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Volvo Maintenance FAQ for 7xx/9xx/90 Cars

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Turbo Idle and Shutdown

[Inquiry:] The figure of a minute or two before shutdown was relevant for the older, non water cooled turbos. Yours ('86) should have water cooling, and thus only require a few seconds. Is this so?

[Response:] Yes, it is. The reason the two minute cool down period was required is that so called 'first generation' turbos had oil cooling, but no water cooling. The effect of oil cooling is less, and thus these units ran MUCH hotter than later, water cooled turbos - after a long drive they could be glowing red! This is hot. And it can burn the oil. This does not cause a problem while the car is running, because the oil pump keep recirculating the oil around, so it doesn't stay in the turbo long enough to burn (and it has that nice oil cooler next to the main radiator as well). The problem is that as soon as you shut down the engine, the oil pump stops. If the turbo is still spinning, it has no pressurized lubricating oil. The oil that sits in the turbo stays there and can burn and coke. If solid sludge particles form in the turbo bearing (which is an oil bearing), they can score the bearing journals - kind of like your very own grinding machine inside the turbo.

Enter second generation turbo.These units have the same oil cooled bearings, but they also have water cooling - much like an engine has oil bearings and water cooling. The effect on the turbo is two fold: One, it runs much cooler - doesn't glow red or anything (the exhaust manifold might (read: does...), though - but that's a different story). Aside from that, the water keeps recirculating even after the

engine is switched off, due to convection (i.e. hot water rises). Hence, the danger to second generation turbos is considerably reduced.

So, one would ask, what is the reason for the few seconds of idle after starting and before switching off? Simple. In the first few seconds after starting (even after the oil warning light is off!) the oil pressure is lower, and fresh oil may not have reached the turbo yet - and if you race the engine, the turbo will spin fast with insufficient oiling of the bearing - not good. Likewise before switching off: when the engine stops the oil pumps stops immediately. The turbo, however, may keep on spinning for a few more seconds if the engine was racing just before being switched off - simply because of inertia. So again the turbo would spin fast with insufficient oiling. This (and the 1st generation problems mentioned before) is the reason behind the different 'turbo pre- and post- oiler' systems.

This is also why a synthetic oil is best for a turbo car (bearing (sorry) in mind the drawbacks of synthetics) - apart from any other qualities they may have, synthetic oils maintain their properties MUCH better in high temperatures - and while a normal engine normally wouldn't have such high temperatures in it, the turbo does.

[Response: David Farrington] Basically your Idling down is merely sitting at idle for 30 seconds or a minute before shutting down the car. The turbocharger can literally get red hot during spirited driving. Naturally we don't normally do that, but depending what our drive has been like - 70 miles at 80 on the freeway is not the same as 5 miles at a steady 25 mph. This idle time gives the turbocharger time to cool down a bit, both with some water cooling and more importantly some oil cooling and circulation. One can purchase and install automatic oil timer pump kits that circulate the oil automatically, but good habits are far cheaper. First word on owning a turbo engine - change the oil & filter! I'm religious, every 3k miles and the turbo seems fine at 190k miles although I'm starting to think of a pre-emptive turbo cartridge replacement.

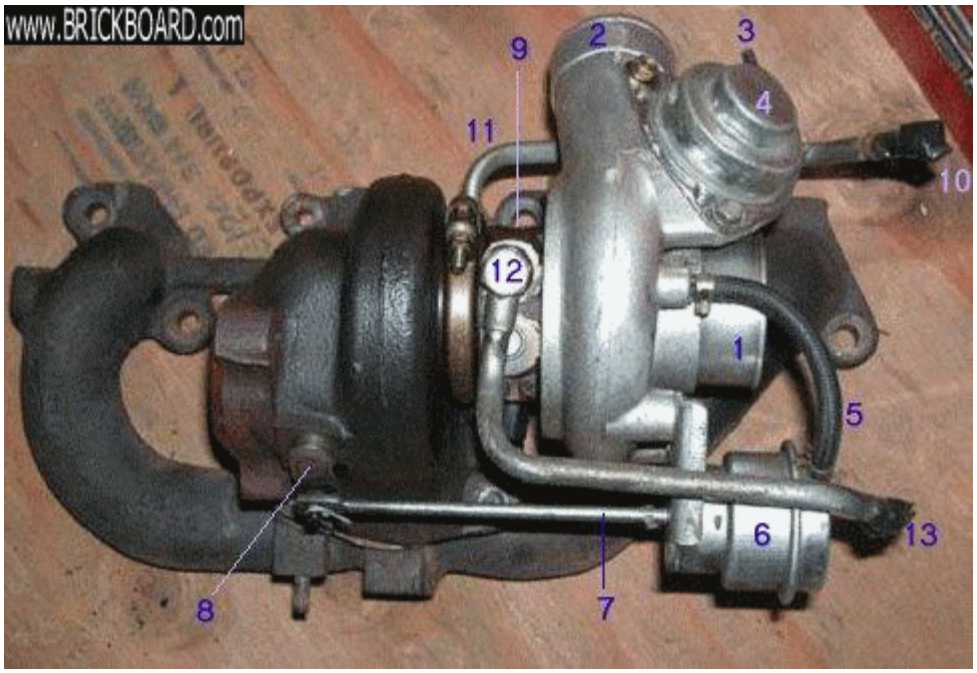
Gasoline Recommendations for Turbo Engines. See the link to the Fuel and Lubricants file.

[Other related comments:] . I could pick up some pinging on 87 octane when boost was up, thus switched to 89 and things are much quieter. I'll even go to 92 octane when I know I'll be up on the boost gage.[Editor] To avoid pinging and lower performance, use the specified 91 or 92 octane gasoline.

Turbo Maintenance

Turbo Components.
[David Armstrong] See the photo for a depiction of turbo components.

1. incoming air from filter



2. compressed air to intercooler
3. vacuum from intake manifold (drives CBV)
4. compressor bypass valve (CBV)
5. hose with compressed air driving wastegate actuator
6. wastegate actuator
7. wastegate actuator rod
8. wastegate shaft
9. oil supply line mount point
10. coolant drawn into turbo from overflow hose split
11. coolant supply line
12. coolant outlet
13. water pump draws coolant here via lower rad hose split

The only things not clearly shown here are where the coolant supply line connects (180 degrees from coolant outlet connection) and oil outlet line (180 degrees from the oil supply line mount point).

Inspecting Turbo Intake Hoses. [Inquiry] I'd like to clean and inspect my turbo hoses. What can I use? [Response: Warren Bain/John Sargent] Use Simple Green and a soft bottle brush to clean the hoses. Inspect them, especially around the bottoms of the clamps, for softness, cracks, and holes. The small coupling hose for the intercooler is vulnerable and the turbo inlet hose from the air cleaner deteriorates at the underside of the hose at the turbo inlet. The next to go is the outside of the rubber elbow at the throttle body. They get soft and then crack. [Editor] Note that you may have turbo oil cooler hoses as well which age and crack, leading to catastophic loss of coolant. During hose inspection, take a hard look at them.

Removing The Turbo and Inspecting.

[Inquiry:] I'll be ripping the turbo off the exhaust manifold soon. Is there any bench top inspection I can do on the turbo? Any turbo tips while the turbo is off the car?

[Suggestions:]You can do a little pm work here. Take the oil return tube and make it spotless. Any blockage from oil gunk has to be removed. Some turbo shops

recommend replacing it; their warranty is void if you don't! Do the same with the oil supply line. An automotive machine shop vat is a good way to make sure they're clean, or a good soak in carb cleaner. Check the rotating assembly by spinning it by hand; it should rotate freely. Look for any obvious signs of contact, or any damage by debris. You'll need to look as far up in the housing as you can. If you are really industrious, match mark the housings and remove them to expose the impellers. Word of warning here: stripped and broken bolts are common here. Also check for radial clearance in the bearings by moving the shaft perpendicular to its axis. There will be a fair amount of play, but it should not move more than maybe a sixteenth of an inch at the end of the shaft (this is a very rough estimate, use good judgment or get someone with experience on this to check it for you). Another area to examine is the waste gate section. Cracks radiating outward from the hole are common and considered to be normal. Only if they have really opened up, or if there are other cracks through the housing, should this piece be replaced. Depending on the mileage and your wallet thickness, consider a new water-cooled center section and ease your worries. For around $400 you can put your housings on a new cartridge; or they will do it for you (recommended). A shop I would recommend is Turbo Engineering Consultants in Colorado; friendly, easy to deal with. Phone number available if you're interested.

Also check out http://www.alliedsignal.com:80/turbos/sitemap/index.html for a sitemap and good general information and pictures related to turbo operation and maintenance.

[More on Turbo Wear Inspection.] [Inquiry] I currently have the Turbo off. The Turbo has 100,000 miles and had no problems before taking it from the car. What can I inspect (without tearing the Turbo apart) to see what the condition is of my Garrett Intercooled Turbo unit. Any information is appreciated. [Response: Thomas] Make sure the compressor wheel has a small amount of play (turbo's have full floating bearings) Check for excessive wear on the compressor blades(not likely), Carefully clean out any coke or sludge in the oil galley's, oil return pipe and oil feed pipe. Check the internal horn passages for cracks. I have a 130K on my turbo, I hope I can get more then that out of it. I wish I knew what exactly makes a turbo last the longest. Anyhow just make sure it's all intact.

Coolant Hoses. [Editor:] My brother bought an otherwise pristine 940T. When changing the oil, he noticed swelling in the coolant hoses going to the turbo oil cooler (the small metal can just behind the oil filter.) These hoses are exposed to oil dripping from the filter housing when the filter is changed. If they fail, all the coolant will rapidly drain out and the engine will seize. SO: when you are changing your oil, take a close look at these two short hoses. After about eight years, you may want to change them using original Volvo brand hoses, along with all the other coolant hoses and clamps, as a preventative maintenance measure. They are unobtrusive but still critical to engine longevity. See the Cooling System file for more information about radiators, hoses, water valves and other components prone to failure in high-temp turbo engine compartments. Volvo part numbers 9161383 and 9161384: use ONLY the Volvo OEM replacement hoses.

Wastegate Arm Lube. [Tip: Jim] We changed a turbocharger today which had failed in a new and interesting way, to me at least. The car is a 1990 740 with the mitsubishi turbo, and only 170,000 km on it. The rod from the wastegate actuator

had seized solid on the pivot where it connect to the arm on the wastegate, which prevented the valve from closing completely onto the seat in the housing. The result is a hole burnt into the casting you can put a pen through and absolutly no boost. The hole looked exactly like an exhaust valve that has burnt due to carbon sticking on the seat. I would think the first sign of a seizing pivot would be excessive boost on first hitting the throttle hard, with the boost leveling off as the actuator forced the valve open, possibly followed by low boost on the quick reapplication of power, as the valve would not yet be closed. A touch of antiseize on the pivot once a year should eliminate any trouble. This is one of those failures that could be avoided easily if only a person knows.

Wastegate Cotter Pin Failure. [Tip: Editor] Remove the small cotter pin clip holding the wastegate actuator rod to the wastegate valve stem occasionally and lube it with high-temp nickel-based antiseize. This clip can rust and fail, breaking off at the edges of the holes and leaving a corroded section inside. This latter piece is a bear to remove. If the clip is rusted, replace it. If you need to drill out the old clip remains, remove the oxygen sensor to gain better access from below and use a Dremel tool with a right-hand drill attachment. Be prepared to use up about five or six titanium 1/16 inch bits on this very hard rod. Replace it with a new clip, a stainless cotter pin, or a piece of stainless wire. If the rod is too tight to pull back onto the stem, just unbolt the actuator, secure the rod, and re-bolt.

Coking Due to Poor Lubrication. [Inquiry] Is coking is the biggest contributor to turbo death? [Response: Herman of Cherry Turbos] A great amount of built up crystalized carbon, or coking, is definitely the reason behind most turbo failures. Next is poor balance, and the rest are blade erosion on the turbine blades, blade strike and exhaust chemical build-up on the turbine blades. The coking occurs in varying degrees at primarily two locations. In the Garretts it usually occurs inside the bearing housing, or center section, and inhibits oil flow to the hot side bushing. In the Mitsubishis it usually occurs behind the heat shield on the turbine side and eventually presses the shield against the back of the blades and machining material of the turbine away rendering it unbalanced or causing it to sieze. The best oils are full synthetics for reducing this problem however the combustion chamber chemicals suspended in older synthetic will release from the oil at very high temps and coke as well. Your best bet is frequent changes, synthetic or petroleum based, to ensure that the oil in the crankcase has a fresh additive package at all times. (The additives are what inhibits wear, evaporation, shear, etc.)

How Does Wastegate Operate? [Inquiry:] This is the first turbocharged vehicle I have owned. My question is how can you tell when the wastegate opens and dumps excess exhaust? Does it open right before the boost gauge goes into the red?

Turbo Wastegate Adjustment. [Inquiry:] Before I start out on my own experimenting, maybe someone can get me going in the right direction. Do you lengthen or shorten adjustment rod? How many turns in or out equates to approximately how much boost? I don't want to grenade the motor just looking for a little more kick.

[Response 1:] Shorten rod. That preloads the spring that diaphragm is working against inside wastegate actuator. If a rod comes out of the block then lengthen it a couple of rounds when you put in new engine... A couple of turns is about all you should do to not have too much stress on head gasket and other drivetrain parts. The best way would be to adjust so that the max boost in a higher gear at 3500 RPM full throttle is not more than 10 psi (70 KPa).

[Response: Caveat] The actuator can normally only be adjusted about +3psi. If you try to get more from it the preload on the spring will be so high that the remaining travel can´t open the wastegate properly.

[Response: John Sargent] The best wastegate adjustment instructions are in the Factory Service Manual. Without the service manual, crawl under the car and cut the sealed wire the factory installs to detect tampering. Then remove the external snap ring that retains the wastegate actuator rod end on the wastegate shaft. Loosen the jam nut that keeps the rod end locked on the shaft. Adjust the end in or out as you desire. One turn equals 0.4 to 0.6 psi. Factory boost is set to 6.8 to 7.7 psi. It is easy.

{Response:] If you wish to increase boost, I highly recommend that you either use the Volvo Turbo + kit which will adjust the boost curve so that you do not get too much boost at low rpm, and give you higher boost overall, or install the Saab APC system (see the directions on the Turbobricks site). Simply increasing the boost with the control rod will increase the tendency to predetonate or ping, and the control system will back off the spark advance negating any gains you might have made. There are also lots of other things that might be going on that can be mis-interpreted by the knock sensor as predetonation with the result that the timing is backed off and you get less than maximum power. It would be wide to check the engine thoroughly to make sure that everything is working properly. Also, be sure to use high octane gas, and if your area adds methanol or MBTE, I recommend use of a fuel additive like AMSOIL PI to keep the fuel system clean and improve the performance of the fuel.

Preventive maintenance: see the notes on Preventive Maintenance above.

CBV and Vacuum Check Valve Operation.

Theory of CBV/BOV Operation. [Notes from Anthony Hyde] There are numerous names for relief valves fitted to turbocharged engines e.g. Compressor Bypass Valve (CBV) / turbo Blow-Off Valve (BOV) / Dump valve / Vent valve / Relief valve. Described below are two main types and the essential difference between them:

- Compressor bypass valve (CBV) In the CBV case, pressurised air is returned to the turbo compressor inlet for reuse. The valve is open under engine vacuum conditions, and closes firmly when positive (boost) pressure is present in the

inlet manifold (or plenum chamber). As you change gear a sudden vacuum condition is created and the valve opens again, directing pressurised air back to the turbo inlet. A CBV is used with Bosch K and LH-Jet injection, as being a closed system, any loss of air for which fuel has already been metered by the movement of the airflow sensor plate, will result in an over-rich condition and possible backfire. A CBV is found on many OEM original engine manufactured EFI turbo systems.

- Blow-off valve (BOV) / Dump Valve / Vent valve This valve type features an adjustable spring design (spring in compression) to keep the valve closed under idle, cruise and boost conditions (eg 0.5 bar). Sudden throttle lift-off (eg 0.8 bar) opens the valve to vent the pressurised air directly to atmosphere (and wooshtssh). Not used with Bosch LH-Jet.

A small diameter hose connects between the intake manifold and the relief valve: changing pressure conditions (vacuum or pressure) will exceed the spring sealing pressure, and the valve will open or close accordingly. Vacuum (pressure less than atmospheric) is formed in the cylinder bore/s when a piston decends on the intake stroke. Vacuum transfers through the opening and closing intake valves back into the intake manifold, and rises when the throttle plate is fully closed. With a valve closed under boost pressure, a sudden throttle lift-off between gear changes creates an instant vacuum inside the intake manifold that pulls the valve open, momentarily venting boost pressure.

Why vent the pressure? - Primary reason is to reduce strain on the compressor turbine wheel due to compressor surge. Between shifts, or sudden throttle lift-off, the turbine is still spinning fast (but slowing) pumping air at the closed throttle plate, as well as placing strain on the intercooler, hoses and fittings. A CBV / BOV keeps air from flowing backwards over the compressor wheel, allowing the turbine to continue spinning freely. When back on the throttle, boost pressure quickly rises again with little lag. A suitable valve location is just before the throttle plate.

Garrett Turbos. [Inquiry:] I was working on my engine last night and I thought I should check the one way valve on the CBV (compressor bleed/bypass valve)for proper operation. I checked the operation of the oneway valve and it was on backwards, meaning boost pressure was being forced into the CBV. I turned the valve around and took it out for a drive. It bleeds now, but it does it almost all the time while in normal aspiration mode.

1. Is the valve destroyed?
2. I noticed I can adjust the valve. Is it worth doing this or should I go buy the Bosch plastic valve and replace it?
3. How should I adjust the valve to get it to only open at max vacuum?
4. One the one-way valve has been opened and vacuum has opened the CBV, how does it close back up? The one-way valve would seal off and not allow air to go back in to re-pressurize the CBV, right? I am having a difficult time understanding how air would re-pressurize the thing.

[Response: Abe Crombie] That check valve should be installed so that it can pull vacuum on the bypass valve. This is so that on deceleration when the manifold vacuum goes up it opens valve and allows the diaphragm to be moved upwards opening the valve and allowing the boost trapped on lifted throttle to in effect re-circulate in outlet plumbing of turbo. The valve would prevent the boost from

reaching the diaphragm of bypass valve when installed properly. The check valve allows vacuum to be pulled and the check valve has a controlled bleed in the reverse flow direction to allow the diaphragm to close in a dampened manner. Reverse check valve and see if all is okay. If it is then nothing else needs to be done. If not you will have to replace the bypass valve.

Stuttering Under Load (Garrett Only):

[Tip from R Tilghman] While driving down the highway with cruise control set, the car will just suddenly stutter. When it happens it feels like the car has reset or maybe an air bubble has passed through the fuel system. It was infrequent and spontaneous. It seemed most common when I had the cruise control engaged and the cc would gas hard, let off, and then gas hard again for some reason (uphill, just engaged cc, etc.). In these instances the turbo needle would be up in the yellow, drop to low black, and then return to yellow. I replaced the check valve and it solved the problem. If you are having this problem pull the check valve (little red valve that sits in the middle of a vacuum hose from the intake manifold to the CBV on top of the engine) aand blow through it both ways. You should get major SOLID resistance (but not full stoppage) going both directions. If you feel a sudden thwap as you blow that means the diaphragm inside is probably shot. This applies only to Garrett turbos. [John Sargent] The Garrett CBV is actually a Pierberg unit. When the unit fails you get a stumble when you let your foot off of the gas pedal unless it is a very slow and easy release. To test the unit use a rubber hose connected to the CBV and suck on the end of the hose. When you have sucked as much air out of the CBV as you can, stick the tip of your tongue in the end of the hose. Wait a minute and see it it holds the vacuum. If it doesn' hold vacuum, it has a bad diaphram and needs replacement.

Mitsubishi Turbo Note on Check Valves.

[Inquiry] Does my '89 740 Turbo Wagon with Mitsubishi turbo have this check valve? I know it has a valve on the turbo (Bypass valve) but I'm assuming that there's also supposed to be a vacuum check valve on the line between that bypass valve and where it connects to the intake manifold?

[Response: John Armero] The Mitsubishi turbos on the late 700 cars do not have the vacuum check valve.

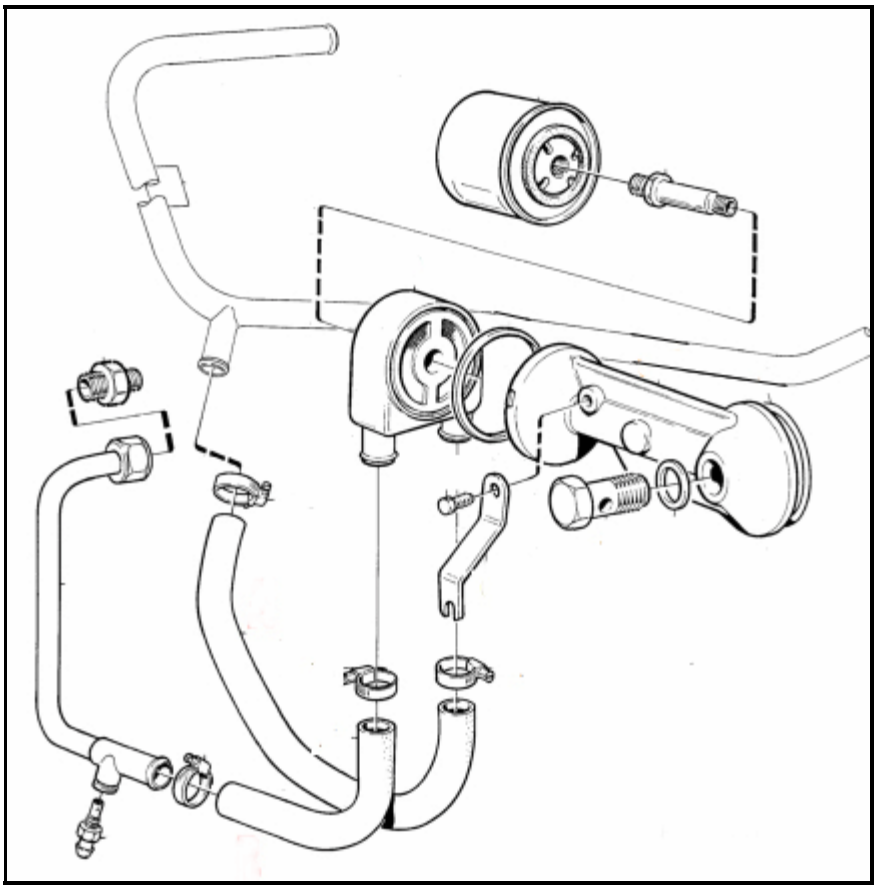
Replacement Diaphragms for CBV. Various turbo rebuilders carry the diaphragm repair kits for reasonable prices. Check Rick Banas at D&W Diesel (r.banas@dwdiesel.com) at 800-824-0151 for Mitsu diaphragms and some Garretts. Mitsu made several types and the year of the car manufacture mattered. Says he sells a lot of them, below retail, but its still pricey.

Failure Modes. A failure in the diaphragm may result in stutter; or stalling at low RPM.

Turbo Oil Cooler Maintenance.

1. **Aluminum Heat Exchanger (Radiator)**. [Tip]
My oil cooler by the radiator sprang a leak on my

91 940 turbo. The top and bottom brackets are rusty (unusual) and when I undid the bolts I found that the bottom (aluminium) leg of the replacement cooler disintegrated. The top legs were also starting to show signs of aluminium corrosion!!! This is due (I think) to contact between the alloy and steel brackets and a poor paint finish on the steel brackets. Both sets of brackets are showing 100% rust coverage and both bottom brackets are rusted into holes! So: check them, paint them and introduce something to stop the action between the 2 metals. [Editor] Check all hoses as well. And make sure the large 28mm/1-1/8 inch nut holding the can to the adapter is tight: at least one Brickboard reader has reported oil losses due to a loose nut.



2. **Coolant Heat Exchanger by Oil Filter**. [Tip] Replace the coolant hoses (see photo to the right) at the first sign of swelling, since they are exposed to oil dripping from the filter above. Volvo part numbers 9161383 and 9161384: use ONLY the Volvo OEM replacement hoses, not aftermarket or old heater hose stock.

3. **Oil Leaks.** If the oil cooler adapter o-rings are leaking oil, see the FAQ tips.

Turbo Model Identification.

[Inquiry] Which turbo unit do I have: Garrett or Mitsubishi?

[Response: Jim McDonald] The most obvious difference between brands is that the

Misubishi has a large hose clamp holding it into the

[Justus/Josh Sawka:] Look at the markings on the turbo. a Garrett will have a tag in it about 1" x .5" and the Mitsu has the little tri-star Mitsu icon on it. Garrett has the emboldened words Air Research wrapping around the fresh air compressor side.

[Roguls:] Volvo used a Garrett T25 turbo on 90+ 740s. Garrett T25 also had an integrated cbv, just like the Mitsu. To identify the specific model, there should be a nameplate on the body of the turbo identifying the model number. See also the photo file showing various models. FCPGroton has illustrated diagrams of turbo configurations: FCPGroton.

Troubleshooting:

Excess Crankcase Pressure in B230FT. [Inquiry:] There seems to be excessive crankcase pressure in my engine (B230FT) I've checked the ventilator under the intake manifold, it is not plugged. Is this the only relief the engine gets from the pressure buildup. What is causing this pressure, the only reason that comes to mind is bad rings. From reading postings it seems that a negative pressure is the norm.

[Response:] I have seen plugged oil traps. Make sure that the oil trap isn't plugged by blowing through it with the oil cap off. Hook a hose to the oil trap where the flame trap goes. Any compression loss into the head or crankcase will cause excessive pressure.

[Response 2:] Excessive crankcase pressure is often the result of bad/worn piston rings, or worse; broken piston ring lands (ring lands is the part between piston ring cutouts on the piston). The main reason of this fault is detonation/knocking... To diagnose this problem; take a dynamic combustion pressure check.
Turbo Oil Breather Box Notes: See the link for more detailed information. Also see Michael Ponte's excellent description and illustration at
http://www.mikeponte.com/volvo/oiltrap.htm

Turbo Performance Problems: Basic Diagnostics [Symptoms:] 740T experienced a number of problems: occasionally hard to start, with intermittent rough idle and stalling out; frequent stumble under boost once motor was warm; lack of power. On a cold start, it ran flawlessly, but I never run much boost on a cold motor, so I don't know if it would have stumbled under boost when cold. Despite many FI and ignition components being checked or replaced, the problem continued. Everything had been checked out or replaced (fuel pumps, relays, ignition system, ECU, etc)

Various Vacuum or Intake Hose Leaks:

[Response 1:] The problem turned out to be caused by a VACUUM LEAK in a rubber tube under the intake manifold. The tube only leaked when it was hot, and subject to vibration/movement of the motor. My mechanic has been elevated to saint of motors. The bright side is we now have all new ignition, wires, ECU, fuel pumps, etc. There is a moral here: Go ahead and get your hands dirty...really dirty. Unless

you know the car's history fully, remove every rubber hose and inspect it closely, even if they are hidden below the intake manifold and throttle body (yes Virginia, that may be a very oily area). A minor vacuum leak there seems to have major consequences with the injection system. The way-high boost TB guys have already found that the main boost hoses can give out and cause poor driveability. I am here to tell you that even with stock boost getting to the local grocery store can be risky if the various minor vacuum hoses develop hidden cracks. [Tip from Chris deCourcy-Bower] If you notice low turbo pressure, reduced performance, hissing noise when accelerating, then check for a split or de-laminating hose. Check ALL of them including the short piece where the air leaves the intercooler. If it turns out to be a damaged intercooler you will need to visit the junk yard. They are not cheap. See the discussion in Special Tools about a homemade leak tester for the intake system.

[Response 2:] I had a poor driveability problem with my 87 760t on take off. Turned out to be a vacuum leak on the big hose from the air box to the intercooler.....and a big dent in the pocketbook since the thing is a preform with a couple other hoses molded into it.....$130 or so. I just replace all the vacuum hoses every 5 years or so.

[Response 3: John Sargent] The turbo on our third 740T was not putting out enough boost. I used a pressure gauge (installed with a tee fitting under the dash) to verify what the boost gauge was telling me, the level of boost was too low, about 1.0 to 1.5 psi. I checked all of the hoses from the turbo on, but all were okay. The turbo spun well and did not contact the housing, and it was quiet. The car seemed to drive fine, and seat of the pants performance was okay, but less than the other cars which have the Turbo Plus. There was no black smoke to indicate a too rich mixture caused by a leak after the AMM. The wategate was connected, and not seized. The catalytic convertor was not plugged. It didn't make sense, everything to check was fine, but the boost was still too low. Finally I pulled the rubber line that connects the intake manifold to the boost gauge, and blew on it. Well, you have probably guessed that the rubber line had a hole in it where it passes under the intake manifold. The hole would mostly seal itself under vacuum, but would go wide open under pressure. That was the cheapest turbo overhaul I've done! Always be sure of your tests, and don't jump to conclusions. [Ernest Smith] When my turbo stumbled under boost, my mechanic first put the complete intake under pressure. He found a couple of bad gaskets at the BOV valve, and made new ones to fit.

Tips for Checking Intake Hoses. [Randy Starkie] I had one intake hose leak that I couldn't find until I applied 15psi of compressed air on the end of the hose that connects to the turbo. I made a plug of the correct size and added a Schrader (tire) valve for this test. The plug I use is the cap off of a master cylinder that has a schrader valve in it for flushing the brake systems on my cars. Put the plug in the hose after disconnecting it from the turbo and apply the air. Listen for the leak. Splits are hard to find sometimes without simulating boost with compressed air. [Tip] A crack in a hose may only show up under boost. I found a leak in a guy's hose by having him sit in the car with all brakes on full and in drive. I opened up the throttle under the hood till it was making boost. I could then hear a leak in one of the hoses. See Special Tools for a simple pressure tester design.

Noise and Whining:

[Inquiry:] I'm getting a whine that sounds like a vaccum leak which comes and goes with the turbo. When the turbo kicks in the sound increases incrementally with the increase in boost. Cannot find a leak in any lines, any suggestions. Turbo is still performing and no loss in pickup.

[Response: John Sargent] My wife's 86 745T made that sound when the small line to the waste gate came off. The other problem was way too much boost. Check the line. If you have the Turbo+ kit, there will be a tee fitting in the line which connects to the Turbo+ solenoid valve mounted at the front of the air filter.

[Response: Abe Crombie] You should also look at the bypass valve. It is the valve on the bracket forward of exhaust manifold. It is plumbed into the turbo outlet hose and the turbo inlet hose. There is a gasket between the valve and the bracket that holds it and the bolts are notorious for loosening and letting the gasket go away.

Low Oil Pressure. See Oil Pump: Wear and Replacement for more information.

Turbo Blows Black Smoke; Poor Acceleration; Hesitation

[Inquiry:] While my 740T used to have great pick up with the Turbo engine, now when I push down on the gas pedal, black smoke comes out the exhaust pipe and it feels like the car is dragging or being pulled back and it stops accelerating. One of the hoses between the turbo and engine has oil in it. Any ideas?

[More Symptoms:] On acceleration under turbo boost, the car will lose power and may have black smoke coming out of the tailpipe.

[Response: David Tidaback] **Background**. This problem may not occur every time it accelerates, but will usually be worse on harder acceleration. The car will run just fine under all other conditions. Initial testing of engine and tuning basics will show everything adjusted and functioning just fine - no problems. Cars manufactured in 1990 and later may output a generic fuel mixture fault code such as 113 or 231, but the MIL will usually not be activated. To understand the cause of this strange behavior, it is first necessary to understand how the fuel mixture control system works. The Bosch LH-Jetronic system (LH 2.1 in 1984, LH 2.2 1985-1989, and LH 2.4 in 1990 and later cars) uses a hot-wire mass-airflow sensor to meter intake air. This sensor is positioned in the intake hose of the turbocharger so that air is metered as it is drawn into the turbo. This means that any loss of air after the turbo will not register at the LH-Jetronic control unit. It will still be adjusting injector duration on the basis of information from the mass-airflow sensor, on the inlet side of the turbo.

Test and Fix. On these cars, it is necessary to carefully check for intake air leaks under pressure between the turbo outlet and the engine. Very often, such leaks will be the result of cracked intake boots or stripped hose clamps that will not show any leakage with the usual tests using propane or brake cleaner with the engine running at idle, with vacuum on the intake system. The system must be pressurized to show leakage (see also Randy Starkie's cheapie intake system

pressure tester below).. The greater the degree of leakage, the richer the system will go under turbo boost. One additional note regarding this problem: Testing with the greatest care may not show any leaks, or the leaks may be repaired and the problem will be unchanged. Another failure that can give exactly the same malfunction symptoms is a fuel pressure regulator that sticks shut with pressure on the vacuum line from the intake manifold, increasing the pressure to the injectors to full pump pressure, which is near 100 psi. To determine if the pressure regulator is malfunctioning, monitor fuel pressure under boost.

[Another Response:] Check the hoses and fittings to and around the turbo to be sure none are loose or have leaks, including the turbo compressor inlet hose. This can cause poor acceleration or running rich. The breather box on the intake side of the engine which is hard to get at, if clogged can cause the turbo to blow oil through its seals. If the turbo has lots of miles on it you may have a bad turbo which is blowing oil also. Don't drive with the turbo blowing oil as it will clog the cat converter! When the engine is cold you can take the rubber hose off the intake side of the turbo and see if the shaft has excessive play, or is frozen.

Turbo Blows Smoke: Overfill Oil. I have received several messages from Volvo neophytes relating the same or similar stories: I went to the quickie lube, where they proceeded to overfill my Turbo-engine oil by [1-2-3] quarts. Just after I started up and drove out, thick clouds of blue/black smoke came out the tailpipe. Now my mechanic says I need a new turbo. What gives?

I am not exactly sure how to diagnose this, but let me throw out a couple of hypotheses for comment:

1. It would appear that anything restricting the turbo oil drain would cause the unit to overfill and blow oil into the exhaust pipe. If the car were seriously overfilled with oil, this may have an effect on crankcase ventilation, probably starting at the oil breather box drain. So overfilling might clog the breather box, interfere with crankcase ventilation, stop the oil drainage from the turbo, cause the turbo to overfill, and allow this extra oil to be forced out past the turbo seals.

2. Similar hypothesis but the unrelieved blowby increases the oil pumped to the turbo and not drained, causing excess oil in the turbo, increasing crankcase pressure, and forcing this oil out the exhaust. If either of these are correct, then fixing the problem merely means draining the oil, replacing with the correct amount, and cleaning the crankcase breather system. Oil burning should then stop at once. Why would the turbo unit be damaged? If indeed it was damaged at all (another dealer boat payment due?) Thoughts?

[Response: Abe Crombie] The seals used in turbos are a single piston ring type seal and a labytrinth seal system. The labyrinth deal is simply slinger washers in a cavity through which the oil would have to travel against centrifugal force to leak out. If you overfill engine the oil is restricted in draining back to the hole in side of block because the hole is now covered by oil being splashed up into the drain tube. With no easy path to drain the oil out of the piston ring seal area the oil can be passed through both the intake housing seal and the exhaust housing seal. The flame trap/crankcase breather system being plugged has similar results.

[Response: Jim Stephenson] I believe this is the answer. My turbo was overfilled and would blow clouds of smoke. The oil was being burped up through the breather box and would run in to the turbo. Under heavy boost it would drag the turbo impeller down and shortly after that a BIG cloud of white smoke would billow out the back. After I changed the oil no more problems. But what a mess!!!

[Response: Rob Bareiss] This experience shouldn't result in a damaged turbo. Mechanical parts don't usually fail due to TOO MUCH oil... The turbo might not pump oil very efficiently, and it could conceivably do something strange if a lot of oil hit the vanes as it was spinning at a high speed, but they're pretty tough little units. I could see damage to a catalytic converter resulting from this.

[Contrary Opinion: John O] I've rebuilt my original turbo using IPD's kit and there's a direct oil feed line running line pressure directly into the turbo unit, which then feeds the bearings. The only thing that keeps the oil in there are the seals. I've honestly never seen this happen, but I think it's possible that if too much pressure got to those seals, maybe one blew out, like the exhaust side? [Response: Dick] You may have messed up the O2 sensor at this point which will generally cause lots of black smoke, at least in my experience.

Slow Throttle Response After Turbo Replaced; Diagnosis

[Inquiry:] Told that my turbo was indeed in a sad state, I opted to have it rebuilt, figuring I'd save some cash. BUT, when I got it back I noticed that the car was slower. I couldn't peel out if my life depended on it. I later found that the turbo was set very conservatively at 5.5 psi, apparently, it was sent out of town to be rebuilt, and the wastegate came back set low. The stock is (or so I have read) 7.5 psi, so I had it pumped up to 8.0, and it hasn't helped. The car is still slower than when I sent it in. When I accelerate the turbo spins all the way up past 2000 rpm, like it used to, but doesn't seem to give any boost until about 2500, at least nothing you can feel. If I start at the bottom of a hill from a dead stop and punch it to the floor, I find myself creeping uphill at a measly 10 miles an hour with the turbo spinning like mad at 2000, and suddenly I am squished into my seat at 2500. Does anyone know what could be causing this delay between the spinning up of the turbo and the acceleration boost it provides?

[Response 1: Kevin] I was told by a very reliable source (Garrett) that the reason for a slower car with a new turbo is as follows. The old turbo probably had a lot of play, slop in the bearings, enabling it to spin up very fast, had you been running higher than stock boost, say 12psi, you probably would have noticed poor performance at the top end bacause of the slop. The new turbo is nice and tight, and there is not nearly as much slop, therefore it takes longer to reach boost, tatke it on a long fast trip, thats what I did. I was told that a turbos bearings have to break in just like any other engine component. On the way there go 65, on the way back you'll be going 120 uphill.

[Response 2: Hunter] I had the same problem. My problem started one day when I was coming home and I had boost one second and the next it was gone. It was like driving a GEO! It turned out that the actuator rod cotter pin had fallen out. My wastegate rod was just sitting there. I attached the rod back onto the bolt and put in a new cotter pin. It solved the problem. Just reach under the turbo and feel, or

climb under the car and see if the rod has come off. If this is not the case it is your wastegate, or vacuums. Check all vacuums to the wastegate. You can remove the vacuum from the wastegate and plug it temporarily with a screw. Then try driving it, be very careful with boost. It could be the APC module. My problem started one day when I was coming home and I had boost one second and the next it was gone. It was like driving a friggin GEO!

Lack of Turbo Boost. [Problem: Lack of Turbo Boost.] Thanks to Steve, Paul, George, Doug and Robert for giving me the help in troubleshooting my lack of Turbo Boost.

The Turbo itself spins smooth and there is virtually no end or lateral play. The Oil Accumulator that has been on this thing since day one. The tests made with the new boost gauge placed in-line before and then after the throttle plate confirmed the problem and it was seconded by the removing of the plug in the catalytic converter housing. The cat is plugged tighter than a crab's ass. So now I need a new cat and with that new pipes.

[Another comment:] That's exactly how I got my turbo wagon cheap -- the PO had a new turbo installed (lucky me!) and then, 5000 miles later, it wouldn't go into boost. She thought the new turbo was toast and junked the car in frustration. [Another comment:] I am experiencing similar problems with no turbo boost on my 83 240T. When I bought the car, the turbo was leaking oil like a sieve. I replaced it, and boost was a little better, but just a little. All the other usual things were done such as new plugs, wires, filter, vacuum lines, etc. Still barely getting boost. After reading the posts on BrickBoard, I began to suspect the catalytic converter. I removed the test plug and noticed a lot of pressure from the opening. Drove around for about a mile without the plug, and had a little more boost. I then had car checked a reputable independent Volvo garage, and they confirmed that cat was so plugged it almost broke their gauge.[More diagnostic comments:] Before you get too carried away, note that at steady state - i.e., constant speed on level ground at 3K in second gear, there will be relatively little boost measured at the MANIFOLD. If you are measuring the boost on the high side of the throttle plate, then it is likely that you have a problem. But if you are measuring the MANIFOLD pressure, then try starting at 3K and flooring it. You should see the boost climb to ~8.5psi until you pass 3700 rpm. Then the boost should jump to about 10.5 psi as the IBS valve opens. IF the boost does not climb smartly and jump quickly at 3700 while you have your foot to the floor, then you have either an intake obstruction, turbo going south, stuck/broken waste gate or waste gate controller, or clogged cat.

Remove the plug at the top of the car, just behind the turbo exhaust housing. Try it again. A noticeable difference indicates clogged cat. No difference indicates turbo, waste gate, or intake plumbing obstruction. Remove intake line from front end of turbo. Use your fingers to wiggle turbo shaft and spin it. Should spin freely and smoothly, there should be SOME lateral play, but NO contact by impellers on housing.

Turbo Overboost.

[Inquiry:] Today I experienced something strange, the turbo seemed to be overboosting. I was on the freeway and accelerated to pass another car, it felt as though I had gained 50 more HP. I looked at the boost gauge and the needle was past the end of the boost indicator. Worried I would toast something or send parts flying, I kept off the accelerator for the most part. It definitely felt and acted like the turbo was working overtime. The car was parked for about two hours, and did not misbehave again. I have no idea what my boost pressure is running, but my last gas mileage check was at about 21mpg(mixed hwy/city driving). Anyone have any suggestions on what to expect next, where to look, what to do?

[Response:] Check to see if the actuator hose is split or broken off. That will not allow the actuator to open the wastegate, causing the overboost.

Turbo Loses Performance under Boost.

[Inquiry:] In my 760 with turbo and intercooler, when trying to accelerate quickly or when driving up a large hill I lose performance the more gas I give it and it blows black smoke out the back. The turbo needle is about at 11:00 when this starts and never seems to get past 12:00. I have not been able to get more that 4000 RPM's out of this car at all except maybe in park.

[Response:] Find the leak in the pressure side of the turbo. Mine happened to be in the bypass valve...allen screws back out. It could also be a leaky hose or clamp or leak/hole in the intercooler ...somewhere your engine isn't getting all the air being blown into it and your dash gauge is showing it! The AMM thinks 9 lbs of boost is being fed to the engine and gives the ECU/Injectors the fuel...since a lot less than boost is getting to the engine, you blow black smoke/overfuel. Could also be fuel pressure regulator, but unlikely since it idles, apparently.

[Woody Sulloway] My engine was cutting out when the turbo was over 50% boost. As the boost increased the car began to surge- almost like a prolonged miss; accelerate, bog momentarily, accelerate, bog momentarily in a rather rapid sequence. It turned out that a rotten AMM-to-turbo inlet hose was collapsing under high vacuum, limiting air flow into the turbo.

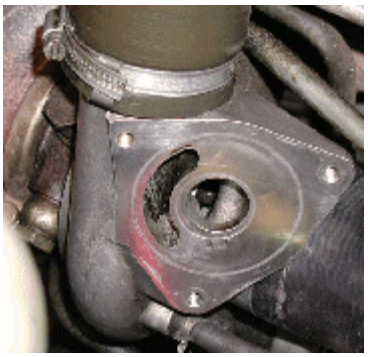
[HenryC] In my case, the hose from the AMM to the turbo inlet was soft and had a small rip in it. The turbo sucks air in through this hose, so it is in vacuum all the time. As a result, the mixture was lean as well as constrained by air flow.

Diagnosing Intake System Leaks. [Tip from Randy Starkie] If you take a plug of the correct size- the inside diameter of the turbo hose- and install a schrader valve you can use compressed air to check for leaks in the system. I use a master cylinder cap with a schrader tire valve to bleed my brakes using a bicycle pump. Turns out the cap is the correct size for the turbo outlet hose. I use a hose clamp around the outlet hose and turn my regulator on my air compresser down to 15psi. I use that to pressurize the system and the leaks are then apparent. I find leaks I miss with visual inspection.

740T Has Weird Deceleration; Anti-Stall Valve Hose. [Symptoms:] Our '87 740 turbo has recently begun behaving very strange. Acceleration is fine, normal

running is fine, but if you lift off the throttle after acceleration (with boost), the car jerks once and a hiss can be heard from the engine. [Response: John Binford] '87 7xxT's had an anticompressor stall valve.....about a foot beyond the turbo, close to the fan. If the hose to the valve is off, it won't release and you'll get compressor stall and maybe the excess pressure can 'hiss' somewhere. The diaphragm in the valve can also die/hole, in which case it won't release either. Check the valve for proper hose to it and operation.

No-Hot-Restart Problem: Boost Overpressure Switch Failure. [Dan Ridenour] The Boost Overpressure Switch is “normally closed” and is designed to “open” if the turbo-boost pressure exceeds some preset limit. This function is designed to protect the engine from a runaway turbo or a stuck waste-gate. On my 1988 760 Wagon, the boost overpressure switch is mounted in the engine compartment, on the right front strut tower, and is effectively “just above” the turbo. High underhood temperatures can cause this switch to fail and shut the engine down. To confirm switch failure, disconnect the waste-gate controller and wire the waste-gate fully open, effectively disengaging the turbo. Then short the boost overpressure switch. If the car starts while hot and runs without incident, then you've found the source of your hot-restart problem. Don't drive the car this way as you may overboost the engine.



Compressor Bypass Valve Diaphragm. [Inquiry] My Mitsu TD-04 with integrated CBV has a torn CBV diaphragm, but no one carries a replacement. Volvo will sell me a $300 rebuild kit with the CBV included but the parts stores don't have a clue about selling just the diaphragm. The rice shops want to sell me a $200 Blow Off Valve that I don't want. Where can I get a NEW CBV diaphragm? [Responses:]

Replacement Diaphragms for CBV. Various turbo rebuilders carry the diaphragm repair kits for reasonable prices. Check Rick Banas at D&W Diesel (r.banas@dwdiesel.com) for Mitsu diaphragms and some Garretts.

Turbo Has Power Loss and Cherry Manifold: Knock Sensor. [Inquiry:] My 740t intermittently looses power and the exhaust manifold turns bright red. I don't know if the two are related but when the car was in the loss power mode I opened the hood one night to check for arcing wires and I noticed the manifold glowing.

[Response: Abe Crombie] Those are the symptoms of a knock sensor problem. The knock sensor may be bad but more likely the connector is the problem. When the ignition control unit detects no input from sensor the timing is retarded which is the safety from excessive spark knock but this does make engine power suffer and the delayed timing sends exhaust gas temp skyward.

Lubrication:

Normal Oil Consumption for Turbo.

[Inquiry:] What is the normal oil consumption for a turbo engine?

[Response 1:] Based on a highly non-significant sample size of 2: my friend with a 245 Turbo says that he levelled out at one quart per 2,000 miles, and that this rate of consumption remained the same from 80,000 miles until he sold the car at 150,000-plus miles. This is the same rate of consumption as my 744 Turbo with 91,000 miles, so I say that 2,000 miles per quart is healthy for a Turbo motor.

[Response 2:] My 87 764T w/187k miles uses zero quarts amsoil synthetic 20W/50 in 10,000 miles, I change the oil and AMSOIL ASF-42 filter every 10,000 miles. My 90 744T w/83k miles uses zero quarts amsoil synthetic 20W/50 in 10,000 miles, I change the oil and AMSOIL ASF-42 filter every 10,000 miles. I also ran a spectrometric oil analysis comparison on wear metals using dino oil at 3,000 mile change intervals and oil samples with synthetic every 3,000 miles to the 10k oil change interval I have settled on. On my engines, the dino oil accumulated more wear metals, had lower residual alkalinity (total base number or TBN for any lube engineers out there), and increased it's original SAE rating by 5-10 points with regard to the synthetic at 10,000 miles. The only reason I change the synthetic at 10k is that I do get carbon particulates (soot) buildup to .5%, the buildup curve turns the corner at around 10-11k (it runs 0-0.4% for the first 8-10k but then climbs quickly...I chose to dump at .5%----BTW, this stuff is so fine that a micron bypass filter won't clear it out past 15k...I've tried AMSOIL bypass filter and while it clears the oil it won't take out the soot.) I believe the soot/carbon particulate buildup is characteristic of the turbo gas engines, inasmuch as my experience is duplicated on my Saab 900t, both the 84T (RIP) and the current 87 900T. I have no experience with turbo diesel engines, but maybe their soot particulate size is somewhat larger than gas engines.

That's not to say either engine has NOT used oil....but when they do, I have invariably found the problem to be an oil LEAK, front or rear main or cam cover gasket. Once the 740t leaked at the turbo oil return gasket at the block and also at the oil filter adaptor. Have also had oil leaks at the distributor on the rear of the hear....but all fixed relatively cheaply with Volvo O-rings. Point is these engines are really good on oil control IMHO.....but they are also b!^&hing leakers!

[Response 3:] my '87 740T with 178,000 miles runs on dino oil. Lately the oil consumption has been 1 quart in about 2700 miles. Since I usually change the oil at 3000 miles, I don't bother adding the oil. I have been just changing instead. Can't tell you anything on how much my '88 740T consumes. It has been a leaker since I bought it last spring. The oil return pipe from the turbo leaks at the block. Maybe 1 quart in 400 miles. I can see it leaking and dripping when the engine runs. Just recently cleaned the throttle body and crankcase vent system. Maybe this will help the problem. If not, I will have to repair the leak with a new o-ring. OTOH, with all that oil dripping and blowing under the car while driving, a good part of my undercarriage is coated with oil, it will never rust.

[Response 4:] My (brief) experience has been 0 quart consumption. I run Mobil-1 10W30 on my 1992 944T with about 80k km (50k mi).

[Response 5:] My wife's '91 940 Turbowagon that has 102,000 miles on it goes through a quart of Castrol Synthetic 10W-30 every 2000 miles. This number seems to coincide with what you have stated. The Turbowagon is in mint condition without

a single spot of oil leak on the garage floor. I have pulled all the plugs to check their condition and there is no evidence of oil in the combustion chamber. The exhaust pipe is also quite clear without any residue or smell of burned oil. I am just amazed with this 940 Turbowagon and the ride fells like new.

[Response 6:] I change my synthetic oil as close to every 3k as I can. The longest interval was just over 5k. I'm not into the turbo a lot, generally I nail it once a day getting on to the highway. This is an '84 with 160k and it uses no oil worth writing home about. Honest.

See below for more information about oil leaks and consumption in turbo engines.

Oil in the Intercooler.

[Inquiry:] When changing my radiator (91 940 137,000 miles and new to me)I noticed black oil in the air hose from the turbo to the intercooler. Is this normal? Or do I have problems?

[Response: RandyS] It's normal, don't sweat it! Unless it spewed out a quart, I'd say you are doing OK.

Turbo, Drain Line, and Cooler Oil Leaks. [Inquiry:] 740T leaks oil out the oil filter adapter and turbo return line

Flametrap and Crankcase Pressure:

[Gary DeFrancesco:] Before going too crazy, make sure you have good crank case ventilation. See the extensive discussion of this at Excess Crankcase Pressure and below under Extended Boost and Oil Consumption.

Sources of Leaks:

[Tips from Gary DiFrancesco] Turbo cars do have some common leak points when the age and mileage build up. There are two places I would check right off. First check the oil return pipe going between the turbo center section and the block. Where the pipe goes into the block, the o-ring at this junction can and will break down and oil will blow out here (even with good crank ventilation) and run down the side of the block. The other leak point is from the oil cooler adaptor. You know about the o-ring between the adaptor and the block, but there is another o-ring in the adaptor assembly. One or both of these o-rings will also start to leak eventually.

[Inquiry:] I have a 88 760 Turbo with 226,000KM on it, losing oil. I am going to look at it this weekend and would appreciate any suggestions on what tends to leak most on these engines. I don't really notice any oil onthe driveway from where I park and it doesn't seem to burn oil. . [Response from Michael Jue:] Oil leaks on B230FT can be due to any or all of the following:

- Oil blowby due to worn valve seals OR clogged flametrap housing (no actual flametrap, just the housing - part of the EGR system; located directly beneath #2 & #3 intake runners. A real knuckle buster.)

- Oil leaking (weeping) from oil filler cap - Either bad gasket on cap and/or clogged flametrap housing. The clogged flametrap creates high crankcase pressure forcing oil by the gasket.)
- Oil leakage past turbo bearings - a fairly likely cause at 226k Km; imperceptible in exhaust (absence of blue smoke).
- Rear main seal - not as likely but possible (changed mine twice in 255k miles); check for inordinate build-up of oil on transmission. See below under Extended Boost and Oil Consumption.
- Front engine seals (cam, crank, idler) - pull the top half cam cover and inspect timing belt for oiling; change if any sign of oil contamination and replace the seals at the same time. (Recommend changing them as a complete set with your timing belt change as the belt must come off for replacement of any of the seals anyhow.)
- The old oil filter gasket was left on the oil filter adapter *face* when installing a new oil filter. Or the 28mm nut holding the oil cooler can to the adapter was loose.
- [Christopher Rowat:] One other possibility for oil leaks is the oil filter adapter gasket, a little O ring that seals the oil filter adapter to the block.
- [Dick Riess] The engine oil dipstick tube o-ring, where it mounts into the block, can fail and allow blowby to carry oil past the tube onto the surrounding block.

Oil Cooler Adapter Oil Leak Repair:

[Responses:] There are two oil cooler systems used on turbo units: the earlier radiator-style with pipes from the oil cooler adapter (740s), and the later can style mounted just ahead of the oil filter with no radiator and hoses to the block (940s). The **oil cooler adaptor** has 2 large o-rings (one between the block and adaptor and the other between the adaptor and the oil cooler unit) that compress and get hard with age. They can leak. The o-rings cost about $2.00 each but are a bit of a PITA to replace. You have to remove the whole adaptor. You will need two large sockets: 32mm (preferably 12-point) for the bolt that holds the adaptor to the block, and a deep 29mm or 1-1/8 inch for the nut that holds the thermostat unit to the adaptor unit. There are two ways to accomplish this: **(1) Early Unit:** You can remove the power steering pump from its mounting bracket. The pump can be left in the car, just remove it from the bracket. This will allow you to move the pump out of the way so that you can get a socket on the big 32mm bolt that holds the adaptor on the engine. Once off, the two parts of the adaptor are separated with the removal of the big nut just below where the oil filter screws on. **If you have the early style oil cooler mounted near the radiator with pipes to the adapter, make sure you mark the adapter parts so that you can reassemble everything in the same orientation.** Replace the two o-rings (using some grease or silicone RTV to hold them in place) and put everything back together. Use Loctite Blue on the 29mm cooler-to-adapter nut to prevent it from loosening when changing the oil filter. **(2) Later Unit:** Removing the entire right hand motormount allows easy access;the job took around 1.5 hours including changing the oil and doing some clean up. I recommend cleaning these areas before attempting this job to keep any dirt out of critical areas.

[Lars] When you insert the new O-ring in the groove, try to reverse-roll it a bit so it sits in place while mounting. Make sure when you reassemble the cooler that you

leave clearance for the turbo oil return pipe right next to it.

Oil Cooler Lines to External Cooler (Early style). [Norm Cook] Note that the cooler lines require 22mm wrench; 7/8" will work but it is .23mm or .009" larger than 22mm. It's useful to have 2 wrenches for this job. I found it easier to thread the fittings into alum filter base and then connect lines. Again, make sure you mark the orientation of all parts prior to disassembly.

Some useful part numbers for various parts in the oil cooler (both early and late style parts noted), thanks to Norm Cook:

- Oil filter aluminum threaded filter base: 1276680 (early)
- Aluminum base to block: 1346618 (both early and late)
- Oil cooler can 3507371 (late)
- O-rings: the black O-ring 3547188 goes between the cooler adaptor and the right-angle adaptor ; the green O-ring 967343 goes between the right-angle adaptor and the engine block. Early models use (2) black o-rings 925093.
- Copper washer 3531702- goes under the bolt that holds the right-angle adaptor to the block
- Aluminum crush washer 957189- placed under the banjo bolt screwed into the block (late)
- (2) Aluminum crush washers 957179- placed under the fittings into which the pipes enter (early)
- Steel washer 824589- placed under the nut that threads down the shaft onto which the filter goes. This washer is re-usable. (early)
- Coolant hoses 9161383 and 9161384- connected between block and oil cooler can (late)

Oil Return Line O-Ring Leak Repair:

Diagnosis. [Various Contributors: John Sargent, Gary DeFrancesco,Paul Seminara, Don Foste, Ryan M, Dick Riess] The leak in the turbo **oil return line** is due to a failed o-ring. The **oil return pipe** in the turbo will start to leak where it enters the block. The return pipe just sits in the block against a rubber gasket/washer and seals through a press fit. .It must be properly centered and seated in the block recess. Make sure that the oil cooler is not preventing this pipe from seating fully. If the cooler is rotated, the pipe will be pushed out. Before doing any repair, get the correct O-ring and fibre gasket for the top end. The proper seal is red; approximate dimensions are 4mm thick, 19mm ID, 25mm OD, to fit the 20mm OD oil tube where the seal slips over. Sometimes dealer techs will shortcut the turbo return line O-ring installation by using silicone sealant slopped around the return line and the block instead of replacing the seal; this silicone eventually fails.

Before attacking the turbo oil return line leak, check your crank case ventilation. If the ventilation system is not working perfectly, the pressure build up can force oil out the turbo oil return o-ring. Replacing the o-ring may not solve the leak entirely, so fix the ventilation first. Once fixed, you may find the leak is gone or at least greatly reduced.

Repair: Removing the Drain Line. Replacing it can be a real PITA on earlier Garrett-equipped cars. On a Garrett turbo, you may have to loosen the turbo from the manifold (4 nuts) and pull away slightly. This gives a little more play. You may

also need to loosen coolant lines and oil line at top to do it completely. Or, remove the oil filter adapter to make room to install the oil return line (good opportunity to change the o-ring between the adapter and the block.) When doing a turbo replacement, bolt the exhaust manifold up loosely, and THEN install the drain tube to engine block and drain tube to turbo lightly. Torque up the manifold and then tighten the turbo drain gasket bolts. Replacing the gasket/O ring with the turbo bolted down tightly can be done but it's a close thing. The bolts on the turbo end, including the wastegate actuator, can be sticky and there is not much room to work. Always use lots of PBlaster and a six point socket on stuck bolts. If you are unsuccessful in removing the two screws/bolts that hold this pipe to the turbo center section, the only other way to replace this o-ring is to remove the exhaust manifold/turbo assembly. With a Mitsu turbo, remove one bolt holding the wastegate valve at the front and the cotter pin holding the wastegate actuator rod, drop the wastegate to one side, and remove the two oil pipe bolts at the turbo.

Once off, clean up the parts.

Repair: Seal Installation. The proper way is to remove the pipe from the turbo center section and replace the old seal at the bottom and the fibre gasket at the top. Put a little grease on the o-ring to help it go back into the block. If the pipe is not inserted into the block properly, it will leak again. The pipe doesn't really sit against a gasket on the block. The O-ring, mounted on the pipe BELOW the ridge, fits INTO a hole in the block (and can get distorted, bent, cut, skewed, screwed, blued, and tattooed) in the process. Be very careful getting it back in with new seal - it is easy to pinch the new seal even after lubing with synthetic grease. I usually keep an extra seal in my tool box in case I pinch one during install. Maneuvering the turbo, pipe, and O-ring into position can be a challenge. If you have problems attaining a good seal, Here are three thoughts:

- The O-ring may have gotten cut during installation. Even a nick can let oil seep out.
- The O-ring might have peeled up over the ridge in the pipe.
- It might not be the correct O-ring -- too thin, so not squeezing into the block.

That tube is only a gravity-fed drain -- there's really no oil pressure there, so there's almost no driving force to push oil out. O-rings get their sealing properties from the squeeze against opposing surfaces. In this case, those surfaces are the tube and ID of the hole in the block. You shouldn't need to push it down solid to achieve a seal. Now twist and turn it to get it to back into position. (Probably want to practice this without the o-ring and gasket before actually doing it.) It sets in the block against a square lip, which you can feel with your finger, and it needs to be square and snug against this lip. And after the installation, use an inspection mirror and strong light to check to make sure that it went in properly.

Turbo Oil Return Bolts.

[Inquiry:] I removed the turbo oil return tube the other day to replace gasket & seal. Got the parts, went to install them, now it seems the bolts that go into the turbo are too long, they bottom out.

[Response: Paul Kane] The bolts in that area LOOK the same - but they ain't. Just a 1 or 2 thread difference can cause a 'bottom out' . You may have swapped 1 or 2

and didn't realize it.

Quick and Cheap Silicone Fix:

If you can't get the pipe out (since some previous grease monkey stripped the socket on one of the cap screws on the turbo end), then you can always seal up the leak like I did. I completely cleaned the area around where the pipe goes into the block. I used a strong degreaser to clean the pipe and the surrounding area. I even used Q-tips soaked in degreaser to get inside where the pipe goes into the block. I then used lacquer thinner to prepare the surface. Once everything was surgically clean, I dried the area with a warm heat gun. I split the new washer so that it could be placed around the pipe. The washer was coated with Permatex Ultra Blue silicone sealant, and some of the sealant was also injected into where the pipe enters the block. The coated washer was then pushed into this space and sealed into place with even more sealant. It is a bit of a patch job, but it is working just fine. No leaks in the year since I did the job and it is cheaper that screwing up the turbo. Before I fixed this leak, I was loosing a quart of oil in less than 500 miles. Since the repair, I am estimating over 5000 miles per quart. Hard to tell for sure since I change oil at 3000 mile intervals. Those are the leaks I am familiar with on the B230FT engines. [Randy Starkie] I cleaned the joint at the oil return line and the block with lacquer thinner, then sealed it with silicone sealant. It has lasted three years with no leaks.

Clean or Replace the Oil Return Line?

[Inquiry] One thing I haven't done to my car is clean the oil supply lines to the turbo. What is the best thing to shove into the lines in order to really clean them well.

[Response: Dick Riess] If your turbo is under warranty, the warrantor will insist on a new supply line. Reason: coke can chip off and destroy your bearings in the turbo. I really believe in buying a new supply line.

[Response: Hermann of Cherry Turbos] The chemicals, time and elbow grease needed to clean the line out are no guarantee that all the coke inside the line is gone. Because the coke is so brittle, it can crack and release just from a heat cycle. Ultrasound would actually be the only safe way to clean the coke out. Buy yourself some peace of mind and order the new line.

Extended Boost and Oil Consumption

[Report from JMars] My 89 745 TIC has had catastrophic oil losses twice. Both times happened when the cruise control caused a downshift from OD and full boost for a time at 4000rpm +/- on a long mountain upgrade. At neither time did the plugs foul - this is a key since the non fouling of plugs told me that the oil lost did not pass thru the combustion chambers. It is impossible to burn that much oil without fouling the plugs!!! Hence it was not a case of a bad head gasket, valve seals, rings, turbo seals, or anything else that would have put oil thru the combustion chambers. The solution: there is a small hose going from the intake manifold to the plastic fitting in the large breather hose. Apparently it is there to vent the crankcase to the intake manifold when the latter is under vacuum. There is NO PCV valve in the system. Apparently extended boost was transferred through

this hose to the crankcase. Oil puddled at the rear of the crankcase with 11 lbs of pressure behind it leaked out the rear seal at higher rpm. So how do you fix this? A check valve in the small manifold hose that lets fumes be sucked into the manifold but prevents pressure to be passed into the crankcase: a simple PCV valve. A check of the PCV valve display at your local AutoZone will will reveal a nice little black&white plastic jobbie (Deutsch # PCV 161 - $3.99) with small barbed inlet/outlet tubes on it that will slip into the suspect hose with no clamps needed. If you pick the wrong one it is no big deal as long as it fits and is positioned the right way. Mine cost $3.99 and was installed in mere minutes by cutting the hose and inserting the PCV valve (white side toward manifold). This solved my oil loss completely and makes sense: . the more you use the turbo the more the crankcase becomes pressurized and the more you blow oil out seals; especially if the seal is completely submerged and cannot vent air. I can see no harm in the addition of this PCV valve - the manifold vacuum still vents the crankcase.

Intake and Exhaust:

Intake Manifold Gasket Leaks.

[Inquiry from Joel Eisner:] Rough idle with some lean backfiring but it holds at 900RPM. Diagnosis steps:

- # 4 plug wire when removed does not affect the idle but the others do.
- good spark (swapped plugs and wires)
- plug looks no different than the others (a little black)
- swapped out the fuel injector with another one
- checked compression (approx 140 psi on 1-3, 130 on #4) and oil helps only a bit
- swapped out a different fuel line to the injector

I am about to give up and part the thing out if I can't fix the idle. I would like to keep the car but it is driving me crazy. Clues?

[Response: Joel Eisner] I found the problem. I pulled the intake manifold and about an inch of the gasket around the #4 cylinder is missing with obvious signs that it has been gone for a while. That area was black.

{Response 2: Warren Bain] The gaskets go quite often on the turbos. Mine went and the idle was very rough. A quick replacement and all was well. It's quite easy. [Tip] The turbo is prone to intake manifold gasket leaks, (so I hear) and mine was no exception. The WD-40 spray test showed much leakage. I used a cheapo gasket (stiff type), put it all back together and voila - NO difference. I tried again with a high quality (rubbery (nitrile?)) gasket and used permatex liquid gasket sealer (although there are various views on sealer use) and voila - BIG improvement at idle. Lesson - use high quality gaskets.

Turbo Hoses: Preventive Maintenance.
Air Intake Hoses.

[Tip from Simon Eng] If your car is equipped with a turbo, please inspect the

rubber air hose from AMM to turbo. This is the one that is about 3" in diameter and is in the form of an elbow about 12" total length with two small connections on the side. Pay particular attention if your car is over ten years old. Inspect the end that is connected to the turbo inlet. Due to the extreme temperature at this location, the rubber deteriorates and actually melted in my case. It is probably cracked and leaking air into the turbo, leaning the mixture, or even collapsing. Cost is over $100.

[Response: Rob Bareiss] Any and all of the air hoses on a Volvo turbo can leak, with two rather unpleasant consequences:

- The car will run like crap and you may have weird symptoms such as cutting out under boost
- You're going to have to spend some money

The usual cause is oil attacking the rubber from the inside out. Some of the hoses are REALLY expensive. The large S shaped one is about $180 list price. The one just before the throttle body is $80-$120 depending on which model you've got. The little one right at the intercooler is only $10. The silicone high-temp L-shaped hose at the turbo is over $100. It's probably a good idea to periodically look inside one of these hoses to see if there is any evidence of oil. If they're wet inside, you've got a turbo leaking oil, AND sooner or later you're going to need to replace these hoses. The only good news in this is that you'd be pleasantly surprised at how well duct tape can seal up one of these, and how long it can last... And it's a LOT less than $180....

Wastegate Hose. The small vacuum line controlling the wastegate on the turbo is exposed to high temperatures and can embrittle. Change this if it feels hard. Not doing so can cause overboost in the turbo when it fails.

Pressure Leak Tester: See Special Tools for a simple intake system pressure leak tester: you can pressurize the intake system and listen for leaks.

Coolant Hoses. [Editor] Turbos run hotter than NA engines, so inspect all your coolant hoses regularly and consider replacing them after eight years or so. These include the radiator, heater, reservoir and turbo oil coolant hoses. Highly recommended: use Volvo OEM hoses from the dealer, not aftermarket or hoses formed from stock coils.

Turbo Hose Sources. [Inquiry:] I'm looking to replace the original turbo hoses. All are either really soft and/or showing signs of interior deterioration. The only problem now is that my dealer's prices are about ten times what I'd expect to pay for these hoses. Does any one know of a cheaper source for such hoses?

OEM Hoses. Try Borton Volvo in Minneapolis or FCP Groton for lower-priced OEM hoses guaranteed to fit your turbo application.

Silicone Hoses.

[Tip:] For a source of silicone hoses for turbo intercoolers and other applications, see: http://www.bakerprecision.com/silicone.htm or

http://www.hosetechniques.com/ These come in standard sizes (elbows, etc.) and will likely not fit your car without additional fabrication.

[Inquiry] I'm thinking of just buying some straight 2" ID silicone hosing from one of the many turbo outfitters for the short hoses that come off the intercooler. However, what should I do about the 90 degree bent hose that comes directly off the turbo outlet?

[Response 1: Don Willson] I just bought a set from an independent parts house for my '89 760Ti. The short silicone was $24.25 pn 127-6963 The fresh air hose air filter to turbo input was $127.42 pn 138-9648 The slight S outlet turbo to intercooler was $47.12 pn133-6815 Mine were failing, not from turbo heat but from exposure to the radiated heat from the exhaust. I found some aluminum tape with high temp silicone adhesive and wrapped around them to reflect some of the heat.

Exhaust Manifold Gasket & Studs; **Turbo to Manifold Joint**

Exhaust Manifold Parts: Use only the Volvo OEM brand exhaust manifold gaskets, studs, and nuts, which are made of special materials and are of higher quality. Aftermarket brands have been known to quickly fail, especially on turbos. Since you will likely have to remove the oil filter adapter, buy a complete set of OEM parts: exhaust manifold nuts (8), manifold gaskets (4), oil filter adapter-to-block o-ring, oil cooler o-ring, turbo oil cooler hoses, turbo oil return line gasket and o-ring, and (depending on your car configuration) turbo to down pipe nuts and lock washers if any. If your car is non-turbo, then you will not need the filter adapter parts. Useful tools: in addition to normal hand tools, jack, etc., some corks to plug the oil cooler lines so you need not drain the system are helpful. Six-point sockets are invaluable for removing stuck nuts. PBlaster is essential and an acetylene or propane torch with a pencil flame are often helpful on stuck nuts. Use nickel-based high temperature antiseize on all bolts and nuts on reinstallation to make future repairs much easier.

Tools. [Editor] Buy a 32mm socket for the oil cooler adapter banjo bolt. Have a complete set of 3/8 and 1/4 sockets and U-joints along with a long 1/4 extension to remove the bolts fixing the oil return line to the turbo. Have a magnetic parts locator for dropped nuts. Use ramps or stands to raise the car; have a garage jack or hoist to raise the engine; and use a bottle jack and a piece of wood to hold the exhaust line up while pulling the engine.

Exhaust Gasket and Leaks; Why Repair?
[Tip from John B] As far as the exhaust manifold to head leaks...my opinion is fix them soonest. The leaking gases will erode the gasket and make the leak worse. For example, the leak from #1 cylinder exhaust at 3 o'clock eats a hole/slot in the timing cover back and front...ask me how I know this! It sound like the manifold leak issue is concurrent with the dealer fix of the turbo.When you do this, plan on renewing other gaskets, o-rings, hoses etc. that you remove while replacing the manifold gaskets.

Exhaust Manifold Gasket Replacement Procedures. [Tips from Turbobricks, John Sargent, and others] Given all the parts you have to remove, this is about a six hour job. Raise the car on ramps or jacks to be able to work both underneath

and above. All the bolts and nuts mentioned below will be rusted so use LOTS of penetrating spray for a couple of days before. To remove them, use the old trick of first tightening a little, then loosening. Heat often helps. Remove all eight manifold nuts (*record where the washers and shields/hoisting hook go* since some are flat and some cupped), remove the plug heat shields, and loosen the turbo to down pipe nuts OR loosen the down pipe fixing bolts at the bell housing and transmission, depending on your car. Remove the oil filter adapter to gain access to these bracket bolts and at least one manifold nut: use new gaskets and o-rings on re-installation. This adapter has a 32mm banjo bolt at the front end. Loosen the two bolts holding the manifold bracing bracket to the side of the block under the manifold. The bracket has one stud into the manifold and two bolts into the block. These are hard to find and access. You will have to remove the turbo oil supply line banjo bolt on the block above the oil filter (DON'T lose the two copper washers to this bolt) and remove the turbo oil return pipe. If so equipped, loosen the EGR pipe which is bolted into the back of the manifold: this pulls back about a centimeter, but is invariably rusted. You will also have to release the transmission bell housing bracket from the down pipe and the down pipe bracket at the rear of the transmission to gain enough clearance to move the manifold; these too are usually rusted solid. Support the exhaust pipe below using a garage jack to keep the manifold and turbo from falling down onto the air conditioning pipes when you pull it away from the manifold. To prevent damage to the radiator, loosen the coolant lines at the radiator using two wrenches. You will have to push or pull the engine toward the driver's side to clear the exhaust manifold studs: use a jack beneath and a piece of wood shaped to fit into the oil pan bolt flange recess or a puller on the top engine lift at the thermostat. The exhaust manifold gaskets fit into each manifold runner. Needless to say, you should replace all four. If you look closely at the exhaust manifold gaskets you will notice they are not symmetrical. If the exhaust gasket are rotated 180 degrees when installed, they will burn out in a month or two. Watch how the old ones were fitted. Each gasket is stamped "UT" on the metal side which means "out"; that side faces away from the cylinder head and toward the manifold. Do not use any gasket sealer or compound; the gaskets are installed "dry". On reinstallation, use high-temperature nickel-based antiseize on all bolts, nuts, stud threads, and the EGR pipe end to make life easier next time around. Note as well that, if so equipped, you need to replace the engine lifting hook in the correct spot: it fits into a recess in the manifold in place of one of the thick washers. The latter are replaced with the concave dished side inwards toward the manifold in the recessed slots. Note that you do not have eight of them: usually only six or seven are fitted into the deeper recesses on the manifold. Replace the heat shields and the flat washers before installing the manifold nuts. Re-torque the manifold nuts to 10-20 ft-lbs for B230F/T/D. Reinstall the manifold bracket and all the turbo parts you removed as well as the two oil lines. This is a good time to replace the turbo oil cooler hoses, which tend to rot from oil dripping off the filter. Use ONLY Volvo OEM hoses in this application.

Replacing Manifold Nuts and Studs:

[Inquiry:] My 744ti currently has 184,000k mi. It is leaking a little at the exhaust manifold so it is time to replace the gasket. I have noticed that it looks like it is the original gasket. I am thinking about replacing the studs and the on the head when the gasket is replaced. Is this a good idea or am I wasting my money. I want to do

the job right from the beginning.

[Response: Rob Bareiss] I always recommend replacing all the exhaust nuts, and to try to save the studs I split the nuts with a chisel. This can save a great deal of aggravation (it's an old VW trick- the studs on VW heads always broke). [Another philosophy from: Onkel Udo] You might want to spray the studs w/a penetrating oil repeatedly for the preceding days. When you reassemble, use nickel-based antiseize compound on the new studs and coat the exposed areas with a silicone spray or a grease of some type. There is nothing more annoying than trying to remove rusted-in-place nuts on exhaust flanges knowing that at least one stud is going to shear off no matter what you do.

[Response: Don Foster] If the original studs appear eroded (rusted away) and you think you can remove them without snapping even one, then new studs would be a cheap investment. I dearly love my oxy-acetylene torch. Every time I use it, I kiss it. You might also consider replacing the big O-ring in the oil cooler adapter at the same time -- they age, dry out, crack, and start leaking at about the 10-year point with your mileage, and are a B*ITCH to get to -- but with the turbo out, the area's wide open, and access is much easier. [Response: John B] I wouldn't fix the stud problem if it's not a problem. OTOH, if you break one stud in the process, might as well replace them all. Editor: turbo studs differ from non-turbo studs: make sure of your part numbers.

Stud Removal Tips See Exhaust Manifold Nuts, Studs, and Gasket Replacement for complete tips on how to remove broken studs. [Paul Seminara] ! When you have it out soak again in PB Blaster, clean and brass brush it, smear with a good Ni or Cu antiseize for future removal. Under no circumstances should you use an Easy-Out or other stick-in-the-hole and simply twist stud remover.

When you pull out the manifold/turbo, then's the time to replace the turbo/tube and tube/block gasket and O-ring. Even if you don't pull the entire manifold/turbo out to replace the exhaust gasket (best case) the turbo oil tube is a lot easier to reseal with the manifold loosened (and the two bolts holding it onto the turbo removed). How's your 02 sensor? It's easy to get to with the manifold out.

Exhaust Leak at Turbo/Manifold Joint: Nuts, Is there a Gasket?; Tightening Procedures:

[Inquiry] I recently saw some condensation on the top of the turbo/exhaust manifold joint just after startup that quickly evaporated as the engine ran. The joint was dry prior to startup so I imagine condensation was forced up out of the joint. The joint is the one tightened by four nuts/studs. I noted that the #2 and #3 exhaust manifold runners were sooted a little bit and could feel a little bit of gases escaping. It was not uncomfortable for me to hold my fingers over the leak. Questions: 1) Other than the obvious exhaust gases in the engine compartment, is this a don't drive it until you fix it repair? 2) Does this joint typically leak? I think the turbo was replaced by the dealer in May 2000, 6K miles ago.

[Response: Abe Crombie] The turbo (as with almost all turbo applications) uses no gasket between the turbo and manifold. It is a flat machined fit. It is not at all unusual to have some seepage when cold at this location. It might actually improve as rust seals it up. You may want to be sure the turbo-to-flange bolts are secure.

That is about all you can do.

[John Sargent] There is no gasket between the manifold and the turbo. Until the 1990 model year, both Garrett and Mitsubushi turbos are bolted to the exhaust manifold with bolts from the engine side of the exhaust manifold (see photo right). For the 1990, and later, model year 700/900s Volvo used nuts to hold the turbo from the front side of the manifold. The later manifold has studs which the nuts screw on to. You will also need new keeper plates which lock the nuts in place.

[Notes from JohnB] The problem with checking the bolts that hold the turbo to the exhaust manifold is that they're supposed to be locked in with a lock plate. The bolts on the manifold side are 12 point cap screws angle-torqued using special tool 5411 to 30 Nm or 22 ft-lbs, then the lock plate is pounded over the bolt heads. Checking the bolts is useless...if they move the lock plate is defeated and if they don't it's no indication of proper installation. If they are loose, then the dealer didn't install the turbo mounting bolts correctly. Generally the exhaust manifold needs to be removed to properly install the turbo mounting bolts and locking plate. A new plate and new bolts should be installed every time since the bolts are torque-to-yield. However, in my experience and in everything I've read, angle tightening isn't that far off from simple torque-wrench, something like 25% variance from specified clamping force vs 35% for torque wrenches. [Inquiry] My turbo to manifold nuts are loose. Is there a gasket in there? How do I tighten them? [Response: Bob] There is no gasket between the turbo and the manifold. If the nuts are loose, don't just tighten them. They will loosen again. Replace them with new locknuts. The Volvo special tool 5411 for these manifold-side nuts is an open end wrench about 6" long with a square drive hole on the other end for a torque wrench which is held at 90 degrees to the wrench. Tighten to 30 Nm (22 ft-lb) in a 1-4-2-3 pattern starting with the top rear as "1" and then going clockwise around the nuts ending at the bottom rear.

Torque Reference. Retorque to 10-20 ft lbs (14-27 Nm) for B230F/T.

Broken Turbo Exhaust Stud. [See also the section under Exhaust: Exhaust Manifold Gasket and Studs Replacement for an extensive discussion of techniques.] [Inquiry:] I have an 86 760 Turbo that was rebuilt about 15,000 kM ago. The problem is that one of the exhaust manifold bolts has snapped off and when the turbo is under boost, it whistles. I think it is on number 3 cylinder and of course the bottom bolt. Is this leak going to harm the exhaust valve over time? I was also thinking about the doing the work my self and was wondering if anybody out there has had success with replacing exhaust studs with the head on? I really do not want to pull the head but I think it maybe the easiest way to get the stud out. My biggest fear is breaking off all the studs in the head. The head was rebuild when the engine was rebuilt so I am hoping all the studs have anti seize on. What should I use on the new bolts for anti-seize? If I remove the head do I need new head

bolts??? I got the specs on torques for the head but what torque do I torque the exhaust manifold too, I think they recommend only about 30 Ft-Lbs? Is this right?

[Response 1:] Look at the bolts that hold the bypass valve on the pressure side of the turbo. This is the valve on top and in front of the turbo unit with the vac. hose leading to the intake manifold. These bolts can loosen slightly and allow boost pressure to leak. It sounds like a whistle when under boost. When I first heard this on my car, I thought I had a turbo starting to die. Fortunately an honest service manager at my local Volvo deal went straight to the bypass valve and showed me the loose bolts.

[Response 2:] A broken exhaust manifold stud and failed gasket usually make a significant exhaust putt-putt-putting sound. I would never describe it as a whistle. You might have a failed hose or coupling on the high-pressure side of the turbo, and you're hearing air escaping.

Turbo Exhaust Stud Replacement. [See also the section under Exhaust:Exhaust Manifold Gasket and Studs Replacement

Stainless studs are an excellent idea for aluminum heads. Try to find a local fastener supplier that offers high-strength metric studs (8mm x 46mm: (std pitch, 1.25mm), 45mm long with approx. 15mm thread on one side (head side), 25mm on the other and 5 mm of no thread.). They are hardened to 10.9 grade. Always use high-temperature nickel-based anti-seize on all studs. Search yellow pages under nuts & bolts. [John B] Almost any stainless alloy is going to be weaker than a good steel alloy...it's only advantage is it's supposed to be proof against corrosion. But you're not a marine environment, so I'd go with stock steel studs. Helicoil the heads if you must, but you'll get higher clamping forces with the stock studs. [Editor] Use OEM Volvo studs, with the part number matching your application (lengths vary). Aftermarket studs are not plated for corrosion resistance and are invariably the wrong length.

Exhaust Manifold Cracks and Repairs. See the FAQ file in "Exhaust" for more information. In a word, replace, don't repair.

Cylinder Head Replacement. [Inquiry] If the cylinder head in my turbo engine fails, can I substitute a non-turbo head? [Fitz Fitzgerald] Tthe heads from a Turbo and non-Turbo B230 engine can directly swap, but note the differences first and then you judge if you want to proceed on that route:

1. Valves: Both the turbo and non-turbo heads have Stellite-flashed exhaust valves to resist burning (can not be machined). Also, the valve stems in the turbo valves are hollow and are partially filled with elemental Sodium. The Sodium is solid at room temperature, but once the engine warms up it becomes liquid. The up & down movement of the valves causes the liquid Sodium to be tossed up and down in the hollow valve stem, and helps to conduct heat away from the valve face at a faster rate. While this isn't an absolutely critical requirement to have on a turbo car, it does help to reduce valve face temperature.

2. Camshaft: The camshafts are different in the turbo and non-turbo engines. You'll need to swap them, and then also re-shim the tappet clearances under the camshaft. This requires having a large kit of spare shims (aka Pucks) of various thicknesses to get the proper clearances under each camshaft lobe. You can rent the tools and shim kit from IPD, and a micrometer and feeler gauge set will also be required.

If this were my vehicle, I would probably just have the head machined flat and re-install it rather than swapping the camshafts to a non-turbo head. I wouldn't hesistate to machine a bit beyond the Volvo minimum thickness specs.

Turbo Rebuild and Replacement:

Turbo Failure Signs . [Inquiry:] Does anyone know what a turbo sounds like when it starts to die? does death usually come slowly, or suddenly. will the car run without it, and if so, for how long? [Response:] Some die slowly, losing output gradually as the engine ages. Others begin to make noise (scraping or rattling), especially under load or when very hot, that may signal that the impeller blades are touching the housing (or have been bent through the introduction of a foreign object), or the bearing is about to go south. Others fail through seal failure, dumping oil out the exhaust. I have been told that turbos can fail without any warning whatsoever, but I would not expect that. Your car should run without the turbo, but you will be driving a car with something like 80-90 horsepower because of the reduced base compression ratio on the turbo cars. In other words, maybe okay to limp to a garage, but no for everyday use unless you are a glutton for punishment. If the car is throwing oil out the exhaust, do not drive it at all. You may be able to clear a little out, once the turbo is rebuilt or replaced, but if you get too much into the exhaust you will be buying that as well.

Turbo Replacement. **Does It Need to Be Replaced?**

[Tip from Herman at Cherry Turbos] Before you conclude you need new turbo seals, you need to check the end play in the shaft first. Do the blades touch the sides? If not, you need to address a very common problem in the B230FT and that is excessive crankcase pressure. Get a new oil trap (under the intake man. 2x3x4 black plastic) and clean out all crank vent hoses. You describe classic symptoms for oil hanging up in the turbo because it can't fall back to the oil pan with the crankcase pressure pushing against it. I've talked myself out of dozens of rebuild jobs as a result of dispensing this advice.

Checking Shaft Play and Wear. [Inquiry] What does "checking shaft end play" in my turbo mean?

[Response: Adam/Dave] Check both front to back (axial) or sideways (radial) clearance. Axial play should not be noticable (< .008"), but radial play can be a max. of .022", which is definitely noticable. The radial clearance allows for a cushion of oil. Radial clearance may be noticeable but it still should not feel sloppy or have spots where you rotate the turbo and it has different play in different positions. When mine went bad I started to hear a ching kinda sound. I took off the intake hose and checked for play and sure enough the compresser blades could

be moved into the housing once I rotated it to a particular position. Look out for wear (small chips, rough edges) on the very tips of the compressor blades that give an indication of your air filtration quality over the years, and for rub marks on the alloy turbo housing from scraping outer blade edges.

Removing the Turbo Unit: Tips and Comments

[Tip from Rob Bareiss] Replacement of newer turbos is not bad as the older ones. There are water lines to deal with now, but they don't get in the way much. You might get real lucky and have a Mitsubishi turbo, which will make you happy. They're pretty easy to replace due to the way the studs face. If not, even with the Garretts, its' not as bad as it was. I always recommend replacing all the exhaust nuts, and to try to save the studs I split the nuts with a chisel. This can save a great deal of aggravation (it's an old VW trick- the studs on VW heads always broke). To identify if you've got a Mitsu or not, the Mitsu turbos have a big clamp in the center between the compressor housing and the exhaust-driven outlet housing. It's like a huge hose clamp made of stainless steel. If it's loosened up the two housings can rotate relative to each other (and it'll leak there). If you don't have this clamp it's not a Mitsubishi. A good many replacement turbos are Mitsubishis. Any case, good luck, hope you don't break any studs, and if you do, get ready to pull the head. Don't try to fix exhaust studs in place. [Removal Tip from John Sargent] The Mitusibishi turbos are made to be removed by removing the one bolt and the hinged clamp. No need to pull the manifold. It is the wastegate which remains fastened to the manifold. The Mitsubishi TD05 turbo used on 87-89 700Ts has the wastegate bolted to the turbo with bolts from the engine side of the exhaust manifold. In order to remove the wastegate, you have to remove the exhaust manifold. The Mitsubishi TD04H used on the 90-93 700Ts and 900Ts has the wastegate mounted to the turbo with nuts on studs which are on the manifold side away from the engine. On this turbo, you can remove the turbo and wastegate assembly without removing the exhaust manifold. Wastegates do crack and sometimes need to be replaced.

[Paul Demeo] Removing: Don't sweat the oil return line for now, you can remove the turbo with it attached. (You'll still have to go through the pain when reinstalling, but for now...) Easiest way to remove a Mitsu: There is a pipe-clamp-ish collar between the center section and the exhaust housing, which should come off very easily. Once removed, the turbo is held in place only by virtue of the fact that it's been there a while. A good thump with your hand and it should pop free, allowing you to pull it up and out with the drain hose attached.

[More tips] I'm writing now to say that I have completed the turbo replacement on my '84 240. Replacement was purchased from IPD and included everything needed (plus some duplicate gaskets with the watercooling conversion kit). IPD sent instructions, plus I had the Bentley book, and things were relatively straightforward except some hassle getting bolts off and back on in tight places. (It seemed to me

I needed to have two hands plus my head/eyes plus a light all in a space that was only big enough for any two of those at a time!) Another hassle was my error in putting the O2 sensor back in before the support bracket (mine's on the bottom); had to take the O2 sensor back out, then do this bracket, which also had spacers between it and the block. I finally figured out I could use masking tape to hold the spacers on the bolts in the bracket while I moved it up into position one-handed and got the bolts started. I've been driving it to work again this week, with no leaks, no smoke, and notably improved power. Should note also that doing it myself saved considerable money; counting new oil pipes (I reluctantly got both, but probably only really needed the "to" pipe) and the IPD costs, I had ~$900 in parts. Local dealer quoted a cost for the job at ~$2100, and one independent shop quoted ~$1400. You'll need the range of basic hand tools, PB Blaster or equivalent if there is one (I used it often, including on exhaust manifold and exhaust flange studs and did not break any of them), and I think a sturdy vice is a must as well to get the manifold and turbo separated, but it was overall not that difficult (at least now that I'm done with it!!) I did have to move the exhaust flange studs to the new turbo, but PB Blaster and the two-nut method worked OK. I at first put the propane torch to the old turbo intending to loosen the studs, but in retrospect it wasn't necessary, once I got the hang of the two-bolt method.

The parts and instructions left me with a pretty good feeling about IPD also (although they apparently just buy the turbo from a different company in Colorado and put it and a watercooling kit together in a bigger box).I don't mean this as an advertisement or a criticism; I'm glad I got the IPD kit and if an ordinary mortal like me can do this replacement, probably alot of others can too!

Installing a Rebuilt Turbo.

[Tips from Dave Schermbrucker] Just installed my rebuilt turbo (745); thought I'd pass on a couple of hints.

1. Installation should take about 2 hours. You will need to get under the car.
2. Try to install the oil drain line before dropping the turbo/manifold unit into place; it's real pain to connect the flange to the turbo core from below once the unit is in place. I say this because most turbo rebuilders and Haynes says to crank the engine a bit after installing, prior to connecting the oil drain, to make sure oil is running through the unit. Forget it. Just hook it up. If you're worried about oil feed, undo the top supply line adter installation to check that oil is getting through.
3. Alternative to 2: use small studs instead of bolts to connect the oil outlet; that way you're only struggling to mount some nuts on a couple of studs rather than trying to feed the bolts from below in an impossible location. I had to remove the wastegate actuator to get the bolts in; tricky and time-consuming.
4. Use new banjo bolts if you possibly can, since they make it so much easier to snug up the new copper o-washers on the oil and water lines.
5. If you have the oil filter sender assembly (most do) you'll need a 36mm socket.
6. You should remove the lower stud from the turbo exhaust-to-downpipe fitting; otherwise it's impossible to line up the turbo unit. After you locate the unit on the two upper studs, you can simply hand-thread the lower stud, then tighten all three.

7. Torque references: Exhaust manifold nuts are 10-20 ft-lbs (14-27 Nm). Turbo nuts to manifold are 22 ft-lb (30 Nm) but you will have to use a 90 degree extension on the torque wrench for access. Tighten in a 1-4-2-3 pattern starting with the top rear as "1" and then going clockwise around the nuts ending at the bottom rear. Exhaust pipe to turbo is 22 ft-lb (30 Nm). Cat to exhaust pipe is 18 ft-lb (24 Nm)
8. Otherwise it's a total breeze.

Changing Turbo Brands:

[Tips from Fox] I went the route of changing brands from a Mitsubishi to a Garrett. I will say - ask questions of people that have already done it. There's a lot of little things that come up, but if you know in advance, it's not too bad. The biggest thing for me was I didn't realize you had to replace ALL of the oil and water lines - even the ones that look like they'll fit - the fittings are different sizes. Past that, if you can get a junkyard manifold for the brand of turbo you want, it should go pretty smoothly. It took me a week to get mine running again, but that was because I didn't know quite what I needed. Now that I do, it is just a matter of getting everything beforehand, and then doing the turbo swap, which shouldn't take more than about 6 hours of working time. And FYI, supposedly my turbo (Garrett) was machined to fit a manifold from a Mitsubishi. I will say that it fit on my stock maifold perfectly, but I can't tell if it really was machined. If so they did a hell of a good job. Look into that if you really want to switch brands for some reason. I switched because I got a higher flowing turbo (500+ CFM @ 15psi) for $750. That was the lowest price I found locally, for either brand, and I didn't want to buy a turbo online.

Clean or Replace the Oil Return Line?
[Dick Riess] If your turbo is under warranty, the warrantor will insist on a new supply line. Reason: coke can chip off and destroy your bearings in the turbo. I really believe in buying a new supply line. [Response: Hermann of Cherry Turbos] The chemicals, time and elbow grease needed to clean the line out are no guarantee that all the coke inside the line is gone. Because the coke is so brittle, it can crack and release just from a heat cycle. Ultrasound would actually be the only safe way to clean the coke out. Buy yourself some peace of mind and order the new line.

Turbo Rebuilders and Doing It Yourself
Rebuilding Turbo at a Shop.

[Inquiry:] The wife's 940 Turbowagon will require a turbocharger replacement in the near future due to oil leak from the turbo itself and the presence of oil in the ductwork into the intake manifold. I found a shop in Rancho Cordova, CA called Volvo & Saab Auto Dismantlers (http://www.vandsautodismantlers.com/). They have a complete turbo replacement for the above car with a 3 month warranty. They are asking for $350.00 and $35.00 deposit for the returned unit. This price looks pretty good in comparision to a new unit from IPD at $1000.00 and approximately $800.00 from Stillman Volvo. [Response 1: Philip Bradley] Your existing turbo can be rebuilt unless the bearings have worn so much that the shaft wobbles and the blades have worn or scraped the sides. The typical rebuild price is around $300. Numerous shops can do this. Check your Yellow Pages. There are

also mail order shops that advertise in Turbo and Hi Tech Performance Magazine.

Oil in the intake hoses is not uncommon. In fact, there is a drain plug in the bottom of at least the pre-1992 intercoolers. Oil drips at the turbo could be due to the oil feed or return connections. The gaskets or copper o-rings can be replaced. On the other hand, your bearings could be slowly going. Sometimes changing to a thicker oil helps. The most definitive test is the shaft wobble test. Remove the rubber intake to the turbo, grasp the center of the shaft and try to wobble it side to side. Anything over about 1/16 inch is a sign of wear. The more the wobble, the worse the wear.

[Response 2: Gary DeFrancesco] I would agree with Philip. Make sure the turbo is not loosing oil due to dumb leaks. The oil supply and return lines can leak and make a mess. A common leak is where the oil return lines goes into the block. The o-ring here will degrade with age and heat, and leaking can be pretty bad. Sometimes poor crankcase ventilation will cause this o-ring to prematurely fail. So make sure the vent system is working properly. (Do the oil filler cap jiggle test.) A film of oil in the intercooler and associated plumbing is not uncommon. A thick/runny film is too much.

If it is determined your turbo is dying, there are a number of options to consider. I talked with Volvo&Saab Auto Dismantlers last fall when I was looking for a transmission for one of my 740s. The people I talked with seemed knowledgable. The used turbo they are willing to sell you sounds interesting. Do they know how many miles are on the turbo? Don't want to get a high mileage unit and face this problem again in the near future.

Turbo Rebuilders. In the US: There are a few places that do turbo rebuilding. Try D&W Diesel in Auburn, NY. 315.253.2324. Generally speaking, the cost for rebuilding a turbo is around $350. More if an exchange is the better way to go. Sure beats dealer and IPD prices. The catch is, you have to R&R the turbo yourself or work with a cooperative shop. [Response 2: Thomas] Noticing the recent messages of people rebuilding there turbo's. I thought everyone would appreciate some info on an excellent turbo builder out of Golden Colorado. I have dealt with them and also I know that the local Volvo shops use them as there turbo supplier. What you may say is so great about these guys? There turbo builds are inexpensive. I have been quoted $200-350 (roughly) for a cartridge, and $350 to $450 new complete,(don't forget your core) depending on year model and if you want to convert to water cooled.Call them for a quote to get an exact figure. I have found they are about half of what everyone else is and I know they give quality products and are the nicest people! Anyways there names are Turbocharge Engineering Corp,(303)271-3997. Hope this is helpful! [Response 3] Try Turbo City - California.

In the UK: Try Turbo Technics

Rebuilding Turbo Yourself. *Instructions:* [Editor] See a complete, illustrated article showing the procedure for a Volvo turbo rebuild (in this case, a Garrett unit) from Import Car Magazine, excerpted in the FAQ file. That file has further references to illustrated instructions.

[Randy Starkie] See the links for rebuilding tips for Mitsu turbos:

Mitsubishi TD05/TD06 Part 1
http://www.dsmtuners.com/forums/articles-turbo-system-intercooler/303828-td05h-td06-turbo-rebuild-part-1-a.html

Mitsubishi TD05/TD06 Part 2:
http://www.dsmtuners.com/forums/articles-turbo-system-intercooler/303829-td05h-td06-turbo-rebuild-part-2-a.html

Parts: See also http://www.turbocity.com or http://www.dwdiesel.com or http://www.gpopshop.com for repair kits, cartridges and rebuilt turbos. See http://www.turbocharged.com/main.htm for upgrades and service. Try http://www.majesticturbo.com/
[Tip from Paul Demeo] I recently rebuilt my Mitsu TD04. Piece of cake. If you're able to do a timing belt, you can do this. I bought a bearing and seal rebuild kit for $120 and paid $30 to have the shaft and wheels balanced at www.unitedturbo.com. To balance a turbo they need the shaft and wheels plus the thrust collar. These parts are not in the turbo rebuild kit. If you wanted to buy the complete center section then the shaft, wheels, center casting and internal parts would come all assembled and balanced. Your cost on the exchange center section would be around $395.00. Contact Chet Greenwood at United Turbo Co / Custom Driveshaft, 1757 Route 9, Spofford, NH 03462, 1-800-779-1780

Turbo Plus System

[Inquiry] My mechanic told me my 1991 940 Turbo Sedan has the Turbo+. All I know about Turbo+ is that it was a dealer-installed option, it cost about $800, and that it adds about 20 or so more HP under boost (info from Turbobricks.com). Is the above info correct? If so, how do I identify the components of a Turbo+ system?

[Response: George Chow] If you want to positively identify it yourself, look at your airbox. There should be an extra black electronic box on the face of it facing the front of the car. This should be easily seen with just the hood open. You should also see some extra plumbing from the turbo wastegate to a gadget mounted on the airbox. The Turbo+ works by effectively raising the boost level at WOT. The spec for your engine with Turbo+ is about 187hp/205ft-lb. Because it only kicks in at WOT, it's unlikely to affect your city mileage. [JohnB] Turbo+ works on full throttle (switched at throttle body) and above 4000 rpm so you probably wouldn't notice it around town.

Volvo Maintenance FAQ for 7xx/9xx/90 Cars
