# Volvo D2-75 Turbo: Soot Cleaning and Carbon Burn Data

## Introduction

While changing the Turbo of the Volvo D2-75 on our sailboat Fabule, we found an answer to an ongoing question: does increasing the RPM while using the engine help cleaning the soot of the turbo? We also investigated several common issues of the Volvo D2-75 turbo, such as:

- Exhaust elbow corrosion (all D2 engines)
- Wastegate getting stuck in closed position
- Turbo soot and corrosion state

Because this information is not easily available on-line, we decided to share our findings in this post together with our plan for the turbo care and maintenance.

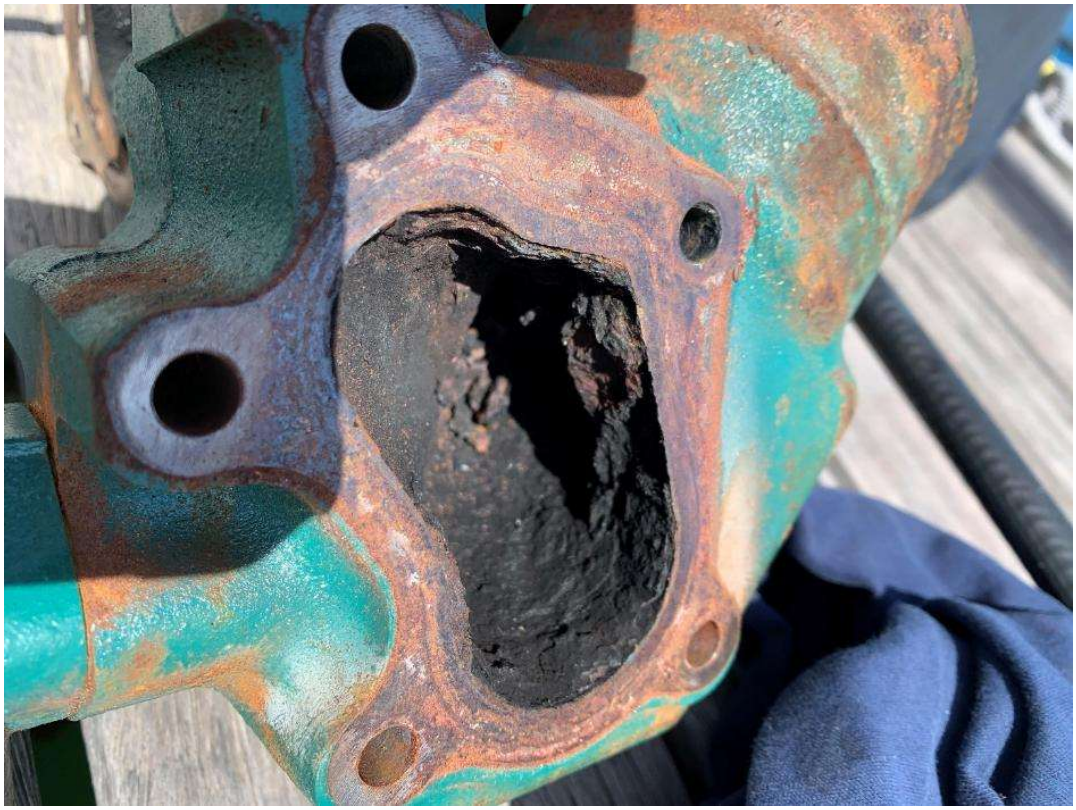
## The Story

This spring, we had to change the turbo on our Volvo Penta D2-75, as the engine was only able to increase the Revolution Per Minutes (RPM) up to 2700 RPMs, even when the boat was at full throttle for 10 minutes. This clearly indicated a problem with the engine.

Upon recommendation from Andrew (L'Elephant, B47.2) we procured a stainless-steel exhaust elbow to replace the standard Volvo elbow. The part was ordered at Parts4Engines in the UK. It comes with the L-pipe attachment and the water pipe gasket and Turbo hot gasket. In parallel, we ordered a new raw water pump from SVB and we added the turbo and the engine exhaust gaskets to the purchase, just in case.

Dismounting the original Volvo iron cast elbow, we could see right away that its exhaust side connected to the exhaust tube and the waterlock was seriously corroded. The exhaust side after the water injection looked like it had spent a century underwater. Therefore, it was time to change it by a new one in inox.

Severely Corroded Exhaust Elbow After Water Injection.



Severely Corroded Exhaust Elbow Turbo Hot Outer Chamber Side.

We initially just wanted to replace the exhaust elbow but discovered that our turbo wastegate was jammed shut solidly. In addition, the inside of the turbo exhaust outside chamber, that connects to the elbow, was severely corroded as well. Why?

Looking at the exhaust side of the turbo, my observations were:

1) The turbine of the turbo exhaust side was very clean. Almost no soot on the turbine.
2) The inside of the exhaust gas collector, between the engine collector and the turbine was also very clean, and had no corrosion (except for corroding the flange a little, due to a salt water ingress, see below)
3) There was significant corrosion on the turbo exhaust chamber after the turbine, as if it had been exposed to sea water. What the hell?
4) The wastegate was jammed solid by corrosion and almost soldered to the housing. This one will never open again. I tried to open it with the big hammer to no avail.
5) The conclusion was clear: the turbo needed to be changed :o(

Outer Chamber of the Turbo After the Turbine and the Turbine. Note the heavy Corrosion near the Turbine which Impedes its Rotation a Little.

Turbo Exhaust inside Chamber Before the Turbine1. No Soot Accumulation there.

Turbo Exhaust inside Chamber before the Turbine 2. No Soot Accumulation but Corrosion Where the Turbine let the Hot Gaz into the Elbow. Please note also the alignment pin.

Turbo Exhaust outer Chamber before the Turbine 3. Heavy Corrosion Burr where the Turbine lets the Hot Gaz into the Elbow.

Furthermore, the outside casing of our turbo had a lot of rust. During Fabule's test sail with Boréal, a wrongly mounted seal of the dagger board casing had caused the ingress of a huge amount of salt water, which made its way from the lazarette to the engine compartment and to the bottom of the boat. Salt water got splashed everywhere by the Vetus Coupler who was bathing in salt water: it splashed on the engine chamber, on the engine, and more particularly soaked the thermal blanket over the hot part of the turbo. This explains why the outer part of the turbo casing became a rusty piece of iron.

Rust Bucket Turbo Housing on the Hot Side.

Anyway, since the turbo was clearly dead after only 1600h hours, we ordered a new one from MarineDustrie in the Netherlands. This is the best deal I could find but it still will make you lighter of about 1200 Euros with the shipping and the Turbo Mounting kit.

New Spiffy Turbo Assembly from MarineDustrie.

Mounting the new turbo on the engine was easy. One key point is to inject engine oil on top of the turbo oil intake and to turn it by hand to spread some oil in the turbo bearings to lubricate them, before connecting in intake turbo oil line to the turbo. They graciously provide a syringe in the assembly bolt and nuts kit (sold separately) for that. Furthermore, IHI, which manufactures these turbos for Volvo, recommended to run the engine in idle for at least 10 minutes, so that a nice flow of oil comes lubricating the bearings before making the turbo work harder and hotter.

Spiffy New Turbo Mounted on the Engine. Note the Inox Exhaust Elbow.

The next step was to start the engine after a last verification: no nut lose, no pipe and hose missing, water added in the strainer to fill in the raw water pipes as much as possible, strainer cover on and tightened and raw water intake valve opened. Ready to start!

The engine started well, the raw water circulated and got to the exhaust. No leak of exhaust gas by smell, or salt water by visual inspection. Good.

We let the engine run idle for a good 15 minutes, never too cautious, the temperature of the engine was at 45°C. Then we engaged the propeller and revved the engine to 1300 RPM: still good. We kept 1300 RPM for half an hour and the temperature increased. But something was wrong: The engine temperature stopped increasing 10°C lower than usual.

What the hell was happening? Did I forget something?

We tried to increase the revs to 1500 RPM. The boat was getting a bit restless in its harness of mooring lines, and the catway complained a bit, but all seemed OK. Again, no water under the engine, and no oil spilling. Still good to go.

We let it run at 1500 RPM for 20 minutes. The engine temperature only reached 71°C, while before the turbo replacement, at the same RPM level, the temperature reached 81°C.

At that moment, I saw the light, like Jake and Elwood Blues saw James Brown's illumination.

The answer was so simple. Here is what happened:

1) Over time the exhaust elbow started corroding. Corrosion started to clog the raw water injection ports that mix water to the hot exhaust gas and cool them down.
2) As the elbow further degraded, sea water started splashing in the turbo exhaust outer chamber which shows heavy corrosion, but could not pass the turbine. This explains why only the outer chamber is corroded and not the inner chamber between the exhaust collector and the turbine.
3) The soot and the corrosion blocked the wastegate which got stuck.

4) As corrosion further progressed in the elbow, the holes of the water injection became more and more clogged, slowly raising the raw water circuit pressure after the impeller Johnson pump.
    a. Higher pressure created a leak at the output hose connection of the pump that we witnessed,
    b. Higher raw water pressure also compressed the pump shaft seal on the shaft, creating increased wear of the seal which started to leak, (symptom that we discovered while motoring back to the Canary Islands after breaking the spinnaker halyard), leading ultimately to an accelerated failure of the raw water pump.
5) Corrosion in the part where the exhaust turbine of the turbo is located also lead to a slight impairment of the turbine rotation on the corrosion burrs.
    a. The turbo efficiency decreased and the engine could not reach the nominal 3000 RPM, but only 2700 RPMs, in conjunction with the wastegate blockage,
    b. The exhaust gas pressure also increased due to the impairment of the turbo exhaust at lower RPM values, and the blocking of the wastegate at higher RPM. **Conjecture:** As the exhaust path was impaired, higher concentration of burned gas remained in the cylinders before the intake of fresh air in the four stroke cycle and explaining why the RPM at full throttle decreased from 3000 to 2700.
    c. This higher gas pressure in the exhaust path before the turbine pushed oil from the Turbo shaft toward the air intake part of the turbo, leading to the oil leaks that are so common to the D2 turbo engines (a turbo is like a piston in an engine; it can never be perfectly hermetically sealed).
6) The whole turbo assembly had to be replaced.

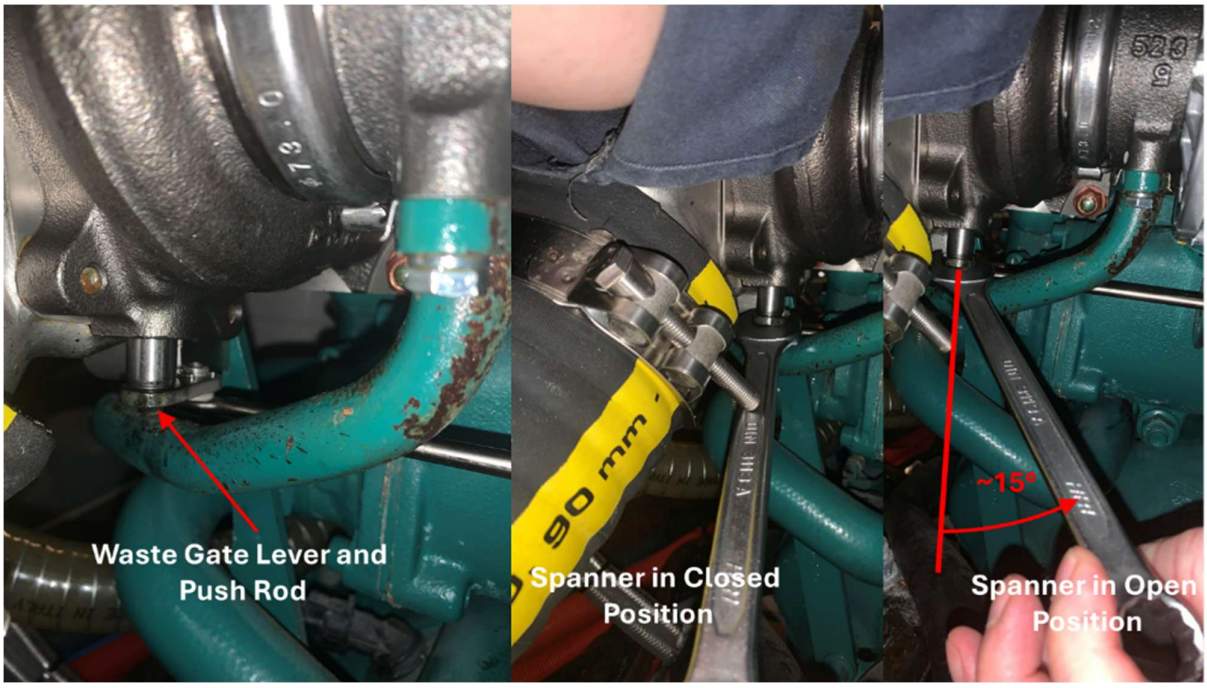
## Turbo maintenance recommendations for Volvo D2-75 (probably OK for D2-60 too):

From the post-mortem study of our turbo, a couple of saliant points emerge:

1) Carbon burns are effective. On Fabule, we did 5h at the RPM of your choice, 1200 to 1800 depending on the conditions, and 1 hour at 2300-2400 RPM to burn the carbon. This was probably overkill as the turbo was really clean even after 1600h. However, such RPM values for the carbon burn did not prevent the wastegate blocking.
2) To exercise the wastegate, higher RPMs values would be warranted. Volvo maximum nominal speed is defined as the RPM values at full throttle minus 300 RPM. So, in principle we could go up to 2700 RPM to exercise the wastegate regularly.

**On Fabule we will try the following from now on**:

1) Approximately 5 hours at whatever RPM we need. If they are lower than 2300-2400 RPM, we plan to modify the carbon burn as follows:
    a. Above 2300 RPM for 20-30 minutes,
    b. 10 minutes above 2700 RPM to open the wastegate.
2) From time to time we will verify the correct opening of the wastegate with a **16mm spanner** or a wrench. See the picture below for the movement of the gate opening.




Exercising the wastegate from Time to Time. Direction of the Gate Opening. About 15 degree movements only.

With the inox exhaust elbow we should not have any serious problems of corrosion in the future. But from time to time, it would be good to dismount the elbow and verify the unimpaired rotation of the turbine. **Be careful to open the raw water strainer cover and close the intake valve at idle to empty the raw water circuit and to switch off the engine right when the circuit becomes empty at the exhaust elbow**. You may damage the raw water pump impeller if you run the circuit dry too long. Before starting again the engine, fill-up the strainer with tap water until the top, place back the strainer cover again and open the raw water intake valve. Verify the flow of water at the exhaust elbow once that the engine is started and running idle.

In case the rotation of the turbine is not as free as before, because of soot or a bit of corrosion burr, it is simple to dismount the turbo and remove the soot or the corrosion to free the turbine.

1) Dismount the turbo to have it on the bench, and cover the holes left open in the engine and the oil drain and intake pipes; you don't want any debris getting inside and damaging the engine. Do the same for the oil intake and drain holes on the turbo. A piece of wrapping plastic foil with rubber bands will do, and if you are fancy, use a bit of cleaning paper to catch the dripping oil from these two holes before putting the plastic wrap.
2) Disconnect the wastegate push-rod coming from the actuator from the wastegate lever. There is a circlip to remove simply before disconnecting the pin from the wastegate lever.
3) Remove the C-clamp by untightening the screw, and open the hot part of the turbo to free the hot turbine from its chamber. (see picture) Be careful to not bump the turbine in the process, so pull open along the turbine shaft axis
4) Remove what needs to be removed, soot or corrosion burrs,
5) To remount the hot chamber on the turbine, use the alignment pin and hole (see picture), and remount the C-clamp.
6) Re-connect the push-rod of the actuator to the wastegate lever. Verify the functioning of the wastegate for good measure.

7) You can remount the turbo on the engine.

Opened Turbo Exhaust Chamber. Please note the alignment hole and pin in the assembly to accurately remount it after cleaning.