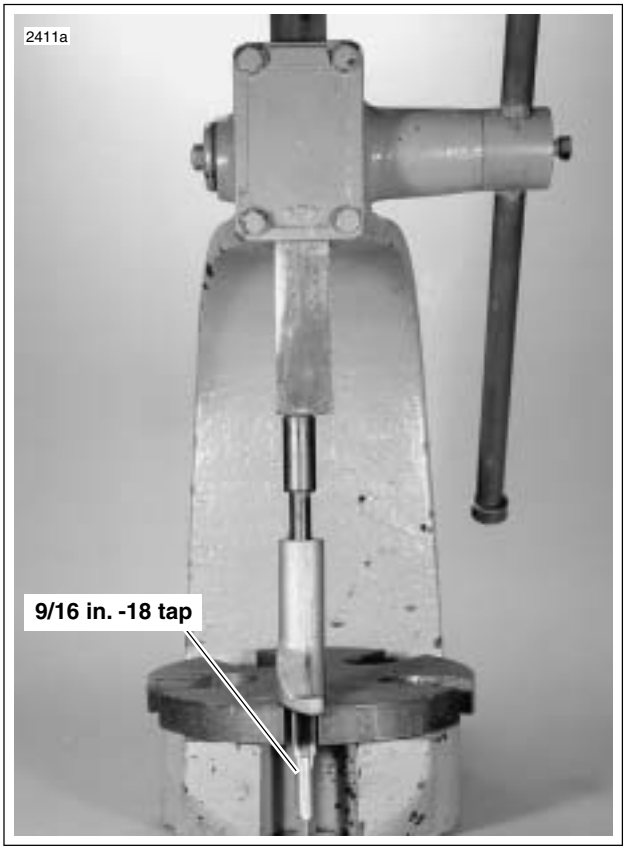


Figure 3-18. Removing Rocker Arm Bushing

Replacing Valve Guides

Valve guide replacement, if necessary, must be done before valve seat is ground. It is the valve stem hole in valve guide that determines seat grinding location. Valve stem-to-valve guide clearances are listed in Table 3-3. If valve stems and/or guides are worn beyond limits, install **new** parts.

Table 3-3. Valve Stem Clearances and Service Wear Limits

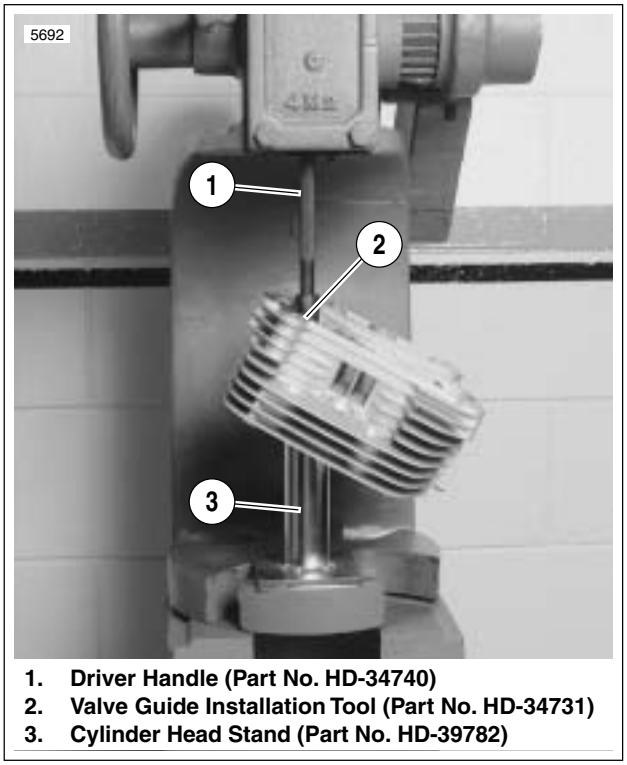
VALVE	CLEARANCE	SERVICE WEAR LIMIT
Exhaust	0.0015-0.0033 in. (0.0381-0.0838 mm)	0.0040 in. (0.1016 mm)
Intake	0.0008-0.0026 in. (0.203-0.0660 mm)	0.0035 in. (0.0889 mm)

1. To remove shoulderless guides, press or tap guides toward combustion chamber using DRIVER HANDLE AND REMOVER (Part No. HD-34740).
2. Clean and measure valve guide bore in head.
3. Measure outer diameter of a new standard valve guide. The guide diameter should be 0.0020-0.0033 in. (0.0508-0.0838 mm). larger than bore in head. If it is not, select one of the following oversizes: +0.001 in. (+0.025 mm), +0.002 in. (+0.051 mm) or +0.003 in. (+0.076 mm) (intake and exhaust).
4. See Figure 3-19. Install shoulderless guides using VALVE GUIDE INSTALLATION TOOL (2) (Part No. HD-34731) and DRIVER HANDLE (1) (Part No. HD-34740). Press or drive guide until the tool touches the machined surface surrounding the guide. At this point, the correct guide height has been reached.
5. Ream guides to final size or within 0.0010 in. (0.0254 mm) of final size using VALVE GUIDE REAMER (Steel, Part No. HD-39932 or Carbide, Part No. HD-39932-CAR). Use REAMER LUBRICANT (Part No. HD-39964) or liberal amounts of suitable cutting oil to prevent reamer chatter.
6. Apply the proper surface finish to the valve guide bores using the VALVE GUIDE HONE (Part No. HD-34723). Lubricate hone with honing oil. Driving hone with an electric drill, work for a crosshatch pattern with an angle of approximately 60°.

NOTE

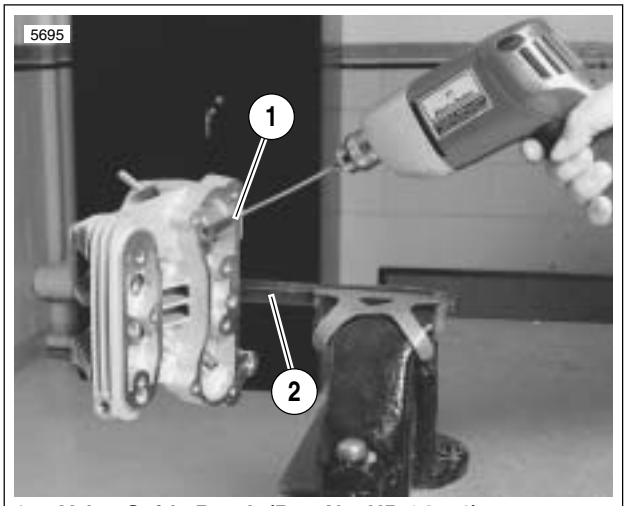
The hone is not intended to remove material.

7. See Figure 3-20. Thoroughly clean valve guide bores using VALVE GUIDE BRUSH (1) (Part No. HD-34751) and hot soapy water.



1. Driver Handle (Part No. HD-34740)
2. Valve Guide Installation Tool (Part No. HD-34731)
3. Cylinder Head Stand (Part No. HD-39782)

Figure 3-19. Installing Shoulderless Valve Guide



1. Valve Guide Brush (Part No. HD-34751)
2. Cylinder Head Holding Fixture (Part No. HD-39786)

Figure 3-20. Cleaning Valve Guides

Grinding Valve Faces and Seats

After installing valve guides, reface valve seats to make them concentric with guides.

Valve face angle is 45° for both intake and exhaust valves. If a valve refacing grinder is used, it must be adjusted exactly to this angle. It is important to remove no more metal than is necessary to clean up and true valve face. Install a **new** valve if grinding leaves the valve edge (the margin) with a width of less than 1/32 in. (0.8 mm). A valve with too thin a margin does not seat normally, burns easily, may cause pre-ignition and can also lead to valve cracking. Valves that do not clean up quickly are probably warped or too deeply pitted to be reused. Replace the valve if end of valve stem shows uneven wear. After valves have been ground, handle with care to prevent damage to the ground faces.

The valve seats may be refinished with cutters or grinders. Cut seats to a 46° angle or grind seats to a 45° angle. Valve seat tools and fixtures are available commercially. Seat each valve in the same position from which it was removed.

The correct 3-angle valve seat angles are shown in Figure 3-21. Use NEWAY VALVE SEAT CUTTER SET (Part No. HD-35758A) to cut the seats. See Figure 3-22. Always grind valves before cutting seats.

1. Cut 46° (or grind 45°) valve seat angle first. Use cutting oil to avoid chatter marks. Cut or grind only enough to clean up the seat.
2. Apply a small amount of lapping compound to the valve face. Rotate valve against seat using VALVE LAPPING TOOL (Part No. HD-96550-36A).
3. See Figure 3-21. Check the contact pattern on valve face. It should be 0.040-0.062 in. (1.016-1.575 mm) wide, and its center should be positioned 2/3 of the way toward the outside edge of face.
4. If valve seat pattern is too close to the stem side of valve face, cut a 60° angle in order to raise seat. If pattern is too close to the edge of valve face, cut a 31° angle in order to lower seat.
5. After cutting either or both 31° or 60° angles to position seat, final cut 46° (or grind 45°) seat angle to obtain proper 0.040-0.062 in. (1.016-1.575 mm) width.
6. Recheck valve seat width and location with lapping compound as described in Step 2.
7. To achieve a smooth even finish, place a piece of 280 grit emery paper under the cutter head and rotate cutter.

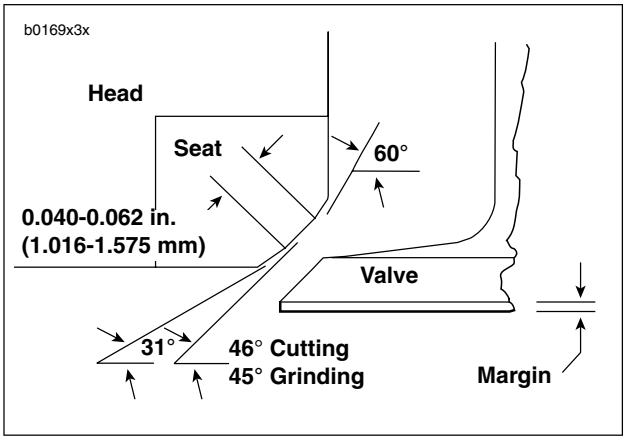


Figure 3-21. Valve Seat Angles

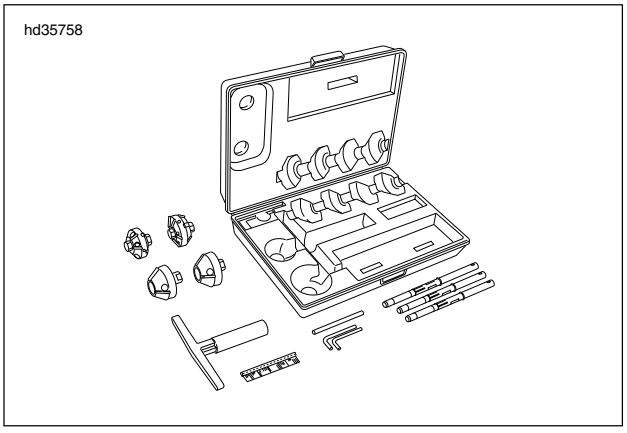


Figure 3-22. Neway Valve Seat Cutter Set (Part No. HD-35758A)

Table 3-4. Neway Valve Seat Cutters

VALVE SEAT	60° CUTTER	31° AND 46° CUTTERS
Exhaust	Part No. 205	Part No. 622
Intake	Part No. 293	Part No. 642

CAUTION

Do not grind valve to shorten. Grinding will remove the case hardening and expose the stem's mild steel core resulting in rapid end wear.

8. See Figure 3-23. Wipe valve seats and valve faces clean. Measure valve stem protrusion.
   a. If valve stem protrudes more than 2.031 in. (51.587 mm), replace valve seat or cylinder head.
   b. If valve stem protrusion is acceptable, valves and seats are ready for lapping.

Replacing Valve Seats

Replacing a valve seat is a complex operation requiring special equipment. If the seat is loose or is not fully seated in the head, then seat movement will prevent the proper transfer of heat from the valve. The seat surface must be flush with (or below) the head surface. See 3.1 SPECIFICATIONS for valve seat-to-cylinder head fit.

To remove the old seat, lay a bead of weld material around the inside diameter of the seat. This will shrink the seat outside diameter and provide a surface for driving the seat out the port side.

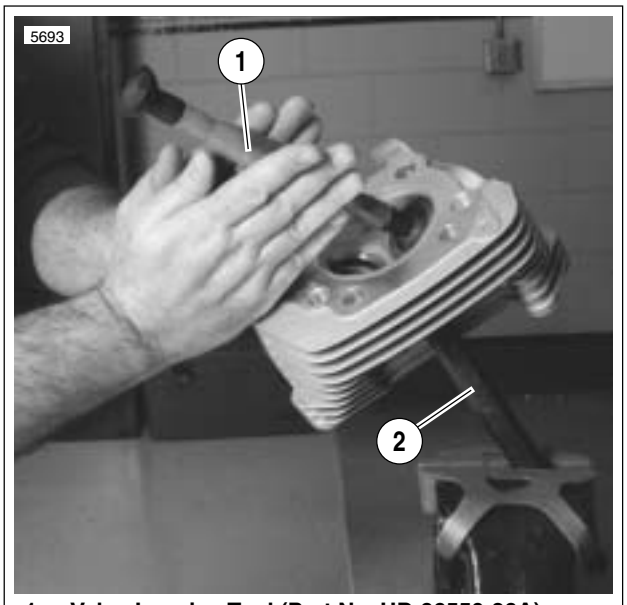
Lapping Valve Faces and Seats

NOTE

If valve faces and seats have been smoothly and accurately refaced, very little lapping will be required to complete the seating operation.

1. See Figure 3-24. Use CYLINDER HEAD HOLDING FIXTURE (2) (Part No. HD-39786) to secure cylinder head.
   a. Apply a light coat of fine lapping compound to valve face. Insert valve in guide.
   b. Place one rubber cup end of VALVE LAPPING TOOL (1) (Part No. HD-96550-36A) onto head of valve.
   c. Holding lapping tool as shown, apply only very light pressure against valve head.
   d. Rotate lapping tool and valve alternately clockwise and counterclockwise a few times.
2. Lift valve and rotate it about 1/3 of a turn clockwise. Repeat lapping procedure in Step 1.
3. Repeat Step 2. Then, remove valve.
4. Wash valve face and seat. Dry parts with a **new**, clean cloth or towel.
5. Inspect valve and seat.
   a. If inspection shows an unbroken lapped finish of uniform width around both valve and seat, valve is well seated.
   b. If lapped finish is not complete, further lapping (or grinding and lapping) is necessary.

Figure 3-23. Measuring Valve Stem Protrusion



1. Valve Lapping Tool (Part No. HD-96550-36A)
2. Cylinder Head Holding Fixture (Part No. HD-39786)

Figure 3-24. Lapping Valves

ASSEMBLY

CAUTION

Make sure all lapping compound is removed from cylinder head and valves after lapping is completed. If lapping compound contaminates any internal engine components or engine oil, excessive engine wear and damage may result.

1. Wash cylinder head and valves in warm, soapy water to remove all lapping compound.
2. Scrub valve guide bores with VALVE GUIDE BRUSH (Part No. HD-34751) and hot, soapy water.
3. Blow dry with compressed air.
4. Apply a liberal amount of engine oil to the valve stem.
5. See Figure 3-25. Insert valve into valve guide and install lower collar.
6. See Figure 3-26. Place a protective sleeve over the valve stem keeper groove. Coat the sleeve with oil and place a **new** seal over the valve stem.

CAUTION

- **Always use a protective sleeve on the valve stem keeper groove when installing valve stem seal. If the seal is installed without using the protective sleeve, the seal will be damaged.**
- **Do not remove valve after seal is installed. Otherwise, sharp edges on keeper groove will damage seal.**

7. See Figure 3-25. Tap the valve stem seal onto the valve guide using the VALVE SEAL INSTALLATION TOOL (Part No. HD-34643A) and DRIVER HANDLE (Part No. HD-34740). The seal is completely installed when the tool touches the lower collar.
8. See Figure 3-10. Install valve springs (5, 6) and upper collar (8).
9. Compress springs with VALVE SPRING COMPRESSOR (Part No. HD-34736B).
10. Insert valve keepers (7) into upper collar (8), making sure they engage groove in valve stem. The keeper gaps should be equal.
11. Release and remove VALVE SPRING COMPRESSOR.
12. Repeat Steps 4-11 for the remaining valve(s).

⚠WARNING

Always wear proper eye protection and gloves when working with compressed air. Debris or solvent may be blown out with enough force to penetrate skin or cause eye injury. Failure to comply could result in death or serious injury.

13. If front isolator mount was removed, install as follows.
    a. Clean residual loctite from threads in engine with a suitable nonflammable solvent and dry with compressed air.
    b. Apply LOCTITE THREADLOCKER 271 (red) to threads of **new** front isolator mount bolts.
    c. Apply a thin film of clean HD 20W50 engine oil to both sides of **new** thick washers and to bottom of bolt heads. Exercise caution to avoid mixing oil on washers with loctite on bolts.
    d. Position front isolator mount and secure with two **new** front bolts with **new** thick washers. Tighten bolts to 60 ft-lbs (81 Nm) initially and then loosen each bolt one full turn. Tighten bolts again to 60 ft-lbs (81 Nm).

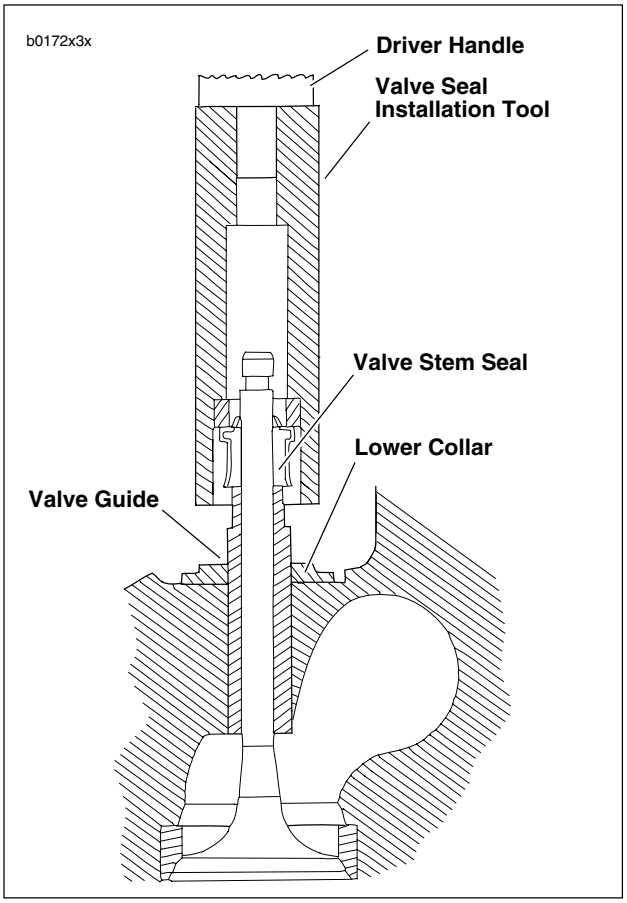


Figure 3-25. Valve Seal Installation

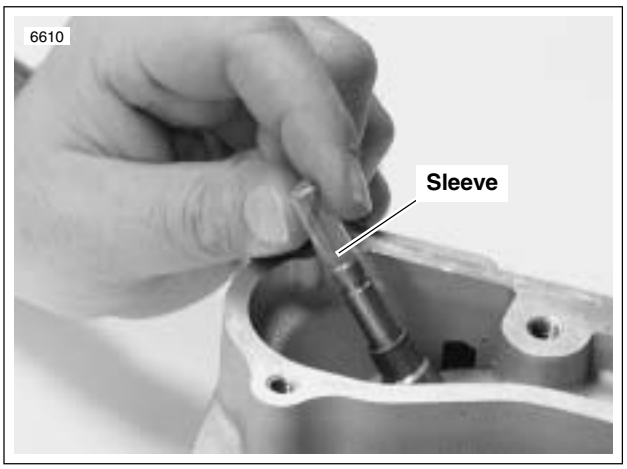


Figure 3-26. Valve Guide Seal Protector Sleeve

INSTALLATION

If only cylinder head work was needed, reinstall cylinder head following these instructions. If further repair is required, see 3.6 CYLINDER AND PISTON.

1. See Figure 3-10. Coat mating surfaces of cylinder studs (12) and head screws (1, 2) with parts cleaning solution.
2. Scrape old oil and any carbon deposits from threads by using a back-and-forth motion, threading each head screw onto its mating cylinder stud.
3. Remove head screws from studs. Wipe or blow dry thread surfaces.
4. Apply oil to stud threads and to the underside of the head screw shoulder.

CAUTION

Only oil film must remain on the head screw surfaces. Too much oil will pool in the head screw sleeve. Pooled oil may prevent proper torque application and full thread engagement.

5. Blow or wipe off excess oil from head screws.
6. Thoroughly clean and dry the gasket surfaces of cylinder (19) and cylinder head (18).
7. Install a **new** O-ring (14) on each dowel (15).

NOTE

O-rings (14) help to properly position the head gasket (4). O-rings must be installed before the head gasket.

8. Install a **new** head gasket (4) to cylinder.
9. Carefully lower cylinder head over studs and position on dowels. Use great care so as not to disturb head gasket.

CAUTION

The procedure for tightening the head screws is critical to proper distribution of pressure over gasket area. It prevents gasket leaks, stud failure, and head and cylinder distortion.

10. See Figure 3-8. For each cylinder head, start with screw numbered one, as shown. In increasing numerical sequence (i.e. – 1, 2, 3 and 4):
    a. Tighten each screw to 8-10 ft-lbs (11-14 Nm).
    b. Tighten each screw to 13-15 ft-lbs (18-20 Nm).
    c. Loosen all screws.
11. After screws are loosened from initial torque, tighten head screws in three stages. Tighten fasteners in increasing numerical sequence (i.e. – 1, 2, 3 and 4).
    a. Tighten each screw to 8-10 ft-lbs (11-14 Nm).
    b. Tighten each screw to 13-15 ft-lbs (18-20 Nm).
    c. See Figure 3-27. Mark cylinder head and head screw shoulder with a line as shown (View A). Tighten each screw a 1/4-turn (85°-90°) (View B).

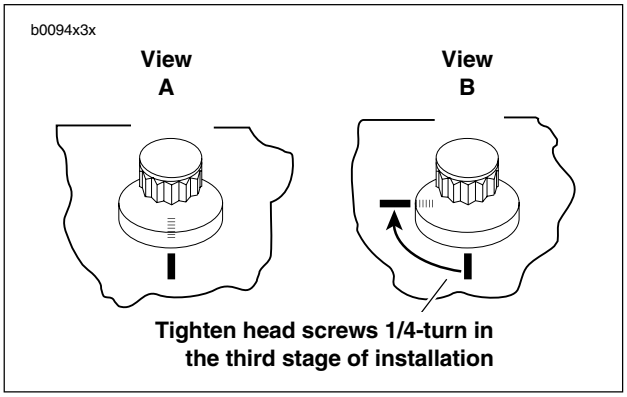
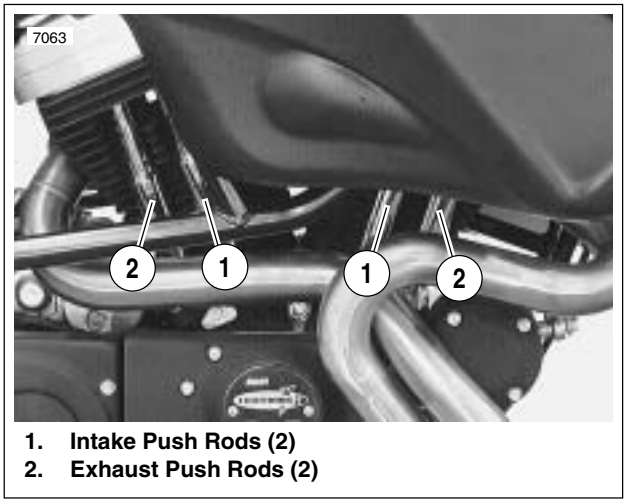


Figure 3-27. Tightening Head Screws



1. **Intake Push Rods (2)**
2. **Exhaust Push Rods (2)**

Figure 3-28. Push Rod Locations (Shown on Assembled Engine)

Table 3-5. Push Rod Selection

POSITION	COLOR CODE	LENGTH	PART NUMBER
Exhaust (front & rear)	3 Band-Pink	10.800 in. (274.320 mm)	17904-89
Intake (front & rear)	1 Band-Brown	10.746 in. (272.948 mm)	17897-89

12. Install lifters and push rod covers. See 3.15 HYDRAULIC LIFTERS.
13. See Figure 3-28. Identify push rod color coding, length and respective push rod positions in engine. See Table 3-5. Place intake and exhaust push rods onto seat at top of lifter.

14. See Figure 3-29. Install **new** gaskets (8, 9) with the bead facing up. Place lower rocker box assembly (with rocker arms and shafts) into position. Place push rods in rocker arm sockets.

CAUTION

Do not turn engine over until both push rods can be turned with fingers. Otherwise, damage to push rods or rocker arms may result.

15. See Figure 3-30. Install fasteners (12, 13, 14 and 15). Slowly snug all fasteners in small increments (one turn at a time). Use a cross pattern on the four large bolts (12, 13) that fasten the lower rocker box to head. This will bleed the lifters. Fastener sizes are listed in Table 3-6.

    a. Tighten bolts (12, 13) to 18-22 ft-lbs (24-30 Nm).

    b. Tighten bolts (15) to 10-14 ft-lbs (14-19 Nm).

    c. Tighten screws (14) to 130-150 **in-lbs** (14-19 Nm).

Table 3-6. Lower Rocker Box Hardware

ITEM	SIZE	TORQUE
Bolt with washer (12)	5/16-18 X 2-3/4	15-19 ft-lbs (20-26 Nm)
Bolt with washer (13)	5/16-18 X 2-1/2	
Screw with washer (14)	1/4-20 X 1-1/2	130-150 **in-lbs** (15-17 Nm)
Bolt with washer (15)	1/4-20 X 1-1/4	10-14 ft-lbs (14-19 Nm)

NOTES

Tubular frame prohibits direct access to bolt (12) on right rear cylinder. Use TORQUE ADAPTOR (SNAP-ON Part No. FRDH 181) and TORQUE COMPUTER (SNAP-ON Part No. SS-306G) to correctly assemble.

16. See Figure 3-29. Install middle and upper rocker covers.

    a. Place a **new** gasket (7) on lower rocker box assembly.

    b. Install middle rocker cover (5) with umbrella valve next to intake manifold.

    c. Place a **new** gasket (6) on middle rocker cover.

    d. Install upper rocker cover (4) using screws with washers (1) and **new** fiber seals (2). Tighten screws to 10-14 ft-lbs (14-19 Nm).

17. Install the other cylinder using the same procedure.

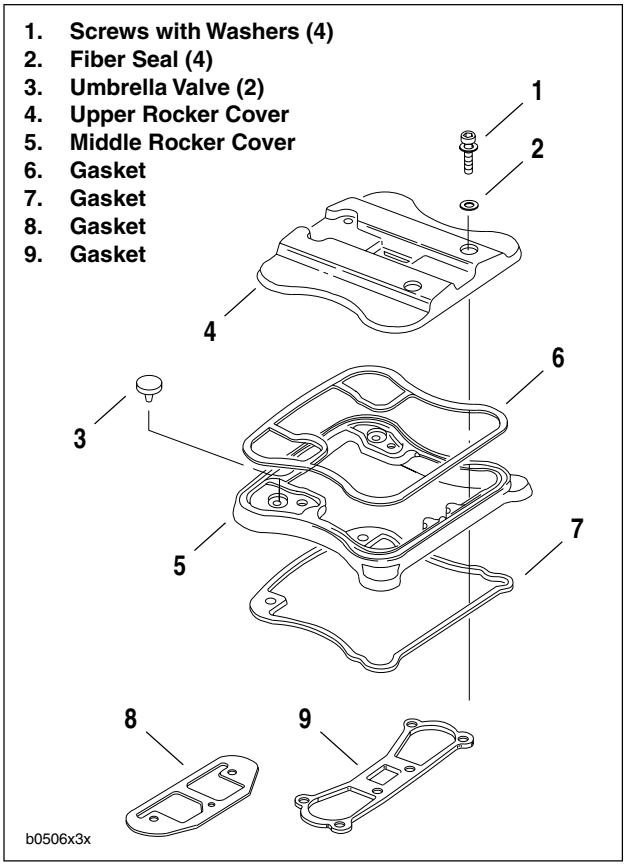


Figure 3-29. Rocker Arm Cover Gaskets

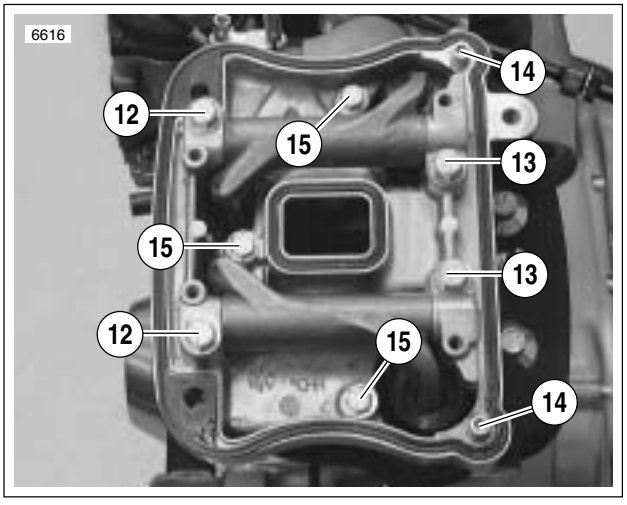


Figure 3-30. Lower Rocker Box Fasteners (Same Numbers as Figure 3-6.)

REMOVAL/DISASSEMBLY

1. Strip motorcycle as described under DISASSEMBLING ENGINE FOR CYLINDER HEAD REPAIR.
2. Remove cylinder head. See 3.5 CYLINDER HEAD.
3. Clean crankcase around cylinder base to prevent dirt and debris from entering crankcase while removing cylinder.
4. See Figure 3-31. Turn engine over until piston (3) of cylinder being removed is at bottom of its stroke.
5. Carefully raise cylinder (1) just enough to permit placing clean towel under piston to prevent any foreign matter from falling into crankcase.

NOTE

If cylinder does not come loose, lightly tap a plastic hammer perpendicular to the cylinder fins. Never try to pry a cylinder up.

6. Carefully lift cylinder over piston and cylinder studs (4). Do not allow piston to fall against cylinder studs. Discard cylinder base gasket (5).

CAUTION

With cylinder removed, be careful not to bend the cylinder studs. The slightest bend could cause a stress riser and lead to stud failure.

7. Install a 6.0 in. (152 mm) length of 1/2 in. (12.7 mm) ID plastic or rubber hose over each cylinder stud. This will protect the studs and the pistons.

⚠WARNING

Always wear proper eye protection when removing the compression rings. Slippage may propel the ring with enough force to cause an accident. This could result in death or serious injury.

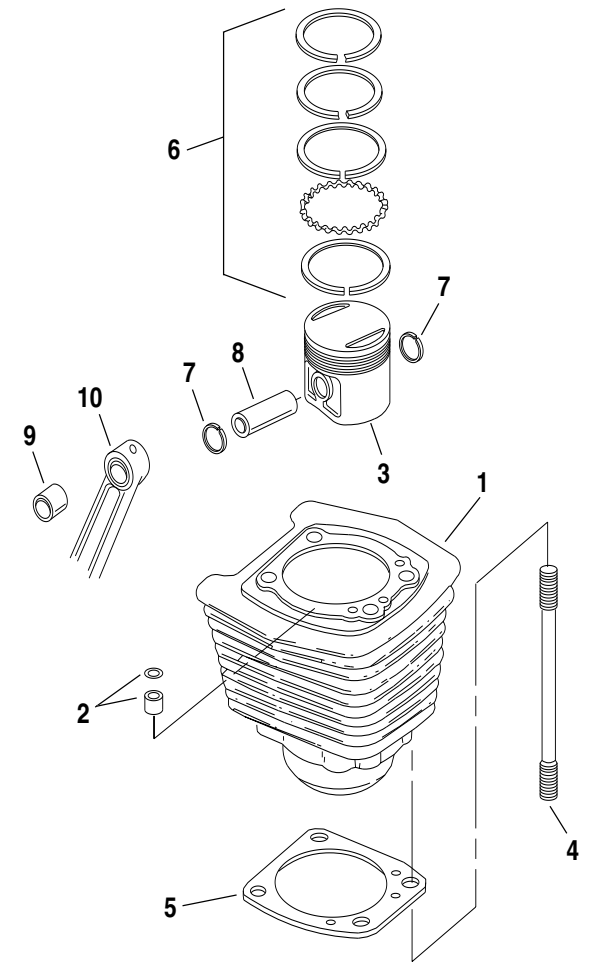
CAUTION

The piston pin retaining rings must not be reused. Removal may weaken retaining rings and they may break or dislodge. Either occurrence may damage engine.

8. Insert an awl in the recessed area below the piston pin bore and pry out the piston pin retaining rings. To prevent the ring from flying out, place your thumb over the retaining ring.

NOTE

Since the piston pin is a loose fit in the piston, the pin will easily slide out. The pins have tapered ends to help seat the round retaining rings. See Figure 3-32. 1200cc piston pins are stamped with a V-groove at one end.



1. **Cylinder**
2. **Dowel (2) and O-Ring (2)**
3. **Piston**
4. **Cylinder Stud (4)**
5. **Base Gasket**
6. **Ring Set**
7. **Retaining Ring (2)**
8. **Piston Pin**
9. **Piston Pin Bushing**
10. **Connecting Rod**

Figure 3-31. Cylinder and Piston

9. Mark each pin boss with either an “F” or an “R” to indicate front or rear cylinder, respectively. See Figure 3-32. The arrow at the top of 1200cc pistons must always point toward the front of the engine.

CAUTION

Handle the piston with extreme care. The alloy used in these pistons is very hard. Any scratches, gouges or other marks in the piston could score the cylinder during engine operation and cause engine damage.

10. See Figure 3-31. Spread piston rings (6) outward until they clear grooves in piston (3) and lift off.

CLEANING AND INSPECTION

1. Soak cylinder and piston in an aluminum-compatible cleaner/solvent until deposits are soft, then clean with a brush. Blow off loosened carbon and dirt particles and wash in solvent.
2. Clean oil passage in cylinder with compressed air.
3. Clean piston ring grooves with a piece of compression ring ground to a chisel shape.
4. Examine piston pin to see that it is not pitted or scored.
5. Check piston pin bushing to see that it is not loose in connecting rod, grooved, pitted or scored.
   a. A piston pin properly fitted to upper connecting rod bushing has a 0.00125 to 0.00175 in. (0.03175-0.04445 mm) clearance in bushing.
   b. If piston pin-to-bushing clearance exceeds 0.00200 in. (0.05080 mm), replace worn parts. See CONNECTING ROD BUSHING on page 3-28.
6. Clean piston pin retaining ring grooves.
7. Examine piston and cylinder for cracks, burnt spots, grooves and gouges.
8. Check connecting rod for up and down play in lower bearings. When up and down play is detected, lower bearing should be refitted. This requires removing and disassembling engine crankcase.

Checking Gasket Surface

CAUTION

If either cylinder gasket surface does not meet flatness specifications, replace cylinder and piston. Proper tolerances will extend component life and prevent leaks.

1. See Figure 3-33. Check cylinder head gasket surface for flatness.
   a. Lay a straightedge across the surface.
   b. Try to insert a feeler gauge between the straightedge and the gasket surface.
   c. If cylinder head gasket surface is not flat within 0.006 in. (0.152 mm), replace cylinder and piston.
2. Check cylinder base gasket surface for flatness.
   a. Lay a straightedge across the surface.
   b. Try to insert a feeler gauge between the straightedge and the gasket surface.
   c. If cylinder base gasket surface is not flat within 0.008 in. (0.203 mm), replace cylinder and piston.

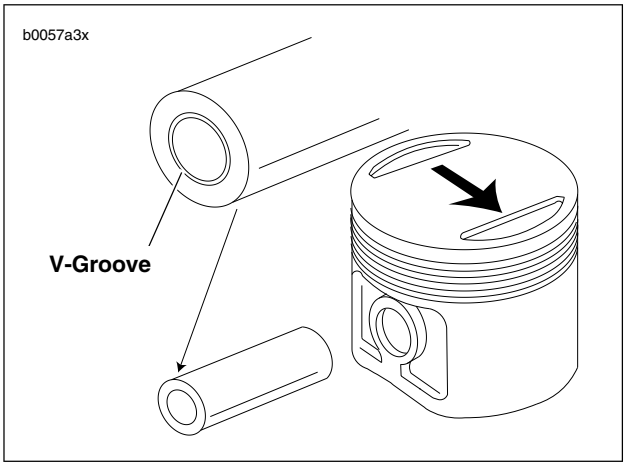


Figure 3-32. Piston Pin and Piston Identification

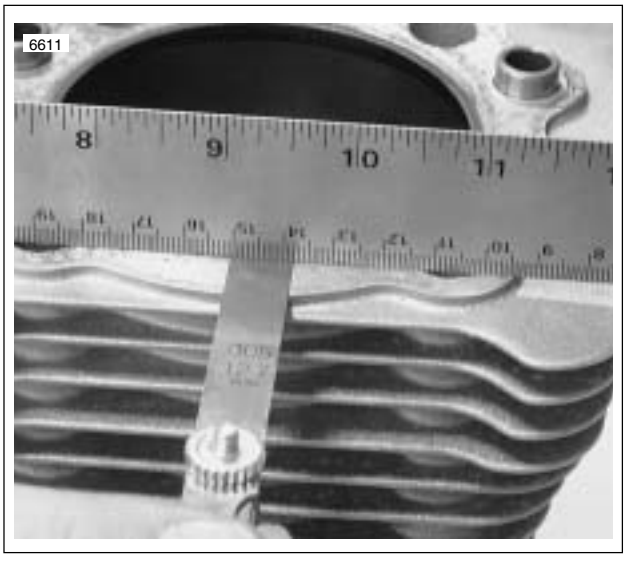


Figure 3-33. Checking Gasket Surfaces

Measuring Cylinder Bore

1. Remove any burrs from the cylinder gasket surfaces.
2. See Figure 3-34. Install a head and base gasket, and CYLINDER TORQUE PLATES (Part No. HD-33446A) and XL EVOLUTION TORQUE PLATE BOLTS (Part No. HD-33446-86). Tighten the bolts using the same method used when installing the cylinder head screws. See 3.5 CYLINDER HEAD.

NOTE

Torque plates, properly tightened and installed with gaskets, simulate engine operating conditions. Measurements will vary as much as 0.001 in. (0.025 mm) without torque plates.

3. Take cylinder bore measurement in ring path, starting about 1/2 in. (12.7 mm) from top of cylinder, measuring from front to rear and then side to side. Record readings.
4. Repeat measurement at center and then at bottom of ring path. Record readings. This process will determine if cylinder is out-of-round (or “egged”) and will also show any cylinder taper or bulge.
5. See Table 3-7. If cylinder is not scuffed or scored and is within service limit, see 3.6 CYLINDER AND PISTON on page 3-25.

NOTE

If piston clearance exceeds service limit, cylinders should be rebored and/or honed to next standard oversize, and refitted with the corresponding piston and rings. Do not fit piston tighter than 0.0007 in. (0.0178 mm). See 3.1 SPECIFICATIONS.

Measuring Piston

Because of their complex shape, the pistons cannot be accurately measured with standard measuring instruments.

The pistons have the typical elliptical shape when viewed from the top. However, they also are barrel-shaped when viewed from the side. This barrel shape is not symmetrical.

Any damage to the piston will change its shape, which will lead to problems.

Fitting Cylinder to Piston

Since pistons cannot be accurately measured with standard measuring instruments, the bore sizes must be observed. Bore sizes are listed in Table 3-8. Example: A 0.005 in. (0.127 mm) oversize piston will have the proper clearance with a bore size of 3.502 in. ± 0.0002 in. (88.951 mm ± 0.0051 mm) for the 1200cc engine.

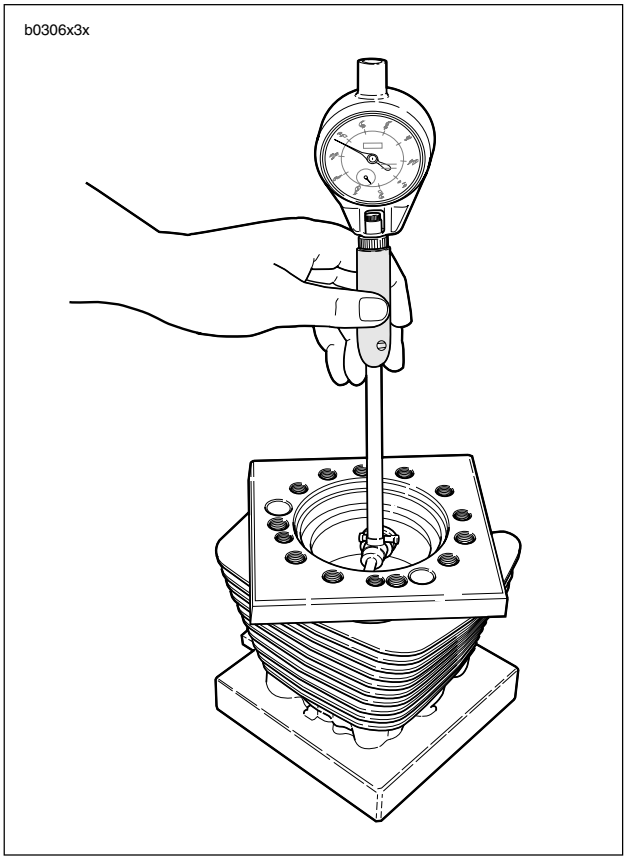


Figure 3-34. Measuring Cylinder Bore Using Torque Plates (Part No. HD-33446A)

Table 3-7. Cylinder Bore Service Wear Limits

BORE SIZES	IN.	MM
Standard Bore	3.5008	88.9203
0.005 in. OS bore (0.127 mm)	3.5050	89.0270
0.010 in. OS bore (0.254 mm)	3.5100	89.1540
0.020 in. OS bore (0.508 mm)	3.5200	89.4080
0.030 in. OS bore (0.762 mm)	3.5300	89.6620

Boring and Honing Cylinder

When cylinder requires oversize reboring to beyond 0.030 in. (0.762 mm), the oversize limit has been exceeded and cylinder must be replaced.

1. Bore cylinder with gaskets and torque plates attached. Bore to 0.003 in. (0.076 mm) under the desired finished size.
2. Hone the cylinder to its finished size using a 280 grit rigid hone followed by a 240 grit flexible ball hone. Honing must be done with the torque plates attached. All honing must be done from the bottom (crankcase) end of the cylinder. Work for a 60° crosshatch pattern.

Fitting Piston Rings

NOTE

Ring sets and pistons, 0.040 in. (1.016 mm) oversize, are not available on 1200cc engines.

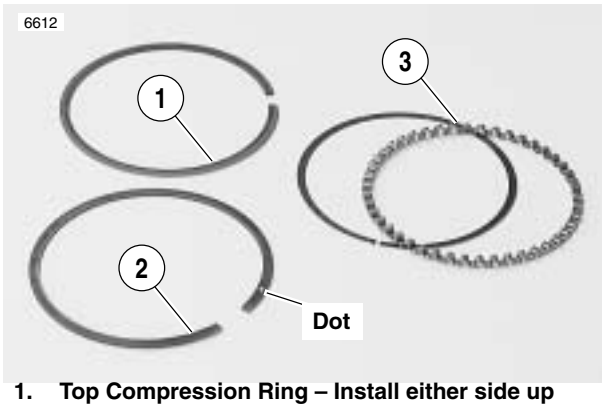
See Figure 3-35. Piston rings are of two types: compression (1, 2) and oil control (3). The two compression rings are positioned in the two upper piston ring grooves. The dot on the second compression ring must face upward. Ring sets are available to fit standard and oversize pistons.

Piston ring sets must be properly fitted to piston and cylinder:

1. See Figure 3-36. Place piston in cylinder about 1/2 in. (12.7 mm) from top. Set ring to be checked squarely against piston as shown. Check end gap with thickness gauge. See 3.1 SPECIFICATIONS for tolerance.

NOTE

See SERVICE WEAR LIMITS for end gap dimensions. Do not file rings to obtain proper gap.



1. **Top Compression Ring – Install either side up**
2. **Second Compression Ring – Install dot toward top**
3. **Oil Control Rings**

Figure 3-35. Piston Rings

Table 3-8. Final Cylinder Bore Sizes

BORE SIZES	IN.	MM
Standard bore*	3.4978 in.	88.8441 mm
0.005 in. OS bore (0.127 mm)	3.502 in.	88.951 mm
0.010 in. OS bore (0.254 mm)	3.507 in.	89.078 mm
0.020 in. OS bore (0.508 mm)	3.517 in.	89.332 mm
0.030 in. OS bore (0.762 mm)	3.527 in.	89.586 mm

*All bore sizes + 0.0002 in. (0.0051 mm)

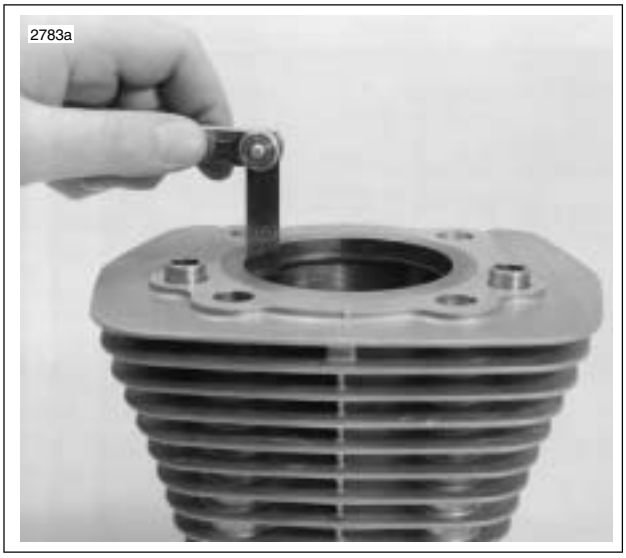


Figure 3-36. Measuring Ring End Gap

NOTE

The same piston may be used if cylinder bore was not changed, unless it is scuffed or grooved. However, replace rings and hone the cylinder walls with a No. 240 grit flexible hone to facilitate ring seating.

2. See Figure 3-37. Apply engine oil to piston grooves. Use TRANSMISSION SHAFT RETAINING RING PLIERS (Part No. J-5586) to slip compression rings over piston into their respective grooves. Be extremely careful not to over expand, twist rings or damage piston surface when installing rings.

NOTE

Install second compression ring with dot towards top.

3. See Figure 3-38. Install rings so end gaps of adjacent rings are a minimum of 90° apart. Ring gaps are not to be within 10° of the thrust face centerline.
4. See Figure 3-39. Check for proper side clearance with thickness gauge, as shown. See 3.1 SPECIFICATIONS for tolerance.

NOTE

If the ring grooves are clean and the side play is still not correct, replace the rings, the piston or both.

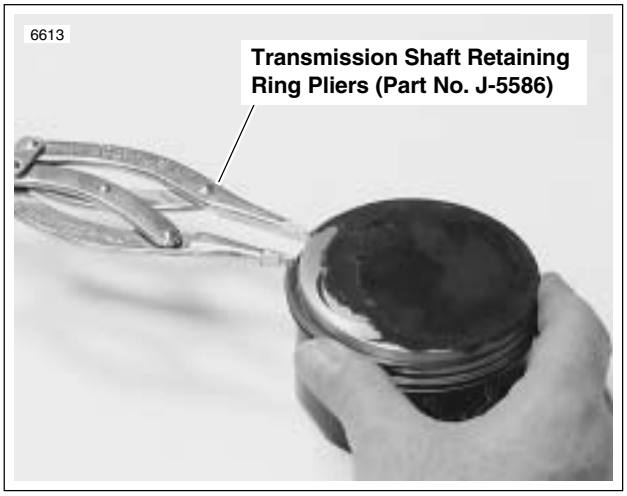


Figure 3-37. Installing Piston Rings

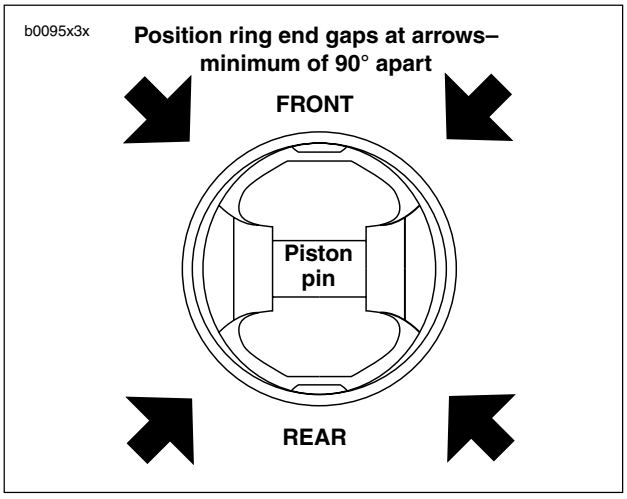


Figure 3-38. Ring End Gap Position

Figure 3-39. Measuring Ring Clearance in Groove

Connecting Rod Bushing

When connecting rod bushing is worn to excessive pin clearance (0.002 in. or more) (0.051 mm) it must be replaced.

1. See Figure 3-40. Install plastic hoses (3) over studs.
2. Secure connecting rod with CONNECTING ROD CLAMPING TOOL (2) (Part No. HD-95952-33B).

NOTE

If CONNECTING ROD CLAMPING TOOL holes are too small, enlarge the holes in the tool.

3. See Figure 3-41. Attach PISTON PIN BUSHING TOOL (Part No. HD-95970-32D) to the connecting rod. The receiver cup (1) fits on one side of the rod while the driver (2) fits on the opposite side as shown.
4. Use two box wrenches and push worn bushing from connecting rod.
5. Remove piston pin bushing tool from connecting rod.
6. Remove bushing from receiver cup.
7. Attach PISTON PIN BUSHING TOOL (Part No. HD-95970-32D) to connecting rod. Place **new** bushing between connecting rod and driver.

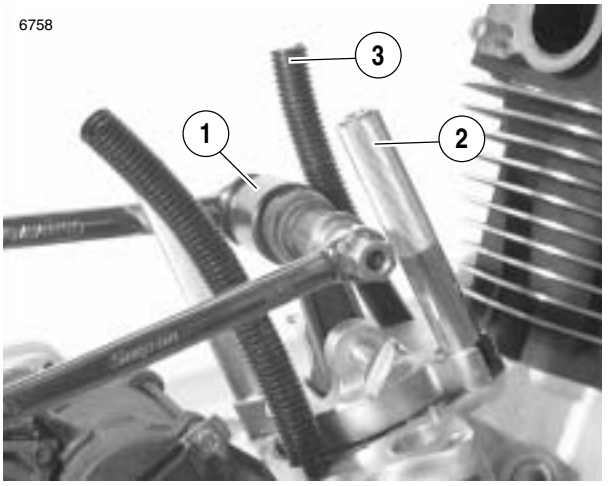
NOTE

The driver must be attached facing the opposite direction as it was for removal of the bushing.

8. Clean up and size bushing to 0.0010-0.0005 in. (0.0254-0.0127 mm) undersize using REAMER (Part No. HD-94800-26A). Sizing bushing with less than 0.00125 in. (0.03175 mm) clearance can result in a bushing loosening and/or seized pin in rod.
9. Hone bushing to final size using WRIST PIN BUSHING HONE (Part No. HD-35102). Use a liberal amount of honing oil to prevent damage to hone or bushing. Use care to prevent foreign material from falling into the crankcase.

CAUTION

Replace bent connecting rods. Do not attempt to straighten. Straightening rods by bending will damage the bearing on the crank pin and the piston pin bushing. Installing bent connecting rods will damage cylinder and piston beyond repair.



1. **Piston Pin Bushing Tool (Part No. HD-95970-32D)**
2. **Rod Clamping Tool (Part No. HD-95952-33B)**
3. **Plastic Hose**

Figure 3-40. Installing New Piston Pin Bushing

1. **Receiver Cup**
2. **Driver**
3. **Washer**
4. **Nut**
5. **Bolt**
6. **Bearing**

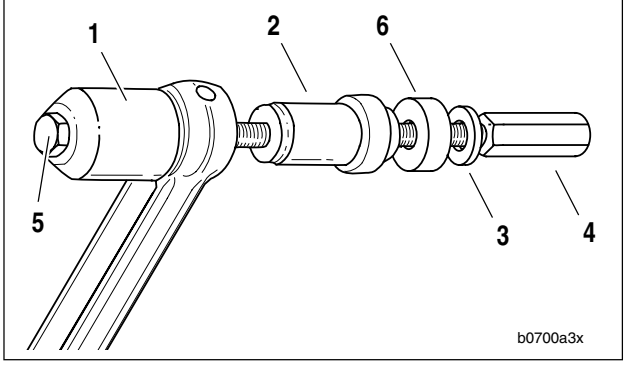


Figure 3-41. Piston Pin Bushing Tool Assembly for Bushing Removal

ASSEMBLY/INSTALLATION

1. See Figure 3-42. Place PISTON SUPPORT PLATE (3) (Part No. HD-42322) around connecting rod.
2. Install piston assembly over connecting rod.

NOTE

New 1200cc pistons must be installed with the arrow, at the top of the piston, pointing towards the front of the engine.

3. Install piston pin.

CAUTION

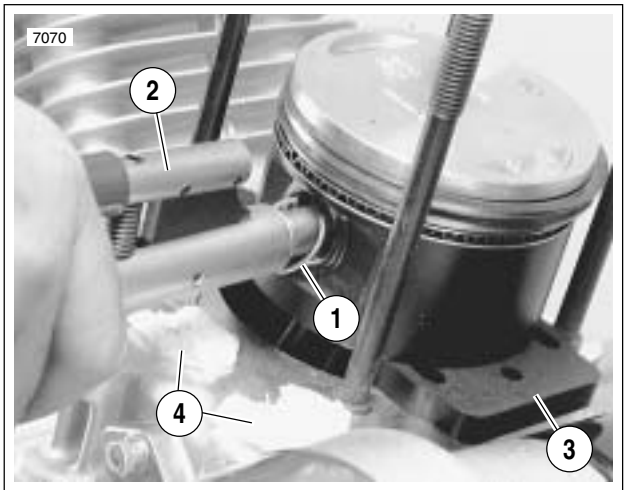
Always use new retaining ring. Make sure retaining ring groove is clean and that ring seats firmly in groove. If it does not, discard the ring. Never install a used retaining ring or a new one if it has been installed and then removed for any reason. A loosely installed ring will come out of the piston groove and damage cylinder and piston beyond repair.

4. Install **new** piston pin retaining rings (1) using PISTON PIN RETAINING RING INSTALLER (2) (Part No. HD-34623B). Place **new** retaining ring on tool with gap pointing up. See Figure 3-43.

NOTE

Make sure the ring groove is clean. Ring must be fully seated in the groove with the gap away from the slot at the bottom.

5. See Figure 3-38. Make sure the piston ring end gaps are properly positioned as shown.
6. Remove PISTON SUPPORT PLATE (3) (Part No. HD-42322).
7. Lubricate cylinder wall, piston, pin and rod bushing with engine oil.
8. Turn engine until piston is at top dead center.
9. See Figure 3-44. Compress the piston rings using PISTON RING COMPRESSOR (Part No. HD-96333-51C).
10. Remove protective sleeves from cylinder studs. Install a **new** cylinder base gasket. Make sure the piston does not bump the studs or crankcase.
11. Install cylinder over piston.
12. Remove PISTON RING COMPRESSOR (Part No. HD-96333-51C).
13. Assemble cylinder head. See 3.5 CYLINDER HEAD.
14. Install cylinder head. See 3.5 CYLINDER HEAD.
15. Install assembled engine. See 3.4 INSTALLING THE ENGINE.



1. **Piston Pin Retaining Ring**
2. **Piston Pin Retaining Ring Installer**
3. **Piston Support Plate**
4. **Plugged Lifter Bores**

Figure 3-42. Installing Piston Retaining Rings

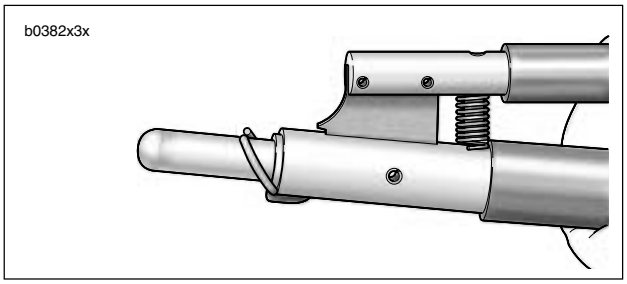
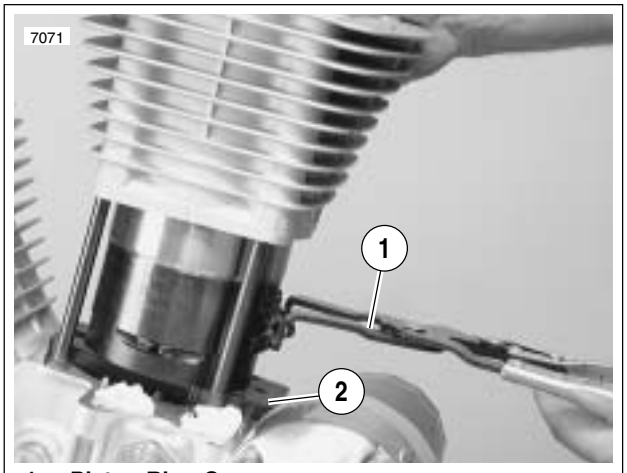


Figure 3-43. Aligning Retaining Ring



1. **Piston Ring Compressor**
2. **Piston Support Plate**

Figure 3-44. Compressing Piston Rings

NOTES