# CHECKING OUT A TURBOCHARGER

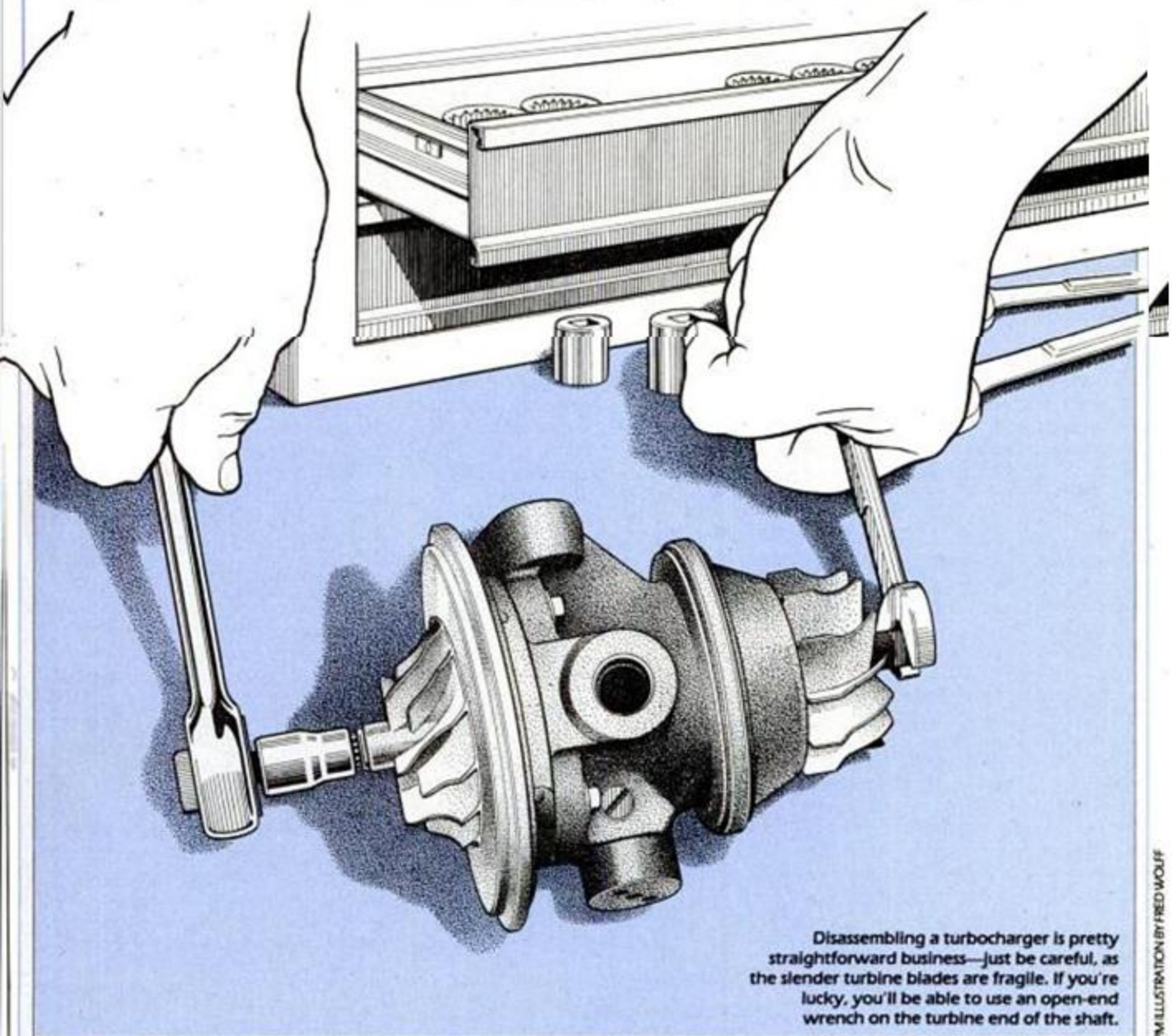
BY PAUL STENQUIST

● It's your turn to ferry mother-in-law to her weekly Mahjohngg night, and she's running late. Not a problem. You've got a turbo under the hood—just the ticket to make up a few extra minutes.

Suddenly, there's a buzzing noise. Power goes down, and a cloud of blue smoke goes up in your mirrors. What gives?

You've blown your turbo. Not only is Mom going to be late, you just *know* this is going to set your bank account back a few dragons. Say as much as $2000, depending on the manufacturer and the dealer's parts department.

Take heart. All is not lost. In spite of their high-tech basis in thermodynamics, turbos are actually simple creatures. With some respect for the extremely close tolerances involved, it's possible to rescue many blown turbochargers, possibly for less than $100 and some simple hand labor.



Disassembling a turbocharger is pretty straightforward business—just be careful, as the slender turbine blades are fragile. If you're lucky, you'll be able to use an open-end wrench on the turbine end of the shaft.

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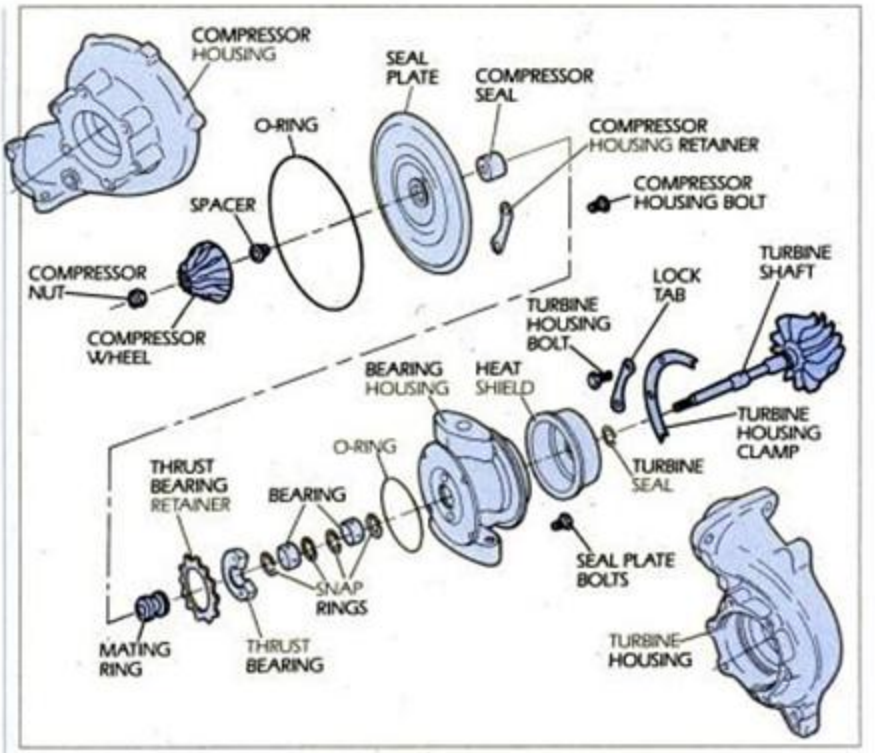



**An exploded view of a typical Garrett T3 turbo. Expect to see some minor variations.**

## Theoretically

As you nail the throttle, hot exhaust gases rush through the exhaust (turbine) housing, spinning the turbine wheel with energy from the otherwise wasted heat in the exhaust. The turbine wheel is mounted on a shaft that drives a compressor wheel. The compressor takes air in through the air cleaner and pushes it into the intake manifold. This extra air causes intake manifold pressure to be higher than without the extra push.

When the intake valves open, pressurized air rushes into the engine's cylinders while the carb or injection adds fuel to match. And your relatively small powerplant pumps out horsepower more typical of much larger engines.

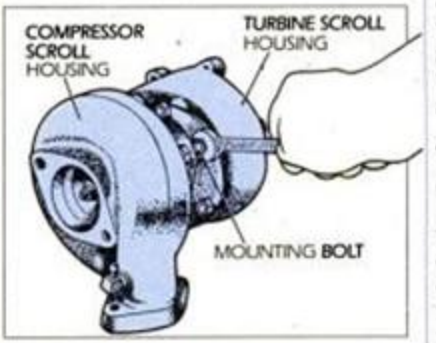
Turbochargers operate under very taxing conditions. And failures are not uncommon. However, many total failures can be prevented if you recognize the symptoms early and do something about it. There are a number of symptoms that indicate possible turbocharger problems. We'll outline some of them here and then show you how to rebuild a turbocharger.

## Low boost

One common turbocharger problem is a lack of boost—first noticed as a loss of engine power at full throttle.

If your car is equipped with a boost gauge, as most turbocharged cars are, you'll immediately notice any drop in boost pressure. If your car is not equipped with a boost gauge, you can check boost by installing a pressure gauge tap in the intake manifold and routing a hose to the passenger cabin. Then, while driving the car at full throttle under heavy load, check the boost reading on the gauge. If it's significantly less than manufacturer's specs, you have a problem.

Before condemning the turbo, check for a clogged air filter, an obstruction or leak in the duct that joins the turbo's compressor outlet to the intake manifold, an intake manifold gasket leak, a leak or obstruction in the exhaust system, or a wastegate problem.




**You'll need an open-end wrench to disassemble the scroll housings.**

Wastegate leakage is a common cause of low boost pressure. The wastegate is a device that opens to divert exhaust at a predetermined level of boost to prevent overboosting. Wastegate leaks are usually caused by carbon accumulation around the wastegate itself. A weak or broken return spring or a defective wastegate control canister (wastegate actuator) can cause the wastegate to open too early, preventing full boost.

However, a control canister failure will usually result in overboost. And because overboost can cause serious detonation problems, it could damage your engine. Other causes of wastegate-related overboost include an obstructed hose between the compressor and the control canister, a leaking canister and a canister diaphragm failure.

On a lot of newer applications, the wastegate canister operation is computer regulated by means of a solenoid. If the solenoid fails to open, overboost can result. If the solenoid fails to close and never limits the application of boost pressure to the canister, low boost pressure may be the result.

If you've ruled out other potential causes and the turbocharger seems to be at fault, you can disassemble it to determine the extent of damage and whether or not a fix is practical. Sometimes a loss of boost is merely the result of dirt accumulation on the compressor blades. More often, it's the result of damaged compressor or turbine blades.

The working parts of the turbo—shaft, compressor, turbine and bearing housing—can sometimes be purchased without the two scroll housings. This assembly is known as a cartridge. If you decide to replace the cartridge, see the rebuild instructions that follow in regard to disassembly of the housings.

If either the turbine housing or the compressor housing is damaged, the turbo can't be rebuilt in the field and should be replaced. In many cases, turbine or compressor failure damages the housings as well.

## Turbo noise and vibration

Strange noises or vibration at the turbocharger usually indicate failure of the turbocharger bearings and/or damage to rotating parts that have caused an out-of-balance condition. In most cases, the damage to the turbo is fairly serious by the time things start shaking and shrieking. A cartridge replacement will usually be necessary



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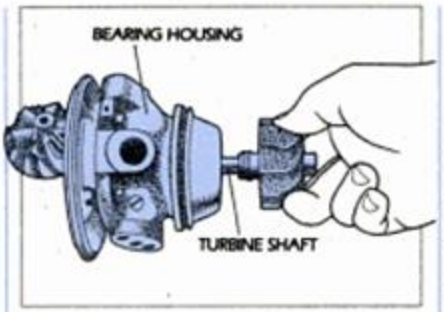



**The turbine shaft can be withdrawn once the compressor nut and wheel are removed.**

to cure a vibration or noise problem. Sometimes, an accumulation of dirt on the compressor can cause imbalance.

## Exhaust smoke

Perhaps the most common signal of impending turbo failure is a puff of smoke when you first start the car in the morning. This condition can worsen quickly to overall smoking and eventual loss of turbo boost. Smoke is the usual first hint that something is going wrong. And it signals the best time for you to try to do something about your turbo problem. In many cases, total turbo failure will occur within 5000 miles of the time when smoke first appears in the exhaust.

But before you dig into the turbo, consider some other possible causes of smoke. Of course, an internal engine problem can cause smoke. Valve guide wear causes a smoking condition similar to that caused by turbo seal failure, though it rarely comes on all at once.

Even turbo-related smoking may be caused by something other than failed turbo seals. On a diesel, a clogged air filter can lead to pressure considerably below atmospheric on the compressor side of the turbo. This can cause oil to be drawn past the compressor seal. On the other hand, a clogged turbo oil-return pipe can cause excessive oil pressure and eventual loss of oil past the turbo's seals into the intake and exhaust systems.

But the most likely cause of turbo-related exhaust smoke is coking of the turbine shaft due to overheating of the lubricating oil. The abrasive fried oil (coke) grinds away at the turbo's shaft bearings. Once the bearings have worn, the shaft wobbles. This causes failure of the seals that separate the turbine and compressor from the oil-pressurized center bearing housing. Once oil enters the turbine and compressor housings, it's drawn into the intake manifold and exhaust systems.

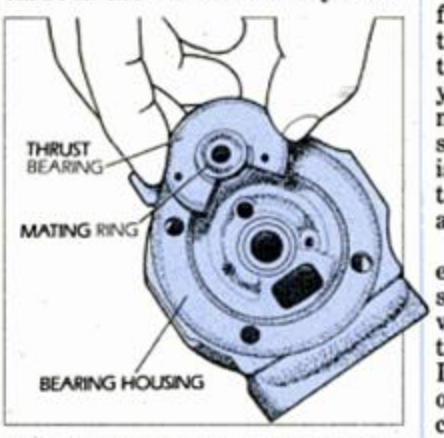
The relatively easy fix for this condition is seal and bearing replacement. A number of aftermarket manufacturers provide replacement parts for passenger-car turbochargers. One that we are aware of (Turbo City, Inc., 1137 W. Katella Ave., Orange, CA 92667; (714) 639-4933), sells a rebuilding kit intended for someone who has never rebuilt a turbo. The kit includes all the seals, bearings, O-rings, thrust plates and gaskets needed to rebuild a turbo, as well as instructions outlining the job.

That same company sells complete turbos and turbo cartridges (the working parts exclusive of the scroll housings). They will also rebuild your turbo for you if you want to ship it to them.

## Turbo rebuild

The rebuild procedure is easy for the experienced driveway technician. The instructions provided with the rebuild kit are fairly good, although one preliminary disassembly step was omitted. (Turbo City tells us they will be correcting this.)

The unit we rebuilt was the Garrett T3, the most common passenger-car turbo in the world. The only other



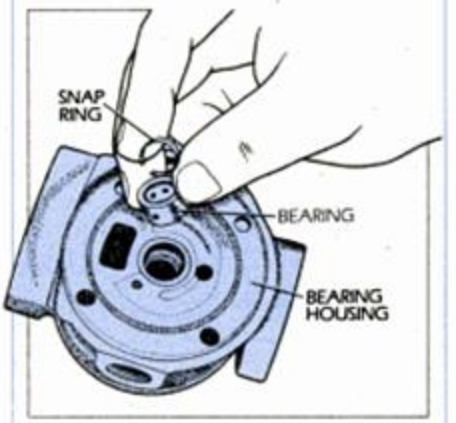

**The thrust bearing (thrust plate) and mating ring can be lifted from the bearing housing.**

type you're likely to encounter is the Mitsubishi turbo, which is used on Mitsubishis and late-model Chryslers. The Mitsubishi and Garrett turbos are very similar, as are the rebuild procedures.

Before beginning the disassembly of the damaged turbo, we found that a brief examination of the new parts provided in the kit was helpful. This way, you'll recognize the parts you'll be replacing as you remove them.

Before you start to disassemble the turbo, mark the four main sections —turbine scroll, bearing housing, seal plate and compressor scroll—with a scribe so you can reassemble them in the same relative positions. (This is the step that was missing from our instruction sheet.) Disassembly of the turbo begins with removal of the wastegate control canister or actuator, then the turbine and compressor housings.

Next is removal of the compressor nut from the turbine shaft. This can be tough because the shaft rotates




**After removing the snap rings, the bearings will slide out of the bearing housing.**

freely in the bearing housing. If you try to jam it by sticking something in the turbine or compressor blades, you'll ruin them. All turbo shafts are manufactured with a hex at the opposite (turbine) end of the shaft, but this is frequently ground away when the turbine shaft and wheels are balanced.

The turbo we rebuilt still had enough of the hex intact to permit restraint of the shaft with an open-end wrench. If you're not that lucky, hold the turbine wheel with a thick towel. If that doesn't work, try wrapping an old V-belt around the turbine wheel a couple of times. Then, hold the belt while you loosen the compressor nut. Turbo City does not recommend that you use an impact wrench, as it can bend the shaft.

The rest of the disassembly process is easy. First, you'll extract the turbine wheel and shaft from the turbine side of the bearing housing. If the shaft is coked, you may have to carefully tap on the compressor end with a plastic mallet. (Our moderately coked shaft came out with a light tap or two.) The compressor spacer will then slip right out of the compressor end of the seal plate. The turbine heat shield can be lifted from the bearing housing on the turbine side.

Next is removal of the seal plate



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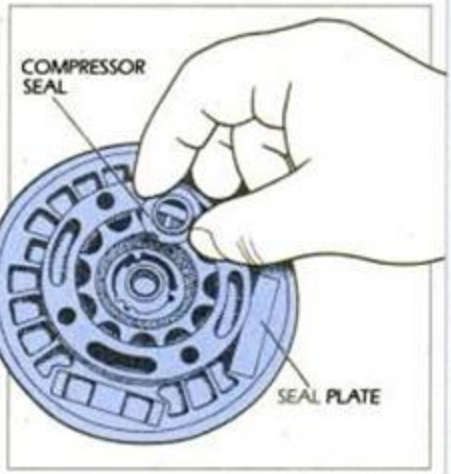
from the bearing housing, followed by removal of the compressor seal from the seal plate. The compressor seal in our turbo was a multipart drop-in unit. The top piece is simply lifted off the three locators in the housing. The internal part, along with the spring that preloads it, must be rotated until its notches align with the locating teeth in the housing.

Earlier turbos may have a press-in positive seal. Use a vise and socket to remove this type of seal.




**Rotate the positive multipart seal to release it from the seal plate.**

Some turbos located upstream from the throttle body, like Saabs and Volvos, may have a dynamic seal that is very similar to the piston-ring-type seal found on the turbine side of the bearing housing.

Turning your attention to the bearing housing, lift off the thrust bearing, the mating ring and the O-ring that you'll find on the compressor side of the bearing housing.

You should use a good pair of snap-ring pliers to remove two outer snap rings (C-clips), one from each side of the bearing housing. Once these have been extracted, the bearings will slide out.

Finally, remove the turbine seal from the seal groove in the turbine shaft. Make sure you don't nick the edges of the seal groove.

Check all turbo parts for unusual wear. The instructions will point you to several areas of concern: the bearing housing bore, the turbine shaft seal groove, the compressor and turbine blades.

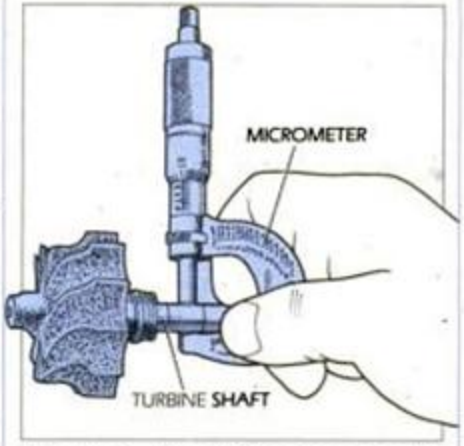
Clean all parts in a glass-beading machine or in cold carburetor dip. If you have neither, your local auto parts store or mechanic will probably be willing to do a cold dip for you. Any good machine shop should have a glass-beading machine. This gadget looks like a sandblaster, but uses smooth microscopic glass beads to remove carbon and rust without damaging the metal surface.

If not, you can purchase a moderately sized container of cold-dip cleaner along with a small parts basket at your auto parts store. Just make sure the can is big enough to dunk the housing scrolls. Give all the parts at least a 4- or 5-hour soak. You may have to brush some of the hardened coke deposits, but take care not to get the cold-dip solvent on your hands—it dissolves organic matter.

Before reassembly, check the diameter of the turbine-shaft bearing journals. For a T3, they should measure 0.3997 in. to 0.4000 in. The shaft in our T3 measured 0.3990 in. A call to Turbo City revealed that some previously rebuilt turbos may have 0.0010-in. or 0.0015-in. undersized shafts. Turbo City immediately sent us a set of 0.0010-in. oversized bearings for the rebuild—as they'll do for any customer who discovers an undersized shaft.

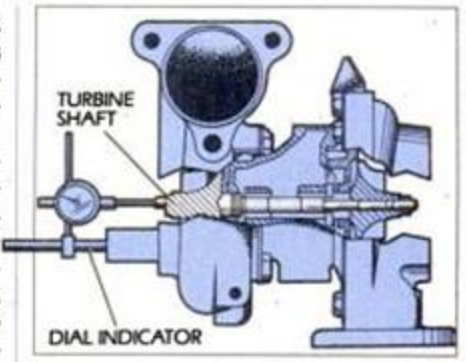
Of course, if your turbo has never been rebuilt, it is highly unlikely that it would be fitted with undersized components. The Turbo City bearings, by the way, are bronze severe-service units. The pieces they replace, in most cases, are normal-service aluminum bearings.

With a 1.0-in. snap gauge and micrometer or vernier caliper, check the diameter of the bearing housing bore at the point where the turbine seal contacts it. It should measure 0.6220 in. to 0.6223 in. When assembled on the turbine shaft, the diameter of the turbine seal ring (piston ring) should measure 0.709 in. to 0.711 in.




**Mike the turbine shaft and compare this measurement to specs in your instructions.**

Assembly is basically the opposite of disassembly. Make sure you coat the shaft and thrust bearings with engine oil. Take care when installing the turbine seal on the turbine shaft. It must fit in the groove and rotate freely. Don't force the turbine seal into the bearing housing. When it is properly centered, it will slide in easily.




**Check assembled end play with a dial indicator along the length of the turbine shaft.**

Tighten the compressor wheel nut to 18 to 20 in.-lb. plus 90°. When you reassemble the housings, make sure the compressor and turbine wheels do not contact any part of either housing. Install the wastegate actuator bracket before you bolt the turbine housing in place.

When reassembly is complete, you should check some other clearances, including axial end play (0.001 in. to 0.004 in.). Radial bearing clearance (the shaft's up-and-down movement) should measure 0.0030 in. to 0.0065 in. Check radial clearance with a dial indicator. On some turbos you can touch the shaft with the dial indicator's probe through the oil hole in the bearing housing. With the correct new bearings and a shaft that specs out on journal diameter, this measurement should be okay.

After installing your rebuilt turbo on the car, clean the oil inlet line thoroughly. Don't use RTV sealer on the oil inlet line connections—it can clog oil passages.

Change the engine oil. Then, pre-oil the turbo by cranking the engine with the coil wire disconnected. (On GM HEI systems with an integral coil, disconnect the distributor BAT wire while cranking.)

Once the oil pressure has come up, reconnect the ignition and start the engine. Let it idle for 3 or 4 minutes before test driving the car.

To prevent bearing wear in the future, run the engine at idle speed for about 30 seconds before you switch off the ignition. This will prevent loss of oil pressure to the bearings while the turbo is spinning at high speed. PM



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