This section of the TurboDirect web page serves to provide an insight into the various kinds of turbocharger failures that occur on a daily basis. Every day, we receive failed turbochargers for inspection and failure reports from companies, mines, fleet owners and members of the public. The common factor in all of these, is the fact that their turbochargers have failed and they would like to know why. The majority of these customers have had previous experience with turbo “specialists" in the market with unsatisfactory results, and often with repeat or continuous turbocharger failures.

In many of the cases, these repeat/continuous failures are not due to faulty or defective product supplied, but instead due to incorrect installation, or an engine component that is the cause of failure or incorrect operation of the turbocharger. Approximately 85% of all of the privately installed passenger vehicle turbochargers have failed due to lack of training and poor knowledge surrounding turbochargers and related components. no less than 65% of turbochargers installed by vehicle agents have failed due to the same installation mistakes. A turbocharger is not in any way or form similar to any other engine component like an alternator, air filter, timing belt or oil pump for example. The turbocharger is a highly intricate and complicated automotive part, and requires a special skill set to understand, handle, remove and install. Due to the nature of the product and the extremely high speeds and temperatures that a turbocharger operates at, without this qualification, it is not possible to replace a turbocharger on an engine correctly and reliably. This is the very reason that TurboDirect consult to many fleet companies, turbocharger specialists, and workshops for correct installation and assistance with forensic failures relating to turbochargers and related components.

In this document we will cover some of the popular causes of turbocharger failures, and i will provide examples of these in the form of previous written failure reports, in order to further educate and outline the most common causes of turbocharger failures on vehicles today..

Before we commence, i would like to mention that the information and reports provided herein have been written by officially educated and authorised personnel. All of the training hereto has been done at Honeywell Official training centres and manufacturing plants around the world. All personnel who has achieved the official training, have official certification in order to prove this level of education. Be sure to request this certification from anyone claiming to be qualified to write a failure report. To date, select TurboDirect S.A are the only company in AFRICA with official, Honeywell failure analysis training, and we are proud to mention that we are the only turbocharger distributor on the African continent who employ qualified Metallurgical expertise in-house.

None of the information in these reports are based on opinion, but instead 100% factual, and can be verified by the manufacturer of the turbocharger at any time.

What are the 4 “big killers” of turbochargers? **(excerpt from our official training program)**

1) Oil Contamination
2) Lack of lubricaiton
3) Foreign object damage
4) Exceptional operating conditions

OIl Contamination

Oil contamination and lack of lubrication failures are one of the most simple failures to identify as the result of these types of failures are clear and definite. To locate the primary source of contaminated oil, is very difficult as the oil is supplied through a complex and long supply from the engines sump to the oil filter, pump and passageways in the engine itself, and finally through the oil feed line into the turbocharger, where it passes once again through a complex oil gallery system to the bearings. The culprit/contaminants inherently exist within the oil channels and passageways leading to the turbocharger inlet. The oil inlet line from the engine to the turbocharger itself, often routes near or over the turbocharger, turbine housing and/or exhaust manifold. This is the worst possible place to route an oil feed, but because of where the pipe needs to provide oil to, it is unavoidable. The oil feed line is often made of a steel pipe, and bolts onto the turbochargers bearing housing with a fitting known as a Banjo bolt, or ferrule type fitting depending on the turbocharger. Due to the high temperatures that turbochargers operate at, the oil feed line is continuously subjected to temperatures upwards of 650deg celsius. Once the engine is switched off after use, the turbochargers temperature is still at high, and acts as a stove plate in the engine bay. Everything around the turbocharger heats up until the heat is dissipated. Keep in mind that the closest component to the piping hot turbocharger is the oil feed line. In a passenger vehicle application the inside diameter of the pipe is 3mm depending on the vehicle. The amount of oil inside this pipe is minuscule, and heats up extremely fast, exceeds its flash point (thermal ceiling) to the extent that it burns. The result is carbon build up inside the oil feed line. The carbon builds up by attaching itself to the inside of the feed line, over time this eventually blocks the line completely, starving the turbocharger of oil, leading to the initial turbo failure.

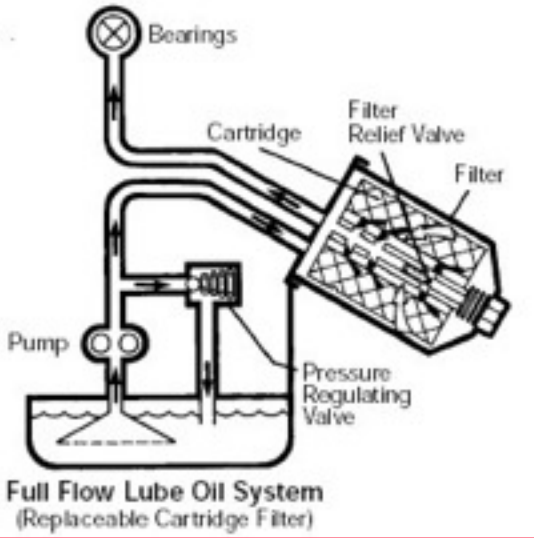
Herein lies the oil contamination failure. The owner of the vehicle removes the failed turbocharger, and by doing so, removes the oil feed line, during the removal of the oil feed line, the pipe is worked on and because turbochargers install into very confined spaces, the feed lines are normally manoeuvred and bent slightly in order to remove the turbocharger from the vehicle. Manoeuvring the oil feed line during the turbocharger removal and re-installation process loosens the carbon build up inside the pipe and by the time the new turbocharger is installed, and the engine is started for the first time, the loosened carbon, now flows directly into the new turbochargers bearing system. Most mechanics claim to have cleaned out the oil feed line - Carbon cannot be broken down by de-greaser, or compressed air and is resistant to some caustics. In extreme case, the carbon build up is so severe that the oil passages which carry oil into the turbochargers bearing system (0.8 - 1.2mm diameter) are blocked and the turbocharger fails almost immediately due to lack of lubrication - this is the different failure illustrated below. In either case, the installer has replaced both engine oil, and oil filter, and refuses to believe that the turbocharger failed due to either lack of lubrication of oil contamination. But the facts are facts, and the failure is clearly visible by the failed components. What the installers don't know is that no matter what - if you replace a turbocharger, you must also replace the oil feed line every time! Keep in mind that the oil feed into the turbocharger has no filter on it. the oil is filtered by the engine, at the engine itself. After the oil is picked up inside the engines sump, it is filtered before being supplied to the engine and related components.

Preventative maintenance tip: - Replace the turbocharger oil feed line after every 60 - 80 000 kms, vehicle specific.

Lack of lubrication:-

Lack of lubrication is simply no oil supply to the turbocharger. This failure is once again extremely

Air trapped in pickup tube causing cavitation of pump and lack of oil flow

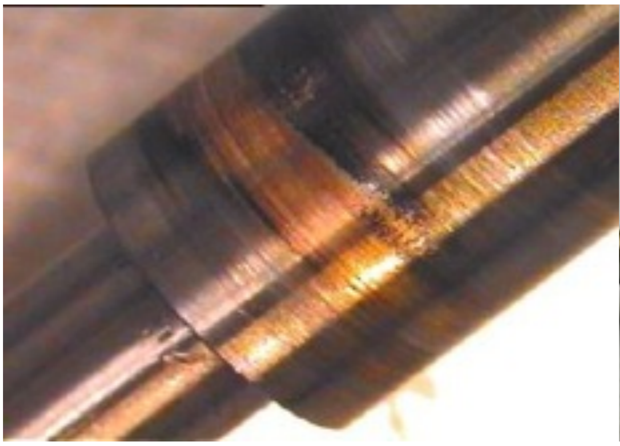


easy to identify, but difficult to locate the cause. Once again due to the complex oil supply system inside the engine and through the turbo feed line, determining the exact cause of the oil blockage is difficult and can be one or more of many possible components on the engine. The following is a list of possible causes of lack of lubrication.

- Faulty oil pump
- Blocked oil pickup
- Sludge buildup in the oil pump
- Sludge buildup inside the sump
- Low oil level
- Blocked oil feed line
- Kinked or bent oil feed line

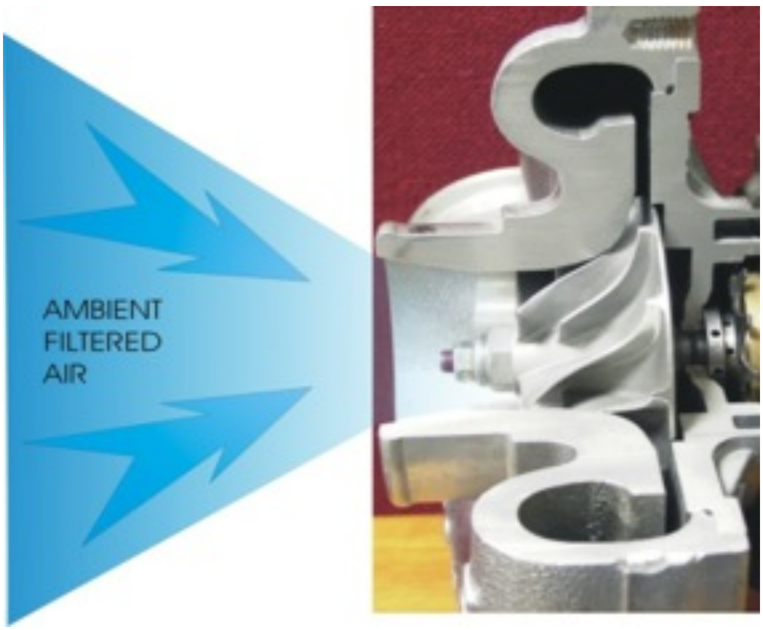
•Contaminated/carbon filled oil feed line
•Sludge buildup lodged inside the turbocharger's oil passageways
•Use of oil additives which causes "caramelisation" of the oil, blocking passageways
•Other

The average passenger vehicle turbocharger (petrol or diesel) rotates around 7000 - 100000RPM at engine idle speed, vehicle dependant. At this speed a 10mm turbine shaft rotating inside a bronze rotational bearing is covering 5.23 meters a second - remove the oil, and the result is a a thermal overload, causing what we term in metallurgical terms “Material Transfer” also known as a seizure. This is clearly visible and depicted as a bronze discolouration on the shaft. What occurs inside the bearing system is simply the thermal ceiling of the bronze bearing reaches its ceiling (maximum temperature) before the hardened steel shaft, and “swipes" itself into the steel shaft.



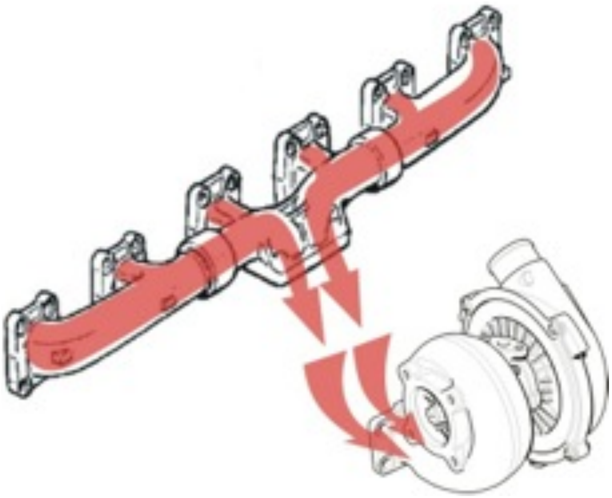
This “swiping” effect is bearing material being removed and “smeared” onto the shaft or thrust collar/spacer etc, the clearance (oil gap) between the shaft and bearing will then increase as a result, and will continue to do so (even if the lubrication to the bearing is restored) until there is enough clearance between the rotating components to allow the wheels to make contact with the end housings. The immediate reaction by the customer and installation mechanic is that the turbo was supplied with faulty bearings form the factory or the product is a poor quality product. This is not the case at all, as every turbocharger in the same batch would then be faulty.

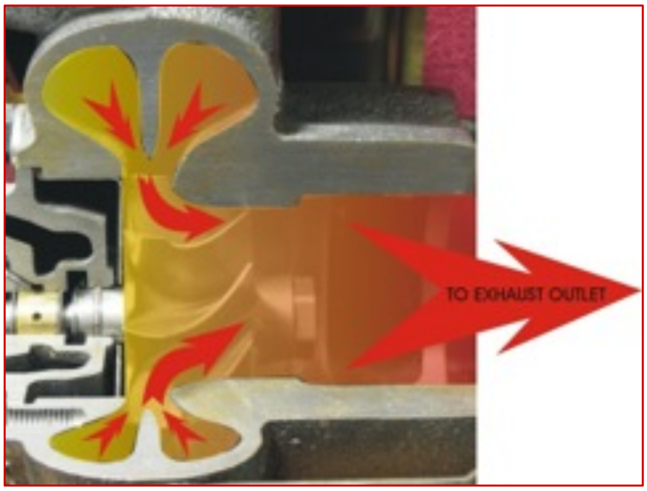
Foreign object damage:



Lets talk about foreign object damage. Otherwise known as “FOD" this is the quickest failure to identify, however in some cases very difficult to locate the primary mechanism associated with the failure itself. FOD can occur on two possible entries to the turbocharger. One on the turbine side, and the other on the compressor side. The inlet to the turbine side of the turbocharger is through the exhaust manifold, via the turbine housing and directed straight into the turbine wheel inducer. The opposite compressor side draws air in through the air filter, and into the compressor housing inlet, directly to the inducer of the compressor wheel.

On the turbine side, there is no filter between the engine and the turbine wheel inducer. On the compressor side, the only component protecting the aluminium made, compressor wheel is the engines air filter. If this air filter is old, damaged, or of the incorrect grade, debris will be allowed to

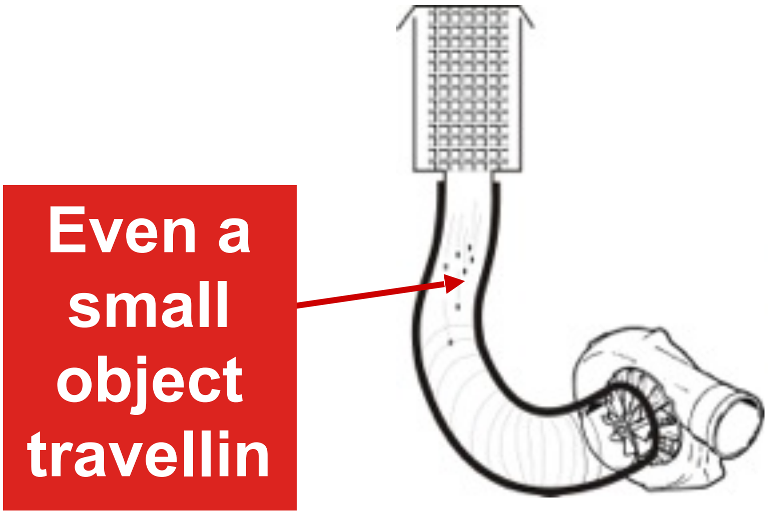




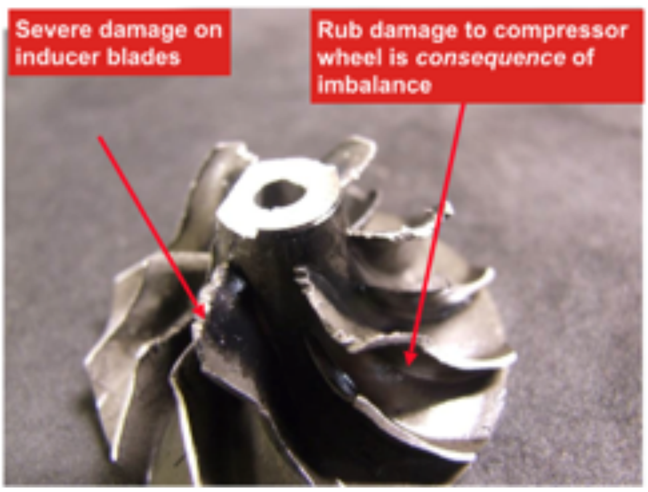
pass through the filter, or the filter itself might be in poor condition that part of the filter material itself will pass through into the compressor wheel inducer blades. In either case the compressor wheel will suffer damage sustained to the leading edge of the blades. Because the compressor wheel is made of aluminium, it is easily damaged by foreign material. Other components which often cause FOD on the compressor side of the turbocharger are auxiliary pipes connected off of the air intake tract, leading to breathers, and charcoal filters for use with EGR (exhaust recirculation) valves etc. If any of these components have failed, or are in poor condition, or have cracked or damaged pipes, dirt and or debris or broken pieces of the components themselves can be drawn into the intake and directed into the compressor inducer.

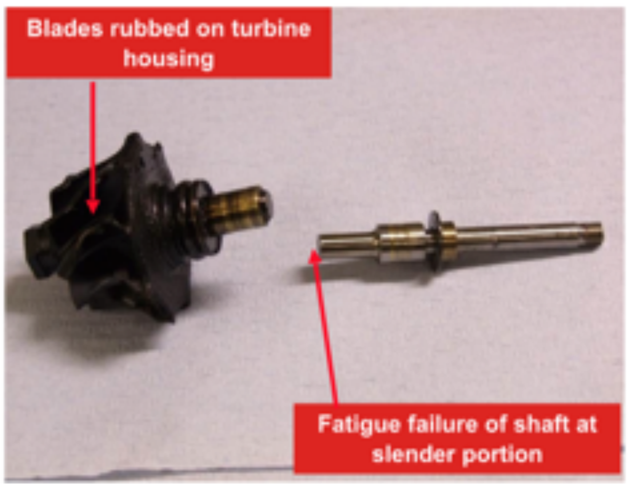
A Personal friend of mine, who is a qualified mechanic and has over 30 years of experience working on cars, and specialises on turbocharged applications, recently had a FOD damage sustained to his VW Caddy turbocharger. He fitted and removed the turbocharger to his Caddy personally. The failure occurred 5 consecutive times, and after checking all the piping numerous times, it was found that one of the breather pipes which attaches to the tappet cover and a small plastic filter ontop of the tappet cover itself was damage inside and small pieces of plastic were being drawn into the turbo each time, causing the FOD. The only way we found this out, was by removing the taper cover and inspecting the cover form the inside. We noticed that the filter didn't look quite that good, and after cutting it open, we found the culprit. The tappet cover had to be replaced as the filter body was cast as one piece with the cover. Once again the facts remain visible and the damaged blades provide proof of a foreign body causing the damage. Other possible causes of FOD to the compressor side of the turbocharger are listed as follows

- Incorrect air filter grade or Cone filter upgrade
- No air filter
- Old/Damaged air filter
- Damaged/cracked Air intake tract
- Breather related pipes connecting to external components which might be damaged
- Faulty/Damaged EGR valve
- Other



On the turbine side, manifolds crack over time, and pieces break off with extensive use. These pieces are routed directly into the turbine wheel inducer and cause damage to the turbine wheel blades. Often during removal and re-installation of a failed turbocharger, mechanics either leave rags inside the manifolds, or loosen old fasteners from the turbocharger, and sometimes these snap off and small pieces of the broken fastener fall into the manifold unbeknown to the mechanic.





Once the new turbocharger is fitted, the engine is started and the exhaust gasses deliver these foreign objects straight into the turbine wheel blades. Failed engines or engines with dropped valves or other similar failures/problems will also cause similar FOD.

-The outer diameter of the turbine wheel has damage edge with deep “cuttings” probably caused by foreign object (*“Washer”*).

- The shaft was supported by journal bearings which kept it in straight position from which I assume that there was no direct contact of the wheel with the shroud or turbine housing.

Although FOD on the turbine side is the least common of the two, it does happen. This can clearly be seen by bent turbine wheel inducer blades. In almost all cases, it is argued that the turbocharger supplied was faulty or of poor quality, however once again facts are clearly visible by the bent/damaged blades. Keeping in mind that the turbine and compressor wheels make no contact with any component during normal operation, it is not possible for either of these wheel’s blades to simply bend or become damaged without something coming into contact with them. Other causes of FOD on the turbine side are listed as follows

- Faulty/damaged catalytic converter
- Modified, or performance exhaust upgrade
- Repaired/welded exhaust manifold
- Cracked exhaust manifold
- Engine failure or component failure on an engine

<u>Excessive operating conditions</u>

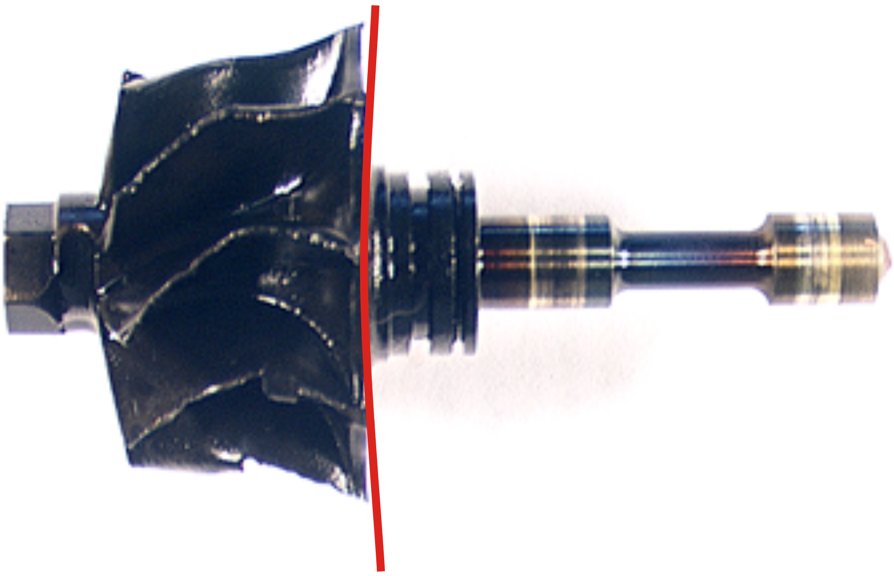
The last of the 4 main causes of turbocharger failures. This is quite simply described as "operating outside of the intended design parameters of the turbocharger” In most cases we are provided a turbocharger which has failed through various causes, and many times, this is due to chip upgrades, incorrect boost settings, racing upgrades carried out to the turbo/engine etc.

It is easily detectable from inspecting the turbocharger, and verified through metallurgical analysis of the materials and other components inside the turbocharger. In most cases over boosting (chip tuning, race chips, tuning boxes etc) installed onto the vehicle will increase both fuel pressure, injection timing, and obviously boost pressure. Increasing boost pressure increases the rotating speeds of the turbocharger. As it is, the normal operating speeds of a turbocharger found in a passenger vehicle is 100 000RPM PLUS. In some cases we have seen rotational speeds close to 240 000RPM which far exceed the maximum tolerance for the turbochargers intended purpose and design.

The failure of which usually results in either a thrust assembly failure and/or compressor/turbine burst. In the cases where the thrust fails first, clear signs of a metallurgical term known as "orange peel" can be seen on the compressor wheel base (showing a deformation of the materials structure)

This can be confirmed with metallurgical equipment in the form of a scanning electron microscope and other equipment. Deformation of the turbine wheel base will also be visible and clearly depicted with the use of a shadow graph machine.

In almost all cases, a failed turbocharger tells a story, which to a trained eye is confirmation of the cause of failure. I have mentioned and covered the basics of the 4 main and most popular causes of turbocharger failures, but not all of them. In some cases there is a dual or tertiary failure, of which the primary failure mechanism would need to be determined. I have attached some pictorial references for you from the official Honeywell training material, aswell as a failure reports relating to each of the mentioned failure mechanisms above.



There are many variations, and additional causes of failure relating to the demise of turbochargers, which are not mentioned here, as this subject becomes exceptionally complex. For simplicity reasons the article is kept as simple and short as possible.

For assistance or advise with a turbocharger failure, please contact us(hyperlink)