

## Helpful Hints for PI Head Swap on 1996-97 4.6L T-Bird

By Jim Phelps

### Introduction

First, I would like to recommend the purchase of a shop manual. I got a 96-97 Thunderbird/Cougar shop manual on eBay for \$60 and it was worth every penny. There are some important procedures listed in the manual that the average mechanic might not know about, plus it has all the proper specs and sequences for torquing bolts and removing and replacing wiring. The average mechanic might have most of the tools needed to tackle this project, but some of the tools I had to buy are 2 torque wrenches (ft-lbs and in-lbs), an 18" breaker bar, crank pulley remover and crank pulley installer, small pipe cutter, vise grips, razor blades, assorted socket sizes and extensions with 1/4", 1/2" and 3/8" universals (swivels). You also will need oil, filter, gasket remover, penetrant, silicone gasket maker, anti-seize, dielectric grease, and I used almost 4 gallons of coolant/distilled water mix.

There are a lot of questions that need to be answered before deciding to go ahead with the new heads:

**First, is my engine a high mileage engine?** If so, you may be better served to find a low mileage 99-03 engine and swap the entire motor instead of just the heads.

**Second, do I have enough time and funds?** The actual head swap itself only took approximately one weekend, but the planning and buying of parts needs to be done well in advance. Also, there are always going to be budget runovers and unforeseen problems.

**Third, how far am I going to go with buying new parts?** This was a tough question for me. Of course, if money were not an object, I would have replaced everything possible. You need to draw the line somewhere. If you are replacing spark plugs, are you also replacing the wires? How about things that can be reused like gaskets, cam sprockets and timing chains? These decisions have to be made in advance of buying parts.

**Fourth, do I have all the tools?** If you are planning to do this on a weekend, inevitably you will need a tool on Saturday night when the stores are closed. Also, are you going to use new heads or used? Romeo or Windsor? The Romeo cam covers will not fit the Windsor heads.

**Last, do I want to make any other modifications while I have the motor apart?** Now is a good time to add pulleys, throttle body, headers, special cams, porting, valve job, etc. Also – ask yourself what you expect to gain from this project. If you expect to end up with a 13 second car, think again.

This swap adds approximately 50 RWHP as a result of longer intake manifold runners, larger ports, larger exhaust valves, better cams and higher compression. You will most likely need to run on premium

unleaded from now on. This is something to consider. Also, I upgraded my stock MAF sensor to one found on a 2003 Mustang GT. This sensor is larger and more accurate than the stock one, and also incorporates the IAT sensor into the MAF housing, thus requiring a new wiring harness if you wish to integrate the IAT sensor properly. The earlier MAF's do not have this problem. You also must run a chip or get a tune to tell the EEC that you are using a different MAF sensor.

## Parts List

1. 1W7Z 6049-AARH (1) Romeo Right Cylinder Head (\$400.55)
2. 1W7Z 6049-AALH (1) Romeo Left Cylinder Head (\$400.55)
3. 3W7Z 9424-AA (1) Intake Manifold (\$218.75)
4. M-6067-D46 (1) Cylinder Head Changing Kit (\$115.50)
5. F3LY 6268-A (2) Romeo Timing Chain (\$34.21 each)
6. XR3Z 18B402-BA (1) Heater Tube (\$10.80)
7. F1AZ 6020-C (1) Front Cover Gasket (\$3.75)
8. F1AZ 6020-A (1) Front Cover Gasket (\$3.75)
9. F6AZ 6020-BB (1) Front Cover Gasket (\$4.49)
10. XL3Z-6306-BA (1) Crank Drive Sprocket (\$17.27) \*
11. F8AZ-6256-BA (1) Cam Sprocket (\$17.78) \*
12. F8AZ-6256-AA (1) Cam Sprocket (\$11.15) \*
13. YF7Z-6279-AA (2) Cam Bolt (\$1.99 each)
14. F1AZ-6278-A (2) Washer (\$2.35 each)
15. F3AZ-6265-A (2) Cam Spacer \*
16. YL3Z-9439-BA (set) Intake Manifold Gaskets (\$13.86)
17. F5AZ-6700-A (1) Front Cover Crank Seal (\$9.50) \*
18. 1R3Z-10153-AA (1) Alternator bracket (\$5.38)
19. F8ZZ-9E926-AB (1) 70 mm Throttle Body (\$67.88) \*
20. F6AZ-6584-AA (1) Left Valve cover gasket (\$14.88)
21. F6AZ-6584-BA (1) Right Valve Cover gasket (\$14.88)
22. 2003 Mustang GT MAF, airbox & intake tube (\$100) eBay auction \*
23. 1U2Z-14S411-AA Wire harness for GT MAF to integrate IAT sensor \*
24. AWSF-22C (8) Spark plugs (\$1.60 each) \*
25. F6SZ-18472-BA & F4SZ-18472-DA Heater core hoses (\$9.96 & 11.81)

These parts are not all necessary to accomplish the head swap. I decided to get new cam sprockets, front cover seal, larger throttle body, etc. The parts with an asterisk (\*) are not necessary but consider replacing them or upgrading them as the case may be. Part #4 (Head changing kit) comes with head gaskets, bolts, exhaust gaskets, dipstick tube and rubber tubes to hold up the head bolts. The cam spacers and sprockets can be reused, but you will need new bolts and washers. In my opinion the gaskets are not reusable, and I wouldn't chance one leaking when they are so cheap to replace. The alternator bracket is necessary when using a '02 or newer intake manifold with the aluminum crossover in the front. You also must have the crossover tapped and threaded to accept the coolant temperature sensor. I also bought new heater hoses, which are easy to get to with the heads off to replace. These prices I negotiated at my local Ford dealer. They are considered wholesale prices. I believe the cylinder heads now require a \$150 core charge when you buy them, but they didn't when I got my heads.

## Instructions

1. Before beginning, I put the car up on ramps and set the parking brake. Then, I disconnected the negative battery terminal. While the car is on the ramps, I removed my oil filter (more on that later) and sprayed the exhaust flange-to-manifold bolts (two on each side) with penetrant. I also sprayed the EGR tube to upper intake nut.
2. The next thing I did was to remove the airbox, air tube, and upper plenum bolts. Then I disconnected the wiring to the MAF, IAT, and the TPS sensors. Remove the cables to the throttle body. I placed them underneath the driver's windshield wiper with a cloth in between them and the glass.
3. I have a strut tower brace from Kenny Brown, so I removed that next.
4. Next, I removed the bolts from the upper plenum to the intake, loosened the EGR nut, removed various vacuum connections, and removed the upper plenum and throttle body.

**NOTE:** Each connection I removed, whether it was vacuum or electrical, I labeled using address labels cut in strips. Each connection got a label on both male and female sides of it. I also put all loose bolts and nuts in sandwich bags, labeling each bag and twist tying it to the part it came off of to avoid confusion.

5. I drained the radiator and disconnected the upper radiator hose. Because the car was on ramps at an upward angle, there was not much coolant in the upper hose. Remove the wiring from the radiator fan and the two bolts that hold it in. You must have the upper hose disconnected to pull the fan shroud out.
6. Next, I removed the accessories from the front cover. The power steering reservoir, coil packs and various brackets come off, disconnecting and labeling the wires along the way. Set the reservoir out of the way.
7. I would next loosen the 4 bolts to the water pump pulley. You need the tension of the accessory drivebelt to stop the pulley from moving while you are loosening the bolts. Once the water pump pulley bolts are off, remove the accessory drive belt, then the pulley. Then you can remove the 5 bolts that secure the alternator.
8. Next, you can remove the PCV valve from the cam cover and the emissions plumbing that goes with it.
9. Next, remove the wiring from the lower engine accessories (compressor, EVO sensor, oil pressure sensor, crank sensor, EVAP purge valve). I had to remove my oil filter to get the wiring harness to the EVO and oil pressure sensors out.

10. Disconnect fuel injector wiring, intake manifold sensors and any other left over connections. Also, disconnect where the wiring is secured to the valve cover studs and intake manifold.
11. Next, I disconnected the oxygen sensors at the harnesses right above the exhaust pipes. This almost has to be done from under the car. Just push up the clip that holds them together and pull down on the bottom half and it should come apart. While I was under the car I got a breaker bar and socket and loosened the 3 lower nuts on the exhaust manifold flanges. There is one upper nut that is accessible from the driver's side by the master cylinder. This is not easy to do and it is quite possible to break the stud right off as I found out, so be careful.
12. Once you get all the wiring disconnected, you can remove the bolt by the passenger side firewall that holds the harness together. Once removed, I fed that end of the harness under the A/C lines and removed all of the wiring at once. Others choose to leave the wires in the engine bay, but it was easier for me to have them out of the way.
13. The next thing I did was to remove the intake manifold. Remove all vacuum connections and disconnect the EGR tube by loosening the nut. Then, using the fuel line disconnect tools (a little plastic flexible ring) disconnect the supply and return lines from the passenger rear of the manifold. There is a trick to disconnecting these lines, and be sure to have something absorbent underneath them for the fuel that will leak out of them. There actually is a sequence to removing the manifold bolts, so consult your manual before removing the bolts. Once all the bolts are out, the manifold will be held on by the heater hose(s) by the firewall. Disconnect the hoses and remove the manifold, injectors, fuel lines, etc. as a unit. There is also a bolt that secures the transmission dipstick to the rear of the passenger side head. This bolt can be accessed from below with some long extensions. I also at this time replaced my fuel filter, which is a good idea when you already have the system depressurized.
14. I then transferred all of the injectors and fuel lines from the old manifold to the new one. Be sure when removing the injectors that you do not leave an O-ring in the old manifold. Lubricate the O-rings with motor oil before inserting them into the new manifold. Place the fuel lines on top and bolt them down.
15. Removing the valve (cam) covers is the next step. All of the bolts are 8mm and doing this job requires shallow and deep sockets and universals and extensions. The gaskets under the covers are held in place by silicone sealer where the front cover meets the heads. I used a razor blade to scrape the sealer and gasket off the heads and cover. I did not reuse these gaskets.
16. At this time, you should have the valve covers off and intake manifold out. The next thing to attack is the crankshaft pulley and bolt. Rotate the tensioner and remove the accessory drivebelt. Most people have to use an impact wrench to loosen the crank bolt. Recently I installed a piggyback crankshaft pulley, so I was able to loosen the bolt using a breaker bar. If you find the engine turning when loosening the bolt, I inserted a 1/2" drive extension 6" long through the passenger side cam sprocket to stop the engine from turning. If you do this, be sure to use some sort of pad or cloth so the extension does not mar the heads or front cover. Once the bolt is out, you need to use the pulley "puller" to get the pulley off. Now would be a good

time to get underdrive pulleys. Remove the water pump pulley if you haven't already and the alternator bolts.

17. You should now have all the accessories off the front cover. The next step is to remove the 4 bolts going from the oil pan to the front cover. You may need to use a universal to get at one or more of them, as the sway bar can be in the way. In the shop manual, they actually have you removing the entire oil pan! You can see this would be next to impossible.
18. One of the most frustrating and time-consuming projects is next. You must remove the 4 bolts holding the power steering pump in place. The top two are not too hard to get at. I used a 10mm ratcheting wrench and had those out in no time. The other two bolts are underneath the pump. One is accessible using a 1/4" drive 10mm socket and universal with extensions. The other bolt is only accessible with a 10mm 12-point wrench. This bolt is a major pain and will only turn one eighth of a revolution before you must reposition the wrench. Also – the PS hardline is in the way and the bolt cannot be removed. You have to let the pump down every so often to get clearance for the wrench. You can turn the white harness where the sensors plug in for easier access. Patience! Patience! Patience!
19. The bolts that hold the front cover on are next. The smaller bolts are 12mm and the larger ones are 18mm. Once the bolts are out, you can remove the front cover. Try and preserve the oil pan gasket that may be stuck to the bottom of the cover.
20. Now you have access to the timing chains, guides and tensioners. Remove the bolts holding in the chain guides and tensioners. Be careful as the tensioners are pressurized. Next, remove the chains.
21. You are now ready to start loosening the head bolts. I think these are 15mm bolts and you **WILL** need a breaker bar. Some of the bolts (mostly lower) on each side cannot be removed from the head. If you are using the Motorsport head changing kit like I did, there are 6 tubes about 3" long included. Lift the bolts out of the head as much as you can, then wrap these tubes around the bolts. These will allow the bolts to stay up away from the block while you remove the heads. Be aware that once the bolts are loosened, you may start to leak coolant and oil. Once this has happened, you need to get the head off as soon as possible. I loosened all of the bolts half way, and then removed them. I did not have coolant or oil leak until I lifted the head and broke the gasket seal. I also had some absorbent material underneath the head to try and catch all of the liquid.

When removing the passenger side head, the EGR tube is still connected to the exhaust manifold as well as a bracket directly behind the engine. These can all come off with the head and be transferred to the new head. When the heads are off, be sure and clean the cylinders out – there's sure to be coolant and/or oil in them. After I dried them out, I sprayed them with WD-40 so they wouldn't rust.

**NOTE:** The driver's side exhaust manifold has the dipstick tube running through it before it goes into the block. There are a couple of ways to deal with the problem of removing the head with the manifold attached. The dipstick tube has a flange where it bolts to the valve cover. This flange interferes with the exhaust manifold when trying to remove the head. Some people have been successful removing the head and dipstick tube at once. I actually found it easier to cut the tube right below the flange. This allows the manifold to slide over the tube with no interference. Of course, this dictates the need for a new dipstick tube, but mine would have been mangled anyway. I don't see a good way to remove the tube without destroying it.

22. After I removed the drivers' side head, I had to remove what was left of the dipstick tube. As stated above, I cut the tube off about even with the side of the head. We pulled and pushed on the tube and couldn't get it to move. Here's how I got it to come out. I attached Vise Grips® to the tube and the end of the handle was pointing upward but parallel to the deck surface. Then I put a 6" long 2x4 flat against the deck. The grips' handle was about an inch away from the block of wood. I then slipped a 6-foot hollow metal pole I had from a swing set over the handle on the grips. Standing on the passenger side of the car, I pulled down on the pole that, in turn, made the grips pull upward on the tube and it popped right out. I am thinking of patenting a design for this as it worked great!
23. Now you should have both heads off and the engine should be just down to the block. Before you start putting parts back on, you must clean the block deck surface so the head gaskets have a smooth surface to mate to. I used gasket remover spray and Scotch Brite® pad to accomplish this. There were some places I had to use a razor blade, but be careful not to score the block. Also, check the front of the engine for any leftover silicone globs from the front cover. You must now transfer the exhaust manifolds, studs and oil galley plugs to the new heads. Be **ABSOLUTELY SURE** you transfer all the oil plugs necessary or you will have a huge oil leak on startup. Been there, done that. Just check where the plugs are on the old heads and be sure to transfer them to the new heads where there are no plugs. Also, install the gaskets for the exhaust manifolds and reuse the studs from the old heads. You will also be transferring the EGR tube and bracket with the passenger side manifold. I used new cam sprockets and realized when I went to put them on I did not get the spacers that go between the sprockets and the heads. I had to transfer the cam spacers (situated between the sprocket and the head) from my old heads to the new ones. You need new 12mm bolts and washers to secure the sprockets and spacers to the new heads.
24. Now you are ready to replace the new heads. First, turn the crankshaft so the keyway is at 9:00. This will put the pistons safely below the deck surface. Be sure the cams and sprockets are oriented the correct way on the head before placing the heads on the block. Then, set the gasket on the dowels for whichever side you are going to do first. I had 2 people helping as I did this. One was holding the weight of the head, another guiding the head down onto the block, and another underneath the car making sure the exhaust manifold studs mate up to the flange correctly. The driver's side head also requires you to maneuver the dipstick tube down through the manifold and motor mounts to get it into the block. This is a very difficult step. You must also figure out a way to keep the bottom head bolts off the head surface. Remember –



some of the head bolts have to go in the head before putting the head on the block because there will be no room to get them in once the head is on the block. These bolts are usually on the bottom and toward the back of the engine. I used the rubber tubes that came with my head changing kit. They worked great.

25. Follow the steps in the manual for torquing the head bolts. Remember, the old bolts cannot be reused. You must oil the bolt-spot faces to get an accurate torque reading. Sequence as well as torque values are equally as important. I used a breaker bar for the last step where you have to turn the bolts an additional 90° for extra leverage. Once the heads are bolted down, get the exhaust manifold to flange bolts secured. I lightly lubed the cams with motor oil so they wouldn't be dry upon startup.
26. You can now bolt the chain guides back on to the front of the engine. First, you have to bleed down the tensioners. This is done by placing them in a bench vise and compressing them. You must release the tooth gear with a small tool while compressing the piston in the vise. Once the piston is sufficiently retracted, you must place a paper clip or other device in the small hole to lock the piston back until you have bolted it in and have the chains in place. The next step is to set the timing chains. Whether you are using new or the old chains, you must determine if the chains are marked with 2 copper links indicating opposite ends of the chain. If they are not, you must lay the chains out on their side and pull them taught. I marked the opposite ends with whiteout so you can visibly see the markings on the chain that you must line up with corresponding marks on the cam and crank sprockets. Rotate the crankshaft so the keyway is 45° up from the 9:00 position (halfway between 9:00 and 12:00). This puts the #1 piston at top dead center. Place the chain on the first crankshaft sprocket with the marked link at 6:00 when the sprocket keyway is lined up. Then place the chain on the corresponding cam sprocket lining up the marked link on the chain with the dimple on the sprocket. A manual is indispensable here. Install the other sprocket and chain the same way, then bolt the tensioners back in. You need to compress the chain so you can place the curved pieces that the tensioners press into onto their dowels. Then you can release the paper clips in the tensioners. Everything should line up with the two links on the bottom of the crank pulleys and one link on each of the cam sprockets. **BE SURE THIS STEP IS COMPLETED PROPERLY OR ELSE PISTONS WILL MEET VALVES!** Next replace the crankshaft sensor pulse wheel.
27. The heater hose that runs along the valley of the "V" needs to be removed, if you haven't already done so. To fit the new hose, I cut the nipple off the hardline coming out from the water pump. You can then take the new heater hardline and mate it up to (slip it over) the water pump line. I used some silicone sealer at the junction and have had no problems. Also, if you have auto climate control (as I did) you must salvage a little piece of hard line from the old setup with the sensor bung. Cut this line down as much as possible giving yourself just enough on each end of the pipe to slip some rubber heater hose over it. You need this sensor in the line to tell the auto climate when the water is hot going to the heater core. You must run heater hose from the new hardline coming out the back of the intake to this piece, then use the hose from the heater core to mate to the hardline. I had some leaking problems from my setup using the spring style

clamps. I went and got some screw type clamps and those have been holding so far. This setup does work, but it leaves a mess of hoses behind the intake on the passenger side.

28. Replacing the front cover is next. **Be sure your timing is set correctly and all the bolts are tightened along with the oil galley plugs. Once you replace the front cover, there's no going back.** You need to put silicone in the areas of the front cover in the corners where the cover meets the oil pan, and where the heads meet the block. I replaced the front crankshaft seal because it was cheap insurance. Just hammer it out and tap the new one in. Be sure when you are placing the front cover back on that it does not disturb the oil pan gasket. Also, be sure the cover sits behind the little tabs on the front of the oil pan. Replace the bolts and stud bolts in the correct holes.
29. You might as well tackle the power steering pump bolts next. When replacing the pump, you can only thread the three bolts that you took out halfway. If you thread them all the way, you cannot get access to the bolt behind the power steering line. I got the others halfway, tackled the tough bolt, and then finished the other three. This step is much easier if you have a helper above holding the weight of the pump while you turn the bolts.
30. After the power steering pump, I continued to replace the accessories on the front cover. The brackets for the coil packs, water pump pulley, crankshaft pulley, etc. You may need a pulley replacer for the crankshaft. I did not need this tool because I have a piggyback crank pulley and it just slid right on the crank. **Remember to use silicone in the keyway of the pulley.** The crankshaft bolt has a special torque sequence when replacing it, so take note. I also just snugged the water pump bolts in until later when I had the accessory drive belt installed and used the tension from the drive belt to stop the pulley from turning when I tightened the bolts.
31. The next step is installing the intake manifold. I have a newer style manifold with the aluminum crossover in the front. There is a flat area next to the thermostat opening that I had tapped and drilled (3/8" pipe thread) to accept my second water temperature sensor. Because of this aluminum piece, the old bracket for the alternator will not bolt up correctly. I got a new alternator bracket from the 97M91 intake manifold recall kit that fits perfectly. The part number is listed on the parts page. Place the gaskets for the intake on the tabs in the head and set the manifold down gently. You may have to slide the intake down under the EGR pipe. There is a special sequence and torque values for the manifold bolts. **Before I fastened the manifold down, I put new spark plugs in the heads.** I didn't want to risk dropping a bolt down the spark plug hole. Don't forget to use anti-seize compound on the threads. You may wish to transfer all the parts possible to the new manifold before bolting it in (upper plenum, TB, etc.). Then install the thermostat (I used a new 180° thermostat) and the O-ring. Replace the upper water hose connection and those 2 bolts. Be sure the EGR pipe is in its place and tighten down that nut. Bolt in the new alternator bracket and then the alternator.
32. The next project is the valve covers. I used new gaskets, so I removed the old gaskets and cleaned the inside of the valve cover where the gaskets sit. Place the new gaskets in the groove all around the cover. Be sure you push the gasket down in the groove to help get the gasket



evenly distributed across the cover. Also, make sure the area where the front cover meets the heads is free of old gasket or silicone. Lay a bead of silicone down on each head/cover junction (2 on each side). Then place the valve cover on the heads and torque the bolts to 71-106 lb/in. Be certain the gasket is still in the right position after wrestling with the valve cover. Make sure and replace the bolts in their prior location, as you need the stud bolts to secure spark plug wire looms to and other wiring.

33. After the valve covers are installed, I started to reconnect the wiring. Lay the wiring harness on top of the engine and start connecting the wires. I started with the passenger side lower (A/C compressor, crank sensor, vacuum) connections then progressed to the injectors, sensors on the manifold like IAT, TPS, and the two water temperature sensors. Don't forget the three connections to the alternator or the coil packs. Then, on the drivers side there is the oil pressure sensor and EVO sensor, the sensors under the fuse box, injectors, etc. It is hard to get these connections confused as they can only be done one way and each connection is specific. Next, feed the wires down behind the engine for the O<sub>2</sub> sensors and connect those. I had a helper here holding down the wires while I pushed up from below. Be sure if you have auto climate to connect the wire to the sensor in the hardline you cut that should now be behind the passenger side head/intake. The last connection is the harness itself. Feed the square box under the A/C line and push it firmly in, then tighten down the nut. Make sure you didn't miss any connections and that all the wiring is secure and not rubbing against any moving parts. Don't forget to replace the bolt that holds the transmission dipstick tube to the rear of the passenger side head.
34. Next, reconnect all the vacuum lines, starting from the vacuum regulator beneath the passenger side coil pack, finishing with the EGR connection. There are numerous connections to the intake and upper plenum. Also, reconnect the plastic pipe to the PCV valve (I used a new one) and the long tube from the rear of the upper plenum to the little metal tube coming up along the passenger side valve cover. This is more emissions plumbing.
35. At this point you can reinstall the accessory drive belt. Once this is installed, use the tension to finish tightening the 4 bolts to the water pump pulley.
36. You should be ready to install the spark plug wires. Use dielectric grease on both ends of the terminals. Push down firmly to seat the wires on the plugs and coil packs. I used new Motorsport 9mm plug wires and looms.
37. The fuel lines go next. I used a little oil to lube the O-rings. Then, just push them in until they click. Use the metal clips so they don't fall out.
38. Reconnect the tube from the air box to the throttle body, then connect the other emissions plumbing to the tube.
39. The last thing I did was change the oil and filter. There probably will be coolant in the bottom of the oil pan. I recommend changing the oil and filter again in a few hundred miles.

I intended this to be a helpful guide but not to replace the Ford manual. There are some things in this writing that the manual will not tell you. If you have done this project, and noticed I've overlooked something, please [let me know](#). Comments are most welcome.



You can see the shape of the intake ports is more square, versus the tear shape on the old heads.



Here is a picture of my engine with the heads removed.