

There are literally millions of turbocharged cars on our streets. Many are out of warranty, and many turbos are failing. Let's face it, customers aren't changing oil at the recommended intervals for normally aspirated cars, let alone observing the more frequent oil change intervals for turbo equipped engines.

Many owners make things worse by running the blower 'til the oil boils, and then revving the engine before they shut it down. In some cases, the turbo has continued to spin after the engine has stopped supplying oil to its tiny bearings. Many customers also ignore the recommendation to let the car idle for a few moments before shut down. Letting the car idle allows cooler oil from the engine to circulate through the turbo. This reduces the tendency of the oil to "coke." Coke is a coal-like substance, very hard and very abrasive. Coke can block the flow of oil through the turbo, and tiny pieces of coke can break free, damaging the turbo's bearing surfaces.

Checking the System

Here's a checklist you should go over whenever you diagnose a turbo problem, or repair or replace a turbo:

- **If the complaint is blue smoke out the tailpipe, check the air filter element first thing.** After all, the purpose of the turbo is to force feed additional air into the engine. A plugged air filter leads to reduced pressure in the intake air system. Normally, pressure in the intake runner helps keep the oil inside the turbo where it belongs. But a plugged filter can create a low pressure area at the compressor seal, sucking oil into the intake runner.

Don't forget the rest of the air intake system. Check the entire length of the intake plumbing for cracked hoses or loose clamps. This inspection should include the intake manifold gaskets.

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- **Let's stay with that cloud of blue smoke for a minute.** The engine pumps a lot of oil through the turbo, and the oil return to the engine must be open. In some cases, the manufacturer will even give a specification for the angle at which the return line exits the bearing housing. If the angle is incorrect, or the return line is plugged, the excess oil pressure can force itself past the seals.

- **Check the crankcase ventilation system.** Turbo or no turbo, a plugged crankcase ventilation system can cause oil consumption problems. It's just another case of eliminating the obvious. And don't rule out piston ring blow by or valve seal problems.

- **Check the basic condition of the engine whenever you encounter a failed turbo.** Make sure the engine's lubrication system is capable of supplying oil to the turbo at pressures recommended by the manufacturer. The turbine and compressor are joined by a shaft which spins in full floating sleeve bearings in most turbos. (This turbine/compressor/shaft assembly is called the rotor.) The rotor shaft, and the sleeve bearings themselves both float on a film of oil, but unlike an engine's main and rod bearings, the sleeve bearings in the turbo spin in their bores. I was informed that the bearing spins at a speed about one half the speed of the turbine shaft. (I wanna meet the guy who figured that one out!)

Tolerances are close, and a lack of clean oil, or tiny bits of abrasive coke from the supply line can ruin the bearings in short order.

- **We've made a point of mentioning oil feed and return lines.** Rebuilders commonly recommend replacement of these lines whenever a turbo is repaired or replaced. It may be difficult or even impossible to remove all the coke from the lines.

One of the cars we worked on for this article was a Toyota Celica. It uses an accordion-like flex tubing as a supply line. There was no way to be sure we had removed all the coke. Cleaning solvents may remove most of the coke from supply lines. But problems start when the solvents loosen, but don't fully remove tiny particles of the abrasive coke. Later, the normal flow of oil through the tube may dislodge the particles and ruin the rotor shaft bearings.

As a result, most turbo specialists prefer replacement of oil lines to cleaning them, especially when they can't be positive they've removed all the coke.

- **Check the cooling system.** Water cooled turbos rely on engine coolant through the turbo housing to remove excess heat. A plugged cooling system, low coolant level, bad water pump, improper or faulty thermostat, or a bad cooling fan can reduce the cooling system's ability to cool the turbo.

- **Check the exhaust chamber ahead of the turbine, and the intake runners ahead of the compressor for anything that looks like scale or debris.** Also check all hoses and connections for a clean tight fit.

- **Another potential cause of reduced turbo output is a plugged exhaust.** Use a back pressure gauge or your vacuum gauge to check for a restricted exhaust. Sometimes a turbo can pump enough oil through the catalytic converter to plug it. If you still have poor performance after installing a new or rebuilt turbo, a plugged catalyst may be your problem.

- **Check the customer's understanding of correct driving and maintenance procedures for his turbo.** Maybe the driver is the worst thing happening to the turbo. If he revs the engine before shutdown, there's a good chance that the engine will stop pumping oil before the turbo stops spinning. When this happens, the turbo spins without oil and the results can be costly. Encourage your customer to allow his engine to idle for a couple of minutes to allow the flow of fresh oil through the turbo to cool it.

Oil changes on turbo cars pose a special problem all their own. The addition of the turbo and all its related plumbing and hardware create an underhood jigsaw puzzle. Our Celica is a good example. Several quick lubes begged off when the Toyota showed up for a simple LOF. They could see the filter, but weren't sure they wanted to remove all the "stuff" above it.

The owner just kept driving until the turbo failed.

Repair Strategies

If you've eliminated any external problems, and decide that the turbo really is bad, you have several repair options:

- Buy a new turbo from the parts department at the local new car dealer. A very expensive proposition.

- Order a rebuilt turbo or center bearing section (depending on how bad the old turbo was). This is a less costly option.

- Go to your local auto parts recycler (okay, junk yard) and try to find a good used turbo. I suspect that this may be like trying to find a good used facial tissue.

- Rebuild the turbo yourself. Kits are currently available which contain replacements for wear items in the turbo. Most kits contain the appropriate bearings, seals and a new thrust plate. Most turbo repair specialists also offer a machine balancing service for a reasonable fee. You ship them the turbo, they balance and return it.

What about the importance of rotor balance? We called a number of folks who routinely rebuild these units, and opinions varied about the importance of rebalancing the rotor assemblies on a dedicated balancing machine. Some suggested that marking the compressor and turbine for index was sufficient to bring them back to their original factory balance (this was the case with our Toyota when we had it checked). But a few rebuilders said that they were finding some

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turbos which required rebalancing even after returning the turbos to their original index. Most weren't out by much, but they could have been better.

Many of the companies listed will machine balance your rebuild for a nominal fee. We all know that down time is a critical factor when impatient customers become a part of the equation, but for your peace of mind it may be a good idea to sell the customer on the delay to ensure a lasting repair. Pay your money and take your choice.

We had toyed with the concept of a turbo overhaul for several months, and even went so far as to install new kits in a couple of used cores. But we wanted to get our hands on a car with a bad turbo and see if our rebuild skills actually worked in practice.

Finally, a turbocharged Toyota Celica came to us wrapped in a cloud of thick blue exhaust smoke. A local dealer had properly condemned the turbo, and had offered to correct the problem. The owner of the vehicle was more than a little unnerved when the price passed the thousand dollar mark and kept going. What the heck, he was too cheap to change the oil.

As things turned out, getting the darned turbo off the car was the hard part. Then, once the turbo was on

the bench, the worst part was getting it clean. Installing the rebuild kit was duck soup.

Cleanliness and attention to detail proved to be far more important than a degree in engineering from MIT. And please, when you start an engine with a new or rebuilt turbo freshly installed, let the engine idle for a minimum of 3-5 minutes before revving it. One source suggested that they recommend letting the engine idle for a full 15 minutes.

Our photos will cover a number of turbo topics including some remove-and-replace cautions and turbo teardown and inspection procedures. We also want to emphasize that the removal and replacement of the turbo on our Toyota were time consuming. You may want to check with someone in your area more familiar with a particular turbo R&R before bidding the job too low. Photos shown are of two turbos: One from our Toyota, and a much abused Garrett from a Z car.

Our thanks to Tom Miller of Turbo City and Dave Robertson and Kevin Draper at Majestic Turbo in Waco, Texas for their assistance in the preparation of this article.

—By Ralph Birnbaum

Turbo Shopping Guide

Here's a list of companies which offer various turbo repair parts, repair services, tools and accessories you may find useful. We called them all, and each was eager to help.

A

A-1 Turbo
Santa Monica, CA
(213) 827-4800
Rebuilt Exchange Turbos
Circle No. 212

Allied Engines
Santa Ana, CA
(800) 421-3746
Rebuilt Turbos and Cartridges
Circle No. 213

B

Blue Ribbon Turbochargers
Long Island, New York
(800) 421-2953
Turbos, Kits, Repair Service
Circle No. 214

C

Cartech Manufacturing
San Antonio, Texas
(512) 637-0373
Add on Turbo Kits
Circle No. 215

D

Dura Bilt
Bradley, Illinois
(800) 346-8641
Turbos, Kits, Repair Parts,
Repair Service
Circle No. 216

H

HKS USA, Inc.
Torrance, CA
(213) 328-8100
Turbo Timer
(see caption 20)
Circle No. 217

M

Majestic Turbo
Waco, Texas
(817) 757-3759
Repair, Balancing, and
Rebuilt Exchange
Circle No. 218

N

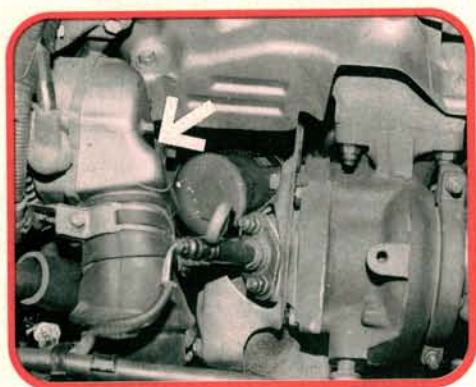
Neward Enterprises, Inc.
Cucamonga, CA
(800) MITYVAC
Makers of the MITYVAC
Turbocharger Test Kit
Circle No. 219

T

Turbo Air West
California
(800) NOW TURBO
Turbos, Cartridges, Kits,
Repair Service
Circle No. 220

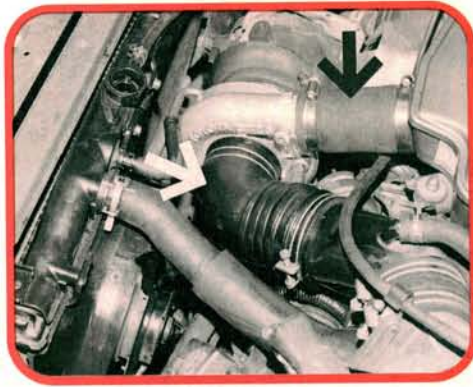
Turbo City
Orange, CA
(714) 639-4933
Turbos, Cartridges, Kits,
Repair Service
Circle No. 221

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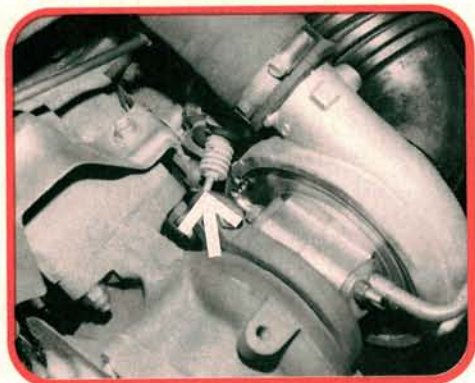
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Let's start with a look at the maze beneath the Celica's hood. Guess why the quick lubes passed on this one. Changing the oil filter requires removal of the alternator heat shield (arrow). Let the engine cool completely before you start. Hot turbo parts may warp if they're unbolted while they're still hot.



2

We remove the air inlet hood at the alternator, O₂ sensor, and the manifold heat shields. We also remove the air inlet hose to the turbo (left arrow) and loosen the intercooler enough to remove the outlet hose (right arrow). After disconnecting the coolant lines to the turbo, we also remove the radiator.



3

The rod from the wastegate control valve comes in beneath the center housing and attaches to the valve with an E-clip. This photo shows how the rod sneaks in tight quarters. We reach from the bottom, and using a mirror we remove the clip with a small pick. Later, replacing the clip proves to be equally entertaining.



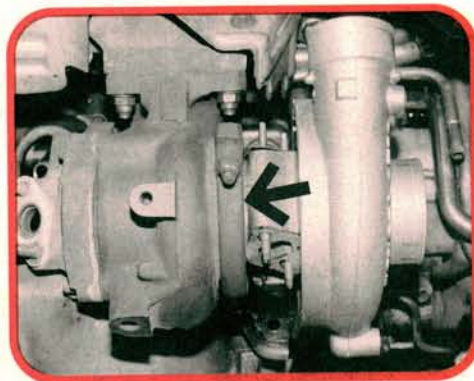
4

The wastegate control valve assembly straddles the turbo assembly. We unbolt the support bracket, pop the control rod off its stud on the wastegate, and remove the control valve bracket bolts. We check the control valve operation and inspect the hoses for tears or cracks. We also make sure the arm on the wastegate moves freely.



5

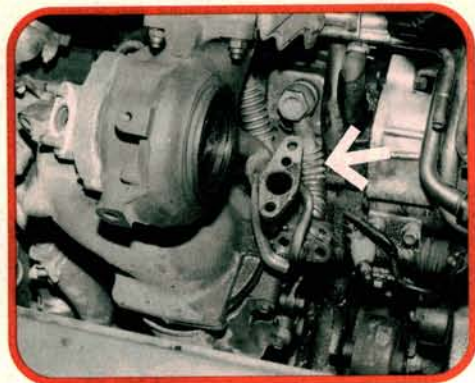
The combination oil feed and return line bolts to the bottom of the center bearing section. As if removing the nuts isn't enough fun, the supply line is bolted to a bracket which runs behind the exhaust over to the engine block, right below the dipstick tube. A long extension and a swivel socket remove the bolts.



6

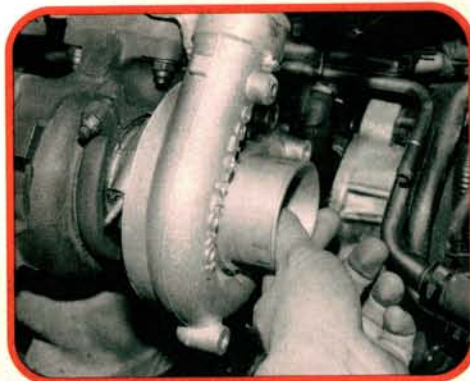
The turbo's center section is held to the turbine housing with a stout, two piece v-band. The tapered edges of the turbo's center bearing section and the turbine housing are wedged together as the strap is tightened. Our inset illustration shows how the clamp keeps the two housings tight and square.

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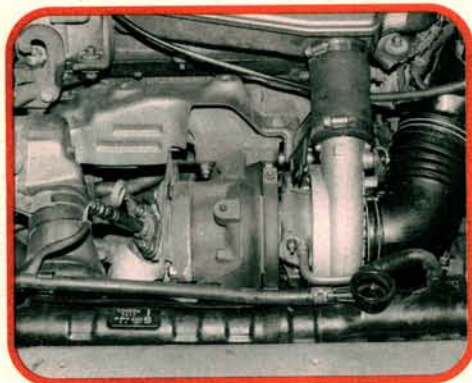
7

Finally. The turbo is removed. Note the location of the accordion style flex tubing (arrow) used on the oil supply line. This is a perfect place for tiny pieces of hardened carbon to hide. We choose to replace the lines rather than take the chance that we won't be able to completely clean the old line.



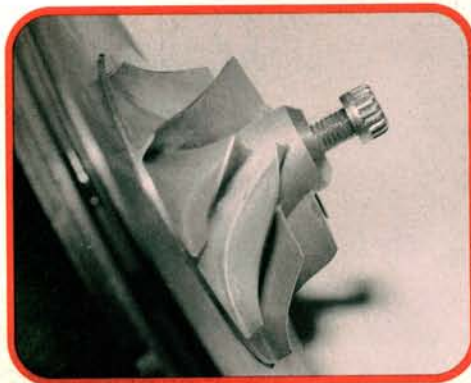
8

Later, when we reinstall the turbo, we'll take great care to slide the turbo's center section squarely into the turbine housing. The clearance between the turbine and turbine housing is very small. If we get the turbo cocked, we may damage the vanes on the turbine. Make sure the rotor spins freely when the clamp is tightened.



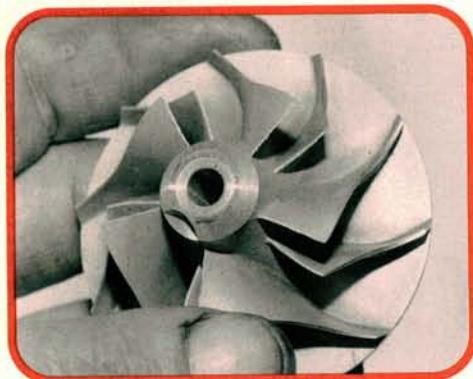
9

We're replacing that ancient oil filter. This brings up an important point about priming the turbo. The oil delivery line is on the bottom of the turbo, so we can't pour oil into it before starting the engine. Instead, we disable the ignition and crank the engine until oil flows from the return line back to the engine.



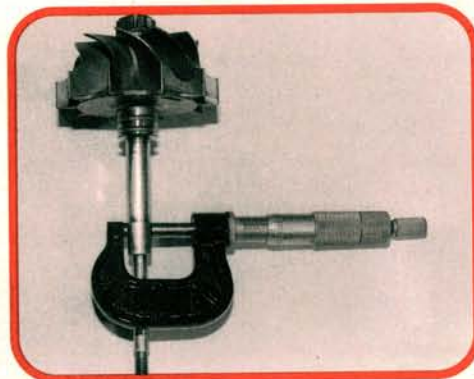
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We won't go through every single step in a turbo rebuild, but we'll emphasize some key points. Mark the turbine and compressor for index before removing the compressor. We used a dental pick to make tiny scratch marks on each. Then hold the nut on the turbine and unscrew the nut holding the compressor to the shaft.



11

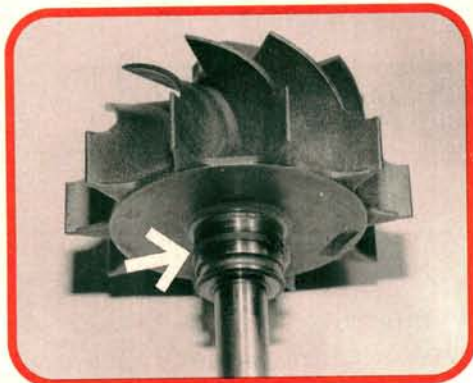
Carefully inspect the compressor and compressor housing for any indications that they've come in contact. The rotor assembly must be properly balanced to withstand speeds over 100,000 RPM. Even the smallest imperfections can cause a catastrophic out of balance condition. And never try to straighten a bent fin.



12

So how do you clean the rotor assembly? A carb dip tank is a good choice since it won't remove any metal and affect balance. But some rebuilders told us that glass beading removes stubborn deposits on the turbine. We polished the rotor shaft with super fine emery, and checked the diameter at the bearing contact spots.

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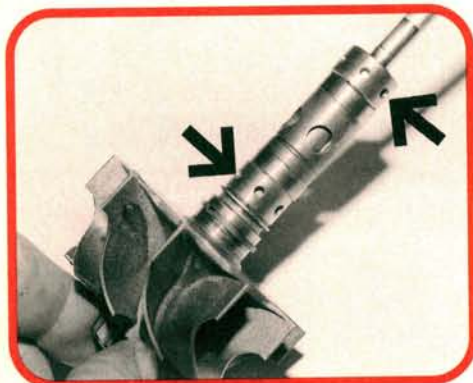
13

The sealing ring on this shaft is a piston ring style. And like a piston ring groove, we need to remove all the carbon in the groove before installing a new ring. The Garrett is really coked up in the area where the sealing ring rides, and it too requires some serious cleaning before we're satisfied that the new ring will seal.



14

The Garrett unit from the Nissan has had a much tougher life than the unit on the Toyota. This turbo is so coked up that the oil passage to one of the bearings is plugged shut. A drill bit was called into service to ream out the hole. Show this photo to the next customer who wants to skip his scheduled oil change.



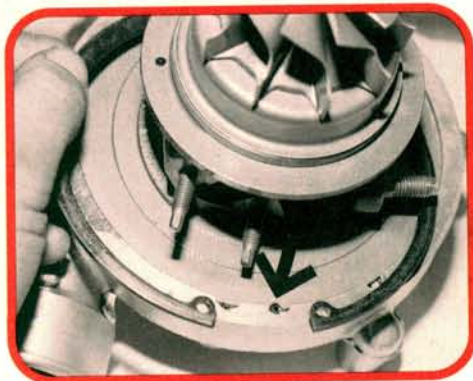
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Here's the rotor shaft assembly with its shish kebab of bearings (arrows) and a spacer in between. Slightly different arrangements of bearings and spacers will be used depending on the manufacturer, but this is representative of the floating bearing setup used on most turbos. It doesn't take much to plug up those oil passages.



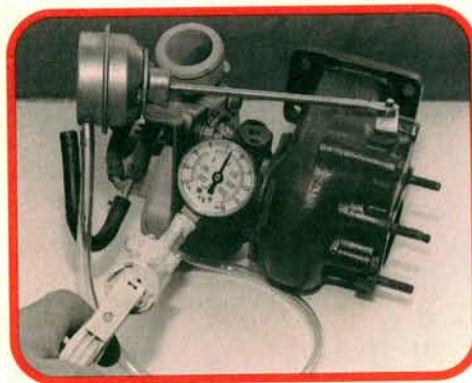
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Bearings generally wear in three ways. If the bearing gums up and sticks to the shaft, there will be more wear on the bearing OD since it's carrying all the load. If the bearing OD sticks in the housing, most of the wear will occur at the bearing's ID, where it contacts the shaft. General oil starvation ruins the bearings—inside and out.



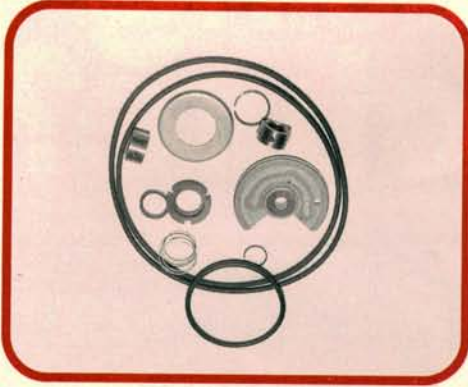
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Our Toyota turbo has a roll pin which is used to properly index the housings at reassembly. Our Garrett has no such locator which means we need to mark the housings for index to ensure that the oil return line is repositioned at the proper angle. An incorrectly positioned oil return can lead to oil consumption problems.



18

Don't forget to test the wastegate control valve before you put everything back together. Our MITYVAC has a pressure pump outlet which allows us to check the valve. Pressurize the valve and look for it to start opening when the pressure is about one pound below the rated opening pressure.



19

Here's a look at the contents of a typical rebuild kit. As you can see, kits provide replacement for wear items: bearings, seals, and the thrust spacer. If the turbo is so shot that the rotor assembly has turned into a "wear" item, don't chance a rebuild. Turbos which disassemble themselves at 160,000 RPM make a mess.



20

Coke forms at about 330 degrees F. One way to make a couple of extra bucks, and save the turbo, is to install this kit from HKS. Even if the customer shuts off the ignition key, the kit keeps the engine running for 0.5 to 9.5 minutes (depending on temperature) to circulate oil and stabilize exhaust temperatures.
