End Float

Load the axle and tighten the nut. Use a dial indicator that is set to zero. Rotate the axle to seat the washers. The end play should be set to .004" - .012" for sport bikes, and .002" - .006" for dressers.

The spacer in the middle of the hub determines end float.

Shorter – Less

Longer – More

If there is too much end float, use a shorter spacer.

Not enough end float will cook the bearings and cause the wheel to lock up.

Too much end float will cause the wheel to wobble.

If using shims, the first shim should have a shoulder that goes toward the bearing.

Spin to set the bearing before pulling up to measure.

Swingarms

Pre – 1982 or 1983

The pivot bolt should be torqued to 50 ft/lbs

The big nut loads the bearings

The swingarm must be weighed. Set it for 2 lbs heavier than the free weight

Look for a ratcheting effect or side-to-side movement. Swingarm movement should be smooth with no ratcheting or side play

Adjust the chain on the tight spot. Compensate for the weight of the bike & rider

On old bikes, visually align the chain

Adjust the chain or belt first, then make all other adjustments on the opposite side of the bike

Models

1936 – 1984 – FL / FLH – 4 speed, 16” Front wheel, 16” Rear wheel, Solid mount

1971 – 1986 – FX – 4 speed, 19” or 21” Front wheel, 16” Rear wheel, Solid mount

Both of these models are covered by one manual

1980 FLT – 5 speed, 16” Front wheel, 16” Rear wheel, Rubber mount

1982 – 1994 FXR – 5 speed, 19” or 21” Front wheel, 16” Rear wheel, Rubber mount

Both of these models are covered by one manual

FLT – Fairing mounted to the frame

FLHT – Fairing turns with the bars

R - Rubber

In 1995 the Dynaglide replaced the FXR.

After 1995 each bike had a separate manual.

The first Softail was in 1984

1984 & 1985 were 4 speeds with kick & electric

1986 – 5 speed, electric start only

Softail – Only Big Twin with a solid mount

On “T” Models the VIN number is on the left side of the neck. On all others, it’s on the right.

When adjusting the stabilizers, there should be an equal amount of threads on each side of the center nut.

Drive train – Engine, Transmission, Swing Arm

3 Types of Final Drive – Belt, Chain, and Enclosed Chain

Harley Wheels

All Harley wheels – 1 spoke crosses 4

Mid 1977 & earlier are laced in the early style pattern

Inside spokes go in the same direction

Inside holes, inside spokes

Outside hole to the left

Late style – Inside spokes cross each other

Outside hole to the right

Sportsters changed in 1998 to the late style laced in the early style pattern

VIN Numbers

3 styles

1969 & Earlier

First 2 numbers are the year (only on the case – not on the frame)

Second letters are the model

Last numbers are the serial numbers

1970

First 2 digits are the model

Next 5 digits are the serial number

Last 2 digits are the year

These are on the right side of the case

VIN number is on the frame and the engine, on the right side of the neck

H0 – 1970

H1 – 1971

H2 – 1972 through H9 – 1979

J0 – 1980 – Only year for the letter "J"

The VIN description is found in the "Chassis" section of the manual

In 1981 Harley Davidson started using the 17 digit code

1 HD 1 – model, engine type, factory numbers, year, where made, serial number

On the engine is the model, engine type, year and serial number

The 1981 year starts with a "B"

From 1981 and later Harley doesn't use the letters I, O, U, or Q

In 1984 the numbers moved back to the left side of the case

Sportster numbers were always on the left until 1991, when most changes in Sportsters occurred:

The timing hole was moved from the left to the right side

5 Speed Transmission

Belt Drive

Fuji Clutch

1 piece push rod tubes

Tappet blocks became part of the case

Bigger charging system

B – 88B Fuel Injection	L – Big Twin Evo	K – Shovelhead	M – 883
Y – 88B Carb	N – 1100	P – 1200	H – Ironhead
R – Fuel Injection Evo	V – Twin Cam Carb	W – Twin Cam Fuel Injection	

1986 – 1st Evo Sportster

1986 – 1987 – 883 or 1100

1988 – 883 or 1200

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883 to 1200 Conversion

Bore cylinders ½", from 3" to 3 ½" (removes 7 lbs of metal from each cylinder)

Cut chambers on the head bigger and use Wiseco pistons

On rubber mounted bikes the components are "hanging"

For vehicle alignment line up the wheels. The 4 points of the wheels must be lined up.

The front stabilizer moves the rear wheel left to right.

The top stabilizer moves the engine left to right.

Use an inclinometer on the front and rear rotors and read. If within ½ degree of each, it's in spec. (An inclinometer is a protractor that gives angles.)

Do the front rotor first and then the rear since the front can't be moved.

Positive caster – The tubes are at a greater angle than the steering head.

All T- models have trailing fork tubes – 30 – 36 degrees

Trailing fork tubes are self centering. Push the wheel to one side and let go. It should swing 3 times and then back to center.

On other fork tubes the fall away is 1 ½" to 2"

An enclosed chain rides in a rubber boot, in oil

Wheel Hub Assembly

1936 – 1966

Running clearance is .001” - .0015”

End play is .003” - .010”

Shims are .002”

Oversize bearings available in .0002” increments from .2502” to .251”

Oversize means running clearance

Measure the shaft with the bearings on it. Then measure the inside of the hub. The difference is the clearance.

End play or end float is changed by shims

Starhub got its name from the dust cover

It has 14 bearings on the left (drive) side and 12 bearings on the right side

All Big Twins drive from the left. All XLs drive from the right (and never had the star hub)

The hub is the same front and rear

1967 – 1972

Sealed ball bearings

Front ends used motor oil (20W-50)

1973 – 1999

Timken bearings. Have end play but no running clearance. Has a spacer on the inside (most bikes).

> If the spacer is too long there will be too much end play.
>
> If the spacer is too short the bearing could weld itself into the axle. Shim to correct.

Big Twin had disc brakes front and rear

Until 1978 XLs had disc brakes on the front and drum brakes on the rear

On drum brakes, if the spacer is left out between the bearings, the backing plate will cut into the drum

Anything with a disc brake has Timken bearings

Anything with disc on the front is Japanese. This started in 1973

End play – Sport bike - .004" - .012"
End play – Big bike - .002" - .006"

1973 to present front ends use Fork Oil

2000 – up

Went back to ball bearings. These are supposed to be 100,000 mile bearings

No running clearance, no end play

Wheel Seals

On 19" & 21" wheels, the seal is flush

On 16" wheels, countersink the seal ¼"

NEVER PUSH THE SEAL IN TO THE BEARING

Repack bearings whenever tires are changed

On 21" wheels always inflate the tires to 40 – 44 psi to prevent rim damage

Anti-Dive

In 1984 anti-dive was introduced. Applying the front brake caused a solenoid to keep air from leaking.

From 1984 – 1987 the fill valve was located on the safety bar.

From 1988 – 1996 (last year of the anti-dive) the fill valve was located on the end of the left handlebar (Schraeder valve)

5 – 20 psi – dressers, road kings, some FXRs

In 1997, dressers got air shocks and heavier springs

Changing Fork Oil

First step in changing the fork oil on dressers is to relieve the air pressure. Drain the fluid from one side & then pump. Repeat procedure on the other side. Replace with the same amount of fluid in each side.

8mm bolt fits the drain hole threads.

The ride can be stiffened by adding more fork oil.

1949 was the last year of the springer front end

1949 – 1957 used the Hydra Glide telescopic front end and rigid rear

1958 – 1964 was the Duo Glide. It was the first swingarm and used telescopic front forks with shocks in the rear.

1965 – Present – Electra Glide. First year of electric start. Telescopic front forks and rear shocks.

On Softtails, extend the shocks to compress. The 2 shocks are under the transmission

Tire Change Demo

Break the bead

Use wood block if necessary to keep rotor off floor

Wire brush to clean wheel

For tube tires, use a rim band or duct tape

To install tire, look for the yellow spot and put it near the valve hole

Make sure the arrow on the tire points in the direction of rotation

Soap up the tire, push over wheel

If using a manual tire changer, always pull and never push the bar

Clutches

Rules Before Working on Clutch

Disconnect the negative lead of the battery

Get maximum freeplay in the cable

Try to turn the compensator. If it spins without turning the engine it's no good & the springs on the inside are worn if it spins

Check the Primary Chain adjustment. Using a socket turn the engine over a couple times. Put a straight edge across the top and bottom of the inner primary just in front of the clutch hub and take a reading off the primary chain with a dial caliper. Then put the straight edge across the top and bottom of the inner primary just in front of the clutch hub and take another reading off the primary chain. If the difference is more than .030" shim behind the sprocket shaft extension to get the correct alignment. To adjust the primary chain find the tight spot. The primary chain gets tighter when it gets hot. The adjusting shoe is tapered in front and wider in the back.

Dry Clutch – 1941 – 1984 ½

Only clutch that is safety wired

Rear wheel does not have to be off the ground to work on the clutch

Improper adjustment and the clutch will drag

1/8" freeplay on spring clutch

There is a thrust washer on the Bendix of the starter

There are 2 types of primary chain oilers

Drip type – Total loss system. Lube fell off chain & ran out inner primary onto the ground. Primary wasn't sealed.

Spray type – Uses engine vacuum to suck the oil back into the oil tank. 20 – 25 hg @ 2000rpm. Sealed primary. To check, take the top left inspection cover screw out and use a vacuum gauge there while running the engine.

Dry clutches from 1965 and later use a sealed primary. 1964 and earlier (kick start) use a total loss system.

Don’t start the engine without the primary cover in place. It can damage the bendix. A damaged primary cover can be cut so that the bendix can be covered.

To adjust the clutch, use the clutch adjustment screw in the center of the clutch hub. The handle should be out all the way with no tension on the cable (maximum freeplay).

Fork & Arm adjustment

Turn the clutch adjustment screw in until it lightly seats, then back it out ¼ to ½ turns. Hold the screw while tightening the lock nut.

To remove the chain adjuster only take the top bolt off. Take the clamp off the hose. Remove the hose.

Use an impact wrench to take the compensator nut off. If torquing, use Red Loctite. If using the impact wrench don’t use red loctite.

The Compensator nut uses regular threads. Inspect the compensator “fingers” for pitting.

On the clutch hub there are 10 springs. Measure 1” from the back of the pressure plate to the front of the clutch release disc to preload the springs. To adjust the springs, loosen or tighten the nuts. The clutch release disc must come out straight no matter if the pressure plate is straight or not. Check for warpage and bad springs. There should be minimal freeplay at the lever on any spring clutch after it’s adjusted. The lever should contact the grip.

Check spring preload

Adjust the set screw

Adjust the cable

Check that the releasing disc is coming out straight

To Disassemble the Clutch:

Take the nut off the adjusting screw

Put large washer on

Put nut back on

Tighten nut to remove the 3 pressure plate adjusting nuts

After the nuts are removed, the plate and springs come out as one unit

The first plate is a fiber plate. All Harleys start with fiber and end with fiber except for the wet clutch found in 1984 ½" to 1989 models.

On Dry Clutches, always clean the plates for 30 minutes in lacquer thinner. Rough the fiber plates with coarse sandpaper. Blow off with air.

Steel plates – Install with the sharp edges out. Stagger so that the large and small cutouts on the edge are staggered.

Check for loose pillar blocks in the clutch basket

The large gear on the clutch basket is the Ring Gear. It is engaged by the Bendix to start the engine.

All rubber mounted bikes are "rotor friendly" meaning that the inner primary doesn't have to be removed to remove the stator. (1980 – Present. Solid mounts from 1989 and later (FXST))

The clutch hub has 3 main studs

<u>All Clutch Hub nuts have left hand threads except the Sportster DC clutch</u>

Clutch hub nuts should have locking tab behind it

Put 2 seals in the clutch hub nut, even though the manual only shows one

Use a puller to get the clutch hub off if the bike is a 5 speed. If the bike is a 4 speed use a "jiffy tool" – a large punch about 8" long threaded on one end. Screw it on and hit with a hammer.

Don't let the puller contact the push rod

The clutch hub is rebuildable. Check the plate on the back for movement – it shouldn't move. Peen the rivets to tighten. The studs can be replaced. Look for indentions on the studs. Replace if necessary. Grease the bearings before reinstalling. A new clutch hub costs about $70 (2003)

Check the Primary Chain tension before installing the Outer Primary Cover

Big Twin Wet Clutch – 1984 ½ - 1989

A-B-C Clutch – First wet clutch used on Big Twins – not very good – always breaking

These years were the only years for the tapered transmission mainshaft

There are 3 settings on the retainer: A, B, & C

The Diaphragm spring should be flat +/- .010". Check with a straight edge and a feeler gauge

B is the tightest setting

A is medium setting

C is the weakest setting

Tighten the bolts ¼ turn at a time in a cross pattern. Start at the A setting

Too tight - .010"

Too loose – rocks

If it still rocks on all settings, add an extra steel clutch plate in the middle of the clutch pack next to another steel plate.

Start at the A setting, then the B setting. If it still rocks, replace the clutch pack.

This clutch starts with a steel plate and ends with steel plate. Install with the sharp side out.

Review the rules before working on the clutch.

Remove the plugs to make it easier to turn the engine over.

Don't use an impact wrench on the clutch hub nut

Remove the compensator nut and the compensator

Loosen the primary chain to take the tension out

Loosen the clutch adjusting screw

Take off the bolts, ¼ turn at a time in a cross pattern

Put in 1st gear, hold the brake, and use a breaker bar and socket. Left hand thread

Use a puller and the 4 clutch retainer nuts (to attach the puller)

Remove the clutch basket and the compensator sprocket at the same time

Remove the diaphragm spring, pressure plate and clutch plates

Always lay the clutch plates flat to prevent warpage

Inspect the fiber plates for wear – check the manual for specs

Inspect the steel plates for warpage by holding them together and looking to see if light can be seen between them

This clutch has a 3 piece pushrod with a flat spot on the last piece.

The clutch vents through the flat spot through the main shaft into the transmission and into the atmosphere. All transmissions are vented to prevent seals from blowing.

If it has a gold ring on the back of the hub, it is a Zipper ring, made by Zipper. It is pressed onto the shaft. It isn't stock. It strengthens the hub. The 1984 model gets one ring, the 1984A gets a different ring.

To reassemble Super Glue the key into the mainshaft keyway (key should be on top), slide the hub on, put the nut on, put the transmission in first gear with the brake on and torque to 50 – 60 ft/lbs. DON"T IMPACT BECAUSE IT HAS A TAPERED SHAFT!!

The key doesn't have to be removed unless the Inner Primary is going to be removed.

AC Clutch – 1984 ½ - 1990 - Sportsters with Alternators

The rear wheel must be raised to find the tight spot in the Primary Chain on XLs

Disconnect the negative lead of the battery before working on any clutch

Get maximum freeplay in the cable

Take the covers out of the primary

The spring comes out first

Take the locknut out next. It has to come out before taking the primary cover off

On 1984 ½ to present back out the adjusting screw until it lightly seats, then go in ¼ turn. If the lever won't hit the grip the adjusting screw is bad.

If the locknut won't drop in the slot, turn it to the right until it drops in

This is a Reverse Action Clutch – Ball & Ramp. It pulls apart instead of pushing apart

Use H-D tool #34761 – the hockey puck clutch tool. It goes on hollow-end first. Tighten only enough to get the clip out.

Inspect the spring plate for movement. There should be no movement.

To remove the hub and basket, remove the snap ring

Remove the sprocket and basket with the primary chain

Check inside the basket before reassembly for metal parts on the magnets

The spacer must be on before the snap ring

Check the hub for bad bearings, etc.

On 1990 & earlier Sportsters the sprocket has to come off to remove the transmission

Fuji Clutch – 1990 to Present

Observe the 4 rules for working on the clutch

The Fuji clutch was changed in 1998 so that special tools wouldn't have to be used

There are 2 Snap Rings – an inner and an outer. Never reuse the snap rings. Install sharp side out.

When using the Fuji tool don't remove the inner snap ring

Remove the inner snap ring only to take off the stator

If removing the clutch as a whole, remove the inner snap ring. The center will come out

Don't remove the outer snap ring without using the tool. YOU MUST REMOVE THE OUTER SNAP RING WITH THE TOOL ON.

NEVER REMOVE BOTH SNAP RINGS AT THE SAME TIME

Start with a fiber disk and end with a fiber disk

Turn the nut on the tool ¼ turn at a time until the outer snap ring will come out with a screwdriver. Unload the tool after removing.

Remove the clutch plates. A magnet makes removal easier

The manual shows the shoulder up but it should be installed with the shoulder down (in)

There is a spring plate in the middle of the clutch pack. Inspect it for movement. There should be none.

The first indication of a worn spring plate is having to constantly adjust the clutch.

Loosen the compensator

Take off the clutch hub nut

Take off the Primary Chain Tensioner

Remove the clutch hub & front sprocket with the primary chain, all together

DC Clutch – 1971 – 1984 ½

Must be in 4th gear to work on

It's called the DC clutch because it's only found on Sportsters with generators

It is a wet clutch

The rear wheel must be raised to find the tight spot in the primary chain on XLs

Review the rules for working on clutches

Screw the tool on tight so the threads won't strip out of the case

Remove the 6 retainer nuts

Back the tool center out

Take out the springs and clip

Impact off, torque on

This clutch hub nut has regular threads. It is the only clutch hub nut with right hand threads.

On installation, fully tighten the retainer nuts

It starts with a fiber plate and ends with a fiber plate

The plate that is ½ fiber and ½ steel goes in first

Remove the clutch basket with the primary chain and the sprocket

A small thrust washer should be on the shifter shaft

A gasket should be on the foot peg mount shaft

4 Speed Transmissions

They must come out of the bike to work on

1936 – 1964 was a kick start, total loss system with a tin primary

The first 4 speeds had a jockey shift

In 1952 the first foot shift was introduced

1978 & earlier lids are interchangeable. Foot shifts could be made jockey shifts and vice versa by changing the lid

1979 – 1986 – Ratchet top

1936 – 1978 – Drum top

4 speed gears, left to right, are 4 – 3 – 2 – 1

On FLH, 1st gear ratio is 3:1

On Superglide, 1st gear ratio is 2.45:1 (Taller gear) (Has a groove around center of gear)

Interchangeable with FLH

2nd gear ratio is 1.82:1

3rd gear ratio is 1.23:1

4th gear ratio is 1:1

Andrews makes a 2.44:1 gear

1st and last thing to do when servicing transmission:

Check Shift Fork Alignment

The Shift Fork Alignment Tool must be used. The purpose of the tool is to simulate neutral & get equal space on each side of the shifter forks.

There are 2 different ones:

Round w/ slots – Fits drum top (’78 & earlier)
Square w/ dowels – Fits ratchet top (’79 & later)

2nd thing to check:

Countershaft End Float

Harley Specs - .003" - .012"

Check between the variable thickness washer and the end of the countershaft gear.

Change the end float by different variable thickness washers.

Never use 2 variable thickness washers.

Never exceed .100"

Finger Rollers

Sit on top of shift forks and go into the drum. They should be replaced whenever the transmission is worked on.

Shift Shaft

1975 & earlier – Held in by a set screw on the right side.

1976 & later – A retaining clip on the inside keeps the shift shaft from sliding out. This shaft will fit earlier transmissions.

To adjust shifter forks, shim one side or the other.

There are 2 shim thicknesses: .007" and .014"

Shim the forks so the clutches will have equal engagement

Early Shifter Fork Nuts face out

1979 & later Shifter Fork Nuts face inside

"Out with old, in with new"

Shifter Forks are **NOT** identical and will not interchange among different models.

1974 & earlier – Transmission Push Rod can be pulled

1975 & later – Pulling the Push Rod will pop off the spring clip on the kicker side

Countershaft has 22 bearings on each end for a total of 44

Standard bearing size is .125"

Oversize bearings are available in .0004" increments

Running clearance is .0005" - .001"

3 Different Countershafts

1936 – 1977 (mid) – Threaded on right, O-ring groove on left, & uses loose roller bearings

Mid 1977 – 1978 – Threaded on right, 2 O-ring grooves (one on right is for ID purposes only). .005" smaller in diameter than earlier. Uses cage bearings.

1979 – 1986 – Slot on right, O-ring groove on left, uses cage bearings

Main Drive Gear

Has 44 bearings – Mid 77 & earlier – Loose
After Mid 77 – Cage bearings

Mid 1977 & earlier – Spacer on main drive gear for "L" shaped key. Keeps bearings & spacer going at same speed & keeps the bearings from tilting. Held on by the sprocket.

To loosen any nuts on the transmission, move the clutches to lock up the transmission. (All Harley transmissions)

There is a seal on the outside on the Maingear side. Drill holes to remove. To reinstall, put a spacer into the seal and reinstall as a unit (using special tool)

<u>To Disassemble the Transmission:</u>

Take off the bearing carrier

Hit the end of the mainshaft

1st gear takes the bearing out

2nd gear takes the carrier out

(On 2:45 : 1 gear, 1st gear takes out both)

The clips in front of 3rd gear must come out. Never reuse the clips.

Shifter Clutches

2 different –

1 is between 1st & 2nd. Large & Non Directional

1 is between 3rd & 4th. Small & Directional

Taper (word "High" on genuine H-D) goes to the back, flat to front. If installed wrong the transmission will be hard to get into gear and will pop out of gear easily. Transmission will have to be disassembled to correct.

Mainshafts

3 types –

Shortest – 1964 & earlier, kickstart only, DC Generator

Mid – length – 1965 – 1969 – Electric start, DC Generator

Longest – 1970 – 1984 – Electric start, AC Alternator

Sprockets

1980 & earlier – Sprocket had concave. Concave goes in

1981 & later – Flat. Assisted by washer. Left hand thread. Assemble washer, sprocket, nut.

5 Speed Transmissions

1st year – 1980

Access door on the right side

1980 – 1986 – Fork & Arm

1987 – Present – Ball & Ramp

Can be worked on without removing from the bike

Drain is on the bottom except on Softails. On older Softails the drain is on the access door

Gears, right to left: 4 – 1 – 3 – 2 – 5

1st & last things to check:

Eccentric (shifter pawl)

Must be in 3rd gear to check

Loosen the nut, turn the adjusting screw to get equal space on both sides

Customer's complaint if not in adjustment: Shifts good one way, not good the other way

Eccentric has 2 springs. When spring breaks shifting lever won't return. Transmission must be disassembled to fix.

On Softails, since the oil tank is on top of the lid feel the stops with an allen wrench and set half way between the stops

1988 & earlier – Starter had to come out to get to lid (round starter)

1989 & later – Starter doesn't have to be removed (square starter)

2nd thing to check:

Positioning on shift drum

1980 – mid 1991 – Check for positioning

After mid 1991 – Not necessary. Has dowel pin for neutral indicator instead of casting.

Must be done in neutral. To find neutral look for 3 detents in a row on the shifter drum:

1st, Neutral, 2nd

Also look for neutral indicator

The shift drum is the only thing to shim in 5 speed transmissions, and only for positioning and end float.

Measure with a dial caliper from the edge of the bearing carrier to the center of the shift fork groove (resting on top of the edge of the shims, but not measuring shim).

Should be 1.992" to 2.002".

To adjust take off the clip & use variable thickness washers

3rd thing to check:

Shift drum end float

.003" to .007"

Check between the bearing carrier and the shim. Use a variable thickness washer to change the end float.

There are 3 shifter forks in 5 speed transmissions – 1 for each 2 gears

All face towards the front @ a 45 degree angle

To disassemble, loosen the shifter fork nuts and slide the gears to lock up the transmission.

To take out shift shaft, remove pipe plug on right side – NOT pipe plug on the left side!!

Slide the shift shaft out. NEVER remove from the left side.

In 1987 the pipe plug was discontinued. The shifter shaft was held in place by a casting on the access cover.

5 Speed Gear Ratios

1st – 3.24 : 1 (Andrews makes a 2.94 : 1 gear – "taller"
2nd – 2.21 : 1
3rd – 1.60 : 1
4th – 1.25 : 1
5th – 1 : 1

The difference between the 4 speed and the 5 speed is that the 4 speed 1st gear is lower

Always replace clips, thrust washers, and bearings on any rebuild.

Split bearings are interchangeable – early or late model

There are 2 slider gears on the mainshaft. The slots face towards the access door.

On a 5 speed 2nd gear & 3rd gear are the same gear.

The transmission mainshaft is the longest shaft.

The "dish" shape on the conical washer faces out (towards the access door)

The conical washer with the "lip" goes on the mainshaft

If the remaining gear needs to be removed from the case it can be driven out but the bearing will need to be replaced.

Main Drive Gear Nut – screws onto 5th gear

Left hand thread. If the nut loosens, oil will leak out

The **Inner Race** slides onto the mainshaft. If the bearing freezes up only the inner race is damaged and not the mainshaft.

<u>The back of the Inner Race to the front of the Main Drive Gear should be .100".</u> If it's in too far or out too far the bearing won't be entirely on the race.

The numbers in the Inner Race should face out.

JIMS Inner Race Remover & Installer Tool is necessary for getting into the transmission

Pushrods - Always adjust with transmission in high gear, rear wheel off ground (to turn engine over)

Unless replacing, always reinstall in same position & location

Solid Lifters - Ironhead XL - 1957 - 1985

To adjust, opposite push rod should be at the highest point.

Push rod should spin freely with zero lash (up & down)

Better off a little too loose than too tight.

If push rod moves from side to side at top of travel, tappet blocks are worn.

To remove push rod, loosen locknut & adjust until push rod will come out.

Hydraulic Lifters - Shovelheads - 1966 - 1984 1/2

Each cylinder is adjusted individually.

Push rods to be adjusted are adjusted on the compression stroke (valves closed)

Turn rear wheel until push rod rises (valve open), then falls (valve closed), then "bump" wheel 1/4 turn

Intake & exhaust pushrods to be adjusted should spin freely or engine is not on compression stroke.

These pushrods and lifters are rebuildable.

Remove lifter, hold check ball in to empty oil, push in & turn 1/4 turn left to disassemble.

Reinstall lifter, then push rods, & adjust push rods by turning the nuts 1/4 turn at a time until the distance from the shoulder of the lifter to the top of the lifter is .520".

Lifter can be "preloaded" by putting in clean oil, pushing in on check ball, & letting out to get the .520"

Adjustable Evo - Aftermarket

Adjust 1 cylinder at a time.

Turn rear wheel until push rod rises (valve open), then falls (valve closed), then "bump" wheel 1/4 turn

Zero lash

Use a pitch gauge to determine the number of nut "flats" to adjust, depending on manufacturer

Mark flat on nut with marker to make it easier to count

NEVER TURN ENGINE OVER UNTIL PUSHRODS ARE ADJUSTED & LIFTERS BLED IN THAT CYLINDER!!

If not sure of engine position, put air in spark plug hole & listen to determine where it is escaping from.

If from the carb, the intake valve is still open, if from the exhaust, the exhaust valve is open. Adjust pushrod until air won't blow out.

Adjust 1/4 turn at a time, or turn the nut the total turns needed, but allow time for lifters to bleed.

YOU MUST BE ABLE TO SPIN THE PUSHRODS W/ FINGERS OR
ENGINE DAMAGE WILL OCCUR

Always start adjustment with zero lash.

Evo & Twin Cam - Stock - Non - adjustable

Must remove rocker boxes.

> On rubber mounted FXR, engine must be jacked up, front motor mount removed, & engine lowered to get rear rocker bolt out. 9 bolts hold the rocker boxes on.

Remove by loosening 1/4 turn at a time, from outside in. Otherwise, bolts may snap.

Reassemble by tightening from inside out, 1/4 turn at a time). Push rods will adjust themselves to within .01".

Each cylinder is done individually. Turn rear wheel until engine is on compression stroke, valves closed

Evos have 3 o-rings per push rod tube. Lifter blocks have a thrust washer that goes on under the o-ring.

Stock push rods are good and are light.

Ignitions and Timing

From right side, the engine turns clockwise.

1981 1/2 & earlier - 1 = advance . = TDC

1981 1/2 & later - . = advance 1 = TDC

Timing hole - 7 degrees

1991 XL & Later - Hole on right side

Dot toward rear - advance

Dot toward front - retard

Rear cylinder piston rises first

Front cylinder runs hotter

Engine runs clockwise, cam runs counterclockwise @ 1/2 engine speed

Timing hole - Left side except Sportster - 1991 - moved to right

Some Harleys had **3** timing marks:

1984 & earlier, & 1991 & later

1st mark is always rear cylinder advance

2nd mark is Front Cylinder - full advance & TDC for Rear

3rd is Front Cylinder - TDC

2 marks - first is front cylinder advance
second is front cylinder TDC

When looking in timing hole, left side, if dot is towards front, timing is retarded.

If towards rear, timing is advanced. Runs better more advanced. Retarded timing sounds like carb problems.

Turn backing plate clockwise to advance timing. Counterclockwise to retard timing.

1969 & earlier - Big Twins had distributor

1970 & earlier - XLs had distributor

1970 & later - Big Twin got nose cone, ignitions are interchangeable.
Set plug gap based on type of ignition.

1971 & later - XLs went to nose cone

Distributor –

Clockwise retards

Counterclockwise advances

Advance mechanism is fully open @ 1700 - 2000 rpm

Always runs fully advanced

Timing is always done on front cylinder, full advance

Parts of Advance Mechanism:

Timing screw - Big head, small body - Holds advance mechanism to cam

On bottom @ back of advance mechanism - small roll pin that engages notch on end of cam

Points cam - Small lobe - front cylinder, Wide lobe - rear cylinder

Flat spot on 1 side goes to another roll pin. If put in correctly, it will click, flat spot will be on roll pin, front cylinder compression, small lobe will be pointing towards front of bike. If put in backwards, 180 degrees out, engine won't run.

Use dielectric grease on advance mechanism to prevent rust. They usually rust in the open position.

Advanced timing is the biggest killer of the starter Bendix.

All bikes start in retard position because of slow piston speed.

When setting timing, hit starter, listen for banging. If none is heard, take for test ride.

Listen for pinging. If there is none, everything is fine.

To Set Points:

Front cylinder compression, small lobe facing front, set points for .018" when in middle of lobe. Turn engine over to wide lobe and set for .018" +/- .002".

If gap is too wide - advanced timing

On distributor, if it won't advance to put mark in window:

1) Widen point gap
2) Move 1 tooth

If timing screw is bent, points gap may stay out of spec. Use small punch and brass hammer & tap back to close gap between front & rear cylinders.

<u>Points Ignitions</u>

Blue wire - trigger side of coil

White wire - always hot

Plug gap - .028"

Magneto - .022"

Dwell time - When points are closed (changes with rpm)

Dwell angle - Degrees of crankshaft rotation that points are closed

Saturation - When points are closed & building up voltage in coil

When points open, plugs fire

When voltage jumps a gap, voltage increases

Open points - decrease dwell

Close points - increase dwell

When gap is too narrow, points will burn

When gap is too wide, high speed miss

On dual fire ignition, trigger side is whatever side you want it to be

<u>Prestolite Ignition</u> 1978 1/2 & 1979 - - Electronic ignition w/ mechanical advance
Air gap - .006" +/- .002"

Small cam lobe - front

Wide cam lobe - rear

Set air gap with plastic or brass feeler gauge due to magnetism

Plug gap - .032"

2 white wires

Pink tach wire

Blue trigger wire

If bike won't start (no spark), try disconnecting tach wire

To replace, use **Dyna S** ignition - Works on magnetism, no air gap
ground VOES to frame if not using.

1980 & later - **V Fire** - Automatic - Works on magnetism - starts retarded - can't static time

3 parts: Rotor - Notch goes into cam

Pickup - Turn to advance or retard timing. Preset air gap.

Brain - **Rev limiter so bike won't blow up. Causes engine to misfire every other time.**

Evo - 5200 - 5300 rpm

Twin Cam - 5500 rpm

Twin Cam B - 5300 rpm

0 - 800 rpm - 5 degrees BTDC spark

800 - 1700 rpm - 25 degrees BTDC spark

1700 & up - Full advance (35 degrees)

1991 - From: White White Pink Blue to White White Pink Pink

Module went to 7 - pin connector

1983 XLs - VOES - Vaccuum operated electrical switch

1984 Big Twins - VOES

VOES has 1 job - to retard timing 10 degrees under heavy load to prevent detonation.

If not using, plug up vacuum line & ground wire from module, to the frame.

A VOES hose leak will cause the bike to run lean.

To Check VOES: For light bike - 3 1/2 - 4 1/2 hg (inches of mercury)

large bike - 6 hg

Using digital multimeter, red lead to brain lead, audible setting, black lead to ground wire, vacuum pump to VOES, pump slowly, watch gauge.

VOES is adjustable - screw on top.

2 things to check with vacuum pump:

1) VOES

2) Vacuum of inner primary on shovelhead with dry clutch

3 things that contribute to detonation:

1) Octane

2) Heat

3) Too high compression

If lean in only 1 cylinder, air leak

Low compression in 1 cylinder, push rods too tight

Batteries

32 Amp Hour - 1965 - 1984 FLH

1967 - 1978 XL

22 Amp Hour - FLT

30 Amp Hour - Fuel Injected

19 Amp Hour - 1979 & up XL, FX, FXR, FXD, & Softails

Sun Vat 40 Load Tester

Black to negative, red to positive, green around negative

Set at 3 times the amp hour rating of the battery to be tested, for no more than 15 seconds or until voltage drops to 9.6 VDC

Use Blue Scale to zero & set voltage. Watch bottom scale for reading.

Remove battery from bike – it could explode.

Harley Plugs

Lower number - hotter plug

Higher number - colder plug

When checking coil, infinite reading = open

Points

Front cylinder compression

Remove backing plate

Set point gap for .018"

Go to back lobe and set for .018" +/- .002"

Use modified pliers to turn points cam to left (full advance)

Go to opposite side & check timing mark. Should be slightly advanced on front cylinder

Dyna S

Test light, hooked to trigger side of coil, front cylinder compression.

Put timing mark where it needs to be in window, hold rotor to left to advance.

Anywhere from center to back of hole is OK.

Crane Hi-4 - 1983 rotor must be used because of VOES

To static time, (red LED lights up)

TDC compression, front cylinder
Turn clockwise until LED goes off

Anytime there are 2 pickups, it's single fire. 1 pickup - dual fire.

To bypass VOES, set to RACE ONLY.

Red wire - center lug on coil w/ white wires from orig. coil

White wire - Rear cylinder on coil

Black wire - Front cylinder on coil

Brown - Tach

Green - VOES (If not used, just tape wire up)

V-Fire - Hook up tach (must be timed Dynamically)

Idle @ 1700 - 2000 rpm

Using inductive timing light, clamp on front plug wire, & holding light at angle to avoid glare, loosen backing plate and turn until mark is in window.

Electrics

1965 - 1st year of electric start on Big Twin

1967 - 1st year of electric start on XL

1981 - Sportster got square starter - Nippon Denso

1989- Big Twin got square starter - Nippon Denso, & inner primary design was changed

On 1989 & up Big Twins - Solid mount bikes are rotor friendly

All rubber mounted bikes are rotor friendly

1988 & earlier - Inner primary had to be removed on solid mount bikes to change rotor

Starter Systems:

Battery is power

Starter motor - 1 post for wire

Starter relay - Necessary for stepped down wire size

Solenoid - 3 posts :

Longest - Battery

Next - Starter motor

Shortest - Relay

On older bikes, pulling out the Bendix energizes the solenoid.

The copper washer that energizes can weld itself & keep the starter motor turning if the battery is weak.

2 Functions of Solenoid:

Electrical - To connect battery to starter

Mechanical - To throw Bendix into ring gear

Starter Relay has 3 posts:

Battery - Standing voltage

Starter Button - Message in from the switch

Solenoid - Message out to Starter

2 Posts on Generator - Armature & Field

If battery isn't charging:

Generator Residual magnetism Test

Check battery standing voltage

Remove wires from generator

Red lead to "A" post

Black lead to Ground

At 2000 rpm, should have 1 - 3 VDC

If no residual magnetism:

Add jumper to "F" post from any ground

Run at 2000 rpm. Should have 25 - 30 VDC or until 10 seconds have passed, whichever comes first.

After 10 seconds coil turns to magnet and burns out.

Polarizing Generator:

In bike: Positive lead to "A" terminal

Flash with jumper from ground to "F" terminal

Out of bike: Positive to "A" terminal

Flash "F" post with ground

When rebuilding Generator, don't have to polarize unless needed

Generator is electromagnetic - magnetism only when engine is running

Load Charge Indicator (Idiot Light)

When Generator is charging, it's not grounded & light goes off

"A" Post to light (always has brown wire)

Light to switch

Switch to battery

Armature Testing:

Short - Use Growler and hacksaw blade - test for magnetism.
A short will still charge but at a decreased rate.

Ground - Using 110 VAC w/ light, test copper to bare metal. Check for continuity.

If light comes on - continuity. Continuity is bad. Infinity is good.

Open - Copper to copper - Light goes off. Continuity is good. Infinity is bad.

Use 110 VAC because electricity will jump a gap causing smoke and spark.

Mica cut on armature should be .025" or deeper. Too shallow-cut deeper w/ hacksaw blade.

Field Coils:

Can be checked for:

Shorts - Post to post with meter - 4 - 7 ohms. Anything less than required resistance is bad.

Opens - Post to post with meter - if you get a reading there is no open. Any reading on short test - no open

Grounds - Post to base metal (ground) - Infinity is good. Continuity is bad.

Test Generator output out of bike by putting double nuts on end of shaft, put in drill, and run in reverse.

Do output test. 3 - 7 VDC - Good

3 Types of Relays - See handout - All are interchangeable and must be grounded

Delco - Remy (Chevy)

Prestolite - Round

Bosch - Small square

1966 - 1969 - Pan/Shovel - Generator

1970 - 1st Alternator on Big Twin

1984 1/2 - 1st Alternator on Sportster

All Alternator Charging Systems are interchangeable

1970 - 1975 - Day/Night Charging System

Better rotor - Magnets were screwed in cages, splined, deeper

Checking Stator - Always check before installing

Check Battery First!!

Regulator should have no voltage in plug going to Stator or there is a bad diode.

Don't connect or disconnect stator with bike running.

Zero meter. Set on Ohms. If digital meter, hold leads together until the number goes down. Always subtract that number from any reading.

Short test - Pin to pin. Anything less than required resistance is no good.

Ground - Any pin to base metal. Infinity is good. Continuity is bad. Infinity is good.

Ground - Trash it

Output Test - Meter on 500 VDC. Pin to pin. Run at 2000 rpm. Reading as below. If no reading, bad.

Big Twins

'70 - '75 4 pins 40 Volts 1000 RPM 13 Amps Day/Nite Charging

'76 - '81E 2 male pins 19-26 VAC 1000 RPM 17 - 22 Amp .2 - .4 ohms

'81L - 88 2 female pins 19-26 VAC 1000 RPM 17 - 22 Amp .2 - .4 ohms

'89 - '95 2 female pins 16-20 VAC 1000 RPM 32 Amp .1 - .2 ohms

'95 - '98 2 female pins 16-20 VAC 1000 RPM 38 Amp < .5 ohms (Low Output)

'97 - '99 2 female pins 19-26 VAC 1000 RPM 45 Amp <.5 ohms (High Output, EFI)

Sportsters

'84 1/2 - '90 2 female pins (under tranny) 12 - 18 VAC 1000 RPM 19 - 23 Amp .2 - .4 Ohms

'91 - Present 2 female pins (right down tube) 19 - 26 VAC 1000 RPM 19 - 23 Amp .2 - .4 Ohms

Last test - Test Regulator

Use test light. Clip wire on fin. Pierce Battery Charging Lead as close to the Regulator as possible.

If tester lights, Regulator is Bad.

Ground test - Clip wire on fin. Go to positive side of battery. Tester should light.

If not, broken wire or bad ground.

Alternators are better than Generators because:

Less maintenance

Less moving parts

Higher output

Less noise

Better ground clearance

If battery goes dead on Points ignition system, problem could be that kill switch or diode allowed current to drain to ground when engine isn't running.

Milliamp test - Done with key off - Dressers w/ radios, etc. Hook up meter. Unhook all components, 1 by 1 (at fuse block is okay) to isolate circuits. Look for current drop.

If the Stator has output but not enough, check the compensator nut.

Some models had no crankshaft spline and could spin.

Starter Draw Test (Last thing to do to determine if starter needs to be removed)

Use VAT 40 Load Tester

Put green lead on starter cable with arrow of green lead pointing away from starter

Use Red scale, zero meter. Hit starter button, needle will spike and then level out. Take level reading.

1988 and earlier - Round starter - If it draws more than 120 amps, starter must be removed.

1989 and later Big Twins & 1981 and later XLs - Square starter - If it draws more than 150 amps, starter must be removed.

Carburetors

1) **Linkert** - Model M - Used on Harleys & Indians. No jets.
Has holes that "dump" gas.

Vertical throttle disc. Last yr - 1964. Better carb than model DC

Model DC - Used on Big Twins & XLs. Used on last Panhead (1965) and first Shovelhead (1966). Not as good as the Model M.

2) **Tillotson** - 1967 - 1st carb with an accelerator pump.

1967 - 1970 - Big Twin

1967 - 1971 - XL. XR - 1000 had 2 carbs.

Synchronize with vacuum test.

No float bowl. Diaphragm works on vacuum. (Wall of Death riders use)

Do a vacuum test to check the diaphragm.

Nicknamed "Pumper"

3) **Bendix** - 1971 - 1978 1/2 - Big Twin

1972 - 1976 1/2 - XL

Rubber O-ring on the main jet. If the O-ring is bad or missing, the bike will idle, but will die upon acceleration.

Used a leather plunger for an accelerator pump.

Lube with Vaseline.

Some plungers are adjustable (they have 3 holes instead of 1) to "shoot" more or less gas.

The Bendix has a lot of flat spots - not a very good carb.

4) **Keihen** - Fixed Venturi

1976 1/2 - 1987 - XL - 3 models

1978 1/2 - 1989 - Big Twin - 2 models

How To Identify:

Early model - 1976 1/2 - 1978 1/2 –

Adjustable fuel screw

One choke mechanism

Single pull throttle lever

4 midrange holes in straight line

Rubber diaphragm

No plunger

Accelerator pump

Mid model - 1978 1/2 - 1982 - XL

1978 1/2 - 1983 - Big Twin

Non - adjustable fuel screw

Single pull throttle linkage

Double linkage choke with high idle cam

4 midrange holes in diamond pattern - works better, better bottom end

Check ball in float ball - can stick open or closed

Notch in choke plate - fuel must shoot through it

If Accelerator pump isn't working, bike dies on acceleration.

Late model - best of the 3

1983 - 1987 - XL

1984 - 1989 - Big Twin

First year of VOES on both bikes

Non - adjustable fuel screw

Push / pull throttle linkage

Double linkage choke with high idle cam

Tall, skinny sprayer

5 midrange holes

5) **CV Carb** - Keihen Constant velocity

1988 - Present

No accelerator pump on 1988 XLs

1989 - XL got CV with accelerator pump

1990 - Big Twin got CV with accelerator pump

Carb is made by Honda. Very good carb.

Only 1 adjustment - Idle adjustment screw

If the diaphragm has a hole in it, top speed will be about 70 mph.

6) **Dellorto Carb** - 1979 - 1985 XL –

Covered in the section of the Service Manual for the XR 1000 - 1983 & 1984

The bottom of a carburetor and the top of the float should be at the same level.

The best way to know how a carb is doing is to "read" the spark plugs –

Slow jet or Pilot jet – center of plug (electrode).

Main jet - outside part of plug.

Turning the fuel screw in slows fuel delivery.

Spray contact cleaner on the intake to check for leaks.

If the idle drops slowly, there is a big leak.

If the idle goes up, there is a small leak.

To put a newer CV on an Ironhead or Shovelhead, take out the pilot jet, fit the hole with a snug fitting jet drill bit, then drill out the jet with the next bigger drill bit.

Continue to drill bigger, one size at a time, until the bike stops "sneezing". (The reason is that the CV carb runs leaner). Use a pin vise to hold the jet drill bit, and use a Mikuni adapter to mount to the manifold.

Signs that the bike is running **lean** at low throttle opening –

Surging,
sneezing through carb,
popping,
running hot,
running better with the choke out,
backfire on deceleration,
cold natured.

Signs that the bike is running **lean** at wide open throttle –

Picks up speed when letting off throttle,
runs better with choke out,
runs hot.

Signs that the bike is running **rich** at low throttle opening –

Fouled plugs,
black smoke,
starts easy without the choke,
runs bad when warm.

Signs that the bike is running **rich** at wide open throttle –

Fouled plugs,
poor gas mileage,
runs cold

Causes of **rich** condition at Low Throttle Opening:

Slow jet too big
Fuel screw out too far
Enrichener not in all the way
Float level too high

Causes of **rich** condition at Wide Open Throttle:
Main jet too big
Restricted air filter
Partially closed choke
Elevation change

Causes of **lean** condition at Low Throttle Opening:
Air Leak
Fuel screw turned in too far
Plugged passageways
Midrange too small
Push rods too tight
Retarded timing

Causes of **lean** condition at Wide Open Throttle:
Main jet clogged, or too small
Clogged petcock
Pinched fuel line
Clogged fuel filter
Float level too low
Atmospheric vents (on carb & tank) clogged
Elevation change
Modified air filter
Push rods too tight
Retarded timing

Harleys have unique carb problems because of Erratic Intake Signal –

the same amount of fuel is not delivered to each cylinder

Worst thing with high fuel level - Fire & Death

Worst thing with low fuel level - Seized engine causing rear wheel lockup – Death

Fuel Injection

First year - 1995

1995 & 1996 - Couldn't adjust

1997 - Adjustable

2000 - Softails went to Delphi System - Uses a laptop computer & phone link to H-D

2001 - Everything else went to Delphi System

Scanalyzer - Plugs into **Data Link** (Gray) - Only place to plug it in. When key is turned on, you hear the fuel pump pressurize to apx. 43 psi. The "Check Engine" light will come on for about 4 seconds and then go off. If the light comes back on, there is a problem. (Don't run out of fuel while hooked up)

Scanalyzer Functions:

System ID - Tells what chip is installed

Trouble Codes - Menu - Display current, Display Historic, Clear History

Data Monitor - RPM,
Idle Speed Control (ISC),
Engine Temperature (ET),
Intake Air
Temperature (IAT),
Throttle Position Sensor (TPS),
Injector Pulse Width in milliseconds (INJPW),
Advance,
Barometric Sensor (Baro Sensor)

Active Diagnostics:

Fuel Pump,
Front Injector,
Rear Injector,
Front Coil,
Rear Coil,
Tachometer

If the front injector is checked and run for a long time, or if the throttle is twisted more than once or twice, DON'T CHECK COIL!!!! It can explode!

If a Scanalyzer isn't available, the key can be turned on, then off, then on again.

The **Check Engine light** should blink fast, then blink slow to give the Trouble Code.

The **Breakout Box** plugs into the top of the ECM & diagnoses circuits without having to probe or remove parts.

The fuel pump on a fuel injected bike is mounted on an **isopod** in the fuel tank, so it can be easily removed and installed. Unused fuel is pumped back into the tank at apx. 3 psi.

Barometric sensor - Can be tested with a vacuum guage (test the diaphragm)

All EFI bikes have single fire ignition.

The sensor plate can't be turned to do the timing.

1999 & later - No timing hole - everything is done with Scanalyzer

The **Cam Sensor Plate** has a small switch –

Vehicle Attitude Sensor (VAS)- shuts bike off if leaned over to 80 degrees.

Carb. bikes have a **Bank Angle Sensor** (BAS) on the left side of the bike, that shuts the bike off if leaned over to 55 degrees.

3 Main Sensors:

Crank Position Sensor - Monitors the flywheel. 32 teeth. 2 teeth missing at TDC

Cam Position Sensor - After 2000, no more cam position sensor

Throttle Position Sensor

Fuel Injected bikes use the **High Output Charging System**: 45 amps, 30 amp hour battery, earth magnets, charges at idle

Valve Spring Tester

Checks for Pressure at Installed Height
Measure Valve Spring Free Length off the tips of the spring, not right on the tips

On the Spring Tester, ¼ turn = 1/64" (16 TPI)
Start with Zero pointing at the 1" mark
The clicker goes off at actual height
Set for desired height, put the spring on, and use the torque wrench.
Whatever the reading is on the torque wrench, double it for the actual reading

Check valve springs for:
- Free Length
- Spring Pressure

Valve Spring installed height doesn't depend on the spring. Changing the spring doesn't affect the installed height.

Installed Height: Top of the bottom retainer to bottom of top retainer.

To correct for Excessive Installed Height: Shim the lower spring retainer if the valve stem protrusion is within limit.

Valve Stem Protrusion – How far the valve protrudes from the cylinder head surface to the top of the valve stem.

Wear limit – The point beyond which the component is no longer serviceable.

If valve stem protrusion is out of the wear limit, it may be because of a worn out valve seat or the head or valve has been refaced too many times.

Sometimes a new valve can get valve protrusion back into spec. Another option is a valve with a larger head.

A sunk valve seat is bad.

To correct Valve Stem Protrusion:
- Use a valve with a bigger head (bigger valve)
- New seat
- Use a service valve - .030" shorter – EVO engines only!!

To correct excessive spring installed height:
- Use shims
- Bigger valves
- New seats
- Service valve

The Valve Seat is not a part of the head. It has .006" - .007" cold interference fit.

Twin Cam Exhaust Valve has a dimple in the center of the valve to distinguish from an Evo valve.

Valve Guide Seals – The last thing to do on a Valve job
- Lube the valve stem
- Put plastic tube on the stem
- The valve seal installation tool registers against the lower retainer

Every time the valve comes out a new valve seal must be installed

3 Critical Things for Assembly
- Clean
- Lubricate
- Torque

For Evo & Twin Cam exhaust valve protrusion measurement, use the long end of the dial caliper

Rocker Arm Bushings
- 2 types:
  - Steel
  - Brass
- Either will work equally well

Remove, install, and ream one bushing at time to avoid loss of alignment between the 2 bushings.

Take an old 5/8 X 11 tap & thread into the rocker arm bushing to be replaced, 4 or 5 turns. Turn the rocker arm over & knock the bushing & tap out at the same time.

On non-Evo or Twin Cams, line up the oil hole in the bushing with the oil hole in the rocker arm, or if there is no hole in the bushing, drill a 3/32" hole**. Evo & Twin Cam** oil holes don't go into bushing.

Use a solid pilot reamer to ream the rocker arm bushing. Use cutting oil! Don't ream dry, turn backwards or force!!

Seat the new bushing flush, then ream, then use ball hone.

It's important to change the rocker arm bushing, if worn. Excessive rocker arm shaft-to-bushing clearance causes overoiling of the top end, and smoke.

Valve Guides

Use the special JIMS tool to change in Evo & Twin Cam engines. (Order apx. 6 extra shafts)

Put Anti-Seize on the bottom of the guide so it won't seize or gall on installation. Oil the threads on the tool and on the wafer bearing.

Heat the head to 250 degrees F before knocking the old valve guide out.

Install the new guide until it stops.

Ironhead & shovelhead guides are shouldered and don't use the same tool to install.

If the new guide snags when installing, remove and go down 1 size.

The valve guide should be .002" to .004" bigger than the hole that it's going into, at room temperature.

Never change valve guides cold! Always heat the head up.

Valve guides should be marked for size, but some aren't. If there are grooves in the guide, each groove is .001".

Too much valve stem – to – guide clearance causes oil to run into the head. The engine will smoke.

Valve guides wear mostly on bottom or top. If the guide is tight in the middle, loose on the ends replace the guides.

Valve guides are Bronze or Cast Iron.

Valves are either hard chrome, carbonized or titanium nitride.

On pre-Evos, freeze the guides to help installation.

When using the valve guide reamer, use cutting oil.

Always use a ball hone on Evo & Twin Cam engines to finish-size the valve guides after reaming.

Wrist Pin Removal Tool – All-thread with a nut on the end ground to fit into the wrist pin hole on the piston. Put PVC on the other side to avoid damage to the piston. Tighten the nut against the PVC to pull the wrist pin out. Don't drive it out!!

An arrow on a **Piston** indicates that it is a directional piston. Always mark pistons and reinstall in the same position. The arrow always faces the front.

Torque Plates must be used on Evos and Twin Cams to:

Bore
Measure
Hone

Use old head or base gaskets with torque plates.

3 reasons why pistons are directional:

One valve relief is bigger than the other. The bigger relief goes towards the intake valve.

Skirt shape. The notch goes towards the other piston.

Wrist pin location. It is sometimes offset towards the thrust side to reduce the tendency of the piston to rock in the bore at TDC and at BDC.

If the word MAHLE is inside the piston, look for a direction lug. The lug goes to the left or clutch side.

If there is a letter on an EVO piston, it indicates the wrist pin.
If there is a number on an EVO piston, it indicates the grade.

Wrist Pin Lock Styles

There were 4 different wrist pin lock styles since 1930.

"Horse collar" lock – Fits in wrist pin. Used in HD through 1972

Spiral Lock – 1973 – 1977

Snap Ring – 1977 – 1982. Directional – sharp edge faces out towards you and away from the wrist pin. A spiral lock can be used in any piston that originally used a snap ring, but a snap ring can't be used in a spiral lock piston. The open ends of snap rings must be at 6 or 12 o'clock.

Round Wire "C" clip – Used when H-D went to moly pistons. 1983 – Present. Can't interchange with any other lock because of the shape of the groove. Twin Cams use a larger C-Clip.

Piston Rings

Normal ring side clearance is .001" or less. If .005" - .006", replace.

The purpose of the 3 piece oil control ring is to let oil back into the bottom end.

The 2nd ring is usually directional.

If the top ring has a bevel, the bevel faces up. The top ring is the compression ring.

If the 2nd ring has a bevel, the bevel usually faces down.

Ring End Gap - .010" to .020" - .030" max!!

.003" to .004" of ring gap per inch of cylinder bore.

Cylinder Studs, Head Bolts, and Nuts

Everything on the top end is hardened on EVOs and Twin Cams

Several styles of cylinder studs in EVOs

84 ½ - 85 – Male thread on bottom, female on top, 3/8 X 16 TPI
L 85 – E87 - Double male stud – short end goes down – uses head nut & washer
M87 – 90 – Double male thread with shoulder on top
91 – Double male thread – shoulder on bottom

The only style cylinder stud available now is the "-85C" used in all Evos and Twin Cams

Late studs can be used on any case that used double male threads.

If replacing 84 – 85 studs that had female ends, heads must be drilled out to fit and head nuts must be used.

On 2nd Generation Head Nuts, a washer is part of it.

Late '92 – Head casting is thicker on the shoulder side & the nut is longer. The head is marked "92".

The same fasteners are used on Evos and on Twin Cams.

If later style heads are used on early evos, longer head nuts must be used.

Torquing Heads

To torque heads on Evos & Twin Cams, torque in an "N" pattern in 3 stages –

7 ft./lbs.
14 ft./lbs
¼ turns (90 degrees)

Per Bruce – 43 ft/lbs

Make sure threads are clean. Oil the threads and the washer/shoulder of head bolts / nuts

DO NOT OVER TORQUE!!

If overtorqued, studs WILL come out of the cases.

Replace studs if they have any marks, dings, etc.

To remove old studs that are stuck, spot heat the case around the stud with a propane torch.

To install, use a 5/16" steel ball as an installation tool. Put the ball into the head nut and thread the nut onto the stud. Thread the stud into the case. DON'T BEND! Torque to 10 ft./lbs.

Evo & Twin Cam Cylinders

Both are cast aluminum with cast in liner.

Cylinders are interchangeable front to rear

Mark the cylinder to put back in the same place

Twin Cam uses an O-ring instead of base gaskets

The blue ring on Evo gaskets faces down on base cylinder gaskets

All H-D cylinders are parallel bored with 280 – 320 grit stone. Then use 240 ball hone

Rocker Arms

Mirror image – Must use 2 of each part number

Evos and Twin Cams use the same rocker assembly

Rocker Arm ratios:

1.43:1 – Ironheads & Shovels
1.6:1 – Evos & Twin Cams

Rocker arms wear out, mostly on the pad where it contacts the valve stem.

In Shovels, make sure the oil hole in the bushing and the oil hole in the rocker arms are aligned or drill the oil hole out – 3/32”

Evos & Twin Cams oil the top end through the pushrods
In Shovels, oil drains through the push rods

Evo & Twin Cam rocker shafts are a piece of drill rod

Rocker Arm endplay:
Evo: .003” - .035” If end play is excessive, replace the rocker arm or the carrier
Shovels: .005” - .025” Can be repaired. Use 7/8 X 45 degree router countersink.
Bore to get the endplay into spec. .010” to .012” is desired.

Rocker Arm Shafts – Shovelheads
Early – End cap had 2 bearing surfaces
Late – End cap had 3 bearing surfaces

Field expedient repair for a leaky shovel rocker arm shaft – Cut a spiral lock in half, put on the shaft, put an 0-ring over it and tighten it up.

On a Shovel, put the rocker shaft in first, then the o-ring, then the cap.

Valves & Guides

Harley used steel guides up to 1979 in Big Twins and up to 1982 in XLs – "carpenter steel valve guides"

You can't use steel valve guides anymore due to unleaded gas

Bronze and cast iron are used now and require a different valve stem material

You must use valves that are:

Hard Chrome
Carbonized – a form of case hardening
Titanium Nitride coated

If hard valve guides are to be used, use soft stem valves
If hard stem valves are to be used, use soft valve guides

When inspecting valves, check stem condition for wear damage at the keeper grooves
Check the valve stem tips.

5 major parts of the valve: Head
Margin
Face
Neck
Stem

2 minor parts of the valve: Keeper grooves
Stem tip

Valve stem should be straight to within .002"

H-D used valve seals since 1981

Old exhaust valve guides were knurled internally to hold oil in the guide and lubricate the valve stem.

The function of the bevel on top of the guides is to deflect oil – old valve guides didn't use seals

Always use assembly lube on valve stems

NEVER USE GREASE AS AN ASSEMBLY LUBE – If you need something to hold a part in place, use Vaseline

SGCC & SCCD are good oils to use

Twin Cam Rocker Boxes

The Rocker Box gasket is directional.

The covers aren't stressed on Twin Cams – won't leak

The Rocker Arm carrier is held on with 4 5/16X18 cap screws

Long, black pushrods are exhaust. Both are the same. Both intake are the same.

Rocker arm cover is held on with 6 double hex nuts.

Big Twin Upper End

Shovelhead cylinder is one piece cast iron. It's not sleeved, but can be sleeved.

Shovelhead cylinders always have an oil drainback passage hole in the bottom of the cylinder.

Use an interference fit to sleeve Shovel cylinders. .001" - .0015". It's cheaper to just get new cylinders.

Shovelhead front and rear cylinders are different:

Rear – 2 wide gasket surfaces and 2 narrow gasket surfaces
Front – 4 narrow gasket surfaces

The notches on the bottom of the shovel cylinders face each other

Early Cylinder – 1966 to early 1978
Late Cylinder – Late 1978 to 1984 ½ / 1985

Early has "-66" part number on the base, a thin base flange and 10 fins
Late has "-78" part number on the base, a much thicker base flange and 9 fins
Early & late ARE interchangeable
80" OHV was introduced in 1978
74" has 3 7/16" bore & 3 31/32" stroke
80" has 3 ½" bore & 4 ¼" stroke

Pistons are different between 74" & 80 "

To use an 80" cylinder on a 74" engine, use a .060"-over 74" piston. The 80" piston is shorter on the top and bottom and will cause extremely low compression if used in a 74" engine.

Base Nuts – Shovel

Early - 7/16 X 20 w/ 5/8 hex head – "high nut"
Later – Same threads, but has 9/16" hex head and integral washer. Uses a triangular washer

Only use the early nut on early jugs. The late nut can be used on early or late jugs.

1948 – e1978 – Same headbolt with a separate washer.
Later – Integral washer

All interchange. 60 – 65 ft./lbs. Torque

14 mm "S" wrench needed to remove rounded shovel headbolts. Use 9/16" Dogbone to torque.

Shovels all have a **spigot** on top of the jug that fits into the head. The head has a corresponding counter-bore. If the spigot is too high, it will leak oil. Use a file or belt sander to lower.

Big Twin Single Cam
Evo Cams won't work in a Shovel

Shovel – 70 – e77 – Cam has smooth gear face & the letter "H" on the front lobe
L77 – e82 – Shape of teeth changed to reduce noise. Big groove machined in gear face. Letter "H" on front lobe
L82 – end of prod. – Big groove on gear face. Letter "S" on front lobe

Evo - 84 ½ - 86 – Single groove in gear face. Letter "V" on front lobe.
87 – 89 – Single groove in gear face. Letter "L" on front lobe.
90 – e92 – 2 grooves on face. Changed gear tooth shape. Letter "L" on front lobe. Won't work on earlier evo. Noise reduction change.
L92 – Present – Final change. Letter "N" on front lobe. 2 grooves in gear face

2 other Evo cams that weren't common:

"O" Cam – 1995 – Factory Fuel Injection. 2 grooves in the gearface.
"C" Cam – California cam. Single groove or double groove versions.

V,L,C, 2 groove L, O, N

Things to check on a cam:

Lobe condition
Lobe dimension – measure heel to toe. Look for shorter lobes - .005" - .006" wear
Bearing surface condition
Bearing surface dimension

95% of catastrophic engine failures are caused by tappet roller failure or cam failure

Cams are usually damaged because of not enough endplay. The result is that the thrust plate is burned down, and the bearing is ruined and sometimes welded.

The cam thrust plate is not variable thickness, but aftermarket thrust washers are available in various thicknesses. They can't be "ordered" in various thicknesses. They have to be measured. H-D part is always 1/16". Look for some that are .045".

The cam thrust plate goes beside the bearing but was not intended to allow adjusting endplay. Cam shims are used to adjust end play. Cam shims are variable thickness.
1936 – 1986

Thrust plates have been used since 1958 when H-D went to needle bearings.

Cams should measure 3.030" to 3.035" from gear face to shoulder.

1987 & later – Cam is longer – 3.070" to 3.080" apx. End play washer was eliminated.

Use end play washer on any cam, whether short or long, if needed.

Cam Endplay

Remove tappet block & measure between the end of the cam & the thrust plate.

On assembly start with the thrust washer if used. Install the cam cover with a new gasket. Torque to spec. Then measure the endplay with a feeler gauge. It should be .001" to .016". (Never let a bike leave with less than .005") Long cam with no washer - .001" to .050".

It's not advisable to NOT torque the timing cover before measuring end play. The gasket thickness WILL change end play!!

Cam thrust washers interchange on all Evos.

Tappet Rollers

In early engines, the rollers are replaceable.

3 Reasons to replace:
- Radial clearance
- Surface damage on roller
- Roller end clearance (.015" to .020")

The cam turns at ½ of pinion gear rpm.

The timing cover has bushings for cam and pinion shaft. Condition of pinion shaft bushing is important because all oil in the lower end goes down the pinion shaft. There are drillways in the flywheel, pinion shaft, and crankshaft to get oil to the rod bearings. There is an oil passage in the timing cover that comes out in the pinion shaft and feeds the bottom end. If there is too much clearance between the pinion shaft and the bushing, oil will spray out.

New pinion shaft – to – bushing clearance is .001" or less. Wear limit is .004" apx.

Excessive pinion shaft – to – bushing clearance results in not enough oil going to the bottom end.

The ignition drives off the end of the cam. Excessive clearance between the cam and bushing results in:
- Erratic ignition timing
- Erratic idle
- Oil in the ignition cavity of the nosecone

Cam – to – bushing clearance should be .004" apx.

Always measure bushings before reassembly

Always pin the cam bushing when changing it, whether originally pinned or not, and ream after pinning because pinning distorts the bushing.

Install order:
- Remove
- Install
- Pin
- Ream

Gears on Cams & Pinion Gears

There are a variety of sizes, color coded.
Biggest: Black
Smallest: Orange
.003" difference

Too tight mesh between cam and pinion = whine
Too lose mesh between cam and pinion = rattle

The easiest way to sidestep these problems is to press the gear off the old cam and install on the new one, OR

Measure the gear on the old cam and the gear on the new cam and compare.

Use gauge pins to measure:
Put rubber band around the gear teeth
Put gauge pins 180 degrees apart
Zero the micrometer
Measure across the pins
Compare the measurements with the manual to get within specifications

Use 105 gauge pins for no-groove or 1-groove cams
Use 108 gauge pins for 2-groove cams

To insure removal & installation of the gear in the same position on the cam, mark around the shaft cutout with a Magic Marker or Prussian Blue. Scratch 2 lines for realignment.

Timing Cover

Remove with a special tool from V-Twin, Jims, etc.

Breather Gear End Play

Install a variable thickness washer
Use a new gasket
Lay a straightedge horizontally across the new gasket and measure between the straightedge and the washer with a feeler gauge
Subtract .006" for gasket compression
.001" - .016" is spec

To Remove Pinion Gear:

1954 – 1992: Must have a 2-sided left hand thread nut
Late 1992 & up: Regular right hand thread hex nut
Use a Pinion Gear Puller to pull the pinion gear
Tap the back of the woodruff key to get the front of the key up, then pull the key, spacer, and oil pump drive gear

Oil Pump Drive Gear

The oil pump drive gear is directional. One side is beveled. The bevel faces in towards the crankcase.

Pinion Shaft Installation

The pinion shaft must be clean, dry, and free of grease when reassembling

Pinion Shaft Assembly

<u>Oil pump drive gear</u> – 2 types:
- 5 tooth
- 6 tooth

Each had a different corresponding gear on the oil pump:
- Pre ’73 – 5 teeth on drive, 25 teeth on driven – 5:1 ratio
- 1973 & later – Shovels & Evos – 6 teeth on drive, 24 teeth on driven – 4:1 ratio

When installing aftermarket or late style oil pump on early engine, install the 4:1 drive gear set.

To count the teeth on a worm gear, count where they begin or end.

DON’T INTERCHANGE BETWEEN DRIVES!!

Install the drive gear with the bevel towards the crankcase. Then, install the spacer, then the pinion gear, and then the left hand thread nut. After torquing insure that the spacer will still move.

The taper must be clean and dry or the gear WILL crack when torquing.

Use Blue Loctite

On early engines, the pinion gear was changed:

- Late ’77 – 89 – Short teeth
- ’54 – Early ’77 – Long teeth

The taper on the shafts is the same, but the teeth must be matched to the cam.

No-groove cams use long-tooth gear – ’54 to E77
One-groove cams use short-tooth gear –L77 to 89

The late pinion shaft isn’t hardened. IT WILL BEND! If bent, a new flywheel half will have to be bought.

Pinion Shaft Gear Sets

Evo engines had 2 styles

Through 89 – Tapered pinion shaft
’90 and later – Pinion shaft is cast into the flywheel. The bearing race is pressed on. If the race is bad, send the flywheel half to Harley. 1 piece shaft, 1 woodruff key.

1990 – E92 – Oil pump drive, then woodruff key, then spacer, then pinion gear, then left hand thread nut. No taper on 1990 and later. An early style nut cannot be used on ’90 – ’92 Evos

L’92 – Present – Longer shoulder on the oil pump drive gear and the pinion gear. No spacer. Right hand thread nut. Can’t interchange with earlier models

Breather Gears

Knuckles & early Pans – Washer made as part of the gear
Late Pans – through early ’77 – Steel endplay washer. Straight timing mark
Late ’77 – ’79 – Timing mark in shape of a “T” with a small center pin. “T” indicates late style tooth shape.
1980 – E’82 – Bigger center pin and the “T” shape timing mark
L82 – E86 – Plastic. 14 slots, 2 holes
Mid 86 – E92 – 12 slot, 2 holes. Interchangeable with 14 slot gear
L92 to present – 12 slot, no holes. Will only work in umbrella valve engines.

All can use high quality plastic washers, but plastic gear can’t use the metal washer. The metal gear can use the plastic washer.

<u>Excessive Breather Gear Endplay</u> causes:
Overoiling of the bottom end
Improper scavenging
Oil blowing out of the crankcase vent

Cylinder Parallel Hone

Also called Rigid Hone

Sunnen & Aamco are 2 manufacturers

There are 4 parts to the assembly. When they are used or worn out, throw them away and replace all 4 parts as an assembly.

Teeth on the shaft face the center so the pinion gear can drive

The assembly consists of 2 stones on 2 sides and 2 guides on 2 sides.

There is a coarse and a fine adjustment

Start at the base of the cylinder

Honing is hard on drill motors!! Use a good one!!

Lube the cylinder with parts cleaner or WD40. Don't use oil!!

Rotate slow and stroke fast. This determines the crosshatch. 45 – 60 degrees is desired.

As the hone loosens, tighten.

120 strokes per minute apx.

Keep hone snug but not so tight that you can't hang onto the drill

To avoid taper, alternate cylinder ends after every 25-30 strokes.

Use Torque Plates with Evo and Twin Cam cylinders

Make a plate to use with Shovels, etc. to enable you to put the cylinder in a vise. Don't clamp onto the cylinder base!!

A piece can be fabricated to prevent the hone from going out the opposite end too far.

Use a 280 – 320 stone, then a 240 ball hone

This makes for easier ring seating

Faster rotation isn't necessary and only wears out the stones faster. Use a slower speed.

Tappet Blocks – Shovelheads

2 styles:

Mid 50s to 1977

Uses countersunk head screws
Usually marked “Front” or “Rear”. Not interchangeable front to rear.
Most are cast iron. Oil passage feeds oil to the hydraulic lifters.
Use ¼ X 24 TPI screws through 1977

1978 to Early 1984

Flat base, not countersunk
¼ X 20 TPI screws
Aftermarket tappet blocks come with 2 sets of screws

Tappet blocks wear out! If they look bad, they are!!

Clearance is .008” max. between the tappet and the block

Tappets - Shovelhead

Tappets are directional – the flat and the hole face towards each other across the center of the tappet block.

If installed wrong, they won’t pump up

The roller assembly can be replaced

Always inspect tappets! If any are bad, they can be replaced individually without replacing them all.

Late ’82 – Quick fill lifter. Identified by heavier spring. Interchanges

Lifters can be cleaned and tested buy only do 1 at a time. Wash out with brake cleaner so it can be shaken and you can hear the check ball. Once clean and dry, hold it down for 10 seconds. It should pop back up, but on new lifters it won’t.

Use motor oil or assembly lube when reassembling

Don’t use metal to push on the check ball. Use a plastic straw, etc.

To reassemble, push in until the spring clicks and then turn ¼ turn

The lifter function is to maintain zero valve clearance regardless of engine temperature.

All the lifters can do is get longer or shorter.

The most common mistake is to adjust the pushrods on 1 cylinder and then turn the engine over and bend valves. Always adjust at TDC. Adjustment on shovelheads and earlier is: Zero lash plus 3 or 4 turns, or use the ".520 tool".

Dirt will hold the check ball off the seat causing the lifter to function improperly.

If lifters aren't working properly:
- Check for oil and pressure
- Check tappet oil filter screen (clean or replace at every oil change)
- Remove lifters for cleaning and inspection

Evo Tappet Blocks

3 Varieties of Evo Tappet Blocks

- Early – Cast iron
- Late 1 – Aluminum with an oil passage plug
- Late 2 – Aluminum without an oil passage plug

They interchange but not front to rear

They must be measured for wear and clearance. .004" - .0045 in Evo
- Too much clearance causes noise.

Tappets

Two types of tappets:

- Early – 84 ½ - 87 – 3 dots, 120 degrees apart in push rod cup
- Late – L87 – Present – 2 square dots, 180 degrees apart in push rod cup

Built in hydraulic unit is not repairable – must be replaced.

Tappets aren't directional in Evos

Don't disassemble tappets because:
- Harley Davidson said don't
- Easily damaged if disassembled

4 Large flat washers, 1 under each bottom o-ring. This is the most commonly lost part. Without the washer, it will leak.

Evo Tappet Blocks must be installed with the alignment tool. Put the tool in the hole closest to the center of the engine. Torque the tool to 30 in/lbs. Snug the other screws, remove the tool, insert the 4th screw, torque to 95 – 120 in/lbs in a cross pattern.

There are no nuts on the crankpin of the Twin Cam. No servicing. The entire flywheel assembly must be replaced.

Evo Pushrods

One piece, non-adjustable.

Oil hole

4 different lengths, color coded, don't mix:

Longest – Front exhaust
Next longest – Rear exhaust
Then – Front intake
Shortest – Rear intake

Make sure aftermarket Evo & Twin Cam pushrods have the oil hole.

If in doubt on adjusting aftermarket pushrods, try zero lash + 2 turns. Coarser threads = more adjustment per turn.

Don't try to straighten bent pushrods.

Pushrods don't usually wear out, but they can.

Chrome moly is better than aluminum.

Shovel Pushrods

Won't fit Twin Cams or Evos. Same parts, but different dimensions.

Pan Pushrods

1948 – 1952 – Hydraulic
1953 & later Pans & Shovels – Hydraulic tappets and adjustable pushrods. Steel with no oil hole. Adjustment on the bottom using a split lock nut. Generator engine front exhaust push rod is ¼" longer.

Pushrod Tubes

Parts of Pushrod Covers

Clip
Bottom tube
Top tube
Cup
Spring – Puts load on clip
Washer – Keeps seal from being damaged by end of spring

1978 and earlier – Cork Seals
1979 to Present – O-rings

The function of the shoulder on pushrod tubes is to support the O-ring. Anything with a shoulder can use either the O-ring or the cork seal.

There are 3 seals on each tube. Damaged seals will cause leaks.

The 5 speed Evo Sportster has 1 piece pushrod tubes

Pinion Shaft – also called Gear Shaft

1958 – 1972 – Oil feed hole on the side. "Side Oiler Pinion Shaft"

1973 – E81 – No oil feed hole on the side. Oil hole through the center. "End Align Pinion Shaft"

3/81 – 1989 – Commonized Taper Shaft. Used on many aftermarket engines.
To identify:
Much smaller woodruff key & taper – ¼ the size of the others. Oil hole is 90 degrees from the keyway instead of 130 degrees.

1990 & Later – Part of the flywheel. None interchange.

The thread pitch on the nut between the communized and earlier is not the same.

Replace the pinion shaft if there is .0002" - .0003" wear, or any noticeable wear. Check the big bearing surface and the small end.

Torque the nut that holds the pinion shaft to the flywheel to 140 – 170 ft/lbs.

Always use Red Loctite!!

Crankpin

Between the flywheel halves

Non-commonized – 1941 – E81 – Large keyway, oil hole is 130 degrees from keyway

Commonized – 3/81 to Present – Smaller keyway, oil hole is 90 degrees from the keyway. Different thread pitch.

Torque crankpin nut to 185 – 210 ft/lb.

Use Red Loctite

The crankpin is usually replaced if the engine is bad enough to need repair or if the rods are loose enough to tear down further.

Motor Sprocket Shaft

1970 – Bigger and longer due to the alternator

1970 – 1971 – Small taper, big keyway. Torque to 140 – 170 ft/lbs

1972 – E81 – Large taper & nut. No key. Torque to 360 – 440 ft/lbs. Use a 1 5/8" socket with the taper "faced" off

3/81 – 1985 – Commonized taper motor sprocket shaft. Looks like earlier. Measure the fat part of the taper to distinguish.

1.320" – Commonized
1.420" – Non Commonized (72 – e81)

<u>Torque the communized taper motor sprocket shaft to 290 – 320 ft/lbs</u>

2 reasons to replace the Motor Sprocket Shaft
- Threads or splines damaged
- Big, tapered roller bearing isn't a tight press fit

Late 1985 – The Motor Sprocket Shaft was cast as part of the flywheel.

Aftermarket engines may have any type of motor sprocket shaft, and should be inspected to determine which shaft it has

S&S has a number on the flywheel to determine which shaft is used

Check the rod sideplay and then put the rod in the middle and pull up and down to check for radial movement.

The wear limit side-to-side is .0018". Any radial movement is too much.

To remove the bearing from the motor sprocket shaft, use a guillotine puller and a harmonic balancer puller.

Disassemble the flywheel assembly from left to right, and reassemble from right to left.

Hit the flywheel with a brass hammer 90 degrees to the crankpin to break free.

Bearing cage on crankpin is narrow on top and bottom and wide in the middle.

Use a bearing installer tool to install the crankpin bearings. Don't load the flywheels.

Connecting Rods

Harleys used 3 or 4 different sets

"XA" Rods – 1941 – 1973 – Says "XA705" & "XA706" on the side

"74" Rods – Began in 1974. The part number "-74" is on the rod ends. It is a direct replacement for the "XA" rods. Will fit any Knuckle, Pan or Shovel. The "XA" rod is .030" longer, but this presents no problem.

Late Shovels & Evos use "-82" Rods. They are heavier and thicker. The front rod is offset (directional). When assembled the "V" is more narrow. If the "V" is wide, they are assembled wrong. When assembled correctly, the part number on the front rod is on the right and the part number on the rear rod is on the left.

"-82A" – Late – Has more metal around the small hole & the oil hole in the top is bigger. The "-82A" won't bolt into an earlier Evo flywheel. There isn't enough clearance on the flywheel. Grind 1" back and 1/8" deep.

Flywheels

The difference between communized and non-commonized tapered flywheels:

Commonized – The dot is advance & the line is TDC front cylinder – 3/81 & later

Non-Commonized – Line is advance & dot is TDC front cylinder

On the right flywheel, the oil hole and keyway location is how to identify.

Commonized – 90 Degrees

Non-Commonized – 130 Degrees

Drive side / Sprocket side bearing

Timken bearing

6 Parts

2 Bearings
2 Races
2 Spacers – Inner & Outer
Early – ’55 – ’68 – Round or C-shaped (later)
Late – ’69 – Present

DON’T INTERCHANGE!!

Bearings are normally changed anytime the flywheel is pressed out of the case.

Bearings are sold as a matched assembly. The only thing that can be changed is the inner spacer to adjust the clearance.

Outer races are pressed into the left crankcase. The bearing is pressed onto the motor sprocket shaft.

A bigger thicker spacer moves the bearing out and increases clearance (endplay).

.001” - .004” of endplay is desired.

Spacers range from .095” to .120” in increments of .002”

Always keep spacers (from overhauls) for reuse.

Don’t put the spacer and the seal in until ready to assemble

Lube with motor oil

Endplay specs are the same on all models

Early and late spacers WON’T interchange

Lower End Pinion Side Main Bearings and Rod Bearings

Pinion shaft – Bearing

1958 – 1986 (and aftermarket to present): 2 washers, 2 cages and bearings, and 1 spiral lock

The cages are reuseable and the rollers are replaceable.

28 Bearings, 14 per cage

.250" is standard

Available in .0002", .0004", .0006", .0008", .001", and in some applications, .002" oversize

The washer goes on first. The first bearing sits open end up. The next bearing sits open end up. Then the washer is installed, and the spiral lock goes on last.

1987 – 1991 – Obsolete. Can't purchase. Replace with either the newer or the older. Had "Black Bearing". Closed cages. Retained with a flat C-clip. Bearing was 2 piece.

1992 – Present – 1 piece, bought as a complete assembly. 2 oversizes available, color coded.

All races can be lapped and sized.

The late race, 1992 & later, has oil holes that are 90 degrees from each other.

Rod Bearings

1941 – 1972 – 4 identical steel cages. Loose bearings. Male – 2 cages over long bearings. 54 rollers.

1973 – 1986 – 3 piece. Will fit Big Twins from 1941 to present (2003). 51 rollers.

1987 – Present – Black. Comes as an assembly. Components can't be purchased individually. No oversizes. Uses different sizes of crankpins. The standard size is 1.249" (since 1941). Replace as a unit.

<u>Normal rod clearance is .0005" to .001"</u>

Oil Pump – Single Cam

2 stage, gear type pump, since 1936

4 types of aluminum pumps since 1968. All have a vertical slot and a tower.

-68 1968 – 1972 – Big round hole at the top of the slot

-68A 1973 – 1980 – No big round hole at top of slot. (Hole is pressure relief outlet.)

-68B 1981 – 1991 – Extra hole above the slot (pressure relief). The hole is for the oil pressure relief valve.

-92 1992 – up – Different bolt pattern. Won't bolt to earlier crankcases.

<u>The only parts that pressurized oil goes to are:</u>

Rod Bearings
Wrist Pin Bushings
Hydraulic Lifters

<u>Everything else is splash fed.</u>

The feed check ball & spring in top of the oil pump keeps oil from filling up the crankcase by gravity.

Keep the check ball cavity clean. When changing the ball use the old ball and place a bolt on top of it. Rap twice with a ball peen hammer to "clean" the seat.

Under the tall tower is the pressure relief (bypass valve) plunger and stiff spring. The function is to keep excess oil pressure from getting to the engine.

1981 & up – The top cap is smaller and there is an o-ring. Earlier models had a big top cap and a gasket.

Oil pump bolt torque is critical!!

The torque is determined by the gasket material.

White Plastic – Torque to 40 to 50 in/lb
White Paper – Torque to 60 to 70 in/lb
Black Paper – Torque to 95 to 120 in/lb

<u>Bolt torque directly affects oil pump gear protrusion.</u>

Always use the same gasket material both inside and outside.

Normal oil pump gear protrusion is .001" to .004" with no gasket. New pumps may have .006".

The oil pump scavenge pickup is directly beneath the cam.

Always clean the oil tank, lines, and oil cooler if there were any problems involving the oil pump.

The oil pump seal separates the feed side from the scavenge side of the oil pump. Replace the seal when working on the oil pump. It is included in the gasket set.

A c-clip goes in the oil pump, and a snap ring goes inside the timing cover due to clearance.

The scavenge gear is bigger than the feed gear. If scavenge isn't working the bottom end will fill with oil, and oil will blow out, leak and the engine will smoke.

If the feed gear doesn't work, the rocker arm bushings will squeak and the pistons will stick. If there is an oil indicator lamp, it will come on.

To check for oil pressure remove the scavenge line at the oil pump and see if oil shoots out.

The engine should have 6 – 7 psi at idle (minimum) , and 12 – 35 psi at 2000 rpm, hot.

Priming a Dry Oil Pump

It is unlikely that the oil pump will prime itself.

Take feed check ball & spring out & put the cap back on. Run engine for apx. 1 minute.

OR

Pump manually into the feed side.

There must be oil pressure within 30 – 40 seconds of startup

When assembling the oil pump don't use gasket sealer. Spray the gasket with High Tach or Copper Coat or something sticky.

Make sure the pump can be turned with your fingers before starting the engine.

Oil pump bolts through 1977 – ¼ X 24 TPI
1978 & later – ¼ X 20 TPI

Lapping Connecting Rods in a Lathe

Use a tapered expandable lap. This enables us to recondition connecting rods that are in pretty good shape.

The lap head is "changed" with lapping compound. Use "Clover" brand because it is oil-base (not water base)

Compound is available in 36 grit to 1200 grit. Use 180 – 220 grit.

Clover Brand is available from Goodson. 1-800-533-8010 or **www.goodson.com**

Don't use valve grinding compound!!!

Put the lap in the lathe and charge with compound, enough to get a thin even surface. Then put the rod on and snug the lap. Tighten right, loosen left makes the lap bigger. Tighten enough to where you can tap the rod with a finger to move it.

Run the lathe at 150 – 220 rpm. Move the rod back and forth on the lap, holding the rod by the big end. Use the full length of the lap. Count the strokes. Every 25 strokes, turn the rod over and go in the other direction. After 25 or so in each direction, wipe the compound out and inspect the inside of the rod. Look for good crosshatch. Do the other rod in the same way, then measure.

Don't leave the tool "loaded"

To measure, use a T-gauge and a micrometer and check the "X" and the "Y" axis. The rod hole must be round to within .0002"

5 major problems in lapping rods:

Too much compound causes bellmouthing
Running the rod too loose on the lap causes bellmouthing
Holding the rod by the small end causes bellmouthing
Use the full length of the lap or a low spot will wear on the lap and will ruin the lap
Turn the rod over every so many strokes or you'll taper the rod

Use this 4 step formula to determine rod bearing roller size:

Race ID (1.625") minus shaft OD (1.249") = (.376") minus .001" (clearance) divided by 2 = the actual roller size.

The dry running clearance should be .0005" to .001"

Crankpin standard is 1.249". Oversizes available - .001" & .002"

Rod Rollers

.1875” is standard

Oversizes available:

+.0002”
+.0004”
+.0006”
+.0008”
+.001”
+.002”
+.003”

Pinion Rollers

.250” is standard

Oversizes available:

+.0002”
+.0004”
+.0006”
+.0008”
+.001”
+.002” (some applications)

Flywheel Assembly Procedures

Lay out everything and clean all parts with lacquer thinner.

Have Brake Kleen, red Loctite, and all tools

Assemble right to left with one exception:

> If the motor sprocket shaft was removed, install it first. Clean the tapers with lacquer thinner. Use red loctite and torque to spec. If the flywheel nut has a retainer, it can be used. It doesn't matter either way. If the retainer doesn't line up with the nut, tighten the nut to line it up – never loosen!
>
> Make sure there is a space between the motor sprocket shaft and the flywheel.

Take the pinion shaft and make sure the oil passage is clear.

Make sure the oil passage in the flywheel is clear.

Make sure the crankpin oil passage is clear.

Put the woodruff key in the pinion shaft and make sure it's seated.

Use red loctite, then torque the pinion shaft.

Make sure there is a space between the pinion shaft and the flywheel.

Put the woodruff key in the crankpin.

Put the crankpin in the right flywheel. Use red loctite. Then torque.

Blow in the oil passage holes to make sure they are clean and line up.

Put the rod bearings and cages together and on the crankpin. Use Vaseline on the bearings but clean it off the taper with lacquer thinner.

Set the left flywheel on, red loctite, and torque

Check the rod side clearance. Side shake is NOT side clearance. Side clearance is measured between the flywheel thrust washer and the side of the female rod. (Side shake is wobble). Rod side clearance should be .005" to .025". A little more is okay. On S&S engines it is .035" to .040"

If there is too much rod side clearance, change the flywheel thrust washer.

> Standard is .065". They are available in +.005" and +.010". As much as .020" can be taken up

Reasons for inadequate rod side clearance:

*Oil or grease on the crankpin tapers. It's critical to clean before assembly

*Worn out taper. The shoulder should not be flush with the flywheel.

Improperly seated thrust washer. Should be flush and uniform

Thicker than standard thrust washer

Overtorque on crankpin nuts. 185 – 210 ft/lbs

Short crankpin – Happens when the taper is down too far or the taper is undersize

* - Most common reasons why flywheels are impossible to align

Aligning Flywheels

3 Things That Can Be Wrong:

Pinched – Flywheels are closer opposite the crankpin

Bowed – Flywheels are further apart opposite the crankpin

Misaligned – Indicators move together like windshield wipers

If it takes a while to true, retorque the nut. Put indicators as close to the flywheels as possible.

Removing & Installing The Pinion Side Main Bearing Race

1976 & Earlier – Set screw in the case must be removed

Use a #1 or a #3 Sportster cam in the timing side. Support the case and press the XL cam to press the bearing out. HEAT FIRST!!

When reinstalling, the oil hole in the bearing race must line up with the oil holes in the case.

Dowels on the case must be supported.

Seat the race fully making sure that it's seated flush

Races are made in standard, +.002", +.005" and +.010"

2 varieties of case races:

Early – 1958 – 1992

Late – 1992 to present

Late has holes through it and an oil groove. Late works on 1958 – present

Early only works in the early case

The race must be lapped anytime it's replaced because it distorts when pressed

How To Determine If The Lower End Is Capable Of Further Service

Rod Side Shake – (not the same as Rod Side Clearance)

Side shake is measured with a dial caliper. The clearance is measured with a feeler gauge.

The Front Rod has a wear limit of .125". The Rear Rod has a wear limit of .090".

Push the rod to one side and measure from the cylinder stud to the rod. Then push the rod to the other side and measure from the cylinder stud to the rod.

Radial Movement – Rod moves straight up and down. ANY radial movement is too much!!

Pinion Shaft Runout

Check with a dial indicator using a ¼" bolt and nut in a timing cover hole to hold the dial indicator. Put the end of the dial indicator on the pinion shaft and rotate the flywheel. The maximum runout is .003"

Pinion Shaft Runout is caused by:

Flywheel misalignment (the primary cause!)

End of the pinion shaft worn out of round

Bent pinion shaft – Unusual on '89 & earlier. Common on '90 & later

Pinion Shaft Deflection – Check by lightly prying up and down on the pinion shaft to see if the bearing is worn out.

Pinion Shaft Deflection is caused by:

Wear in bearings
Wear in pinion shaft
Wear in race
All 3

Pinion Shaft Deflection causes:

Noise
Vibration
Damage to main bearing
Damage to Pinion Shaft
Not enough oil to the bottom end

Flywheel End Play

> Use a dial indicator on the end of the pinion shaft. Push and pull hard on the motor sprocket shaft. Endplay should be .001" to .004" if new - .007" if used and the bearing is quiet. If the bearing is bad, it will sound like a bad wheel bearing in a car.

<u>If any check fails, disassemble the lower end. If everything is within wear limits, check to see if the connecting rods are straight.</u>

Checking Connecting Rods For Straightness

Rods can be bent, twisted or both.

Use a Rod Checking Tool from JIMS. It is a piece of rod with .001" to .002" clearance in the wrist pin bushing, long enough to rest on both sides of the case. Put strips of paper under both sides of the tool, at the front and at the rear position in the cylinder.

If twisted, the paper will be tight on opposite corners and loose on opposite corners.

If the rod is bent and twisted, the paper will be tight on 3 corners and loose on 1. Take the bend out first.

Tricks

Don't yank – apply the load carefully

The small end of the rod needs to be parallel with the case mouth

If you can see that the rod is bent, replace the rod.

Bent connecting rods can cause:

> Rapid ring wear
>
> Wrist pin to blow out and ruin cylinder

Change and size wrist pin bushings before checking rods for bend

Check rods for straightness AFTER installing

Installing and Reaming Wrist Pin Bushings

Clamp the middle of the rod in a vise.

Use JIMS tool to remove and install.

Ream with a 25/32" expansion reamer.

Use a piece of tubing over the reamer and on the rod to press on

Ball honing isn't required unless it's necessary for final fit.

¾" Ball Hone for anything except Twin Cam

Wrist pin - .790"

Clearance - .0005" to .001"

Don't leave the reamer loaded!!

Removing and Installing Wrist Pin Bushings in the Engine

Use a connecting rod clamping tool available from V-Twin or HD

Cover the hole with dry rags and cover the dry rags with oily rags to keep chips out of the bottom end.

Aftermarket wrist pin bushings vary in dimension. H-D isn't too variable

Make the 1st pass with an expansion reamer.

Then use a "1pass" reamer.

Get a square socket from Sears to drive the reamer

BETTER – Use a Ram Jet Wrist Pin Reamer from Ram Jet Enterprises (V-Twin). It has a hex head instead of a square head.

Put the new bushing in and size before checking the rods for straightness.

Bushings are available in .001" and .002" oversize OD, but if needed, make sure the rod isn't bad.

Lapping Pinion Side Main Bearing Race

Put the crankcase together with alignment studs

Use tool and a new Timken bearing on the motor sprocket side

Slide the lap tool in from the gearcase side

Snug the lap. Turn using the full length

Check the case race. Lap until it's gray all the way around and within .0002"

Then do the formula to get the bearing size

Keep lapping compound off of the shaft of the tool and out of the bearing assembly

Use 180 to 220 grit compound

Running And Installing Timken Bearing In The Left Crankcase

1989 & Earlier – Knock out the bearing and the spacer from the inside shoulder against the bearing

Use the bearing removal tool to remove the case race

Support the case and press from the inside

Turn the case over and do the same from the other side

Move the center snap ring to where it doesn't line up with the oil hole

Knock out

To reinstall, make sure the open end of the snap ring lines up with the oil hole

1990 & Later - The race is aluminum. Use JIMS tool to remove the snap ring

Reinstall in reverse order

Make sure the race is against the snap ring.

Heat the crankcase or you will destroy it.

Heat case, freeze race

Reaming The Cam And Pinion Shaft Bushings In The Timing Cover

Bushings must be reamed anytime they are replaced and before installing cam seal

Necessary equipment:

Cam
Right crankcase (JIMS makes a tool so you don't need)
Cam Bushing Remover – Fixed, solid – fits into camshaft bearing like a cam to insure alignment

JIMS Plate

Put the reamer into the cam bearing from the gear side.
Put on the timing cover without the gasket.
Bolt securely with at least 4 screws.
Put the JIMS plate on the nosecone so that it can be held in a vise without damaging.
Put the entire assembly in the vise.
Ream, using cutting oil.
When the reamer drops through, remove it.

Pinion Bushing

Use a different reamer with an adapter that fits in the plug that fits the pinion side main bearing.
Ream, making sure it goes all the way through the bushing.
Make one turn and pull it out.
Don't pull backwards!!

To put the seal back in the nosecone, use a junk cam with the gear turned down to fit inside the nosecone.

Dress up the cam and / or the pinion bushing with a ball hone if needed. .001" clearance

Removing and Replacing the Cam Needle Bearing

To remove the cam needle bearing, put collet fingers through the bearing. Put the large part over the shaft, then the brass washer, and then the nut. Tighten and pull the bearing out.

To replace, make sure the letters on the bearing face out. (Always replace the camshaft bearing on 1993 & later Evos). Use a tool to support the shoulder and tap in until it bottoms. Make sure it will spin freely.

Twin Cam Oil Pump

3 types. All interchange, but the parts don't interchange between the 3 types.

-99 – Earliest

-99A – Different body and different rotor dimensions. 2 additional parts – 2 thin washers and a wave plate. The wave washer puts a spring load on the pump

-99B – Latest. The part that goes in the tube in the crankcase is longer. There was a change in the cam doors. They have an extra oil passage for balancers on Twin Cam B engines. This hole can be plugged for use on earlier engines with no blockoff casting.

The Twin Cam Oil Pump is a Gerotor Oil Pump, or Truncoidal

It contains 2 feed rotors, 2 scavenge rotors and separate washer

It runs off the pinion.

Always inspect the rotors and body for damage and check rotor tip clearance.

Use a feeler gauge between the rotors in several places.

Wear limit - .004" clearance

If the rotors look good and the clearance is good, the pump will work

The scavenge rotors are bigger. They go in first.
Then the washer.
The feed rotors go on top

The Cam Plate is the front of the pump housing.

To reassemble, put the pump on the cam plate with 2 bolts and 2 tappet block alignment tools

Rotate, snug, rotate, torque

The tappet block alignment tool insures alignment on the pinion shaft

XL Upper End – 1957 – 1985

2 styles of **XL rocker boxes**:

Early – 1957 – 1970 – No notch

Late – 1971 – 1985 – Has notch

Interchangeable, but not front to back

Rocker boxes are held on with 5/16 X 24 cap screws. Torque to 15 – 16 ft./ lb

Rocker arms are smaller than shovelhead but use the same bushings, end caps, nuts, and washers.

Bushing clearance - .004" - .005"

Rocker arms are spring loaded

Intake & Exhaust rocker arms are different. The exhaust has an oil hole near the pad

Interchanging the exhaust and the intake will cause:

Overoiling the top end
Smoke

There are 4 different part numbers for XL rocker arms

Ironheads have solid lifters. Zero lash

Early and late XL rocker arms interchange

Excessive valve stem protrusion causes upper spring retainer to be hit by the rocker arm and causes the valve stem to fatigue and break out of the keeper groove.

Cure: Bigger valve or new seat

Rocker boxes don't interchange front to back. The oil line fitting goes on the intake side

Push rod tubes – Same 6 parts as the Big Twin

XL Pushrods 1957 – 1985

All 4 are the same but should be reinstalled in the same location to prevent noise

Pushrods are aluminum with pressed in steel ends. If bent, replace

XL Tappet Blocks

1957 – 1966 (apx) – Cast iron

1967 – 1976 – Aluminum with puller groove

1977 – 1985 – Aluminum without puller groove

All are the same, front to rear. All interchange.

Worn tappet blocks cause noise.

Wear limit - .008”

Not repairable

Bad tappets will damage new tappet blocks.

New clearance - .001”

When installing tappet and block, don’t allow tappet to drop down out of the block. Hold by the top of the tappet and tap the block down with a plastic hammer. The o-ring needs to be in place on the outside of the tappet block or it will leak.

XL Tappets

3 different types

1957 – 1970 – 3 holes in each side to reduce weight and reciprocating mass in the valve train

1971 – 1976 – No holes but weight is the same as earlier

1977 – 1985 – 2 holes in the top due to different oiling system – oil drainback

All interchange, but must have holes drilled for 1977 and later

The roller assembly is replaceable (all pre-evos)

Standard tappet OD is .730”. They are available oversize in +.005” and +.010”

Ball hone with a .750 hone if necessary

XL Cylinders and Pistons – 1957 – 1985

3 different cylinders

3 different types of pistons that are likely to be seen

1957 – 1971 – 54 cubic inch – 900 cc

3" X 3 13/16" stroke

Directional piston with a full skirt

Cylinder part number is "-57"

The front fin is cut away on the front cylinder and the rear fin is cut away on the rear cylinder for the exhaust

Front and rear cylinders don't interchange

1972 – mid 1973 – 61 cubic inch – 1000 cc

Bigger bore diameter – 3 3/16"

Headbolt threads to the top of the hole

Cylinder walls are thin – NOT GOOD!!

Smaller bolt pattern

Late 1973 – 1985 –

Much thicker cylinder walls

Headbolt threads start ½" down in the hole

Headbolt pattern is bigger

"-72A" part number, if it has a part number

Most head gaskets for Ironheads are copper and will eventually weep oil. Spray the gasket with Copper Coat. Don't reuse.

Thich head gaskets were used in 1982 to lower the compression ratio

Torque headbolts to 60 – 65 ft / lb. 7/16 X 24 TPI

Early 1973 and earlier had 6 point headbolts with separate washers

Late 1973 and later had 12 point headbolts with separate washers, ½" longer

Don't mix headbolts!!

The cylinder has a spigot. Make sure it's not taller than the counterbore in the head. If necessary, use a thicker head gasket.

-72 piston was used from 1972 – 1985 and is directional

Pistons require .003" piston to wall clearance, no matter what the manual says!!
The wear limit is .007"

Karl Schmidt pistons were used the last year of production. They have a beveled end wrist pin and use a round wire c clip wrist pin lock

1957 – 1985 XL Cylinder Heads

5 different

-57 part number – 900 cc – Head bolt measurement is apx. 3.440" from the inside of one hole to the inside of another hole

1972 – 1000 cc – Head bolt measurement is apx. 3.540" from the inside of one hole to the inside of another hole. Don't go by the part number!!

1973 Late – The head bolt pattern changed. Don't go by the part number. Measures 3.640" from the inside of one hole to the inside of another hole.

1978 and later – All heads got an air cleaner mount hole

1982 Late – 1985 – The head is thicker where the rocker arm bolts down. It uses special upper and lower retainers. Check valve stem protrusion.

Ironhead XL Spark Plugs

All XL Ironheads used short reach spark plugs.

Champion H8 or J12
Harley #4

1957 – 1985 XL Valve Guides

1957 – 1982 – The valve guides are different heights and different diameters

Intake - .309" - .3095"
Exhaust - .339" - .3395"

The valve guides had shoulders

1983 – 1985 – Shoulderless. They will fit and work in any ironhead but won't work well with old valve guides.

Pay attention to the valve spring installed height.

Standard intake – 1 15/16"
Standard exhaust – 1 9/16" (available in 1 5/8" & 1 ¾")

Use "-80" or equivalent

1957 – 1985 Valves

Aftermarket valves – Many are "long stem" valves.

"R" valves (XLR) are .080" longer

Valve Guide Seals

Ironheads never used valve guide seals

Oiling System

Different oiling system. Most of the oil goes to the bottom end

Valve Clearance

.001" - .0015" Intake
.0015" - .002" Exhaust

Use different size reamers for intake and exhaust. They don't have to be ball honed.

1957 – 1985 XL Timing Side

Ironhead Camshafts – 4 different sets. Arranged and numbered back to front, from 1 – 4

1957 – 1970 - #2 cam has gear to drive the magneto on the circuit breaker.

#4 cam is shorter than the later models with no tach drive

Won't fit anything else because of #2 and #4 cam

1971 – 1980 – Tach drive on #4 cam (can be pressed off to use on 1981 to E1984)

1981 – E1984 – Interchanges with 1971 – 1980 if tach gear is pressed off.

1984 ½ - 1985 - #4 cam changed. 3 short cams and 1 big cam. No generator drive

4 Different XL Lobe Profiles

1957 – 1958 – XL

1959 – 1979 – P

1966 – PB – Factory Performance Option – not a very good cam

1980 – 1985 – Q

These were color-coded gears. There is a chart in the manual.

Check: Lobe surface condition and dimension
Bearing surface condition and dimension

The "Dogbone" cam thrust plate is directional. The bevel faces away from the case. They are not variable thickness.

H-D endplay shims come in .005" and .007" sizes. Multiples can be used to get correct endplay. Aftermarket shims are available in .005" and .020" sizes.

Shims can go on either side of the cam but are easier to put on the outside. Stock shims have to go on the inside of #2 cam but aftermarket has shims to fit on the outside.

Cam endplay - .005" - .025". Most engines will be in spec without the shims. They either tend to be in spec or way out of spec.

Check cam endplay with a new gasket, cover on. Check through the tappet block hole.

The Generator Drive Gear has a big hole that faces out.

Evo XL Timing Side Cams and Timing Covers

4 different cams for Evo XLs

2 for the 4 speed, 1986 – 1990

"C" or "T" – won't interchange with 5 speed

2 for the 5 speed, 1991 to Present

"D" or "W" – won't interchange with 4 speed - longer

4 speed cams

1986 & 1987 – "T" - any displacement – no longer available – replace with "C" cam

1988 – 1990 – "C" – any displacement

"T" or "D" interchange so long as exhaust are the same or intake are the same

5 speed cams

"D" – 883 or 1200

"W" – Sport model – A little better than the "D" but not much

Evo XL doesn't use cam shims

The 4 speed uses the same dogbone plates as the ironhead, but no shims

Evo 5 speeds don't use dogbone plates or needle bearings. Instead it uses bushings.

Evo XL Timing Covers

-89 part number has a waffle pattern inside and no crankcase vent. 5 speed cover won't fit 4 speed.

-84A part number is a 4 speed cover and won't fit ironheads. No waffle pattern. Has a big black knob inside which is part of the crankcase vent – separator. Has an umbrella valve (since 1984 ½). If the "cap" part of the black knob is missing oil will leak.

Wear limit in bushings is .003" - .004"

In 4 speed covers the #1 and the #4 cam bushings are relieved to clear the #2 cam gear. When changing the bushing they must be notched.

Flow Bench – Super Flow 110

The Flow Bench is like a giant vacuum cleaner. The purpose is to see how much air goes through the port.

Polishing the port doesn't help except in the exhaust port, where it keeps carbon buildup down and keeps heat up

The exhaust port should flow apx. 75% of the intake port

Ironhead XL Timing Covers

Always check all bushings for any in or out movement.

1957 – 1967 – Single "bar" cover. "-52" part number inside cover. Magneto mount

1968 – 1970 – Replaced the "bar" with 6 fins. Otherwise identical to "-52"

1971 – 1976 – Has a "-71" part number inside the cover. First nosecone cover.

1977 – 1978 – Much lower pinion shaft bushing. Won't work on earlier models. Can be replaced with '79 – '81 cover. Vent tube on the bottom. Can use a Chevy PCV valve if necessary. Has a PCV valve under the generator part of the cover for the breather vent tube to screw into. It will leak without the PCV valve.

1979 – E1981 – Has a crankcase vent on top that goes to the air filter.

1981 – E1984 – Has a threaded hole where the crossover shaft was. Has the crankcase vent on top. Uses a different gasket with a new location for the top end oil feed passage.

L1984 – 1985 – Smooth hole for the crossover. "-84" part number. No generator gear. Uses a different gasket with a new location for the top end oil feed passage.

XL Primary Drive – Primary Chain Tensioner

Early - 1957 – 1970

1971 – 1976 – Has a piece that bolts over the chain. (The lug can be cut off to use on earlier models.) Has a short bolt and a special lock washer. Attaching bolts should have a lockwasher and a hardened flat washer. If too long, they will hit the flywheel. There should be no clearance between the tensioner or the pad.

1977 – 1979 – The flat tensioner mounts on the stud in the case. It has a flat spring. Replace it with the model for 1977 – 1990.

1980 – Has a coil spring. The shoe is held on with screws. This tensioner works from 1977 – 1990.

There should be ½" – ¾" freeplay at the tight spot.

XL Primary Chains

All interchange from 1957 to present

1957 – 1980 have figure 8 side plates

1981 – Present is heavier and better. It has flat side plates.

Diamond Chains and Duckworth Chains are the best and are OEM

When the chain is out of adjustment or has a bad tight spot, REPLACE IT!

Freeplay at the tight spot should be ½" to ¾"

XL Motorsprocket

1957 – 1969 – Shortest offset, shortest shoulder. Used a hex nut. Use Red Loctite!

1970 – 1976 – Middle offset. Used a sleeve nut. Don't use an air wrench and don't red loctite. Torque to 125 ft/lbs

1977 – Present – Long offset. Uses a sleeve nut. Don't use an air wrench and don't red loctite. Torque to 125 ft/lbs (4 speed) or 210 ft/lbs (5 speed)

None of these motorsprockets interchange.

Splines are the same in each

All 4 speed motorsprockets have 34 teeth. All 5 speed motorsprockets have 35 teeth.

All have 5/16 X 18 tapped holes for a puller.

XL Clutch and Primary Drive

<u>1957 – 1970</u> – Dry multi-plate standard action clutch

Uses a traverse screw release mechanism

The cover helps keep oil out. It uses a gasket. It's held on by 12 #10 screws with small lockwashers.

It doesn't require any special tools to work on it.

The wave plate acts as a spring retainer.

3 of the nuts take a 7/16" socket and 3 of the nuts take a ½" socket. The ½" nuts are sleevenuts.

The 7/16" nuts and the ½" nuts are 180 degrees apart. They will only go on 1 way. The nuts have a groove on the bottom to keep them from backing off. Always back the nuts off evenly.

The spring retainer plate retains the springs!! It serves as an adjuster block.

There are 6 clutch springs. This clutch doesn't need Barnett heavy springs.

The springs go in sheet metal buckets.

The releasing disc (pressure plate) should be replaced if warped or if the hole in the middle is cracked

The end of the clutch relief rod has a small head that can damage the release disc

Pick up the clutch inner hub and the race to take it out

The studs are ¼ X 20 on one end and ¼ X 28 on the other end

Make sure the seal is good or it will leak

The clutch runs on needle bearings. The inner race falls out easily. DON'T LOSE IT!!

The Torrington bearing presses on from the back.

The inner and outer hubs don't wear much

The clutch runs on the main clutch gear

There is a rubber seal in the main clutch gear shaft. Make sure it's replaced. It keeps oil out of the dry clutch.

Start with 2 steel plates.

The first is thicker with a step. The step faces out towards you.
The regular steel plate is next.

Fiber plates are raybestos

Barnett plates are best

Alternate fiber and steel

Don't leave the derby cover off and run wet!!

The sharp edges of the steel plates need to face in the same direction.

On reassembly, the studs need to be in the center of the spring buckets.

The release plate has a big dot in it at 12:00 position and a small dot at the 6:00. Line up the big dot with the mark on the tooth on the inner hub.

<u>Clutch adjustment</u>

There should be 3/16" (.190" - .200") from the top of the wave plate to the lip of the spring bucket. Check with a dial caliper along the lower part of the wave plate.

<u>1971 – E1984</u> – Wet clutch. "Wet Multi-plate reverse action clutch"

Uses a ball & ramp release mechanism. Not very good.

Requires a clutch spring compressor to disassemble.

Replacement springs are usually 1 spring instead of the original inner and outer springs

The spring plate contains the clutch release bearing. If it feels crunchy, replace it.

The inner hub and basket don't usually wear out. The inner hub has 2 tapped holes for a harmonic balancer puller. The holes are ¼ X 20

The clutch basket has a ball bearing that usually needs to be replaced. It's held in with a snapring. Press the new bearing in with a socket that fits on the outside bearing race.

The pressure plate is on the bottom. If it's damaged or has loose studs, replace it.

Sleeves go over the pressure plate studs and adjust the clutch spring preload:

Shorter – More
Longer – Less

Standard length is 1.525" +/- .040" to .080"

A big snap ring holds the clutch together. When it has notches in it, replace it.

The clutch ends in a half plate. The half plate is the last plate in, and the first plate out. It's function is to hold the clutch together. The lined side faces in towards the clutch.

The steel plates should be checked for warpage, damage, or funny colors from overheating.

The holes and slots in the plates are thermal slots. Install the sharp edge of the clutch plates in the same direction, either all facing in or all facing out.

Look at the grooves on the friction plates to determine wear.

Anytime there are problems with the clutch, do the clutch adjustment procedure first to see if that cures the problem.

XL Lower End

Motor Sprocket Shaft

1957 – 1976 – 1" where the Timken bearing presses on. It has a keyway.

1977 – E1981 – 1 1/16" (1.062") where the Timken bearing presses on. Has keyway.

L1981 – 1985 – Commonized – No woodruff keyway in the taper. Has ID groove at the base of the spline.

Torque the nut to 120 ft/lb and use red loctite

Replace if the splines and threads are damaged or the bearing fit is loose.

There is a space between the shoulder of the motor sprocket shaft and the flywheel.

Evo XLs – 1986 – Present – The motor sprocket shaft and the pinion shaft is made 1 piece with the flywheels.

Crankpins

Commonized – 3/81 – 99 – Oil hole and keyway are 90 degrees apart. The thread pitch is different

Non – communized – 1957 – e1981 – The oil hole and the keyway are 130 degrees apart. It has a bigger keyway and different thread pitch.

Connecting Rods

The ironhead, 1957 – 1985, used 1 type of connecting rod. It had a "-52" part number, if it has a part number. It uses the same rod lap and the same bushing reamer as Big Twins.

Evo rods have a "-83" part number. The front rod is directional.

2000 and later uses a different crankpin pressed into the flywheel.

Flywheel assembly is not rebuildable and won't work in an Ironhead. The rods are too short.

Torque crankpin nut to 150 – 175 ft/lb

The bearing clearance is the same as on the Big Twin - .001" - .004"
The rod side clearance is the same as on the Big Twin - .005" - .025"

Evo bore and stroke – 3 ½ X 3 13/16 Ironhead bore and stroke – 3 3/16 X 3 13/16

XL Pinion Shafts

1957 – 1976 – 4 splines, 1 wider than the others. Pinion gear only goes on 1 way.

1977 – E1981 – Pressed on inner race. 6 splines, ½" longer. Threaded protion for the nut to hold the timing gears. Notch on 1 spline lines up with the pinion gear.

3/81 – 1985 – Commonized taper pinion shaft. Bearing inner race is made as part of the shaft. The oil hole is 180 degrees from the keyway. Smaller woodruff keyway. The pinion shaft nut is torqued to 120 ft/lbs

All Evo XL pinion and motor sprockets are made 1 piece with the flywheel and must be OD ground.

Timing the XL Oil Pump (Breather Gear)

1976 and earlier – (1977 and later doesn't have a breather gear so there's no need to time)

Rotate the engine to the "advance" mark in the timing hole.

Push the oil pump drive gear onto the pinion shaft and back against the shoulder making sure that the hole in the oil pump gear lines up with the notch in the oil pump upper housing.

Installing the Pinion Gear

There is a left hand thread hole in the end of the pinion shaft (the only left hand thread on XLs).

Put the tool in the hole and crank on the nut until the pinion gear is pressed onto the shaft.

The gear should fit tight.

When the tool bottoms, the space is correct. 5/16" from the face of the gear to the gasket surface.

XL Oil Pumps

2 styles of Gear oil pumps from 1957 – 1976

1952 – 1971 – K model and Sportster – Smaller gears. Smaller breather gear. –52 part #

1972 – 1976 – Bigger gears. Bigger breather gear. –72 part #

Pump assemblies are interchangeable

To disassemble the engine must be removed from the bike.

The timing cover must be removed.

Gear protrusion is .001" to .004"

No pressure relief

Pull the pin to remove the breather gear

Check the bottom plate for damage

Check gear protrusion

Check the check ball and spring

Torque the cap of the check ball to 12 – 14 ft/lb

Torque the oil pump bolts to 90 – 100 in/lb unless using the brown paper gasket – then torque to 50 – 60 in/lb

Gasket materials:

Brown paper – not good – use High Tack

White paper – Better

Light paper – Don't use

Black paper – Best!

Aftermarket oil pumps are available from V-Twin for about $400

Normal operating oil pressure: Hot @ idle – 5 – 6 lbs. – good

3000 rpm – 7 – 10 lb. Average

To check, with engine hot and at idle, loosen the top nut of the top end oiler. If oil spurts out, it’s good.

The feed line fitting is on the back of the oil pump.

The scavenge is on the crankcase

Most oil pump gaskets should about .010” uncompressed

XL Oil Pump – 1977 – E1984

Trachoidal (Gerotor) pump

Feed on 1 end, scavenge on the other

Not timed

Engine doesn't need to be removed from the frame to disassemble

Replace the rotors in sets because they are matched

Driven by a drive pin in the pump shaft

The inner rotor has 2 notches – 1 square and 1 round. The Square fits the drive pin

Check for rotor tip clearance with a .004" feeler gauge

Check rotor protrusion of the feed rotors in the lower housing. .001" - .011"

For inadequate protrusion, replace the lower housing and / or rotors

No gasket! It has an o-ring. Most protrude above the surface slightly for a good seal

The small o-ring in the counterbore seals around the feed check

The only gasket goes between the pump body and the crankcase

The snap ring is special. It's round on the outside with ears on the inside

The scavenge rotors are much larger than the feed rotors

Remove the drive pin and the shaft with gear (1 piece) will fall out

To remove the feed check valve, use a bolt to push it out. Don't use a tool so small that it will enter the feed check or it will cause damage. Don't disassemble! It's only held in with an o-ring. The arrow points up.

Oil pressure – At idle – 7 – 9 psi – normal
At 3000 rpm – 15 – 18 psi

Check the scavenge rotors for tip clearance

To reassemble:

Put the shaft in the body.

Put the drive pin in.

Put the inner rotor in with the square notch over the pin.

Put on the outer rotor.

Spin!

Put the washer with the lip on one side and the notch but no seal in first. The notch goes on the roll pin in the pump body to keep the washer from spinning in the pump.

The flat side goes in first.

The wave plate goes in next, feet facing in.

The washer with the seal and the shoulder goes in last with the flat side facing out. It fits in the counterbore of the other washer.

The pump should spin with an even drag

Torque to 95 – 120 in/lb

Feed out and oil pressure switch are on the same side of the pump

The rotors need to be for the particular pump

1977 – E1982 – Beveled edge pump rotors

L1982 – E1984 – Square edge pump rotors

XL Oil Pump – 1984 ½ - 1990

The 1984 ½ and 1985 ironheads are similar to the 1986 – 1990 but have no pressure relief

This pump is a "filter pump". It has an oil filter housing

The oil filter housing contains: The pressure relief sending unit
The feed check
The pressure relief valve

The oil filter is on the pressure side of the pump (like the Twin Cam)

The filter is between the pump and the engine

The pressure relief consists of a piston and a spring

Oil is pumped into the timing chest

The feedcheck is under the filter adaptor. It consists of a rubber ball and a spring.

The filter has a bypass built in in case it becomes plugged. The filter needs to be for motorcycle applications. DON'T USE *EMGO* BRAND!!

The pump has bigger feed rotors than earlier pumps, and the housing is different to accept bigger rotors

The rotors must be for the particular pump.

XL 5 Speed Oil Pump

2 versions –

Early – 1991 – 1998

Late – 1999 – Present – A little deeper with an extra hole that leads into the Scavenge

Both interchange

4 Bolts – 2 hold the pump on, 2 hold the pump together

.004" wear limit on rotor tip

The bottom plate is directional

The Pressure Relief is cast into the crankcase

Priming Oil Pumps

Big Twin – Single Cam – Manually pump. Remove the spring and the feed check ball

Sportster – Take out the feed check ball and spring.

Fill the oil tank.

When oil runs out, it's primed

Twin Cam – Use assembly lube on all parts.

Fill the oil filter.

Spin the engine with the plugs out (put plugs in the wires and ground to the case or you'll blow the electronic ignition module)

There should be oil pressure within 30 – 40 seconds

If in doubt, remove the return from the oil pump, put it in a bucket, and turn the engine over. If oil comes out, you have pressure!

Rotor Tip Wear limit - .004"

Feed Rotor Protrusion - .001" - .011"

Twin Cam – Cam side

1st model – The drive cam (longer of the 2 cams) has a woodruff keyway and ran in a ball bearing. The cam drive sprocket had a key made into it. The bolt that held it on was made wrong. The head nut should be 90 degrees to the shank, but wasn't on many models. It would sometimes back off.

The first warranty was simply 2 bolts and 2 washers.

Sometimes the drive cam ball bearing would fail. The cam would lock up briefly and the engine would strip the key out of the gear.

The second warranty was a new cam plate, cams, oil pump and 4 tappets.

H-D then went to a splined end cam that has a master spline that is wider than the others. It will only go on one way. When the bearing failed the engine kept running! BAD!!

In late 2000, H-D went to a needle bearing. The needle bearing made it much easier to change the cams. There was no need to press a cam into the needle bearing.

The big end of the cam (case end) always used needle bearings. No dogbones, no thrust plates and no alignment reaming is necessary. No bushings.

The tool for cam removal is the JIMS #1277 (3 piece). The bearings are pressed on with one of the pieces. That tool:

Bears on the outer edge of the bearing to prevent damage
Insures alignment
Seats the bearing to the proper depth

One piece of the tool presses the cam into the plate.

REMOVE THE CAM BEARING RETAINING PLATE BEFORE REMOVING THE CAMS!! 4 screws

Later models had longer cam sprocket retaining bolts

1999 TC88 CAM BOLT RECALL NOTICE
January 8, 1999

SAFETY RECALL CAMPAIGN 095

Dear Dealer/Distributor:

Harley Davidson has become aware that on certain 1999 model motorcycles the engine cam bolt could lose its clamp loading and/or break. This condition could cause the engine to quit running with or without prior warning. In some instances the engine could run erratically before quitting. Certain 1999 model motorcycles equipped with Twin Cam 88 engines (engines which were built from the start of 1999 model year production through September 27, 1998) are affected. To help you identify motorcycles please reference the crankcase number stamped on the left side of the engine.

Affected 199 Twin Cam 88 engines must have a 99 stamped in position 3 and 4 and have numbers from 035 through 270 stamped in position 5 through 7.

Harley Davidson has voluntarily declared this a "defect related to motor vehicle safety" (Campaign 095) and plans to recall all potentially affected vehicles. A service bulletin containing complete details concerning this campaign will follow within 14 days. Owner notification, in accordance with NHTSA regulations, will follow the bulletin. In the interest of mutual customers, DO NOT SELL OR DELIEVER any potentially affected motorcycles to your customers until the recall service hasbeen performed. If you have sold any of these motorcycles, we urge you to contact the customers immediately to make them aware of this recall.
All registered owners of affected vehicles will be notified by Harley
Davidson to bring the vehicle in for recall service.

Twin Cam Removal / Replacement

To convert ball bearing to needle bearing

Mark the cam drive chain before removal. Install with the same side facing out.

Unload cam chain tension using a short piece of welding rod to hold the tensioner off the chain.

Remove the retaining plate screws and remove the plate

Put the cam plate on the press and press the cams out.

Put the cam in BRASS jaws of the vise. Using a harmonic puller and a guillotine puller, remove the bearing.

Mark the teeth on the cam at the timing marks for reassembly. The drive cam goes in the hole OPPOSITE the 2 shoulders that protrude from the front of the cam cover.

Install the bearings in the plate, one at a time

Put the cams in the chain and line up the timing marks with each other.

Put the cam plate with cams on the press.

Press in the driven cam while insuring that the drive cam drops into the needle bearing. DON'T PRESS THE DRIVE CAM IN! Make sure the timing marks line up.

Put the retaining plate back. It is directional.

Use Blue Loctite on the retaining plate screws.

Put the snap ring back in the groove on the cam.

Don't take out the pin holding the tensioner until the cams are reinstalled in the engine.

Removing and Installing Pinion and Cam Shaft Bushings

Take an old motor sprocket shaft and use to knock the old cam bushing out of the timing cover.

Use the tool from the backside of the cover to remove the pinion bushing.

Don’t lose the old pins. They will be reused.

The flat on the bushing faces the oil hole.

To pin, use the installation tool. The installation tool has a drill guide hole in it.

Use a #31 drill bit (.120”).

Don’t use the old hole.

The pin is .125”.

Drill through the guide, making sure of the depth.

Seat the pin flush or just below flush.

Make sure the oil passage is clean.

Drill the oil hole if necessary.

Ream

XL Transmissions

Must have vents due to created pressure and to prevent leaks.

-76 – Transmission vent is in the primary case, like feed check valve in a 1977 XL. Also has a hole in the inspection cover of the primary.

1977 – 1980 – Vent hole in the left top of the crankcase.

1981 – Hole in the same place but not threaded

1986 – 1990 – Evo 4 speed – Vent close to the same location, behind the starter in the center of the crankcase

1991 – Present – Evo 5 speed – Big tube

On the mainshaft, the first gear has a relief to clear the roll pin.

From outside in: c-clip, round washer, bearing, teardrop washer

Mainshaft bearing race – The washer goes next to the c-clip

Shifter Pawl Carrier Mechanism:

Snap Ring

Washer

Shifter Cam Plate

The Shifter Cam Plate has cam slots cut in. The function is to tell the shift fork what to do

Finger Rollers – Bearing between shift fork pin and cam slot

Clearance between finger rollers and cam plate - .003” - .009”

Wear limit - .015”

Check with a feeler gauge and new finger rollers, between the points of the cam plate and the finger rollers.

If the finger rollers are bad, it will start out with hard noisy shifting. Then it will jump out of gear. Then the finger rollers will break up. Then the transmission will come apart and break the case.

The Cam Plate locates the shift fork

The Shift Fork moves the sliding gear

The back angle on gear dogs holds the transmission in gear

The shift fork gets bent because the transmission jumps out of gear. The problem is probably the cam plate and / or the sliding gear

Bad cam plate symptoms –

Hard noisy shifting

Jumps out of gear

Countershaft falls out

Always replace, whenever inside the transmission –

Finger rollers

Pawl carrier springs

Under the cam plate:

Shifter pawls

Shifter pawl spring

Shifter pawl carrier

Replace the shifter pawl springs when you can see the light through it. When it's worn out, it won't shift correctly.

The pawls don't wear out often. When they do they wear round on the corners.

Replace the pawl carrier if it's damaged. Don't attempt to repair it.

The pawl carrier housing contains:

Pawl carrier springs

Cam plate steps

Replace pawl carrier springs if bent or if they have shiny flat spots. Always replace anytime you're inside the transmission. If broken, shifter won't return to position.

Inspect the housing for:

Cracks

Loose cam plate stops (tighten rivet heads if loose)

There were 2 versions of housings:

Early – 1957 – 1976 – Shaft protrudes above housing

Late – 1977 – 1990 – Shaft doesn't protrude above housing

Housings and cam plates don't interchange between early and late.

The pawl carrier assembly interchanges with any 4 speed.

XL Shift Forks – 4 speed – Same part from 1957 – 1990

9 different lengths. Standard is 1.440" from side of pin to side of fork.
+ or - .005", .010", .020", and .030"

1972 & earlier – steel

1973 & later – brass

The letter "C" on the shift forks designates standard

Good aftermarket shift forks can be obtained from V-Twin or Custom Chrome.

ALWAYS MEASURE!

3 things to look for with aftermarket shifter forks:

Flat place on the shaft to clear the countershaft 1st gear. If not there, the transmission will lock up when assembled.

Shoulder on the end of the shaft. In 3rd or 4th gear position the shoulder clears the transmission access door and allows the transmission to clear 4th gear.

Check the bore for smoothness and ease of movement on the shaft.

Always replace shifter forks if they are bent or damaged.

XL Mainshafts

Always inspect for wear or damage to the 3 bearing surfaces.

Early short – 1957 – 1969 – Has a hole through the center for the dry clutch release rod

Early long – 1967 – 1970 – Has a ½" longer hole through the center for the dry clutch release rod. Changed for electric start.

Late short – 1971 – e1984 – No hole.

Main Clutch Gears

Early short – 1957 – 1969 – Has a shoulder above the threads

Early long – 1967 – 1970 – Longer, has a groove below the splines

Long short – 1971 – e1984 – 2 different, both interchange. No shoulder above the threads. No groove at the base of the splines.

The needle bearing needs to be replaced occasionally. Use a blind hole puller. Don't use a slide hammer. Use a press. When you feel the bearing move 1/8" stop and spread the puller. Remove. Use an old mainshaft to seat the new bearing. The washer with 2 notches on top of the bearing is pressed in. The notches let oil into the bearing. Reinstall in the correct position – NOT UPSIDE DOWN!

Always replace the bearing on the countershaft in the case when the transmission is being serviced. Remove and install from the outside in. Don't hit with a brass hammer. Use a plastic hammer.

Shifter Shafts

Old style – 1957 – 1974 – Pinned in and has a spot weld or stake on both sides.

Look for flat spots on the side of the ball. Replace if it has flat spots. Look for straightness. Replace if twisted.

1975 – 1976 – Long

1977 – Shift shaft ran through the primary cover

1977 – 1985 – Long long

1986 – 1990 – Short long – evo

XL Transmission Disassembly and Reassembly

The only snap ring is on the main shaft 3rd gear

Knock out the countershaft oiler with an extension or deep socket. The tube lets oil into the countershaft 1st gear bushing. Clean the oiler carefully. The hole on the side faces up

Inspect the countershaft bearing surfaces and splines

Inspect the gears and dogs and doghouses. If rounded more than 25% replace

On the mainshaft, inspect the 3 bearing surfaces

Upon reassembly, the transmission can be set up and tested on the bench

There are 8 gears, 2 sliding

Countershaft Assembly

Start with the thrust washer

Then freewheeling gear

4 dog gear (5 dog on mainshaft)

Spacer

4 dog sliding gear

Variable thickness washer

Countershaft 1st gear (smallest gear)

Mainshaft Assembly

3rd gear

Non-variable washer

Last gear – groove faces away from the access door

Shift Forks

Cam plate has a bolt with retainer for the pawl / carrier assembly detent with lockplate

In neutral, the sliding gears should be centered relative to the gears on either side
3 things that affect centering:

Shift fork length

Variable thickness washer under the countershaft 1st gear

Pawl carrier shims

Pawl carrier shims move both shift forks away from the access door

Shift through the gears on the bench and look for a minimum of 50% engagement

If not enough engagement at 1st gear, change the washer

All drive is on the dogs

Direct drive transmission – 4th gear ratio is 1:1

If you shim under the countershaft 1st gear it will affect countershaft endplay

Mainshaft endplay is controlled by a teardrop washer

Check countershaft endplay after the transmission is installed

The mainshaft endplay should be .003” - .020”

Excessive endplay causes hard noisy shifting

Inadequate endplay burns down the shaft washer and ruins the bearing or gear.

XL Kickstart Mechanism

Through 1966 – Kick only
Through 1979 – Available with kick

Primary kickstart – Drives through the clutch and primary drive and not through the gearbox

The bushing in the gear wears out or gets loose. Sometimes the sleeve (clutch basket spacer) gets loose

The shaft has a thrust plate and a little square o-ring on it. This goes in the hole first

When replacing the shaft, use an old shaft from the other side to locate the thrust plate

The notch on the shaft should be in the 11:30 position

Check aftermarket kick shafts for: Shoulder that is too thick

Shoulder that is too thin

Squares on each end that aren't lined up in relation to each other

The big gear has a u-shaped groove on the back that runs on a pin in the primary

Shaft play should be .015" - .020". Shim if too much

Use a lockplate with tab behind the nut and use red loctite

The shoulder on the nut MUST face out. Torque to 45 – 50 ft/lbs

Check the big spring for damage. Make sure it's installed with the end behind the gear and in the 12:00 position

If the teeth on the plate are rounded, replace. Make sure the teeth on the new gear match the teeth on the old gear.

2 styles of kickstart:

Early – 1957 – 1970 – Dry

Late – 1971 – 1979 – Wet

These don't interchange!!

The teeth need to mesh good or it won't work

Clutch Main Bearing Removal

There is an inner and an outer snap ring

Knock out the shaft with a plastic hammer

Knock the old bearing out

If there is too much play where the bearing rides, use the oil ring rail off an XL. Clip apx. 1" off

To press in the new bearing, use an old 45" piston or something 2 ¾" in diameter

Use a sleeve for the Big Twin Timken bearing tool

Press the shaft in but never load the bearing

1980 and later has a different snap ring

XL Motor Mounts

Always tighten the rear motor mounts first, then the front.

The rear motor mount is mounted on studs. It won't come off with the cases together without cutting. A "Motorsport" mount should be reinstalled. The engine will still have to be removed, but the cases won't have to be split.

Vibration

Primary causes:

- Loose or broken motor mounts
- Worn out compensating sprocket
- Bad primary chain
- Bad clutch basket bearing
- Loose transmission mounts
- Broken rubber motor mounts
- Bent transmission mainshaft (dropped on left side)

To balance the engine, use a combination of rotating and reciprocating mass

Rotating:

- Bottom half of connecting rods
- Crankpin, nuts
- Rod bearings
- Bearing Cages

Reciprocating: (Balance factor or %)

- Top half of rod
- Pistons
- Wrist Pins
- Wrist Pin Locks

Static Balancing

Total weight of connecting rods, then weigh each end separately. Total should be within 1 gram of total rod weight

Weigh the crankpin, nuts, rod bearings, cages, pistons, rings, wrist pins, and wrist pin locks

After getting the rotating weight, hang a weight with exactly that weight on the flywheel in the crankpin hole

Put the flywheel assembly on LEVEL balance stand. Check the assembly in 3 places.

Don't drill around the crankpin hole

Use lead to "weight" the flywheel. Thread the inside of the hole and pour molten lead in.

Holes – 7/16" max in XL
½" max in BT

Never drill more than ½ way through the flywheel

Don't use wheel weights or body lead. Use pure lead if possible. Plumbers lead is good

Checking Mainshaft Endplay on 4 Speed XL

Use a dial indicator and bolt with 2 nuts

Put the bolt with one nut into the crankcase hole above the transmission mainshaft. Put the second nut on

Mount a dial indicator on the stud

Put the end of the indicator on the transmission mainshaft. Move back and forth to read the endplay.

Endplay should be .003" - .020"

Checking Countershaft Endplay on 4 Speed XL

Put a ¼" bolt with a nut in the lower rear primary cover hole. Mount a dial indicator on it. Fix the dial indicator to bear on the countershaft end. Use a bent spoke to move the countershaft.

Endplay should be .003" - .012"

When assembling the transmission use the thinnest washers to check the play

Torque the transmission mounting bolts to 12 – 14 ft/lbs. Use Blue Loctite and a star lockwasher.

Boring Bar

Bore Master – Made by Precision Mfg. in Clearwater, FL. Apx. $3000

Another good brand is Kwik Way, but it cost twice as much

Bore Master Mdl. CT 175 – 1.75" Shaft (quill) diameter

Use for cylinders up to 4" in diameter (there are 3 sizes available)

To Use:

Clean the Bore Master "table" – the cylinder registers on the table, upside down. The cylinder head gasket surface must be clean and flat.

Use parallel bars on the shovel or ironhead cylinder because of the spigots.

Lube the machine and the threads of the clamps

Use the centering core that comes with the Bore Master. It "almost" centers the cylinder.

Make sure the clamps are tall enough to do Evo and Twin Cam cylinders with torque plates attached.

Make sure the clamps don't touch the cylinder sleeve

If the clamps won't bear on the cylinder, use "jack" bars for the clamp to bear on. Position so that the jack bar is 1 or 2 notches higher on the clamp side than on the cylinder side.

2 types of bits – both are interchangeable and replaceable. The best is solid. They have to be replaced or recut.

When facing the switches, the 3 screws on the quill should face you. The cutting edge will be on your right and facing away from you.

Hold the bit down and against the cylinder. Tighten the center screw.

The Drive Pin goes in the center hole which is the one closest to the middle

Make a pass by hand and tap the cylinder with brass or aluminum to center the cylinder

Controls are Fast, Off, and Slow

Down is Counterclockwise, Up is clockwise

Always leave in the “Down Counterclockwise” position with motorcycle cylinders

Never start with the bit touching the cylinder

Turn on “Fast”. ALWAYS hold onto the switch

Don’t take a bigger cut than .007” - .008”. The finishing cut should never be more than .005” and preferably .003”

When finished with the first cut, take the drive pin out and put in the other hole for “Rapid Travel” to bring the quill back to the top

Take the pin out and unplug the machine and clean the bit

Use a boring bar micrometer but never assume that they are accurate

Measure the cylinder after every cut with the same micrometer that the piston was measured with

Put the Boring Bar micrometer over the quill. Snug the screw up with your fingers. Move it in until it touches the end of the bit. Loosen the 2 end screws. Put your thumb behind the bit with the forefinger on the top. Move it until you get the reading that you want. Turn it beyond the measurement that you want and then back it up for accuracy.

Run the quill down until it almost touches the cylinder but not quite

Put the pin back in the Boring Bar. Plug in the machine and hold the switch.

On the final bore, don’t run the quill back up. Take the cylinder off the machine

Piston Fitting – Non Evo

Anything except Evo –

Bore to the size of the piston, with no clearance or .001” under.

Then hone the cylinder to size

The piston – to – wall clearance should be .001” - .003”

Usually you must bore .001” - .002” to get the boring bar marks out

You must have the piston that you are going to use in your hand

MEASURE CORRECTLY!!

Measure the cylinder at the bottom

Deduct the width of the piston

The difference is how much to bore

Piston Fitting – Evo

The piston can’t be measured

Check the chart in the manual for:

Bore Diameter

Specs

Dimensions

High Lift Cam Cylinder Head Setup

To determine, you must know:

Cam lift at the valve

Rocker Arm ratio (it affects the lift at the valve)

Valve travel – How far the valve moves before anything hits. Usually the upper retainer hits the top of the guide

To measure valve travel, measure from the head to the top of the retainer. Using a carb spring, push down the valve until something hits. The difference is valve travel.

Take the cam lift at the valve & add .040" minimum at full length. .060" is better

To increase valve travel, the most common way is to shorten the top of the valve guide

When the valve guide is shorter, guide life expectancy is shortened but this is usually no big deal

If not running the valve guide seal, put a sharp taper on the valve guide for oil deflection

If running a valve guide seal add .125" (for height of the seal) to the length of the guide. This is problematic in iron head sportsters but everything else is okay

If the valve guide is too short for the seal to seat fully, the lower retainer must be machined so that the seal goes down into it some

OR

In instances where a valve with a long stem is used or the upper retainer is not as deep, the clearance is between the upper retainer and the guide seal

Don't ever "thin out" the upper retainer. The keepers will pull through

Don't use aluminum retainers on the street

Spring travel is how far the spring will move from installed height to coil bind

To check spring bind, take the spring(s), put in a vise, put paper between the coils and tighten the vise until the paper pulls apart. Deduct that measurement from the installed height.

You need as much spring travel as you have valve lift. Minimum of .040", .060" is better, and .080" is better still and has twice the life

To get more spring travel cut the spring seat out in the head (Kurt isn't fond of this method – you can go into the port if not careful! Last resort!)

The best method is to call the cam manufacturer's tech dept. and order springs from them.

Check spring travel on each spring and valve

6200 rpm is max on Evo

7000 rpm is max on Twin Cam

The 2003 103" Twin Cam engine has no Timken bearing on the left side. It uses a big roller bearing that is self aligning. It is retrofit – "plug in" "Super Blend Bearing"

On Evo and Twin Cam valve guides, there is no shoulder. Take metal off the bottom of the guide. Sink the guide that much further in the head. Adapt the guide tool to seat deeper.

Compression Ratio –

Useable upper limit – 10:1

Higher compression needs a sophisticated ignition system and won't run well on pump gas

9.5:1 is okay

9:1 is high for ironheads

To determine the compression ratio, get the difference in cylinder capacity (wet) from piston BDC to the spark plug hole, and from piston TDC to the spark plug hole. The difference is the ratio

1948 – 1965 Panhead

61" – 1948 – 1952 or 1953

74" – 1948 – 1965

61" – 3 5/16 X 3 ½

74" – 3 7/16 X 3 31/32

1948 – 1954 – Straight bearings

1955 – 1957 – Timken bearings & o-ring heads

1958 – 1962 – Different heads

1963 – 1965 – Outside oiler

Heads

1948 – 1954 – Plumber intake

1958 – Increased the diameter of the head ¼"

1958 – 1962 – O ring manifold

1963 – 1965 – Outside oiler lugs on the heads

Exhaust spigots are problematic. The steel exhaust pipes wore out the aluminum

Intake and exhaust valves are 1 ¾"

Bronze valve seats that aren't compatible with unleaded fuel. Machine the old seats out. .006" - .007" interference fit with the heads

Cast in steel inserts for the head bolts and spark plugs

It's not unusual for hairline cracks to develop between the spark plug hole and the head bolts, caused by overtorquing the spark plugs

Short plug – 3/8" – H8 or J2, Harley # 4 or #3/4

Most pan covers were aluminum

The D-ring is on the outside to prevent distortion. They are usually thin steel or thick aluminum

Rocker arm cover screws are 10-24 thread. Tighten until the gasket just bulges. There are 12 in each head.

Always use cork gaskets with aviation permatex on both sides

Pan always has a felt pad glued in the rocker arm cover with JB Weld

There isn't much room for valve stem protrusion

Rocker Arms

Top bearing half is bronze. The bottom bearing half is cast iron. Wear limit is .003"

The 61" engine has a smaller bore and a shorter cylinder

The earliest 74" engines have an oil feed passage and a drainback in the cylinder

In 1955 – 1962 engines, the feed passage and drainback comes in under the piston like a shovelhead

In 1963 – 1965 engines, the drainback is inside but no feed passage. It has outside oil lines

The base bolt pattern is the same for knuckles, pans and shovels

The headbolt pattern is different on all 3

The 74" pan uses the same pistons as the 74" shovel and the same headbolts and base nuts as the early shovels

Panhead Cams & Breather Gears

1948 – 1969 – 4 different cams

> 61" – Marked on gear on the front lobe – "61" and is hollow billet for weight reduction
>
> 1948 FL – The FL cam isn't marked
>
> 1955 – "H" cam – small bearing surface on each end
>
> 1958 – Dimensional cam change – went to a needle bearing in the case, from a bushing

Color coding started in the mid 50s to reduce noise

Panheads had hydraulic lifters

Knuckles and Ironheads had solid lifters

Oil fed out of the rocker arm.

The lifter was in the top of the push rod on early models.

Panheads can't use Knucklehead rocker arms. They are a different ratio and will cause damage.

Knuckle – 1:1
Pan - 1.5:1

Before 1958 there was no cam thrust plate. There was a shoulder on the bushing that did the same thing

Breather Gear

Pan – 1950 – Same as knucklehead – had a built in washer

Breather gear with a big hole works in knuckles and pans

Andrews J cam is good for stock Panheads

S&S sells breather gears for all models

High Performance for 45” Flatheads

Use K model cylinders, heads and intake – not KH or KHK

One cylinder stud will need to be relocated

Use KH, KHK, or KK cams but not K cams

Install 1 ½” carb or 36mm Mikuni

If using stock heads, stone around the valve seats to break the top angle

Relieve the area from the valves to the cylinder to a depth of .003”

Dynomometer

Horsepower calculations:

HP= RPM X TQ divided by 5252

CHP – Crankshaft HP – 5 – 7 % Parasitic loss
BHP – Output shaft HP – 10 – 15 % Parasitic loss depending on final drive
WHP – Rear wheel HP – 10 – 15 % Parasitic loss depending on final drive

Factors that influence parasitic loss –

Oil viscosity - #1 factor
Chain or belt tension and gear lash
Metal combinations (ie mild steel, hard steel, aluminum)

Chain – avg. 98% efficient – 9% PL
Belt – avg. 92% efficient – 18% PL – alignment is critical
Shaft – avg. 84% efficient – 26% PL

Rod tangency – 90% of rod tangency gives the greatest mechanical advantage, commonly between 59% and 78%

The crank stroke vs. rod length @ 90% delivers the most efficient engine leverage for power production depending on degree of E.V.O.

1) Confirm mechanical condition before dyno testing

2) Confirm electrical system condition before Dyno Testing

Coil saturation – Rise time and spark timing must all be identical

Heat range of plugs, determined by ceramic insulator

Spark gap tuning

Hotter plug develops heat closer to the piston

Colder plug develops heat closer to the head

If running lean, widen the gap
If running rich, narrow the gap

High heat plug throws flame front further away from the cylinder head
Low heat plug throws flame front closer to the cylinder head

3) Confirm air/fuel management

No air leaks

No fuel leaks or stuck needle valve assembly

Uniform fuel height in the float bowl

Uniform jetting in the pilot, needle and main jets

Be consistent with fuel types and fasteners

The specific gravity of fuel and compounds will determine the burn time of the fuel

How long and how efficiently the fuel will be able to be burned in the combustion chamber is the burn time

Burn time is 15:1 (stolki)
Avg. .064 -.980
Measure in .001 of a second
From lean to rich – short to long burn time
More oxygen – Shorter burn time
Less oxygen – Longer burn time

4) Confirm test conditions

Calculate correction factors including atmospheric conditions

The bore and flow of the head determine HP
The stroke determines TQ

Oversquare = HP – Bore is bigger than stroke
Undersquare = TQ – Stroke is bigger than the bore

Other influences – Compression – Affects HP & TQ

Octane – Number at which compressed fuel self-detonates

Air, fuel, spark & free radicals (gives greatest amount of power)

The faster the heat rise, the faster power is made

BMEP – Brake Mean Effective Pressure – Measured at the output shaft

X1R Oil Additive is the BEST! It's a friction eliminator.

Reasons to change oil – Heat, shearing of oil, acid buildup in oil

Rod length and stroke changes the angle of the rod tangency

Set exhaust valves by temperature

With a degree wheel on the crank, set TDC at zero

Put a dial indicator on the valve. When the indicator comes off zero, mark it on the wheel (this is the degree that the valve is open). Add to zero + 180 degrees of closure. Add valve close to get the total valve duration.

Use TDC stop to determine TDC, to enable you to zero the degree wheel properly

Superflow SF 250 Dyno

Most sophisticated Dyno available and the hardest to run

The sensor box is the heart and soul!! It holds all the intelligence gathering devices

6 computers, synchronized

Eddy brake (current) (360 lb – 500 HP)
- How much pressure to apply
- When to apply
- When to shut off the pressure

Weather station processor
- Air pressure
- Vapor pressure
- Humidity
- Source for correction factors

In Sensor Box

Keyboard & Display – Remote

PC for printing and display

Processed @ 400 times per second
Fuel Injection – 200 times per second

Closest competition is the Land N' Sea Dynomometer