All ECOTEC Powered

Swap an ECOTEC LSJ Clutch

One of the first vehicle upgrades many enthusiasts perform on their Ecotec 2.0L LSJ-powered Cobalt SS or Ion Red Line is the installation of a performance clutch. This is not a negative comment on the stock clutch—it is an excellent piece. But this supercharged four-cylinder engine makes it so easy to add big horsepower—like when you install a Stage 2 Upgrade kit (check out the details in Chapter 4) and go from 205 hp to 241 hp—you will need a new clutch to enjoy that power! That means you'll need to upgrade the clutch.

The Insider Tip

While some enthusiasts will pull both the engine and transmission to get to the clutch, there is a much easier and faster way to replace it. Instead, the inside line is to add a temporary engine support and remove just the transmission. Now, there are some finesse aspects and special steps required to make this happen—but you're in luck. This chapter is going to show the details to complete this process. So take some time and look through this chapter to understand what it looks like to remove and replace the stock clutch on the Cobalt SS Supercharged and Ion Red Line.

When does your clutch need to be replaced?

Other than just changing the clutch to minimize the chances of having an unplanned clutch failure, many ask, "How do I know my clutch needs to be replaced?" Well, the simplest way to know is when your car doesn't move under power—as in, the engine is running and you've got the transmission in gear, but nothing is happening (except maybe some smoke). Now, if you have a clutch system issue, such as air in the hydraulic clutch slave cylinder system, a mis-matched clutch/flywheel/slave cylinder system, or a damaged clutch master cylinder the vehicle will not go in gear, but it's not because your clutch is bad.

Another way to know you need to replace the clutch is when it is slipping. This situation is best described as when you're cruising along in gear and apply more throttle, but instead of speeding up, the engine just spins freely.

In general, a clutch problem never gets better, so if your vehicle is exhibiting any of these symptoms or you're increasing the power output of your engine, you need to read through this chapter and get ready to swap in a performance clutch.

The short story: clutch removal process

The clutch will be accessed in this chapter by removing the transmission and leaving the engine in the Cobalt SS/Ion Red Line. To perform this, a temporary engine support will be used to hold the engine in the vehicle. The first steps of the process are performed under the hood, then everything else is performed from underneath the vehicle until the transmission is removed. The clutch is removed from under the vehicle.

This clutch swap was performed on a 4-point lift, but you could do this work with this vehicle on floor jacks.

The transmission is reinstalled from under the vehicle and everything else reinstalled in reverse order from the disassembly process.

Tools To swap a clutch

The recommended list of tools includes the common sockets, wrenches, pliers, side cutters and zip ties, but there are some specialized pieces that really make this job go smoothly—like the swivel sockets, impact socket guns and the one 'shorty' wrench (the 18 mm one). We'd suggest you do your best to buy, borrow or rent these pieces—as they are what make the job go quickly and easily.

Tools List

- Sockets (7 mm, 10 mm, 15 mm, 16 mm swivel, 18 mm swivel, 19 mm, 30 mm)
- Socket Extensions (2, 4, 6 and 12 inch)
- 3/8 and 1/2-inch ratchet wrench
- 3/8 impact
- E10 Torx star socket
- Torque Wrench
- Temporary Engine Brace
- Brass hammer
- Rotary Grinder with scotchbrite pad
- Wrenches (8 mm, 15 mm, 16 mm, 18 mm and shorty 18 mm)
- Pushpin removal tool
- Large prybar
- Side cutters
- Pliers
- Long zip tie wraps (12 inches)

Lefty loosey, righty tighty

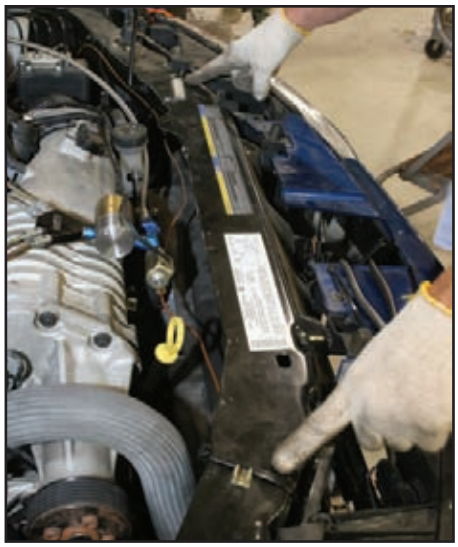
Unless otherwise called out, all threaded fasteners discussed in this book are removed by turning them counterclockwise around their axes (the "lefty loosey" theory) and tightening a threaded fastener is done by turning it clockwise ("righty tighty").

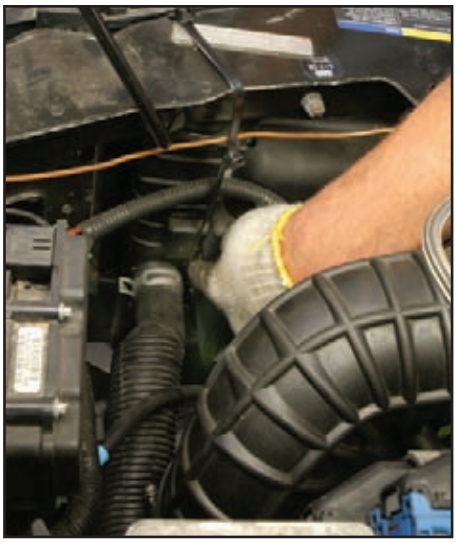
The best way to replace the clutch on the Cobalt SS Supercharged and Ion Red Line is to remove just the transmission—not the engine—like this.

This transmission is being removed from an Ion Red Line, but the Cobalt SS supercharged is very similar in the removal, so whichever vehicle you own, this chapter will show you the basics to swapping the clutch.

As always when working on your car, start your servicing by removing the 10 mm (5/16-inch on Ion) negative cable on the battery, wrapping it in a rag and pushing the cable down next to the battery to minimize the chances of it coming close to the battery stud as you work on the vehicle. Also, set the steering wheel in the straight position and lock it there by removing the key.

Zip tie radiator in place





The engine/transmission cradle will be removed during this process—and the cradle has the lower radiator mounts on it. To avoid having to remove the radiator with the cradle, loop two large zip ties around the top of the core support and the inlet and outlet hoses of the radiator in the areas where the two hands are pointing (left photo)—this will hold it in place—and save you from having to refill the coolant system.

Disconnecting Powertrain Control Module (PCM) plugs and removing PCM

The PCM and its holder need to be removed to gain access to the upper transmission mounting bolts that need to be removed to get the transmission out of the vehicle.

Start the removal of the PCM plugs by lifting the pivoting lock tab up and wiggling the connector off the PCM pins. Start by removing the top (blue) connector and work your way down to the black and gray connectors.

Remove the PCM by peeling back the lock tab on the controller holder and pulling up on the controller to remove it from the holder.

This is what the engine bay will look like with the PCM removed. You'll need to remove the black plastic PCM bracket next.

Removing PCM bracket

Peel the PCM bracket plastic clip up off the black metal rod on the top.

Then peel the plastic clip off the metal rod near the bottom of the backside of the bracket.

Pull the plastic PCM bracket forward and remove.

This is what the area will look like with the PCM bracket removed.

Removing air inlet tube

The upper inlet tube needs to be removed from the vehicle. This creates more room to access the upper transmission-mount bolts.

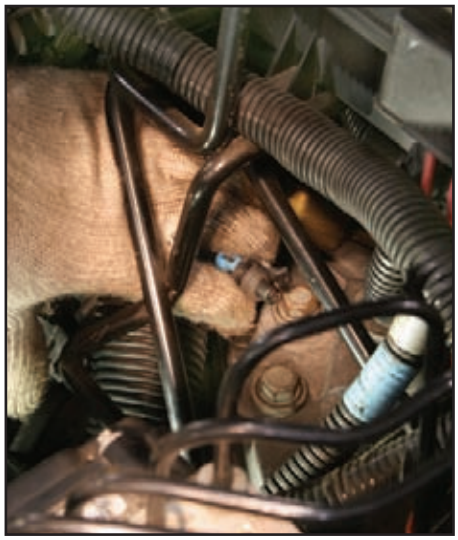
Loosen the air tube clamps with a 7 mm socket on a 1/4-inch drive ratchet (8 mm on the Cobalt SS).

Twist the tube at its base to 'break it loose' from the airbox and throttle body flange. Pull the air inlet tube off the engine.

Remove the PCV (positive crankcase ventilation) tube that feeds into the inlet tube by pulling it off the main inlet tube.

Remove the Mass Air Flow (MAF) sensor electrical connector by pulling back on the safety tab and pushing down on the lock tang to remove it from the MAF sensor. The Cobalt SS MAF is in the driver's side corner of the front fascia—reach the Cobalt SS MAF there.

Disconnecting reverse light connector



Remove the reverse lights electrical connector (located on top of the transmission by the shift arms) by lifting the lock tang and wiggling the connector off the transmission connector.

Installing temporary engine support

Install the temporary engine hanger bar across the engine bay. These are commercially available from OTC (P/N 1722) or you can make one out of a large metal beam. Make sure the ends of the support beam rest on the inner fender upper rail and not the exterior edge of the fender to avoid any body damage.

Feed the hook of the temporary engine hanger through the factory engine lift point (located on the driver's side of the engine). Adjust the threaded hook anchor on the temporary engine hanger to make the hook loosely touch the lift point—don't pull the engine up with the hanger—this will allow the engine to relax slightly in the engine bay which gives you some room to get clear the shift levers as you lower the transmission out of the engine bay.

Removing upper engine-mount bolts

You'll need to remove these three bolts before moving under the vehicle for the rest of the removal process.

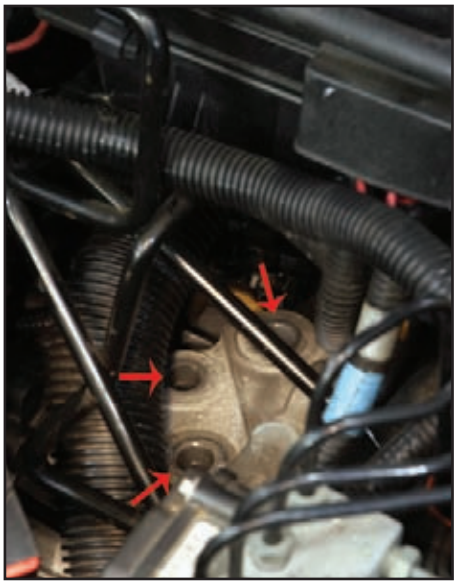
The best way to access these three bolts is with a 3/8 or 1/2-inch drive 16 mm swivel socket on an impact gun or breaker bar.

The bolts are located on the driver's side of the engine compartment, slightly underneath the electrical wiring box—which is why you'll need the swivel head socket. You can't get a 'straight down' orientation on them without removing the electrical box—which you don't want to remove unless you have to!

This is what the bolts will look like loosened and removed (one has been taken out of the mount).

— Removing inner fenderwells and side covers —

The engine/transmission cradle needs to be lowered out of the vehicle to remove the transmission—and to get that out, the front portion of the inner fenderwells and inner splash panels need to be removed—and that's the next activity.



Here are the three holes the 16 mm bolts seat in. This is what the mount will look like when you are ready to move to underneath the car for the rest of the transmission removal process.

Start by pulling out one of the inner pins on the pushpins on the lower portion of the front fenderwell. Then pry the pushpin body out of each hole in the plastic fenderwell.

Continue pulling the inner pins on the pushpins to release it and prying the pushpin bodies out of the holes in the fenderwells until the inner fenderwell from the centerline of the front axle is loose.

There are two 7 mm bolthead screws holding the front section of the inner fenderwells on the chassis. Remove and save these for reinstallation.

On the left is what the pushpin will look like after you have pulled up on the inner pin to release the pushpin "lock". The pushpin on the right shows you how the center 'pin' locks the pushpin in place when pushed down. When you reinstall these, just push the body into the hole of the inner fenderwell and mount, then push the center pin down to lock it in place.

This is what the inner fenderwell will look like after all the fasteners have been removed. Carefully pull the fenderwell back and slightly outward to clear the front suspension.

With the inner fenderwell pulled back, the side cover closeouts will be exposed. These need to come out now—pull the pins on the pushpins and pry out the pushpin bodies. These panels will also have 7 mm bolthead screws that need to be removed—once out, save all fasteners for reinstallation.

Remove the side cover closeouts on both sides of the vehicle.

With the inner fenderwells and side covers removed, you will have a good view of the engine/transmission cradle that will be removed soon.

Removing lower radiator mounts

With the radiator supported by the zip ties, the lower radiator mounts should now be unbolted and set aside until the reinstall.

The lower radiator supports are located at the front driver and passenger corners of the engine/transmission cradle and each is held in place with three 13 mm bolts.

Remove the 13 mm bolts, mark the brackets 'passenger' and 'driver' (this will save time during the reinstall) and set them aside.

Removing lower ball joints

The lower ball joint is held in place with a 16 mm pinchbolt and 15 mm nut. Remove the bolt/nut combo now.

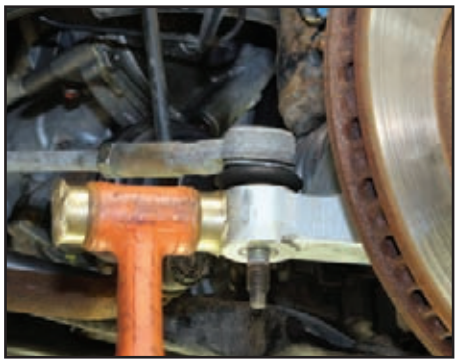
Once the bolt is out of the steering knuckle (as shown), pull down on the A-arm to release the ball joint from the steering knuckle.

Removing tie rod ends

The steering tie rod is held on the steering knuckle arm with an 18 mm nut.

Remove the 18 mm nut with a socket—preferably on an impact wrench as this will usually get these off without "spinning" the tie rod shaft. If the shaft comes loose before the nut comes off, grab the shaft with a 5 mm socket as you loosen the nut with an 18 mm open-end wrench.

This is what the tie rod will look like after the nut has been removed.



If the tie rod shaft doesn't lift out of the steering knuckle arm by hand, lightly hit the knuckle arm with brass hammer to release the taper lock of the tie rod shaft.

Removing swaybar mounts

Remove this 18 mm nut to release the upper swaybar mount on the shock strut. Notice the small visegrip pliers being used to hold the swaybar shaft that was spinning.

Removing steering U-joint

The steering U-joint needs to be removed from the rack and pinion steering shaft. This is because the steering rack is attached to the engine cradle and that is going to be lowered out of the vehicle. Make sure the steering wheel is locked in the 'wheels straight forward' position before removing the U-joint from the shaft to make the reassembly go faster. Also, locking the steering wheel prevents someone from spinning it after the shaft is disconnected and breaking the wires coiled on the steering shaft in the process—an expensive and unnecessary mistake!

The steering U-joint is accessed through the driver-side wheelwell, just behind the axle assembly. A 13 mm bolt on the U-joint locks the U-joint on the steering shaft and needs to be removed at this point.

This is what the U-joint looks like with the bolt removed.

You'll probably need to apply some force to separate the steering U-joint and shaft. The easiest way to do this seems to be to use a large pry bar and hammer—place the tip of the pry bar up under the lip of the U-joint and hit it with the hammer until the two components separate.

This is what the U-joint and shaft will look like when separated. Notice the location of the tip of the pry bar on the lower edge of the U-joint—this is where it was placed to help remove the U-joint from the shaft.

Removing lower engine mounts

With the engine supported by the temporary engine hanger and many of the engine cradle-mounted components released, you can now remove the two main lower engine mounts as the last step in preparation to remove the engine/transmission cradle.

Remove the three 15 mm engine mount bolts at the rear of the cradle. This will leave the large aluminum engine mount structure on the engine, but now the cradle is free of the engine.

Remove the 18 mm engine mount through-bolt at the front of the cradle

This is what the underside of the vehicle will look like when the engine cradle is clear to be removed.

Removing engine cradle

This can't be emphasized enough: Use caution when lowering any large components out of a vehicle, like the engine cradle. Use specially designed transmission jacks (they can be rented) and ask for help from at least one other person to steady the cradle.

Remove only two of the four 21 mm cradle bolts (the front left and the rear right bolts) before sliding the transmission jack under the vehicle as this will make it easier to lower the vehicle down for transmission removal. Be sure the two removed bolts are diagonal from each other.

Position the engine/transmission cradle on the transmission jack and clamp it in place to stabilize this large component. Ask for help from at least one other person to hold it in place as you lower it out of the vehicle.

With the jack firmly in place on the engine/transmission cradle, remove the two remaining 21 mm cradle bolts.

If you are on a vehicle lift, it seems easier to raise the vehicle off the cradle. If you are working on a fixed lift (like jackstands), you can drop the cradle down. But, if it doesn't immediately come loose, recheck to make sure everything is unbolted! Once out, set aside the cradle until reinstallation

Prepping steering shaft

The steering shaft gets rusty pretty quickly, which can make it tough to reinstall. Now is the time to correct this issue.

An easy way to address this is to lightly buff the metal of the steering shaft with a scuff pad (either by hand or as shown on a rotary grinder); remove only the rust—do not remove any metal!

Removing intermediate shaft

With the cradle lowered out of the vehicle, the transmission is exposed to be unbolted and removed to access the clutch. The first step towards this is removing the drive axle from the intermediate shaft on the passenger's side of the engine compartment.

Begin the removal of the passenger-side axle from the intermediate shaft by prying between the axle collar and intermediate shaft engine mount with a 24-inch prybar in this location. Use the closeup photo to really see how to pry on these two components. Pry the two shafts apart less than 1/2 inch before moving to the next step.

Once the axle is loose from the intermediate shaft, pull the entire front suspension assembly away from the engine and let the axle hang off the strut assembly.

This is what the backside of the engine will look like with only the intermediate shaft on it. Now, you'll need to remove the intermediate shaft engine mount as this will go with the transmission when it is removed.

Removing intermediate shaft mount

Remove these three 15 mm bolts to release the intermediate shaft engine mount.

Removing engine-mount bolts and accessories

The easiest way to remove the entire lower engine mount bracket is to unbolt it from the transmission. Prepare to remove this bracket by removing the plastic pushpin holding the O_2 sensor in place. This bracket needs to be removed to allow you to maneuver the transmission out of the vehicle.

These bolts can be removed with a ratchet and socket, but if you've got access to compressed air, an impact gun with an 18 mm socket on it will make this job go very quickly.

This is the bracket coming out of the engine compartment.

To avoid damaging it, remove the small dust shield in front of the halfshaft at the engine mount by taking out these two 10 mm bolts.

Removing driver's side axle

The axle on the driver's side will stay with the transmission, so it needs to be unbolted and slid out of the front hub.

With a buddy in the car holding the brake pedal down, loosen the 30 mm nut on the drive axle (this has the standard lefty-loosey threads).

Unthread the 30 mm nut until the nut is just above the last few threads on the axle so you can …

Hit the nut on the halfshaft to help release the axle splines from the inner splines of the drive hub. Remove the nut and washer.

Peel the hub assembly out from the engine bay until the shaft falls loose from the hub assembly.

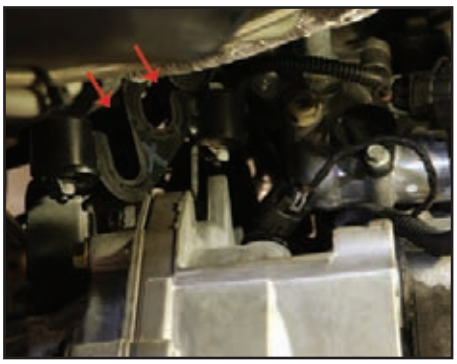
Removing transmission cables

The shifter for the 5-speed manual transmission in the Chevy Cobalt SS Supercharged and Saturn Ion Red Line selects gears through two cables that mount to two armatures on the transmission. These cables need to be removed from the arms and their anchor points as the next step in removing the transmission from the vehicle.

Important: The shifter arms must be put back into the exact position they were in when the cables were removed for the shifter to work properly.

Peel the two white plastic shifter cable ends off their respective transmission arms with the pushpin tool.

Remove the cable anchor points from their brackets by pulling back on the white and black collars, respectively, then lifting up on the collar to remove the cable from the bracket.



This is what the transmission shift cable bracket will look like after the cables have been removed.

Removing wiring

Disconnect the electrical vehicle speed sensor connector that is installed on the top of the transmission by lifting the lock tang and wiggling it off the transmission.

Removing air filter housing on Ion Red Line

The Ion Red Line (Cobat SS is different, so skip this step if you have an SS) lower air inlet tube and air filter housing need to be unbolted from the transmission case.

Use a 7 mm socket to loosen the two clamps holding the lower air inlet tube in place. Wiggle it off the air scoop and air filter housing mounting flanges.

No, that's not the factory air cleaner housing—the bottom has been cut off this unit to allow more air to get into this performance tuned engine. This works great on a performance car that won't be driven in the rain. If you plan on driving in the rain or even on wet roads, don't make this modification to your stock airbox!

After removing the three 13 mm nuts on the transmission stud/bolts, you can remove the air filter housing from the transmission. This is a snug fit, so don't be surprised if you have to pry the airbox off the studs.

Removing two bellhousing bolts

There are seven bellhousing bolts that need to be removed to pull the transmission off the back of the engine. The removal of the bolts is interrupted by a few secondary steps that need to be performed, so those steps are detailed in sequence.

Start by removing one 18 mm bellhousing bolt situated behind the starter on the front side of the engine. There is another 18 mm bolt next to the starter.

To fit in the tight space these two bolts are located in (both side-to-side and out front where the wrench will need to be turned), a 'shorty' 18 mm open end wrench will be needed for the outside bolt and a 6" extension on an 18 mm shorty socket to get the bolt behind the starter.

This is one of the two 18 mm bellhousing bolts near the starter being removed from the bellhousing.

Removing clutch slave distribution block

On the top of the transmission, there is this distribution block for the clutch pedal hydraulic line. This needs to be removed to pull the transmission. As a note, the clutch and brake systems on these vehicles use the same reservoir (the brake reservoir)—this comes into the process when the clutch is being "bled" of air.

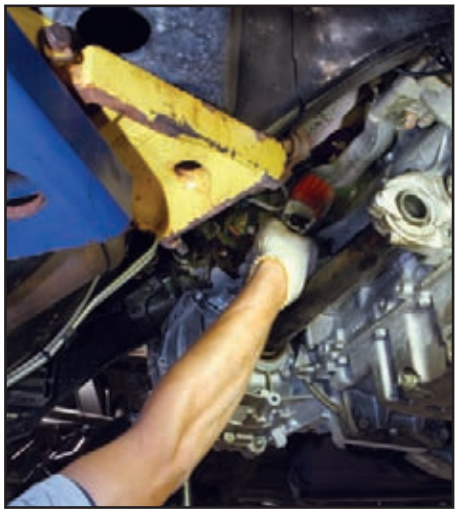
To remove the clutch distribution block, use a small dental pick to pull this (arrow) C-clip out of the distribution block and another C-clip that holds the hydraulic line in the block. Don't lose these! You'll need them during the reinstall process. Pull the distribution block straight up to remove it from the transmission.

Put a rubber cap on the end of the hydraulic line (like this) otherwise it will continue to drool brake fluid down onto you (not pleasant).

Removing more bellhousing bolts

Unbolt the two top 18 mm transmission stud/bolts using an 18 mm deep swivel socket on an extension. These stud/bolts will most likely be covered by a plastic clip holding a wire on the engine—peel that off with the pushpin tool to get to the bolt head.

These two 18 mm bolts are between the engine and the firewall on the bellhousing, and need to be removed.



This overall shot should give you a better idea of where these two bolts are located. After these are removed, the bottom bellhousing bolt will be the only fastener holding the engine/transmission assembly together. You'll want to get the transmission jack in place before removing this last bellhousing bolt.

Preparing to remove transmission

Position the transmission jack under the main case of the transmission with a 2x4 block of wood under the driver's side of the transmission case to stabilize the non-flat transmission on the jack face.

Now, remove the final (of the seven in total) 18 mm bellhousing bolt on bottom of engine, while a helper holds the transmission with you (it shouldn't come loose with just the removal of the bolt—but you want to focus on safety with this).

Use a small pry bar or screwdriver to separate the engine/transmission and move the transmission off the engine a few inches before lowering it out of the vehicle. This is where not having the engine held tightly up in the engine compartment pays dividends—it leaves lots of room to lower the transmission out of the vehicle. Again, have a helper hold the transmission with you as you lower it down out of the vehicle.

Tape the factory transmission-to-engine shim in place with some masking or duct tape.

Removing clutch

With the transmission out of the vehicle, you'll be looking at the clutch bolted to the back of the engine (which is still bolted in the car). Now is the time to remove the clutch and flywheel as the first step in replacing the clutch. The flywheel also should be replaced.

To unbolt the clutch, remove the six external E10 Torx (known as a 'star socket') bolts holding it in place, with a criss-cross pattern.

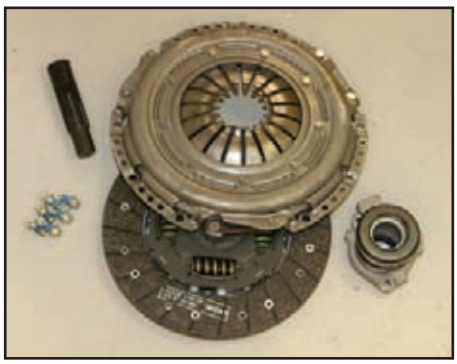
Use a pry bar to start the removal of the clutch and pressure plate assembly from the flywheel pins.

Be careful as you remove the stock clutch and pressure plate assembly as these are heavy components with distinct edges—you'll want to have a firm grip on them and get them down out of the vehicle with care.

Prepping for new clutch

Remove the stock flywheel from the engine by unbolting the eight 17 mm bolts and replace if needed.

Installing new clutch



Here is what you'll want to buy for your Cobalt SS or Ion Red Line: a performance clutch, pressure plate, bolts, alignment tool and, if needed, a new throwout bearing. The throwout bearing might be required if the clutch uses one different than the stock piece—if it doesn't, most enthusiasts don't swap out the throwout bearing as they are very durable.

When taking the clutch/pressure plate out of its packaging, make a note of how they go together (like these two pieces). Most clutch/pressure plate combos will only assemble one way—but there are those that can be improperly installed, and taking your car back apart because of this is miserable! As a note, most clutches are marked "trans" and "flywheel" to show how to assemble them.

With the replaced flywheel torqued to 39 ft-lb (53 N-m) on the crankshaft and each bolt rotated another 25 degrees, it's now time to install the new clutch on the engine. Start by positioning the clutch on the three small pins at the outer edge of the flywheel. Then, finger start all the bolts in their threaded holes.

Slide the clutch alignment tool through the clutch and into the pilot hole on the crankshaft. This might require some wiggling and pushing—but shouldn't take more force than that.

Tighten the clutch bolts onto the flywheel with an impact gun (set on low) or a socket wrench.

Pull the alignment tool out and you should have a new clutch installed like this.

Torque the clutch bolts in a radial pattern to 21 ft-lb (28 N-m).

Reinstalling transmission in vehicle

Congratulations, you are over the hump to getting your Cobalt SS or Ion Red Line back on the road and stronger than ever. The transmission will now be reinstalled. As a suggestion, if you are performing this work on the floor it will help to have a floor jack placed under the transmission to hold the transmission securely as it is maneuvered into position to thread the three upper transmission mount bolts in place (this can take some time).

Lift the transmission back up into the vehicle while keeping the intermediate shaft mount face flat against the backside of the engine (because it's practically impossible to re-clock this once installed, so get it right!). Install at least one bellhousing bolt to just past hand tight once the engine and transmission are mated to hold them together. As a tip, you might need to knock the transmission into gear and rotate the engine slightly to get the splines to line up, but this should be a relatively rare situation.

Here's something that could trip you up: Make sure this little 'cap' is on the fitting for the hydraulic clutch line on the top of the transmission and is seated properly before the transmission is reinstalled. If it's not there, the system will leak profusely when you go to pressurize the clutch system and you'll be unhappy—because a lot of rework will need to happen to properly install this piece.

This is what the cap will look like when properly installed on the clutch hydraulic fitting on the top of the transmission.

Installing bellhousing bolts

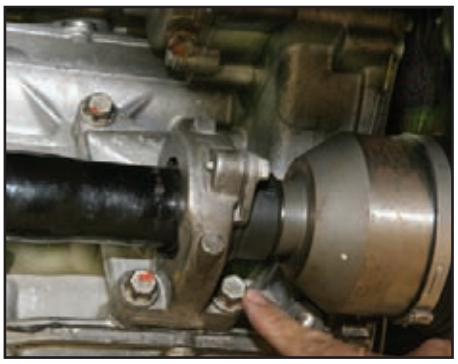
Here is the intermediate shaft mount properly positioned.

The bellhousing holes are very close to the size of the bellhousing bolts, so the engine and transmission will need to be perfectly aligned for the threads to "grab" on the bellhousing bolts. This is good, as the chance of "cross threading" the bolts is minimized—but don't force any bolts that don't thread in smoothly! Take them out, reposition the transmission and start again.

Getting all seven 18 mm bellhousing bolts started and hand tight is a two-person job. One to help repositioning the transmission, the other to work the bolts into the threaded holes.

Once all the bellhousing bolts are hand started on the threads, tighten them to just past hand tight.

Installing intermediate shaft engine mount



Install the passenger's side intermediate driveshaft mount on the engine with the three 15 mm bolts. Torque these bolts to 37 ft-lb (50N-m).

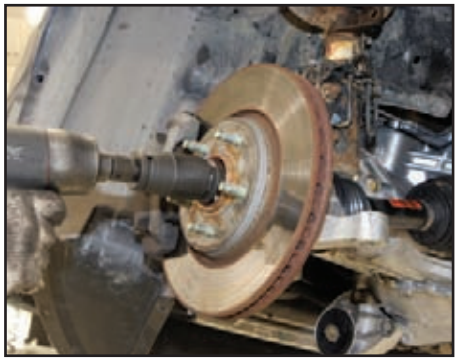
Installing passenger's side axle in intermediate shaft

Install the passenger axle shaft into the intermediate shaft by pulling back on the suspension assembly and sliding the axle into the intermediate shaft. Add a light wipe of anti-seize compound on the splines before installing the axle to ease removal in the future. Be careful to keep the axle centered in the intermediate shaft as you feed it in, to avoid damaging the seal. As the splines meet, you might need to turn the axle slightly to align the splines. Slide the axles together until they are fully mated.

Installing driver's side axle in hub

Lift the driver's side suspension assembly outward and position the axle so it will feed into the drive hub in the steering knuckle.

You might need to rotate the drive hub slightly to align the splines—once they are aligned, push the two together until the threaded end of the axle pokes through the drive hub.



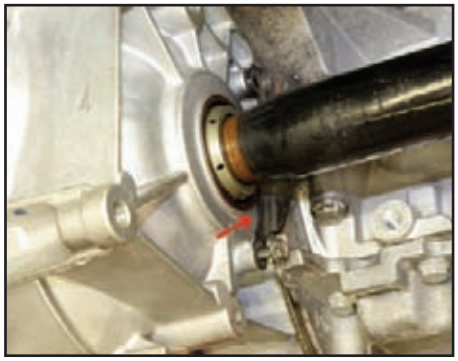
Hand start the 30 mm nut on the axle threads (you did put the washer on first, right?) and tighten with an impact wrench set on low (shown), or a ratchet wrench to just past hand tight. Torque the nut to 155 ft-lb (210 N-m) by having a helper hold the brake pedal down to keep the axle from turning.

Installing shifter cables

Reinstall the transmission shifter cable anchor points in the brackets by pulling back on the lock collars and pushing the cables into the metal bracket. Place the cable with the white connector in the lower bracket hole, then install the black collar in the top opening of the bracket.

Make sure the transmission arms are in the same position as when the cables were removed. Then, snap the shifter cable ends onto the transmission armatures they are laying on and plug in the vehicle speed sensor at the back of the engine (not shown in photo).

Installing dust shield



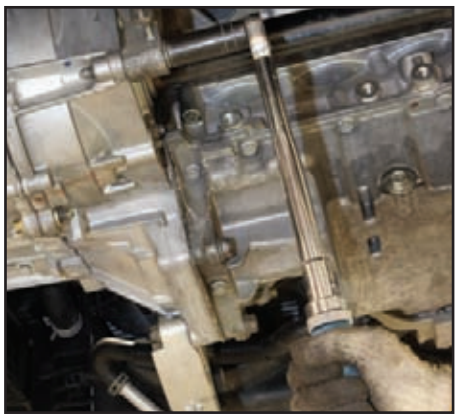
Install the dust shield on the back of engine/transmission assembly with the two original 10 mm bolts.

Installing rear engine mount

Install the rear engine "torque reaction" mount with the three 18 mm bolts. The mount attaches to the cradle, which is not in the car yet—so that will just hang in the breeze for right now.

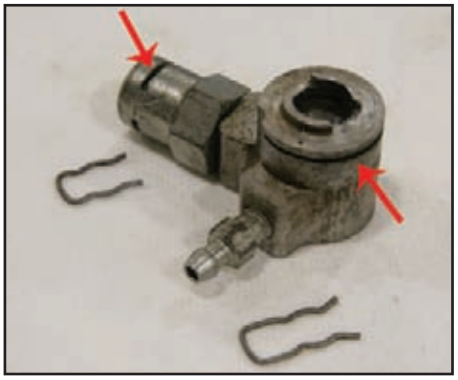
Torquing bellhousing bolts

Now, use an impact wrench on a lower setting to tighten all seven bellhousing bolts.

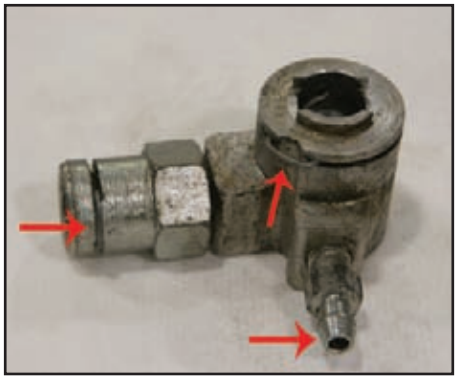


Torque all bellhousing bolts to 55 ft-lb (75 N-m) in a radial pattern. Install any plastic grommet cable holders onto any stud/bolts (these stud/bolts go in the top two bellhousing holes).

Installing hydraulic clutch slave distribution block



In preparation for reinstalling the clutch slave distribution block, reinstall the big and small "C-clips" using the two red arrows as a guide for the direction to push the clips into the body.



This is what the clutch slave distribution block will look like with the C-clips properly installed. **Note:** The clutch slave hydraulic system bleeder screw (lower right arrow). An easy way to bleed the system is to pump up the clutch pedal and release this bleeder until the clutch pedal bottoms out. Close the bleeder and repeat until you have pedal pressure.

Reach up from under the engine bay to the top of the transmission with the clutch slave distribution block positioned with the hose end pointing toward the passenger's side of the vehicle. The block needs to be "clocked" properly to "click" into place—so don't push too hard on this if it doesn't go on right away. Reposition and push until the block snaps onto the fitting on the transmission (you do have that little, black tip on the fitting, right?—see "Reinstall the Transmission" a few pages back for what that should look like)

This is what the clutch slave distribution block will look like when it is fully installed. Now the clutch line needs to be installed on the distribution block.

Install the hydraulic clutch line on the transmission. Push the line in until it "clicks" into place, then lightly tug on it to ensure it's locked in place.

Installing Ion Red Line air filter housing

It's now time to reinstall the air filter housing in the Ion Red Line (remember, the Cobalt SS air box will not need to be removed to swap the clutch).

Reposition the air filter housing in the vehicle and on the three stud/bolts on the transmission. As a note, this housing MUST be installed before the cradle is installed—forget and you'll have to remove the engine cradle to get the air filter housing in place.

Note: The Cobalt air filter housing is outside of the frame rail and does not require this step.

Install the three 13 mm nuts, the lower inlet tube and tighten the 7 mm adjusters on the clamps to complete the installation of the air filter housing.

Installing engine cradle in vehicle

With a helper and the transmission jack, lift the engine/transmission cradle back up under the vehicle in preparation for bolting it in place. In case you get confused as to the positioning of the cradle, the steering rack-&-pinion unit bolted to the cradle is located behind the axle centerline.

As the cradle gets closer to the vehicle, you'll need to position it close to the four cradle bolt holes. This is not as easy as it seems, so sneak up on it. Get the passenger's side two holes lined up—you're going to install the ball joints before tightening all the bolts as this will help to align the cradle to the vehicle.

Keep "repositioning" the cradle up to the vehicle until you can hand start two passenger's side 21 mm bolts (of the four total bolts) in the framerail. The engine will need to be lifted slightly to fully install the cradle bolts on the driver's side, so they can wait.

Installing ball joints

To help align the cradle in the vehicle and continue the reinstallation, push the ball joint shaft up into the steering knuckle.

Install the "pinch bolts" on each side (15 mm bolt, 16 mm nut).

Tighten the bolt/nut combo to past hand tight and torque the fasteners to 37 ft-lb (50 N-m), then add 30 degrees of twist to the bolt/nut combo.

Installing engine cradle bolts

This is what the 21 mm cradle bolts will look like when hand started in the threaded chassis holes.

The passenger's side bolts are tightened to past hand tight to help align the cradle in the vehicle.

A jack is used to raise the engine up to hand start the remaining 21 mm cradle bolts into the chassis. Torque all four bolts to 74 ft-lb (100 N-m), then twist 180 degrees.

Installing rear lower engine mount

The three 18 mm rear lower engine mount bolts are then reinstalled and torqued to 37 ft-lb (50 N-m).

Installing front engine mount

Install the one 18 mm bolt through the front torque reaction mount for the engine. Use an extension with a 18 mm swivel socket to tighten and torque to 74 ft-lb (100 N-m).

Installing tie rod ends

Push the tie rod end shaft into the tapered hole in the steering knuckle arm in preparation for bolting it in place.

Hand start the 18 mm nut on the tie rod.

Torque the 18 mm nut to 44 ft-lb (60 N-m).

Installing swaybar ends

Push the swaybar end up to mate with the hole in the bracket on the strut and push the shaft through the hole.

Hand start the 18 mm nut and tighten to 59 ft-lb (80 N-m).

Installing steering U-joint

Position the steering knuckles in the "straight forward position" and push the steering U-joint down onto the rack-&-pinion shaft. Hand start and tighten the 13 mm bolt to 25 ft-lb (34 N-m) to hold the U-joint on the shaft.

Installing lower radiator brackets

You did mark the two radiator brackets, didn't you? No matter, you'll be able to tell what you're looking at by comparing these to your brackets.

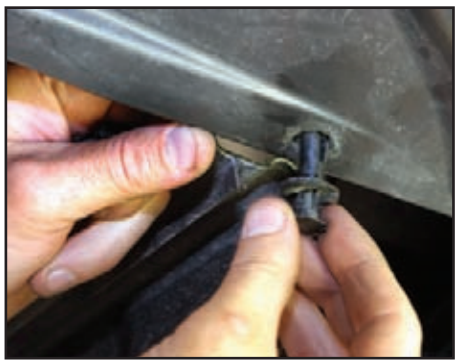
Install the passenger's side bracket like this and hand start the three 13 mm bolts through the bracket into the cradle. Torque to 18 ft-lb (25 N-m).

Install the driver's side radiator bracket on the cradle and hand start the other three 13 mm bolts. Torque the fasteners to 18 ft-lb (25 N-m).

Reinstalling closeout panels and inner fenderwell lip

Reinstall the inner splash panels with the pushpins and 7 mm bolt-head screws.

Peel the front portion of the plastic wheel liners back into position.



Fasten the wheel liners in place with the push pins they were originally held in place with.

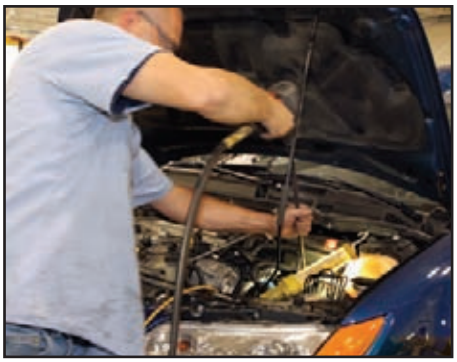
Install the 7 mm bolt-head screws and tighten to hand-tight.

Reinstalling upper engine mounts

You're now in the final stages of this reinstallation process. The action will now move to the top of the engine bay.

Loosen the hook on the factory lift point of the engine and remove the temporary engine support cradle.

Hand start the three 16 mm upper engine mount bolts with a swivel head socket on an extension.



Torque the upper engine mount bolts in a radial pattern to 37 ft-lb (50 N-m).

Installing inlet tube

Lower the upper inlet tube that goes between the air filter housing and the throttle body down into the engine bay. Install the EGR tube by pressing it on the tube fitting.

Push the inlet tube on the mounting flange of the throttle body.

Push the inlet tube on the mounting flange of the air filter body.

Carefully tighten the 7 mm adjuster nuts to just past hand tight. Install the front wheels/tires on the vehicle at this time also (not shown) and torque the lugnuts to 100 ft-lb (136 N-m).

Reinstalling PCM and electrical connectors

Reinstall the PCM holder in this area and push on it until the clips snap onto the metal tubing structure it attaches to.

Snap the PCM back into the holder and start to reattach the electrical connectors (gray first). Snap the lockdown clip down to lock the connector onto the PCM.

Reinstall the black and blue connectors next until your PCM looks like this. Reinstall the reverse electrical connector on transmission (not shown) at this time.

Removing zip ties on radiator

You can now cut the zip ties off that were holding the radiator in place.

Bleeding the clutch Pedal

(**Note:**: This is part of the brake system!) This is a critical aspect of the clutch installation, so take your time here. The most important point is that the clutch and brake system utilize the same fluid reservoir—so the process of getting pressure in the clutch pedal also involves getting brake pedal pressure. DO NOT DRIVE YOUR VEHICLE UNTIL YOU HAVE PEDAL PRESSURE IN THE CLUTCH AND BRAKE PEDALS.

To start the process of 'bleeding' the air out of the clutch pedal, you'll need a vacuum bleeder. Install the vacuum plug on the fill opening of the brake/clutch reservoir.

Pump up the vacuum bleeder until it is pulling 15 Hg vacuum on the master cylinder/clutch reservoir. Leave this system pulling a vacuum for about 10 minutes. Release the vacuum and move to the next step—but keep the vacuum bleeder installed as you will repeat this 'pulling the vacuum' process a few times.

Inside the vehicle (and with the vacuum released), pump the clutch pedal 5 to 10 times. Take a note of the "pedal feel"—the pedal will not have any 'resistance' in the beginning, but this should build as you repeat the vacuum/release/pump process.

Take your foot off the clutch pedal. Reapply the 15 Hg vacuum on the brake/clutch reservoir. Hold that vacuum on the system for approximately 4 minutes. Bleed off all the vacuum and pump the clutch pedal again 5 to 10 times. Repeat this process until you have suitable clutch pedal pressure.

NOW READ THIS! Perform multiple brake pedal pumps to pressurize the brake system again. This needs to be performed as the clutch bleeding process will pull fluid out of the brake lines, pulling the pistons in the brake calipers away from the rotor. Once you have clutch and brake pedal pressure, you are ready to hit the road again.

Breaking-in the clutch

Driving your car with that new clutch should be done with care for the first few heat cycles—so don't plan on drag racing in the first 10 minutes out. Once you have a few easy engagements in the clutch and at least one heat cycle, the clutch should be ready for regular usage—if there is such a thing with one of these rockets!

Building a 300 hp ECOTEC 2.0L Supercharged LSJ Engine

You're about to learn the steps required to build a supercharged, 300 hp Ecotec LSJ four-cylinder engine! Get ready to make some power.

The General Motors 205 hp Ecotec 2.0L Supercharged (Regular Production Option – LSJ) engine is a perfect starting point for a performance engine. It comes from the factory with great foundation pieces like its forged crankshaft and forged steel connecting rods. It also has a high flowing intake and exhaust tract and is packaged in a compact, efficient system. But, as with any engine, learning how to swap out the stock parts for performance equipment involves some special tools and processes that can be hard to learn on your own. To help you through those events, this chapter documents the installation of aftermarket fuel injectors, forged pistons, higher-rate valvesprings, ported cylinder head and performance grind camshafts to create a 300+ hp LSJ ground-pounder.

The Project

The engine assembled in this chapter would be perfect for a road racing or street/strip racing-style performance vehicle, and maybe a "hot" show car. It produces a thick and meaty powerband that would make any car enjoyable but it is a performance engine: it exhibits an aggressive idle, does not meet production emission standards and wants to run in a high rpm operating band. This engine package is durable, though. It was run for a considerable amount of miles before requiring a refresh.

The engine used as the basis for this project is now available in the 2005-7 Chevrolet Cobalt SS Supercharged and 2004–7 Saturn Ion Red Line and also as a crate engine from GM Performance Parts (P/N 12499466).

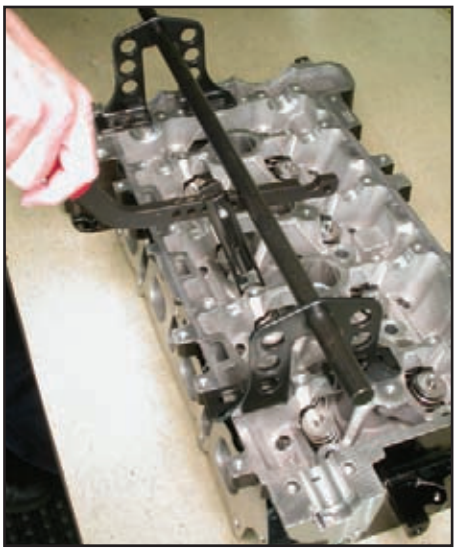
As you will find, practically every step to go from the factory-rated 205 hp to well above 300 hp is detailed here with photos, torque specs and more. Read on to learn what there is to know about building real horsepower with an Ecotec LSJ engine.

SPECIAL PARTS NOTICE

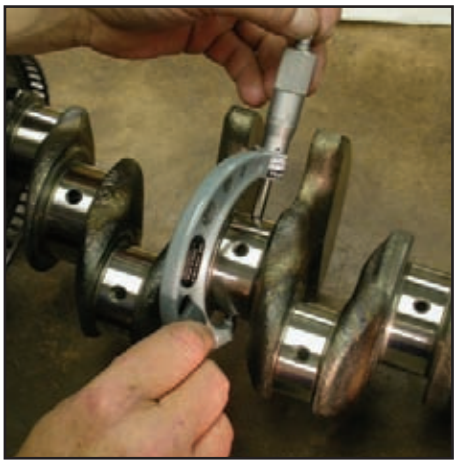
Parts used in this engine have been specifically designed for Off-Highway application only. Since the installation of these parts may either impair your vehicle's emission control performance or be uncertified under current Motor Vehicle Safety Standards, they should not be installed in a vehicle used on any street or highway. Additionally, any such application could adversely affect the warranty coverage of such an on-street or highway vehicle.

Most of the components used to build this engine are bone-stock—a testament to the capability of the stock pieces. The performance components needed to make a big Power-per-liter number (like 150 hp/L) include fuel injectors, forged aluminum pistons, higher spring rate valvesprings, more aggressive camshafts and a new calibration and controller.

The Ecotec engine can be disassembled with simple Metric hand tools and a few specialty tools (piston ring spreader, rod vise, etc.). A multilevel cart or shelving unit (in background) should be used to store and organize all the pieces—as most can be reused. For more details on the disassembly process, refer to the Ecotec Handbook, (GM Performance Parts P/N 88958646) or view a downloadable image of this at www.gmtunersource.com.



The cylinder head requires a few special tools, like this valvespring compressor assembly (a Goodson P/N CF-300), to tear down and then reassemble. This step of installing performance valvesprings is required to handle the more aggressive lobe profiles of the performance cams, and for engine rpm higher than 7,000.



We have heard from many performance engine builders about how impressed they are with the Ecotec's stock component tolerances and materials quality. But even with that, it is a good idea to measure the critical interface areas, like the crank main and rod journal diameters (being measured above). The crank mains should be measured at three points on the face of the bearing surface (center and close to the sides) to ensure it is "flat" across its face and round in circumference, then the measurements recorded for future reference.

Pre-assembly work:

The one issue that needs to be addressed regarding the stock cast components is they have very sharp edges, left over from the machining processes, that should be removed as is being performed here. In a production-usage engine, these sharp edges pose no threat, but in the increased vibration and heat of a performance engine, there is a chance one of these sharp edges could fall off and be swept through the oiling system into a bearing or other critical surface interface. Use a three-edge deburring knife or a machinist's deburring tool, as is shown here, to knock the edges off.

As an added level of insurance, some engine builders recommend going over the deburred edges with a rotating abrasive wheel to remove any metal that has been "folded over" by the knife or machinist's tool—as has been performed on the combustion chamber lip on the Ecotec head (shown). This step requires extremely thorough cleaning in a wash tank afterwards to remove ALL of the abrasive debris from the engine—any of this abrasive will quickly destroy an engine.

Buildup of reciprocating assembly

All the components need to be thoroughly washed in a solvent tank and blown off with compressed air (make sure there is a water separator in the air line to minimize the moisture in it) to ensure the engine components are clean as they go together.

With the engine completely disassembled, the first step to building a performance Ecotec engine is to replace the stock aluminum pistons with aftermarket forged aluminum pistons like these available from Diamond Racing Products (586-792-6621, Diamond racing.net). The stock connecting rods, piston pins, piston pin locks and piston rings will be reused, so carefully disassemble them from the stock piston. Here, the piston pin circlip is being pryed out of its groove in the side of the piston with a "pick" tool so the piston pin can be slid out.

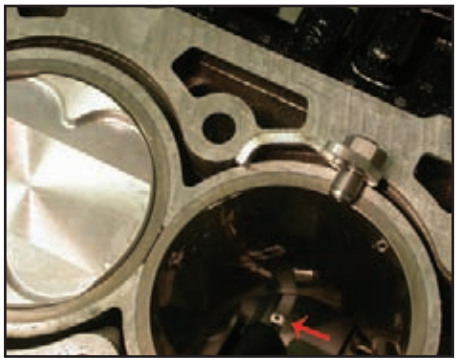
To install the aftermarket forged aluminum pistons on the stock rods (which are more than capable of handling up to 300 hp), install a circlip on one side of the piston (to see how to do this, refer to next caption). Then, wipe down the stock Ecotec 2.0L pin with assembly lube and slide it into the piston pin bore. As a note, the stock pins received a small 45-degree chamfer on the ends of the pins to increase the "lock" on them—a common performance modification when using stock pins.

To lock the piston pin in place, install the second 'circlip' in the forged aluminum piston. The best way to do this is to seat one end of the circlip in the piston pin circlip groove while holding the circlip close to the piston with the finger on one hand and push on the other open end of the circlip with a large, flat metal dowel with your other hand until the end of the circlip snaps into place in the piston groove.

The stock eutectic cast aluminum pistons (right) are quality pieces for the 205 hp supercharged production engine, but once you start to move up in power production, aftermarket forged aluminum pistons (left) are required to handle the rigors of big power. These pistons have a slightly higher piston height, which raises the compression ratio from the stock 9.5:1 to 10.0:1.

While the stock pistons need to be replaced, the stock rings are more than ready to handle big power. To install the rings in the forged pistons, start by wiping the rings off with a lacquer thinner soaked lint-free paper towel and then lightly lube the rings with engine oil (in this case 5W30 synthetic oil was used).

Using a ring spreader, carefully open the ring to remove the stock rings from each stock piston and do the same to install them in the ring lands of the aftermarket piston. These rings can be a little brittle during this step, so do not spread them any more than you have to—or you may break them.



The Ecotec engine uses these piston oilers located at the bottom of the engine bores to spray engine oil up into the bottom of the pistons to cool them. If they are removed during the teardown, they need to be reinstalled now. Each oiler seats in a small locator hole that allows it to swing about 50 degrees—so you'll need to position them carefully to avoid hitting the connecting rod, yet still spray the oil at the piston. This position is usually close to perpendicular to the rod (shown). Apply 1 drop of red Loctite thread locker to the mounting bolt and torque to 18 ft-lbs.

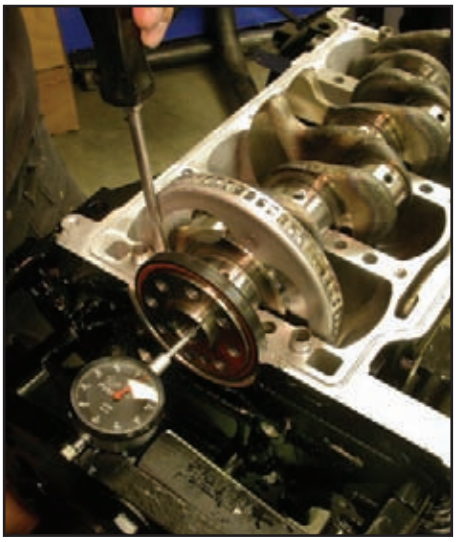
Installing crankshaft in block

This was a brand new engine, so the stock crank main engine bearings are being reused. If you've removed them from the engine block, make sure to keep them in the order you found them and clean them thoroughly. The reinstall process should include wiping the inner face with either engine oil or Torco engine assembly lube, then pushing the upper half into the block receiver groove until it "clicks" into place.

The rear seal is an O-ring-style piece that should be seated on the crank (like this) before the crank is installed in the engine block. Wipe the crank seal surface with a light coat of Torco engine assembly lube before sliding the seal into position.

The stock crank can then be reinstalled. To do this, it should have been cleaned, measured and stored until the time came to install. Then, with the main bearing surfaces liberally coated with Torco assembly lube and the rear seal in place, the crank can be lowered into the top half of the engine block (with the block on an engine stand in the upside down position).

With the crank seated in the engine block, the rear seal should pushed up against the engine block sealing face. Do this around the circumference of the block material.



The Ecotec engine has its main caps integrated into a single bottom end girdle, which makes checking end clearance (the amount the crank can move front to rear once the mains are torqued down) very difficult. You can get a very good idea of what the end clearance will be by checking it before the main girdle is installed. Do this by zeroing a dial gauge at one end of the block and pushing the crank forward and back. The end clearance should be between 0.001 and 0.0015 inches.

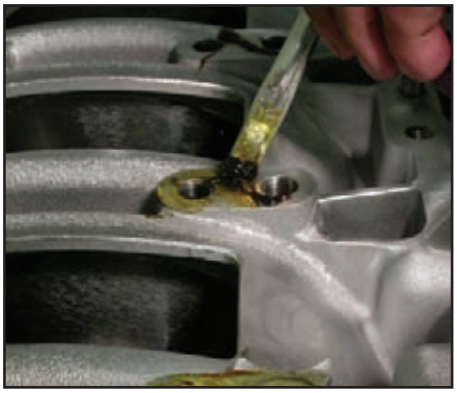
Installing main cap girdle

Install the "lower half" of the main bearings in the rear girdle and wipe the bearings with assembly lube.

To final install the bottom end girdle/main caps, a 1/16 to 1/8 inch diameter bead of Threebond 1280B-GM liquid gasket sealer is applied to the groove in the bottom of the engine block. This sealer will not "tack up and harden" like most liquid sealers, so you don't have to rush to mate these two components—but it creates a very substantial bond between these two components, so make sure you are ready to have these pieces go together. The sealer is used to minimize the chance of leakage and increase engine block rigidity.

There are dowels that locate the engine main cap girdle on the block, so it needs to be carefully aligned and pushed on evenly. A little force will be required to seat the girdle on the dowels—it might help to carefully work the girdle back and forth on the dowels to get it fully seated.

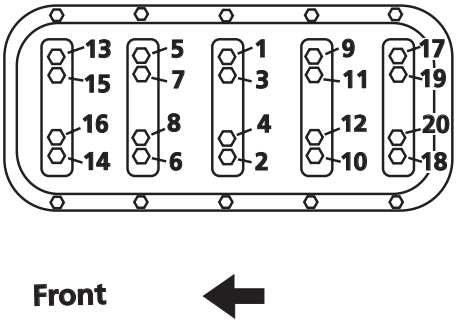
The fasteners for the main girdle are what GM calls "torque to yield"—which means they stretch beyond a reusable limit to provide consistent clamping force through multiple situations. You'll need to buy a new set (GM P/N 11519783) when building this engine (along with a set of head bolts shown later). Apply engine oil to the threads of the bolts.



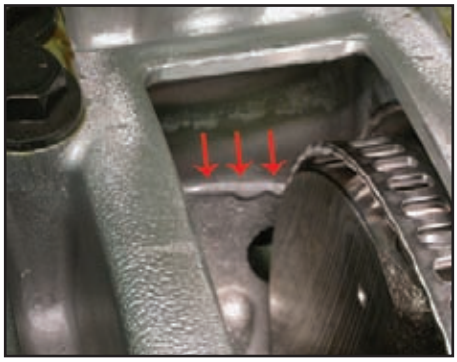
The "torque to yield" bolts are installed at a low torque level, then "twisted" a certain amount of degrees to final install them. To help minimize the chance of getting a false torque reading, it is a good idea to apply a light coating of CMD #3 high pressure lube to the bolt face area on the girdle.

The girdle bolts are all torqued to 15 ft-lbs starting with the center bolts and moving radially outward to the bolts at either end of the girdle (see torque sequence illustration on right)).

Then, using an "angle socket" like this one (available from Snap On, SPX or other tool outlets), twist the bolts 70 degrees further. Follow the same sequence (at right) as torquing with doing twist. All the bolts then need to be twisted a final 20 degrees in the torquing sequence.



As the last step in assembling the bottom end of the engine, torque the girdle rail bolts to 20 ft-lbs, install the oil pump pickup and install the cast oil pan, torquing the oil pan bolts to 10 ft-lbs.



The sealer that is forced out from between the girdle and block will appear on both the inside (arrows) and outside of the block. It is important to peel this off the inside of the engine to minimize the chances of it clogging a passage in the oiling system. But wait a few hours before attempting to remove it, as it will get slightly stringy—making it much easier to remove. Once it has gotten stringy, use a pick or small screwdriver to scrape off the excess.

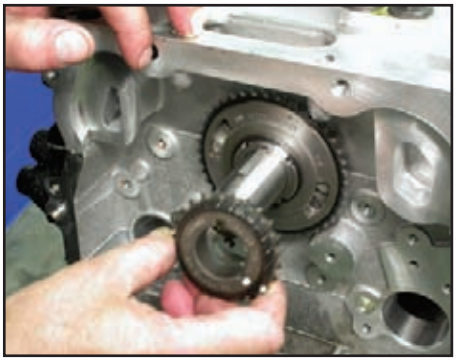
Installing piston/rod combos

The piston/rod combinations should now be lowered into the cylinder bores.

Apply a light coat of engine oil to the piston skirts and Torco assembly lube to the rod bearing. Make sure to remove the rod cap and two bolts. Then, use a ring compressor, as is shown here, to seat the rings in the piston lands so the piston can be pushed down into the bore.

Installing accessory chain drive

Seat the big end of the rod on the crank journal (which should be coated with Torco assembly lube) and install the rod cap and two A1 Technologies (248-761-5372, Walled Lake, MI, www.A1Technologies.com) aftermarket rod bolts. Apply the provided rod bolt lubricant to the threads before installing and follow this torquing sequence. Torque both bolts to 35 ft-lbs, loosen them both, then torque them to 35 ft-lbs again, break loose and torque to 65 ft-lbs. Now, the rotating/reciprocating components of your 300 hp Ecotec are together.

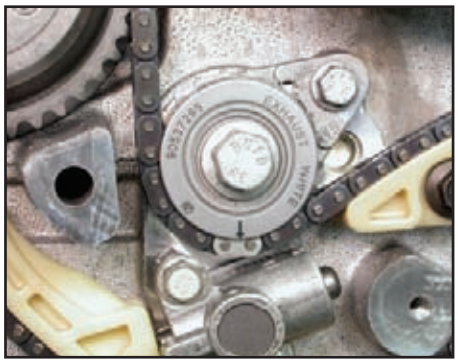


The water pump and neutral balance shafts on the Ecotec are driven by chains, which should be installed now. To start this process, the crank chain gear needs to be slid on the snout of the crank. The key needs to be installed in the keyway groove first, but all should go in by hand.

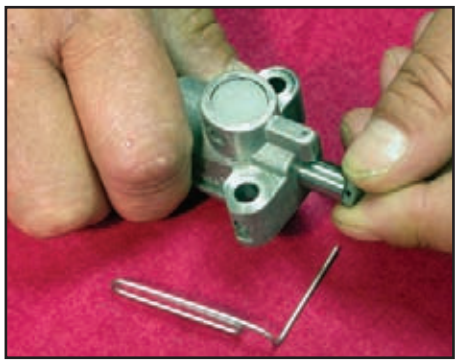
The water pump is installed from behind the front cover mount on the side of the engine. Three of the four bolts that hold it in place should be installed now—the fourth is installed from the front and should go in after the cam chain drive and front cover is fully installed. Torque these bolts to 15 ft-lbs.

The stock balance shafts are scalloped (top) so when they spin, the forces generated by the movement of the internal components are offset to smooth the operation of the Ecotec engine. Racing-oriented engines aren't concerned with this "comfort", so a tube (bottom) is installed to replicate the balance shaft, but not lose the 10 hp it takes to spin them (GM P/N 88958615).

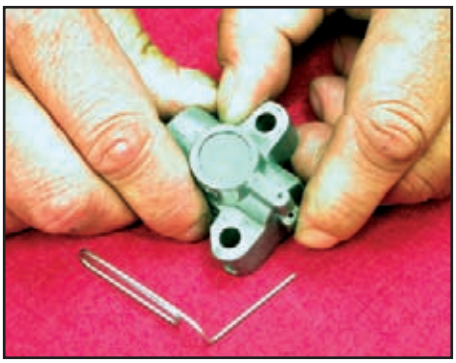
This engine is using the stock engine balance shafts. Lube up the bearing surfaces with Torco assembly lube and slide them each into the engine block. The shafts are marked with an "E" and "I", with the I shaft going on the right (under the intake cam) and the E shaft on the left (under the exhaust cam).



With the No. 1 piston at Top Dead Center (TDC), begin to install the chain (coat it with engine oil before installing) that drives the balance shafts and water pump. We say begin because the drive chain has colored links that need to mate with specific 'dots' on each gear—and this usually takes a few shots before you get it all correctly 'timed'. Put colored links on the arrows on the gears like this (more later).

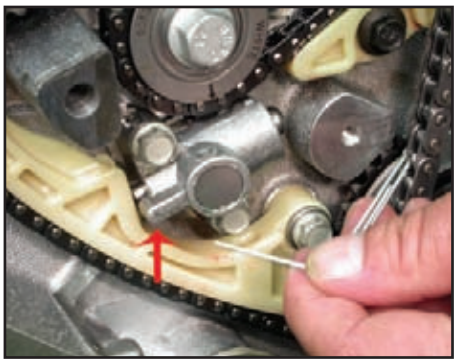


The chain tensioner needs to be 'set' in a relaxed state for installation. To begin this process, twist the piston 45 degrees.

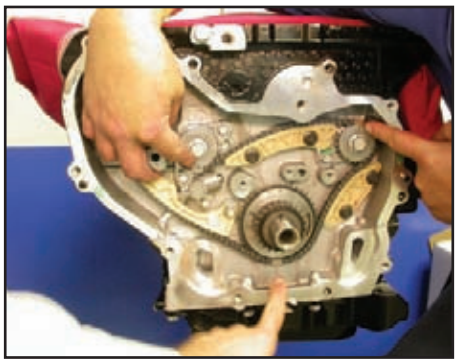


Depress the piston fully and twist it back to its original location to line up the two holes—one in the body, the other in the piston.

Using a paper clip that has been straightened, push the paper clip end into the tensioner body/piston hole.

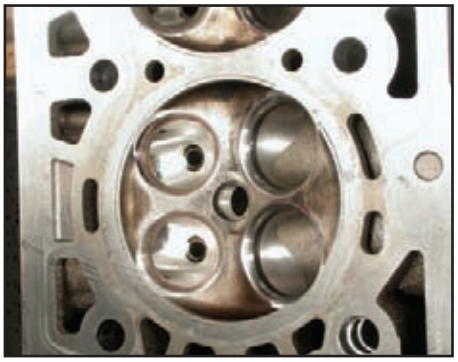


Now is the time to hand-tight install the three cream-colored chain tensioners (apply Torco engine assembly lube to their faces) on the engine (when the chain is installed properly, torque the 6 mm head bolts to 89 in-lbs). You'll need to release the tensioner when the chain is correctly "timed" on all the gears (see next caption) by pulling the paper clip out of the holes (shown).



So here's how the accessory chain drive should look when installed correctly. The No. 1 piston should be at TDC, the keyway on the crank should be in the 12 o'clock position and the silver link at the bottom of the gear should be in line with the dot on the crank gear. The intake balance shaft should have the gold link lined up with the green dot behind the gear, with the arrow pointed up. The exhaust balance shaft should have the silver dot lined up with the white dot behind the gear and the arrow pointed down. Got that? Good.

Cylinder head buildup details



GM Performance Division, working with GM Performance Parts (GMPP), has created a very efficient, low cost CNC-ported cylinder head for the Ecotec. It has fully CNC-ported exhaust ports and the intakes have the bottom side of the intake port seat matched to the intake port. This head can support 320 hp, which should be more than enough for most street applications.

The performance valvesprings are installed at a 1.290-inch height and feature an 85 lb/in seat pressure and a 190 lb/in over the nose pressure. If you make a change to a performance cam, you must add performance valvesprings to maintain control of the valves during the engine operation.

To change the valvesprings, this valvespring compressor should be used along with safety glasses. It consists of two stands and a round bar to that allows a lever-action spring compressor to be used across the length of the head.

With the valve out, it's a good time to apply Torco engine assembly oil to the stem before sliding them back in the guides.

Before installing the performance valvesprings, you must check the 'installed height' with a height measuring gauge and spacer. On the Ecotec cylinder head, it is recommended a 1-inch spacer be used to minimize the struggle of maneuvering around the throat depth and tight confines of the head design. Make sure the valve stem seal is installed over the valve stem during this procedure, as its thickness is part of the "installed height" measurement.

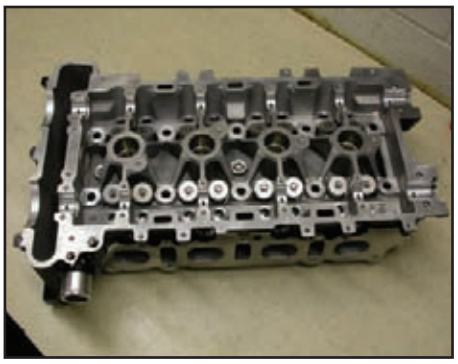
This measuring gauge has an extension (a machined billet of aluminum that ended up as a 1.000 inch diameter and 3.150 inch long extension) to make it easy to measure the valvespring height. The Ecotec head should have a 2.290-inch valvespring height—in this case, the gauge reads 1.290 to take into account the 1.000-inch spacer. If the measurement is less than this, shims will need to be used under the valvespring. If it is more than this, the valvespring seat will need to be machined or the valve ordered longer, to get the height back to where it should be.

With the valvespring height checked out, the spring needs to be compressed with the retainer on top of it and the valvespring keepers installed. Getting the keepers into the tight confines of the valvespring compressor on a pushrod engine can be accomplished with the lock installation tool on the left, but on an overhead cam engine, this tool can't be used. But there is a low dollar way to do this. Take a small screwdriver and apply a dab of white grease to one side of its tip. Push the keeper up against the grease and it will hold it in place just long enough to install in the retainer.

A Goodson (P/N CF-300) universal OHC/DOHC valvespring compressor gets the spring compressed as the screwdriver w/ one of the keepers on it gets pushed up against the valve.

Once the first keeper is seated on the three grooves it sits in, use the screwdriver you installed it with to "push" it around the backside of the valvespring retainer. This way, you can install the second keeper in the same opening.

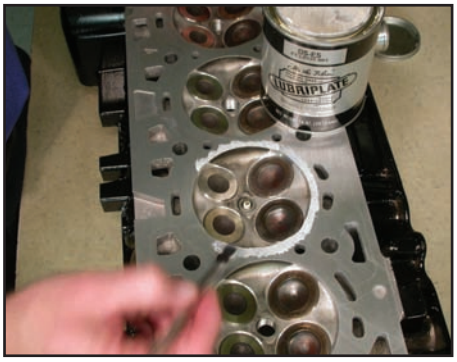
Put a new dab of white grease on the screwdriver and the second keeper on the grease to install it in the retainer. Compress the spring and slide the keeper into the three grooves on the valvestem to seat it completely. This can be tricky as the keepers on the Ecotec butt end-to-end to allow the valves to rotate—this is why it's so important to get the keepers properly seated in the retainer.



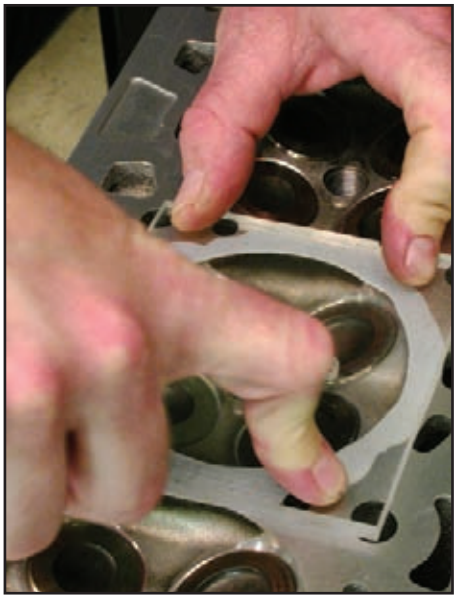
With sixteen valves, changing all the valvesprings on the Ecotec engine can take a little time. But now you know what tools are required and how to use them to accomplish this task. Whatever performance additions you make to the Ecotec, plan on upgrading the valvesprings to handle either the more aggressive cam or increased rpm.

CC'ing the chamber

With the cylinder head assembled, it is a good idea to check the chamber volumes to make sure the static compression is what you planned. To close up the spark plug hole, install a "mock" spark plug that is the same as one of the plugs you will be using in the engine.



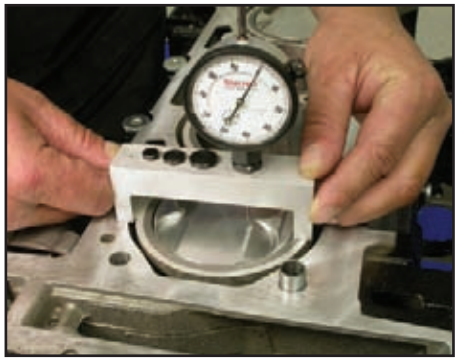
To begin this process, apply a light skim of grease around the perimeter of the chamber.



A lexan CC'ing cup is required to seal off the chamber volume. Press the cup firmly against the face of the head to seal it tightly to the grease.

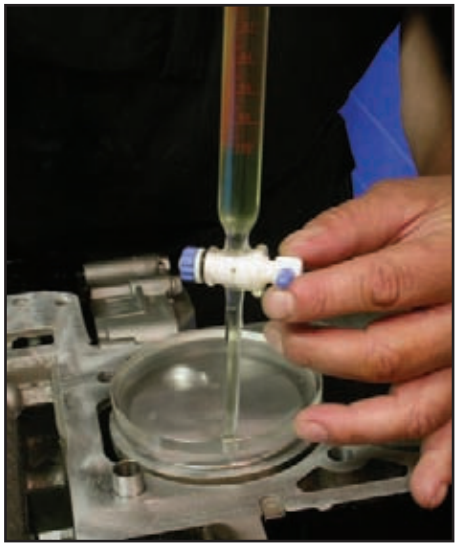
With a 100 cc burette filled to a measured level, fluid is poured into the hole in the CC-cup until the chamber is filled. Read the new level on the burette—the change is the volume of the combustion chamber. Record this value for each chamber.

CC'ing piston at TDC



It's also a good idea to check the volume of the top of the piston—if it is not flat. A flat piston is represented by the CC-cup. To check piston volume, first rotate the crank to be even with the deck of the engine block, which is called "zero deck" (the Ecotec engine has the positive deck height piston travel—which means the piston actually sticks up over the deck when it is at TDC). Measure with a dial gauge on a piston height bridge (as shown).

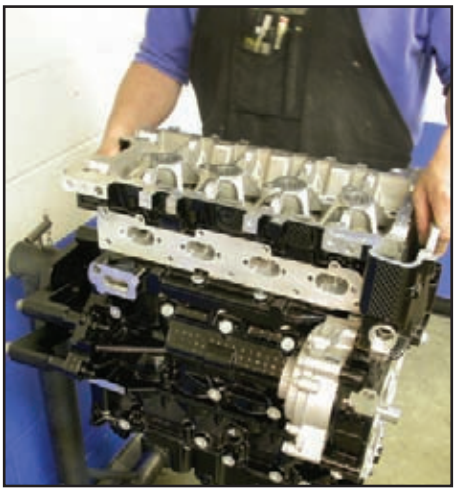
Apply a light coat of grease around the perimeter of the bore and install a CC-cup. In this case, a 65 cc Plexiglas CC-cup was used.



Pour the fluid from a burette to measure the volume. Record this number.

Installing cylinder head on block

The stock multi-layer steel (MLS) head gasket is more than durable enough to handle over 300 hp, so install it on the engine block now by pushing it carefully onto the face until it is seated on the two dowels. The deck of the block was scuffed with scotchbrite during the cleaning process to prep it for the head reinstallation.



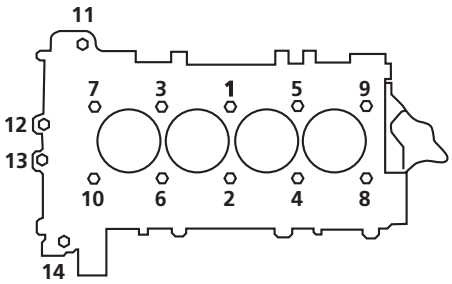
Install the cylinder head on the engine block with the chain drive opening at the front of the block, like this.

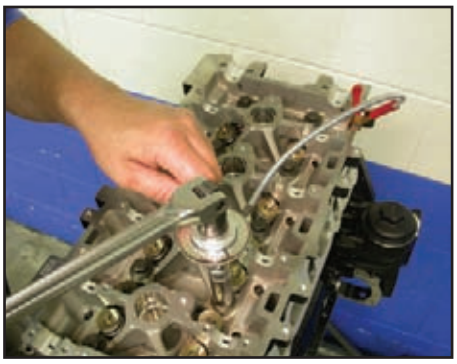
The stock head bolts are a torque-to-yield design, so they should not be reused. Use the new head bolts that come with the Head Gasket Kit (P/N 12595961)—it also includes the head gasket, intake gasket and exhaust gasket.

Apply a light coat of CMD #3 extreme pressure lube where the head bolts will seat on the head, to minimize variations in torque.

The bolts are long, so it will help if you use a speed wrench to get the bolts seated down onto head.

Torque the head bolts to 22 ft-lbs in a radial pattern—starting with the center bolts and working outward to the ends of the head (refer to the torquing sequence illustration at right). It is a good idea to go over the head bolts twice with the torque wrench, as the head gasket crushes as the bolts are torqued down.





The head bolts then need to be "twisted" another 155 degrees to complete the clamping down of the head on the block. Again, start with the center head bolts and work radially out towards each end of the head.

Installing remaining valvetrain components

There are four E12 Torx 8 mm bolts at the front of the head that need to be torqued down (oil threads, lube backside of heads and torque) to 15 ft-lbs.

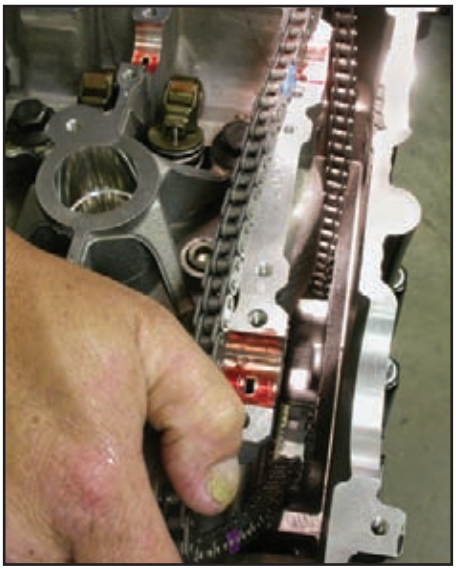
With the head bolted down, the valvetrain assembly can be started. The first step toward this is to oil up the cam lifter followers with Torco assembly lube and insert them into their bores in the cylinder heads (hole on the right). Make sure the radiused end is pointing up, as this end engages with the rocker face.

The factory rockers are more than adequate for a performance application, as they feature a roller tip in a stamped steel body with a ratio of 1.69:1. When installing, make sure Torco assembly lube is applied to the cup where the follower engages to the top of the valve.

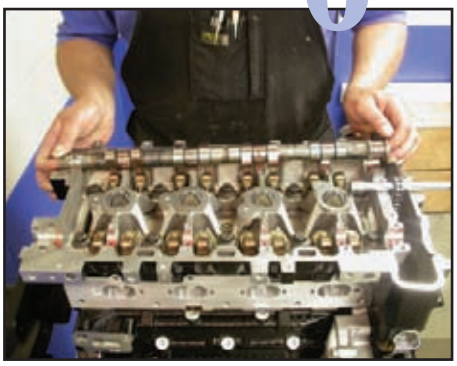
The rockers can "fall" to either side of the valve head and follower, so before installing the camshaft, make sure they are all "straight-up" to avoid torquing the cam down on a rocker that is cocked sideways—this often leads to a damaged cam lobe or broken valvetrain components—which is definitely not what you want to have happen.

Apply engine assembly lube to the full circumference of the roller on the rockers and bearing surfaces on the head and also to the camshaft (not shown) lobes and bearing faces in preparation for installing the cam in the cylinder head.

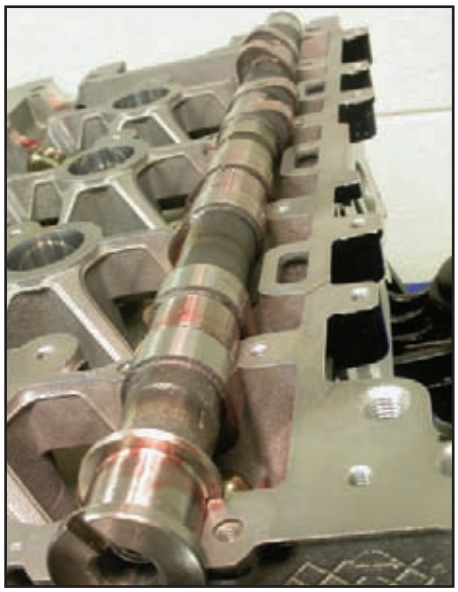
The cam chain should now be lowered into the space at the front of the cylinder head in preparation for final installation. The best way to do this step is to rotate the chain 90 degrees (as shown) from its final positioning. This allows the chain to be lowered all the way down to the crank gear area.



Then, carefully rotate the chain 90 degrees while spreading it to out past two tight spots in the chain area. Be patient … the chain will fit between these two areas, but there is not a lot of room to maneuver it.



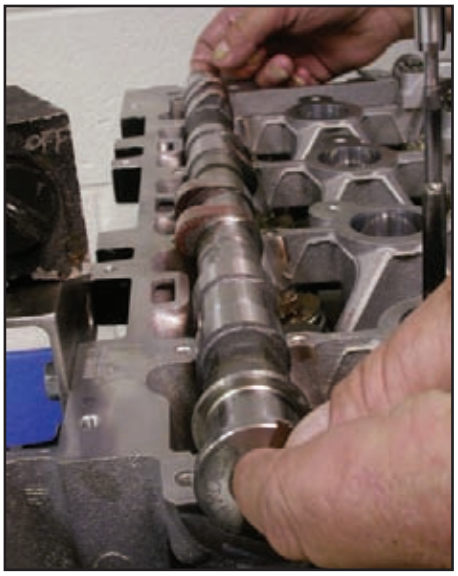
The factory camshafts have been replaced with performance cams from Comp Cams. The intake cam needs to go in the engine first. The Comp intake cam has the following specs: 0.441 inch net lift with 218 degree valve duration at 0.050 inch lift on 109 degree lobe separation. Apply engine assembly lube to the lobes and bearing faces before installing in the engine (see next caption for how to position cam in "sweet spot").



There is one position in which the cam can be installed so that none of the lobes are pushing on a follower—and you're looking at it. This simplifies the process of torquing the cam caps to 89 in-lbs and reduces the chances of getting a component 'cocked' while doing the torquing.

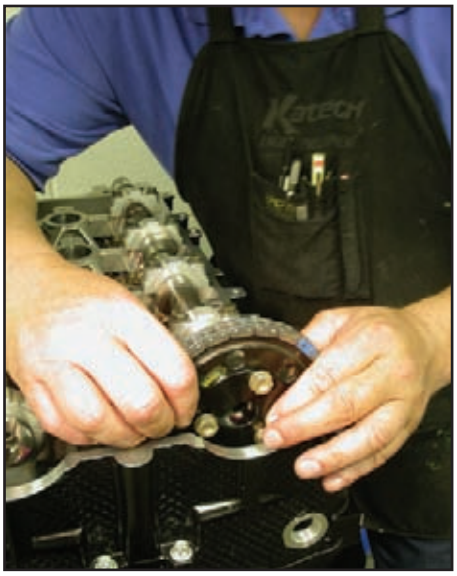
With the intake cam bolted in, slide the harmonic balancer/pulley onto the key in the front of the crank and rotate the No. 1 piston to TDC (use a dial gauge to read this).

All of the cam caps are numbered with an arrow next to the number. The number corresponds to a number on the head and the arrow should always be pointing towards the front of the engine. Lube up the bearing races of the caps with assembly lube and install the caps. Tighten the bolts on the cap steps, starting with the center cap, to slowly pull the cam down into position, and then torque the bolts to 89 in-lbs.

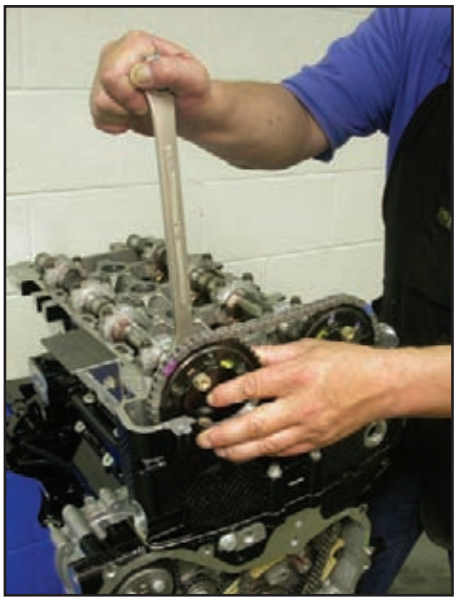


The Comp exhaust cam specs are 0.437-inch net lift with 220-degree valve duration at 0.050-inch lift on 109-degree lobe separation. Install the exhaust cam in a similar fashion to the intake cam—position the cam in this location, the "sweet spot" where it will sit free. Follow the same process of torquing down the caps as performed on the intake cam.

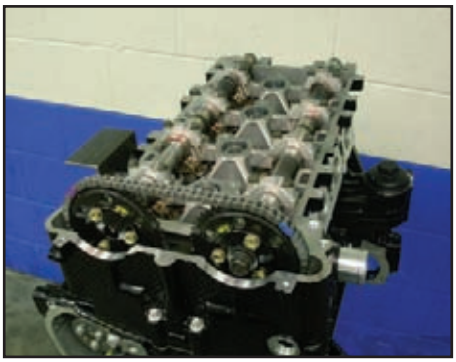
Now is the time to start positioning the cam drive chain by placing the crank gear with its arrow pointed in the 5 o'clock position and this purple-colored link on the arrow.



Position the intake cam gear (it will have an "I" marked on it) on the cam and hand tighten the bolts to hold the gear in position. Make sure the blue colored chain link lines up with the single line on the adjustable cam gear.



With the chain in the correct position (purple key on line) on the exhaust cam gear (marked with an "E"), position it up against the front of the cam while slightly rotating the cam clockwise (from the front of the engine) with a 15/16-inch open end wrench mated to the slot in the cam to the gear. Hand tighten the three 13 mm bolts and center 18 mm bolt until the engine is timed (then torque to 65 ft-lb).

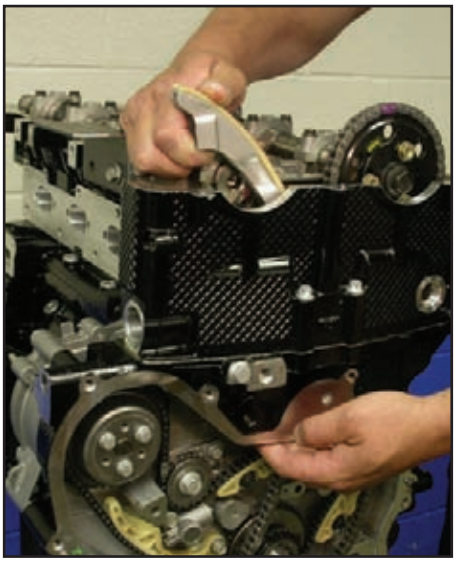


This is what your Ecotec engine should look like at this point. You are nearing the home stretch with just the final install of the cam drive, checking cam timing and installing the remaining external components separating you from big Ecotec power.

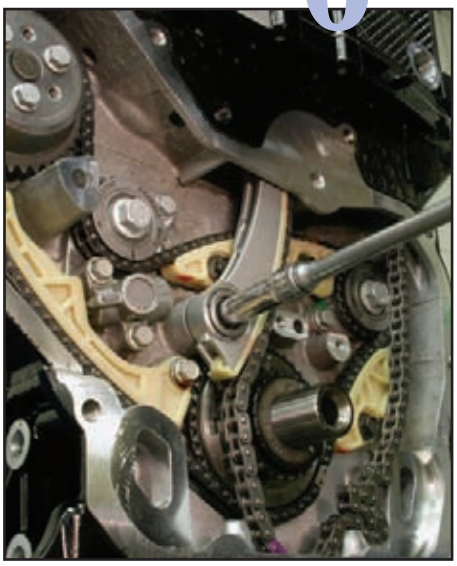
Final tuning front drive chain

The cam chain is tensioned via this piston-style, spring-loaded apparatus that is threaded into the top end of the engine. To set the tensioner for installation, pull the center piston out of the tensioner, place it in aluminum non-marring vise jaws and turn the inner piston clockwise 90 degrees with a flat-blade screwdriver while pushing it down. The center piston should ratchet down about 1/4-inch to allow it to be installed.

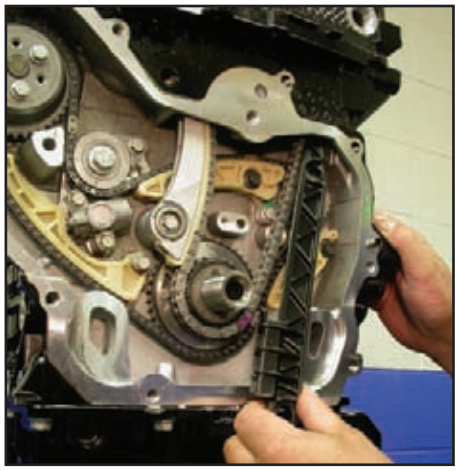
There are three chain guides on the cam drive chain. The first to install is the pivoting chain guide/tensioner that is held in place with one 8 mm bolt. It should get one drop of 277 red Loctite on the bolt threads and Torco assembly lube on the face of the guide before being installed.



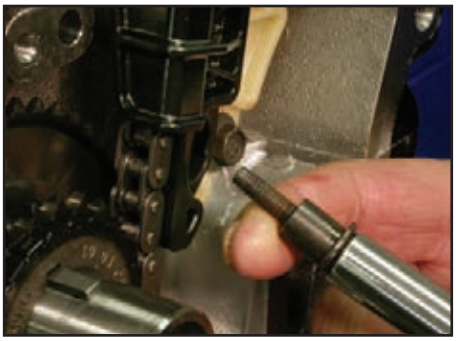
The best way to install the chain guide/tensioner is by lowering it through the top of the engine front drive cavity, as shown.



The single 8 mm bolt holding the guide/tensioner should be torqued to 89 in-lbs.

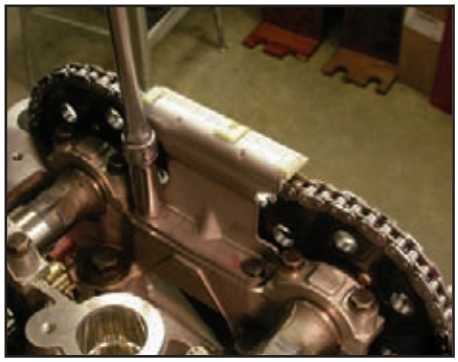


The next chain guide to be installed is the black one, which is held in place with two 8 mm bolts.

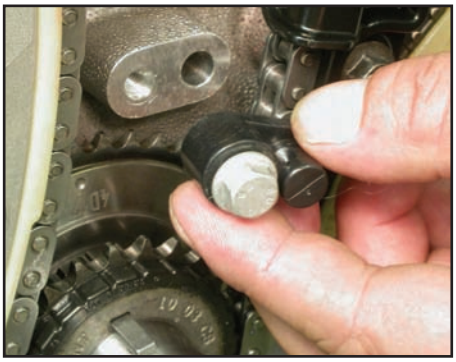


To final install the black guide, apply one drop of 277 red Loctite to the bolt threads and Torco on the face of the guide, make sure the floater shims are on the bolts and then install. Torque the bolts to 89 in-lbs.

The top bolt is installed through an access hole in the block that has a plug to cover the hole.



The top chain guide is then installed. By now, you should know the two 8 mm bolts will get a drop of 277 red Loctite, Torco assembly lube on the face and the bolts torqued to 89 in-lbs.

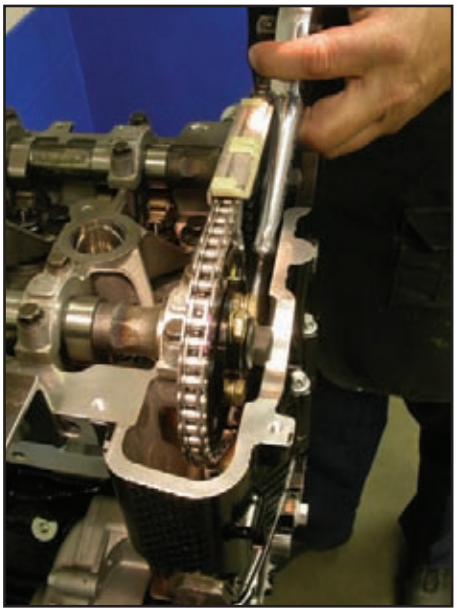


The pressurized chain oiler should then be installed with a drop of 277 red Loctite on the threads of the 8 mm bolt and torqued to 89 in-lbs. This provides a constant flow of oil to the chain in two streams.

The black guide bolt access hole is now going to be closed up with this Allen plug. A 10 mm Allen wrench will be needed and some Loctite 567 thread sealer applied about two threads wide around the plug. Install about a 1/4-turn past hand-tight.

Now comes the interesting part of installing the cam chain tensioner piston. You're looking at how the tensioner piston has a slot in its piston that mates with a raised guide on the chain guide/tensioner—these need to be lined up when the piston is installed or the chain tension will not "set" properly.

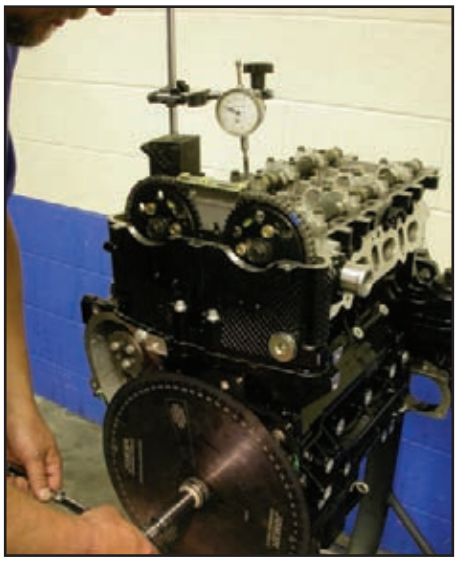
The slot and guide are aligned by inserting the tensioner piston assembly into its mounting hole and viewing the mating of these two components through the chain drive access in the top of the head. Use a flashlight to add light to the tight confines. Once these have mated, tighten down the threads on the piston tensioner (make sure to add the 567 thread sealer Loctite to the threads). Tighten to about a 1/4-turn past hand tight.



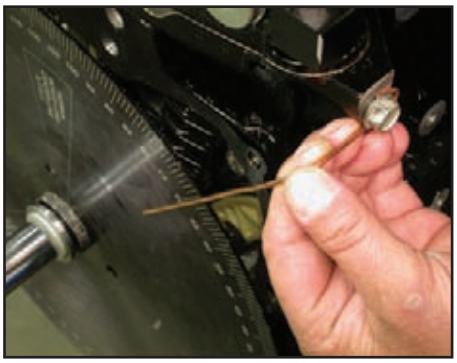
The piston tensioner is activated by "bumping" the guide/tensioner from behind with a blunt instrument—in this case the handle on a 1/2-inch ratchet wrench. You'll know when it has applied tension as it really "lets go" and locks the chain down tight.

Checking the cam timing in relation to crank location

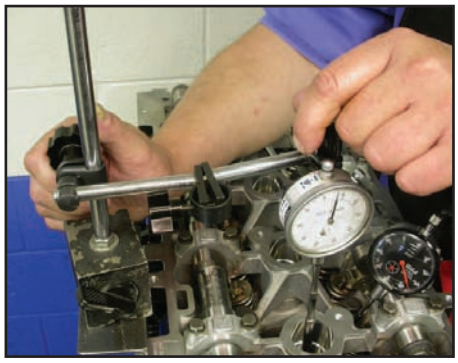
It is important to know exactly where the "timing" of the camshafts is in relation to the crankshaft location. This is even more important on a dual overhead camshaft (dohc) engine than a cam-in-block, pushrod engine because if the a cam is improperly phased in relation to the crankshaft on a dohc engine, the intake valve and piston on many cylinders will come in contact with each other. To avoid this problem, you are about to see how to determine the exact "timing" of the cams in relation to the crankshaft and how to set the timing of the cams on an Ecotec engine.



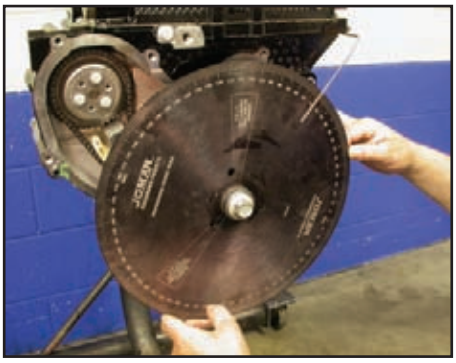
A large degree wheel needs to be acquired for this activity. Bolt it hand-tight (for now) to the snout of the crankshaft.



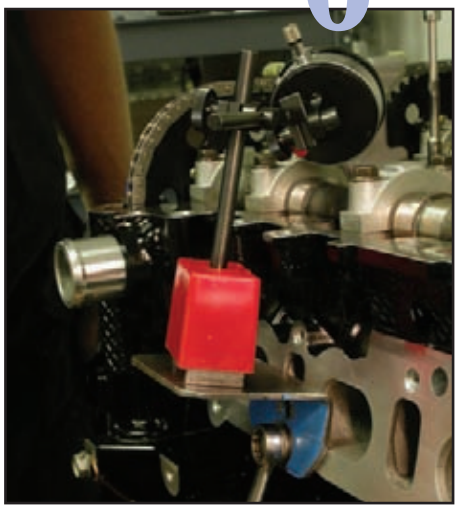
Create a wire "pointer" and mount it firmly on the engine block. The end needs to be placed close to the surface of the degree wheel face so the numbers can be read clearly without variation.



Two dial gauges with stands will also be needed to measure the piston location and valve locations. Simple angle-iron mounts with a hole drilled into one of them work great—mount them on the side of the head and affix the dial bore gauges to these with their magnetic bases.

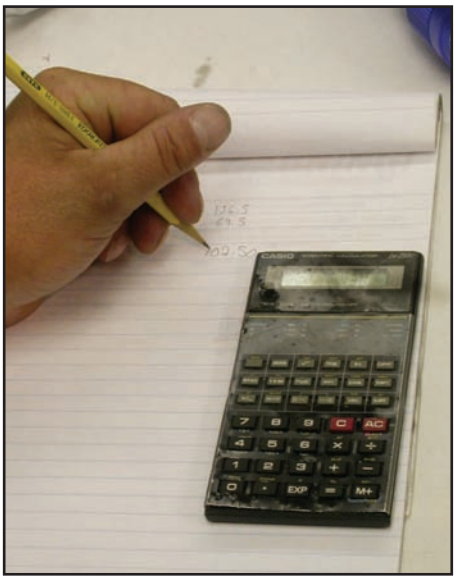


On the No. 1 cylinder, install the dial gauge so its plunger reaches down through the spark plug hole to touch the top of the piston. The other dial bore gauge plunger should rest on a retainer of one of the No. 1 cylinder intake valves. Align both gauges so the plungers are "in line" with the stroke of the piston or valve—so their measurements are accurate.



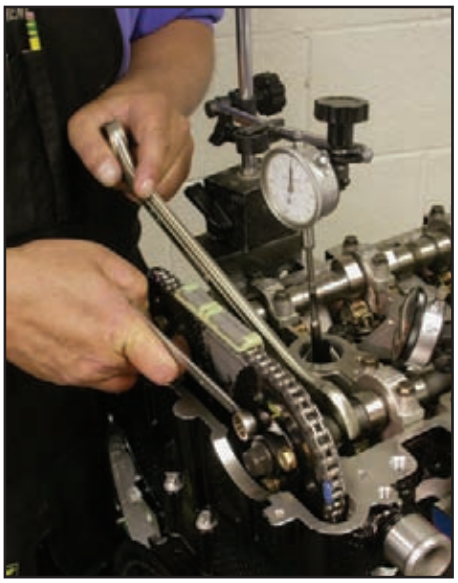
Rotate the crankshaft until Top Dead Center is located on the dial gauge—the piston will change direction at TDC, so keep "zeroing" in on this location. Then "zero" out both gauges by rotating the dial until the pointer is aimed at "0" on the gauge. Also rotate the crank degree wheel until it reads "0". As a caution, carefully rotate the crank to avoid the chance of the valves hitting the top of the pistons—remember, you don't know where the cams are located in relation to the crank!

Rotate the crank until the valve lift reaches 0.050 inch and stop. You are going to read the degree wheel, then rotate the crank around to 0.050 inch lift on the other side of TDC, so make sure you take good notes of these points. As a note, you could pick any valve lift number you'd like, but most engine builders use 0.050 inch lift because this is enough to eliminate any slack in the valve-train but not so much you get false readings on the camshaft lobe.



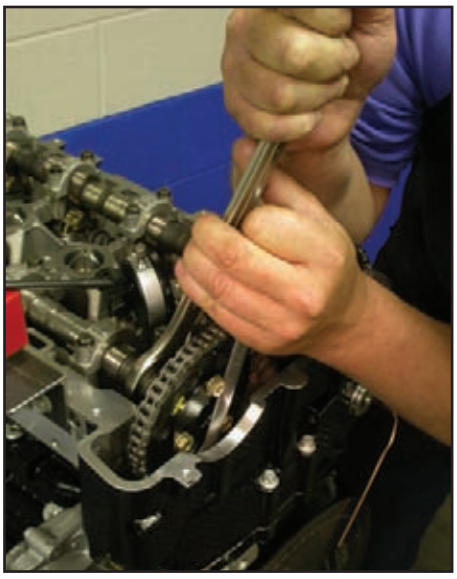
So you've written down the crank position (in degrees) for both the before and after TDC at 0.050-inch valve lift. Now what, right? Well, add these two numbers together and divide by 2 to determine the centerline of the intake cam lobe location in relation to the crank location (also in degrees).

The intake cam was supposed to be centered at 102 degrees on the crankshaft. The 0.050 inch lift numbers were 136 degrees and 69.5 degrees. Adding these together and dividing the sum by 2, equaled 102.25—which for most engine builders would be called 102 degrees.



With that, we snugged down the intake cam gear holddown bolts to hand tight in preparation for doing the exhaust cam timing. You'll torque these down in the final steps of this process.

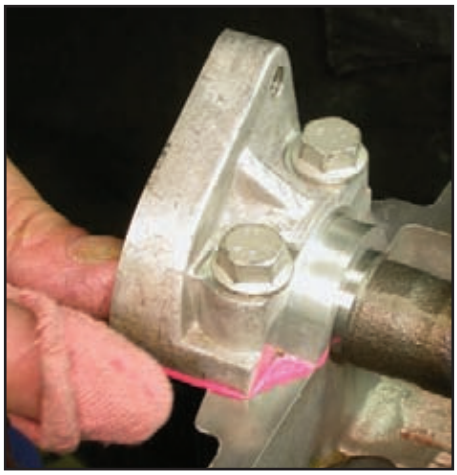
Move the valve height dial gauge to an exhaust valve on the No. 1 cylinder and repeat the process of determining TDC, zeroing the gauges and degree wheel and running through 0.050 inch lift at before TDC and after TDC, recording the degree wheel location at each point.



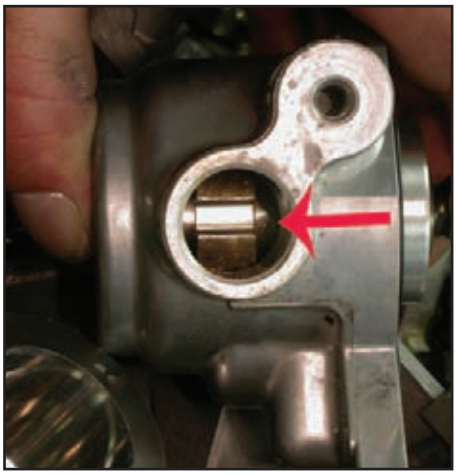
Once you have done the math on the cam lobe centerline location (in this case, the cam showed 149.5 + 80, which was divided by 2 to equal 114.75—close enough to 115 degrees, which is what we wanted). You will probably have to twist on the hex portion of the exhaust cam with a 15/16 inch open-end wrench to get the cam gear to line up with the correct position needed on the exhaust cam. With both cams located properly, torque the three 13 mm head bolts to 89 in-lbs with one drop of red Loctite on each bolt and then torque the center 18 mm bolt (with one drop red Loctite on the threads) to 65 ft-lbs. Finish this entire process by positioning the crank with the No. 1 piston at TDC.

Installing cylinder head top end components

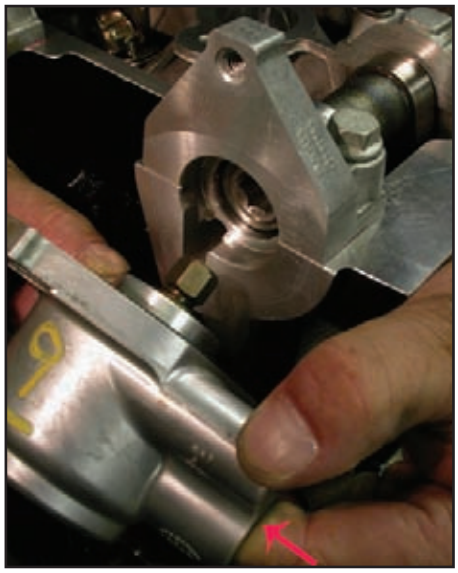
The two rear cam caps sit outside of the valvecover and therefore require a light coat of Loctite 510 flange sealer (a non-hardening sealer) to be applied to the mating point between these two metal parts. The caps should then be torqued to 15 ft-lbs.



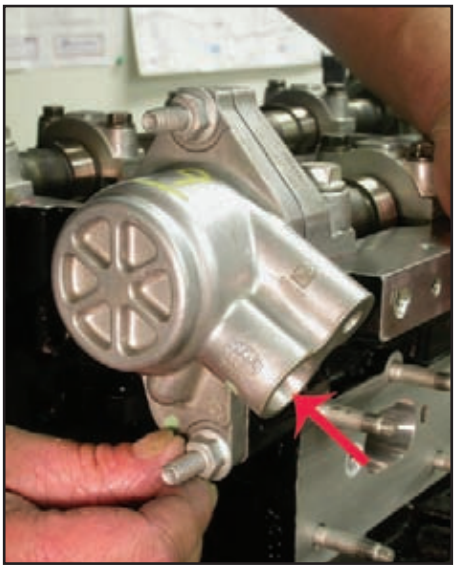
It is important to completely wipe off any sealer that is forced out of the mating point between the cap and cylinder head to avoid it getting into the engine oiling system.



A key step that needs to be carefully completed is the installation of the cam sensor wheel and body. This notch is read by the sensor to indicate where the engine is in its firing order, so it is critical to get it installed on the hex gear drive in the properly clocked location.

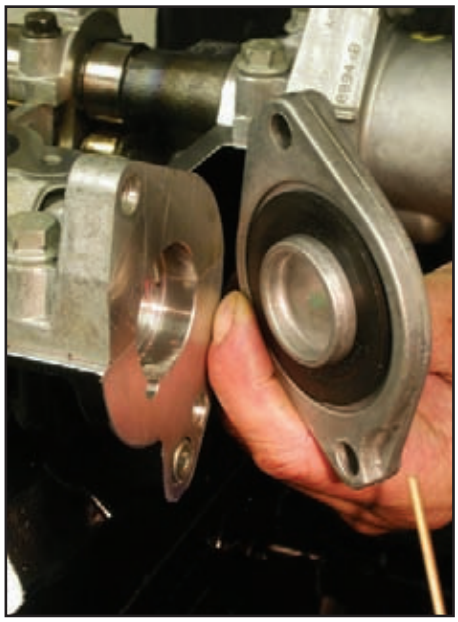


As you can see, there is a male and female hex engagement that must go together. To get the sensor wheel installed correctly, place the notch in the 4 o'clock position when looking at the wheel body from the back of the engine. Make sure the engine is on the No. 1 piston's compression stroke and slide it onto the hex drive gear coming off the exhaust camshaft.



The stud/bolts holding the cam sensor body on the head should be torqued to 10 ft-lbs with a drop of red Loctite on their threads.

The cam sensor should now be installed in the sensor wheel body by torquing the bolt/stud to 89 in-lbs.

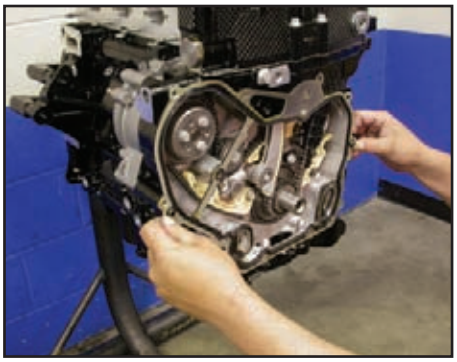


The rear cam cover plate on the intake cam side needs to be installed with the notch in the face of the cover located near the bottom bolt. This is to clear the Allen head bolt in the block—if you don't do this, the plate will leak profusely on startup of the engine! Torque the two 13 mm bolts to 10 ft-lbs.

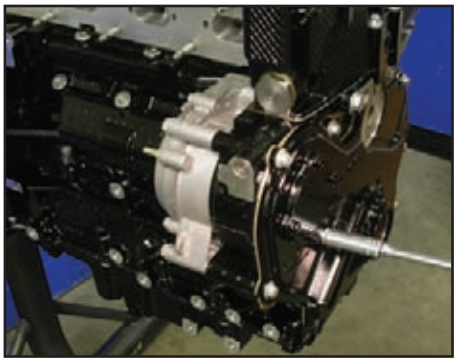
The valvecover, with its compression style gasket, can now be installed. Torque the bolts to 10 ft-lbs.

Installing front cover/oil pump and systems

The final steps of installing the front cover with the integrated oil pump require attention to detail, but are not difficult.

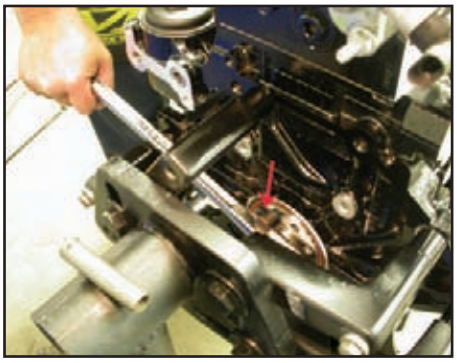


Position the compression-style front cover gasket on the dowels protruding from the block in preparation for installing the cover.



Rotate the oil pump until it is clocked to locate on the key so it will slide on the crankshaft. Then, install the integral front cover/oil pump over the gasket and locate it on the dowels. Install the front cover bolts to hand tight and install the final water pump bolt to hand tight. Now torque the front cover bolts down to 10 ft-lbs in a radial pattern and install the water pump bolt to 12 ft-lbs.

Slide the integral harmonic balancer/front pulley on the crank with its pointer located on the TDC position (this will allow it to mate with the oil pump drive) and torque the NEW bolt (GM P/N 11589123) to 76 ft-lb (100 N-m) and twist it 125 degrees (+/- 4 degrees). Apply engine oil to the bolt threads before installing.



When torquing the harmonic balancer bolt down, hold the crank in position with a breaker bar wedged between three bolts threaded at least 3 inches deep into the crank flange.

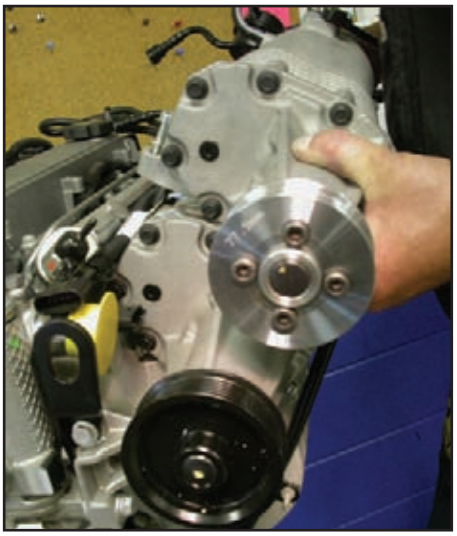
Installing intake system

The intake manifold is initially installed on these two E12 Torx studs that have been torqued to 100 in-lbs. Then, install the five 13 mm bolts to 15 ft-lbs. Apply a drop of red Loctite to the threads of every fastener here.

This engine was a testbed for the GM Performance Stage 3 upgrade kit (see P/N listing at the end of this chapter) now available at your GM dealer. The GM Powertrain Ecotec LSJ engineers were testing a modified intercooler (on right) to determine if turning it into a two-pass intercooler would help make power. What they found was that above 240 hp, the dual-pass intercooler helps to maintain the high levels of intake charge cooling—which is one of the key parts of the Stage 3 system. As a result, a 2-pass intercooler endplate is now available from GM Performance Parts (P/N 88958721).

The factory fuel injectors need to be replaced with performance units. In general, if you're making more than 240 hp, you'll need injectors that flow at least 5.64 gallons per second (gps). To swap the injectors, lift the tang locking the electrical connector on the fuel injector and pull the connector off. Then, pop this clip off the injector body and pull up on the injector. Make sure to apply a light dab of fuel injector lube or vaseline on the new injector O-ring before pushing it into the body to minimize the chances of the O-ring folding over and causing a leak when it seats in the injector bore.

The stock supercharger can support up to 300 hp with a different pulley. Install it with the factory 8 mm bolts and studs torqued to 18 ft-lbs. The pulley will need to be replaced with a smaller unit from the Stage 3 upgrade kit to take advantage of the new performance camshaft, valvesprings, pistons and fuel injectors.



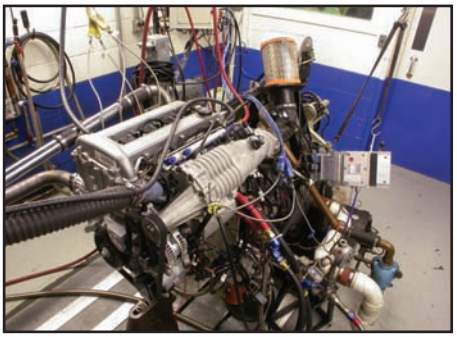
This is an early prototype of the new GMPP Stage 3 pulley that increases the rpm of the blower vanes in relation to the crankshaft rpm, which increases the inlet air boost to the engine. It is installed by removing the bolt holding the stock pulley in place, using a pulley puller on the stock pulley and pressing the pulley hub on with a pulley installer. Torque the pulley bolts to 16 ft-lbs after applying one drop of red Loctite to its threads.

Ignition system install

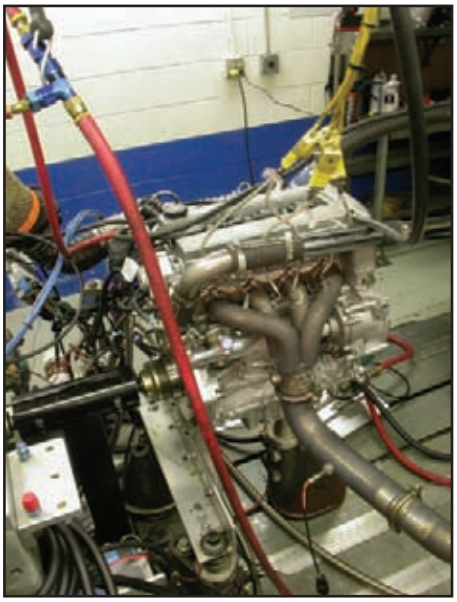
The stock 'coil-on-plug' ignition is more than capable of firing the air-fuel mixture on this newly built hottie. "Colder" spark plugs are used to handle the increased compression, engine heat and power output. The spark plugs receive a light coat of copper-slip thread prep to minimize the chances of them galling in the aluminum cylinder head and are torqued to 12 ft-lbs.

Various external component installs

On the intake cam side of the engine block, torque the crank location sensor holddown bolt to 18 ft-lbs and the engine knock sensor holddown bolt to 89 in-lbs.



The Stage 3 upgrade kit comes with a shorter belt to work with the smaller front pulley. On this engine, the fuel injector rail has been modified by welding on a male bunge to attach a braided steel line onto it to run the other end to as fuel pressure with gauge.



As an FYI, this 300 hp Ecotec runs a custom shorty tube header, stock wiring harness and a modified thermostat housing for the application it is being bolted into. Check out the dyno chart to see exactly what kind of power this engine produced.