



ABOUT US

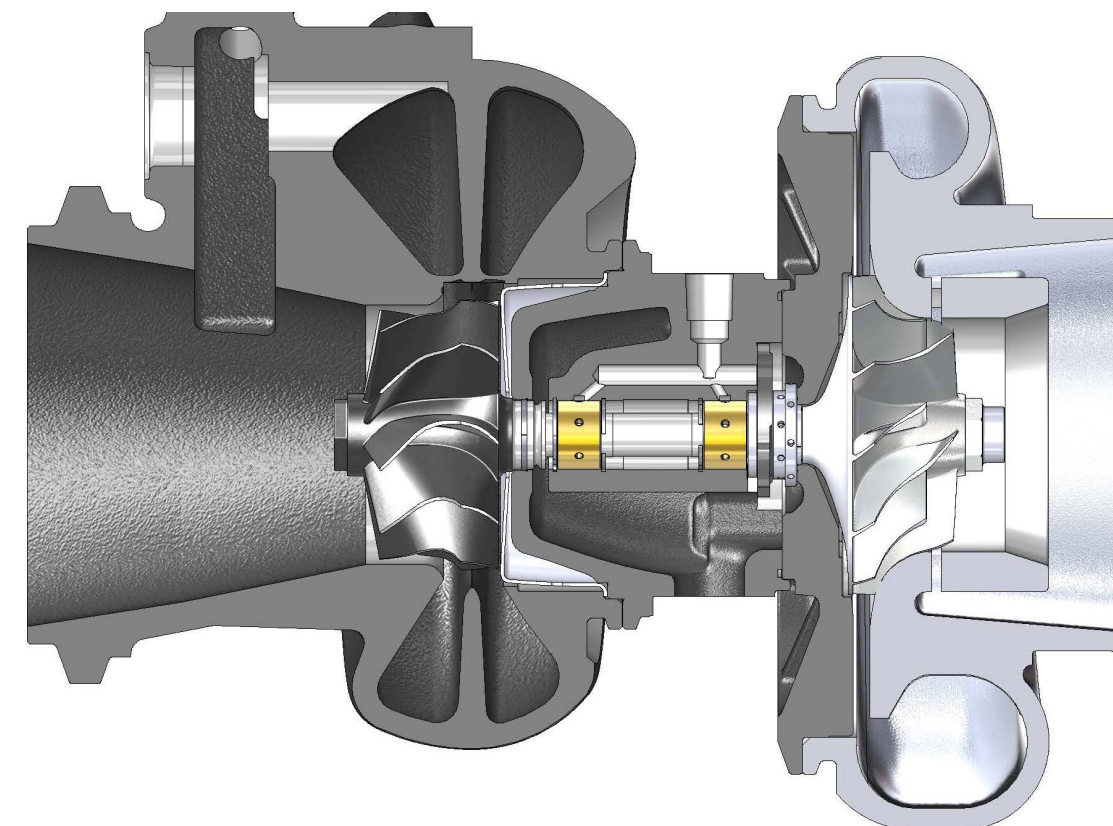
Rotomaster is a turbocharger manufacturing company driven by customer demand and focused on our customer's success.

The quality put forth by Roto is world class utilizing modern CNC (Computerized Numeric Controlled) machines, precision measuring equipment, and state of the art balancing machines (VSR). Combining these assets with a certified Quality Management System (ISO9001:2008) ensures our product is accurate and consistent.

Roto also houses a custom designed turbocharger testing facility which allows us to reproduce application specific parameters such as temperature, mass flow, pressures, etc. This testing facility is capable of producing complete compressor and turbine wheel characteristic maps. We are continuously testing our product through a multitude of endurance and diagnostic tests.

Rotomaster aims to protect its turbocharger distributors and be loyal to their needs.

**The aftermarket is our market,
Not an afterthought!**



18940 94th Ave, Surrey
BC, V4N 4X5, Canada
Toll Free: 1-888-800-3826
Phone: 604-888-3726
Fax: 604-888-5389

TURBOCHARGER WARRANTY ANALYSIS GUIDELINES

AUTHORIZED AGENT USE ONLY

Introduction

Rotomaster is a world class manufacturer of turbochargers dedicated to our customer's success and driven by customer demand.

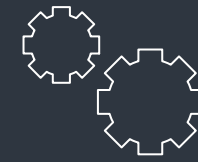
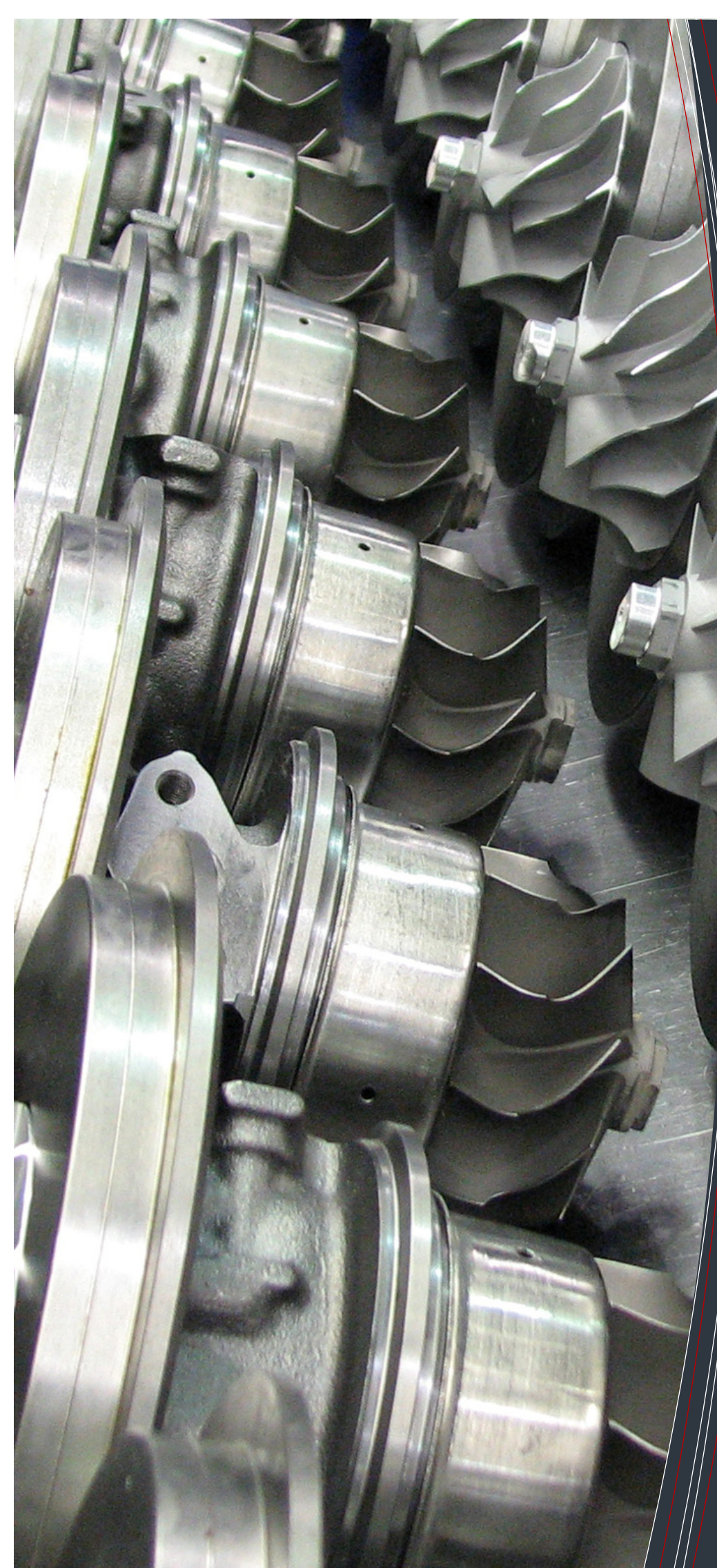
This text is designed to serve as a guide to in-the-field failure analysis of Rotomaster turbochargers. These guidelines, combined with experience, will assist individuals in isolating the cause(s) of failure. It will also discuss proper maintenance procedures and possible indications of premature failure.

It is hoped that this text will aid in all daily activities related to preventative maintenance and troubleshooting of turbochargers.

Prior to disassembly and component examination of a failed turbocharger, it is critical to acquire as much information as possible relative to the installation, operation, and reason for removal. This information will greatly influence the failure analysis process and aid in preventing repeat failures.

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CUSTOM SOLUTIONS

Rotomaster is driven by customer demand and thrives on "in-the-field" information which can aid in the selection of new projects as well as many decisions regarding company direction. Please contact Rotomaster with any inquiries for turbocharger related products and we would be happy to assist you.



WEB SOLUTIONS

We realize the increasing demand for reducing company expenses and the increasing technical knowledge. That is why Rotomaster is putting a large focus on creating a fast, easy to use, informative website to aid in our customer's day to day activities.

www.Rotomaster.us



OEM SOLUTIONS

Rotomaster is very interested in beginning relationships with Original Equipment Manufacturers as their primary turbocharger supplier to aid in the design and manufacturing of turbochargers and systems to accommodate their requirements.



1. Turbocharger Overview

1.1. Definition

A turbocharger (**Figure 1**) is a radial fan pump driven by the energy of the exhaust gases of an engine. Turbochargers consist of a turbine and a compressor on a shared shaft. The turbine is a heat engine in itself. It converts the heat energy from the exhaust to power, which then drives the compressor, compressing ambient air and delivering it to the air intake manifold of the engine at higher pressure, resulting in a greater mass of air entering each cylinder.

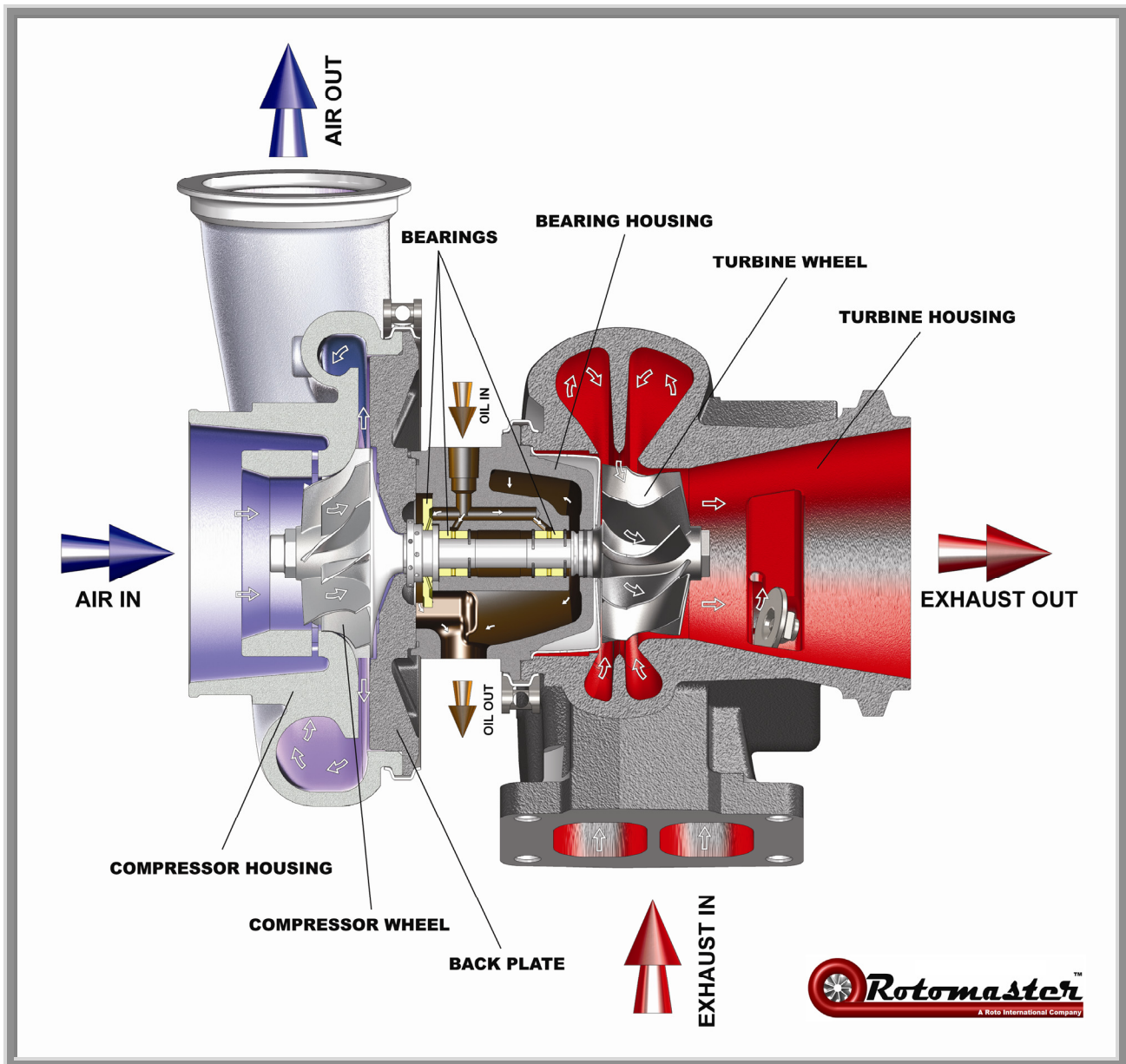


Figure 1: Diagram of Air & Oil Flow through a Turbocharger



2. Maintenance & Teardown Procedures

2.1. Periodic Maintenance & Inspection

In most cases, the damage severity of turbocharger failure can be greatly reduced by performing routine inspections during normal vehicle maintenance. Start by removing the turbine and compressor housings and inspect the state of the wheels and housings. If there are no abnormalities, do not disassemble further but rather inspect the bearings by manually turning the wheel assembly. The wheels should turn freely without any hindrance. You can also place a dial gauge on the wheel assembly to measure the axial play. If this play exceeds the maintenance standards in the service manual, the turbo should be removed and fully inspected.

2.2. Teardown Procedure

Start by performing a visual inspection of all components prior to removal. It is a good practice to keep detailed notes and take pictures of any visible abnormalities throughout this procedure. These notes will aid in the analysis, comparison to future cases, and also provide excellent feedback to the customer.

A typical teardown procedure is shown below (**Figures 3 to 6**). Do not clean the components until they have been carefully inspected for oil blockages causing a lack of lubrication. Label the journal bearings as they are removed to aid in bearing analysis (Compressor Side and Turbine Side).



Figure 3: Remove Housings



Figure 4: Remove Wheels



Figure 5: Remove Back Plate



Figure 6: Remove Bearings, Washers, Etc.



3. Common Causes for Turbocharger Failure

This section will discuss the four primary causes for turbocharger failure. It is important to note that when a turbocharger fails for any reason, there is almost always secondary (and often more severe) damage caused by the resulting shaft motion. You must look passed the obvious damage to locate the root cause. Note that some “cause of failure” descriptions contain very similar indicators so be sure to read through all prior concluding your analysis.

3.1. Lack of Lubrication / Contaminated Oil (*Causes over 40% of Failures*)

The lubrication system plays a vital role in extending the life expectancy of a turbocharger by lubricating, cooling, and cleaning the bearings. The shaft and bearings must “float” on a constant, clean film of oil to prevent direct contact with each other which will result in damage. Any lack of oil flow or foreign contaminant (i.e. dirt, sand, or metal shavings) in the oil will cause excess wear and/or scaring on the bearing surfaces. This wear will often increase the clearances between rotating components resulting in excess “shaft motion”. A large amount of “shaft motion” is detrimental to the life of a turbocharger.

Common causes of lubrication failure:

- Low engine oil pressure/level
- Obstructed oil supply / drain lines
- Improper weight of oil
- Contaminated oil
- Fast starts in cold weather
- Hot shutdown (**Figure 6**) - *Engine is shutoff at high rpm/temp; instant oil flow loss causing overheating*
- Engine Blow-by

A. External Lack of Lubrication:

- Occurs when anything exterior to the turbocharger is affecting the oil flow (supply or drain lines, engine blow-by, etc.).
- All thrust & journal bearings as well as the turbine shaft will show signs heat discoloration (**Figure 7**) as well as wear from the resulting shaft motion. The wear will appear smooth or “wiped” (**Figures 8 & 9**) and should not have any significant scaring (**Figures 10 & 11**).
- Unwarrantable: The cause of this failure is external to the turbocharger.

B. Internal Lack of Lubrication:

- Visible when one or more, but not all, of the bearings show the above mentioned wear. This indicates that only one of the oil feed lines have been blocked from either contaminated oil (see *below*) or a manufacturers defect.
- Warrantable: If there are no signs of contaminated oil.
- Unwarrantable: If there are signs of contaminated oil or “coking” of the oil caused by overheating.

C. Contaminated Oil:

- Occurs when abrasive material such as dirt, sand, or metal shavings enters the oil passages. This is generally easy to notice as the bearings and connecting components will show abnormal grooves and scratches (**Figures 10 & 11**). This may also cause a lack of lubrication failure as noted above.
- Unwarrantable: The cause of this failure is related to the installation or oil quality within the vehicle.



Figure 6: "Hot Shutdown"
Turbine Wheel Shows Visible Bearing Pattern and Heat Discoloration



Figure 7: Turbine Shaft Lack of Lubrication
Turbine Wheel Shows Visible Heat Discoloration and Smeared Wear



Figure 8: Journal Bearing Lack of Lubrication
Left = New Bearing; Right = Smooth Wear & Heat Discoloration

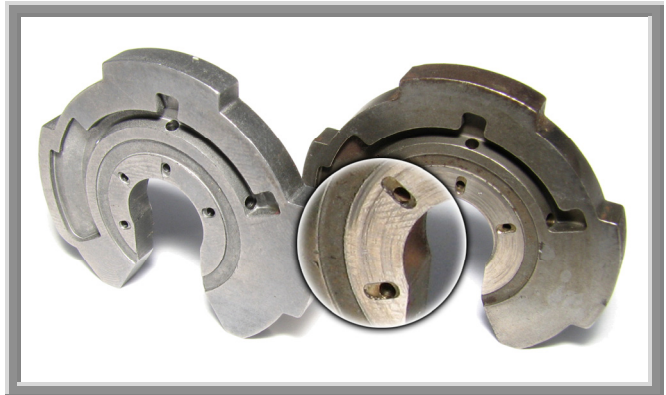


Figure 9: Thrust Bearing Lack of Lubrication
Left = New Bearing; Right = Smooth Wear & Heat Discoloration



Figure 10: Journal Bearing Contaminated Oil
Visible Scarring on Inner and Outer Diameters

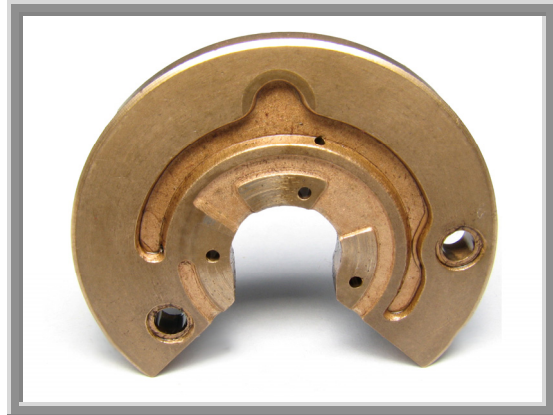


Figure 11: Thrust Bearing Contaminated Oil
Visible Scarring on Pads



3.2. Foreign Material in Exhaust or Air Inlet

Foreign particles (i.e. Screws, nuts, sand, metal power, broken air filters, etc.) entering the turbine or compressor stages will damage the rotating turbine or compressor blades. Both wheels are accurately balanced to perform at extremely high operating speeds required by their application. If either wheel is damaged in any way, the rotating assembly will no longer maintain its balanced state which will result in severe shaft motion causing almost every component of the turbocharger to fail.

In many cases, this is the most obvious damage to recognize as the compressor or turbine wheel will often show severe damage without removing the housing (**Figure 12 & 13**). However, in some scenarios, this is a gradual erosion of the wheel from fine particles such as sand or dirt. In this case, the wheel will display small pits across the vanes or minor wear on the inducer tips.

Although rare, this failure may also be caused by the compressor wheel lock nut loosening off and entering the compressor vanes (**Figure 17**). This failure originates from assembly if the lock nut was not tightened to the specified torque setting or the Loctite® compound was not applied.

- Warrantable: If the compressor wheel lock nut is the visible cause of failure.
- Unwarrantable: If caused by any other foreign material external to the turbocharger.



Figure 12: Compressor Wheel Foreign Material
Severe Damage to the Vanes on the Wheel

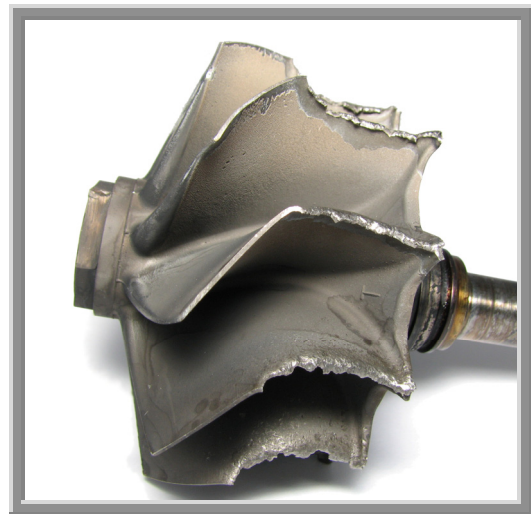


Figure 13: Turbine Wheel Foreign Material
Severe Damage to the Vanes on the Wheel



3.3. High Exhaust Temperature

Excessive temperature in the exhaust system will cause the lubricating oil to “coke” in the bearing housing drain annulus at the turbine end (**Figure 14**). This causes oil leakage into the turbine housing. Coke and carbon deposits will be visible and eventually damage the back of the turbine wheel and cause abnormal wear on the thrust bearing. High exhaust temperatures can also erode (**Figure 15**) and crack (**Figure 16**) the turbine housing and/or bearing housing. Excessive heat discoloration of the turbine shaft is usually visible. The piston ring in the turbine side of the bearing housing will often appear relaxed if it has been submitted to these high temperatures.

High exhaust temperatures can originate from several operating conditions shown below:

- Incorrect fuel ratio (high fuel setting)
- Insufficient air supply caused by a plugged air cleaner, etc.
- A leak in the intake manifold or piping
- Excessive exhaust restrictions
- Plugged aftercooler core
- Unwarrantable: Unless incorrect compressor or turbine housings were assembled.

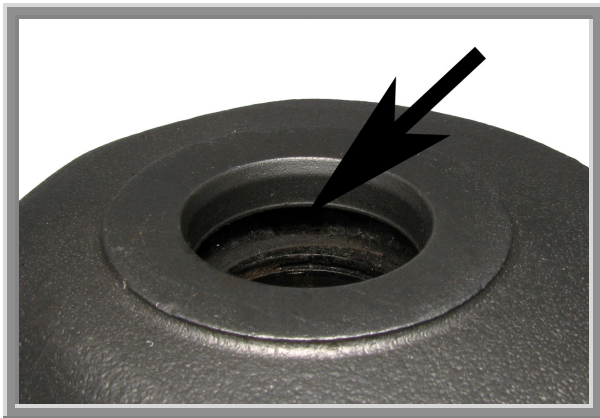


Figure 14: Bearing Housing High Exhaust Temp
Blocked Drain Annulus from Oil Coking



Figure 15: Turbine Housing High Exhaust Temp
Erosion of Web Caused by High Temperatures

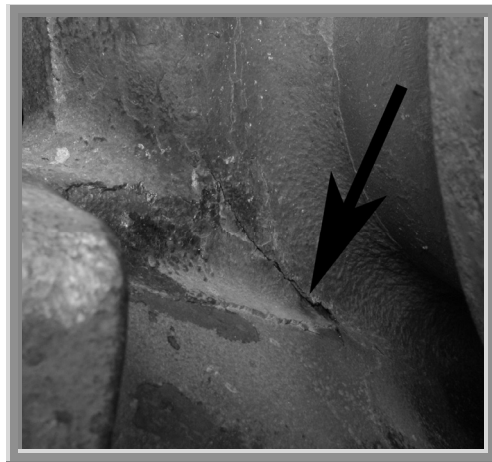


Figure 16: Turbine Housing High Exhaust Temp
Cracked Housing Caused by High Temperatures



3.4. Defective Workmanship or Material

While these occurrences are rare, the visible evidence is often easy to recognize. Some examples are displayed and explained below.

- Warrantable: If the defects originate from the manufacturer.
- Unwarrantable: If the defects originate from the installation.



Figure 17: Compressor Wheel Lock Nut Failure
Nut is missing, foreign object
Damage to vanes



Figure 18: One Sided Wear on Compressor Housing
Can be caused by improper manufacturing or assembly

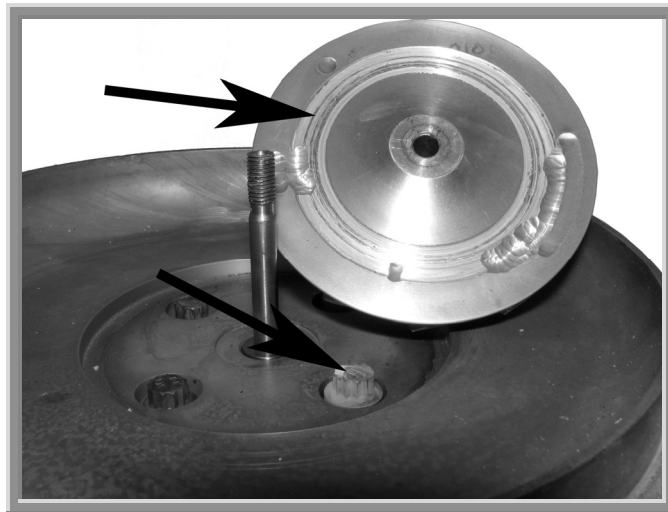


Figure 19: Back Plate Bolt Loosened and Contacted Back of Compressor Wheel
Can be caused by improper assembly (No Loctite®)



3.5. Common Failure Diagrams

Below are four examples of Turbocharger failures due to improper installation or vehicle systems.

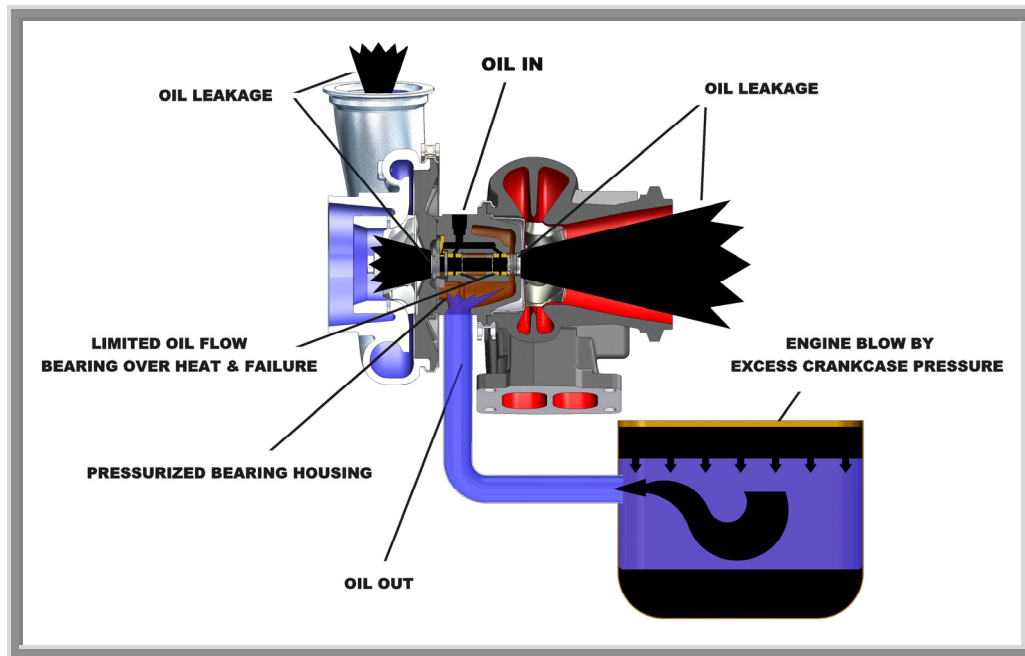


Figure 20: Engine Blowby

Increased crank case pressure causes flowing oil to squeeze out of the piston ring gaps and also reduces the amount of oil flow to the bearings causing failure

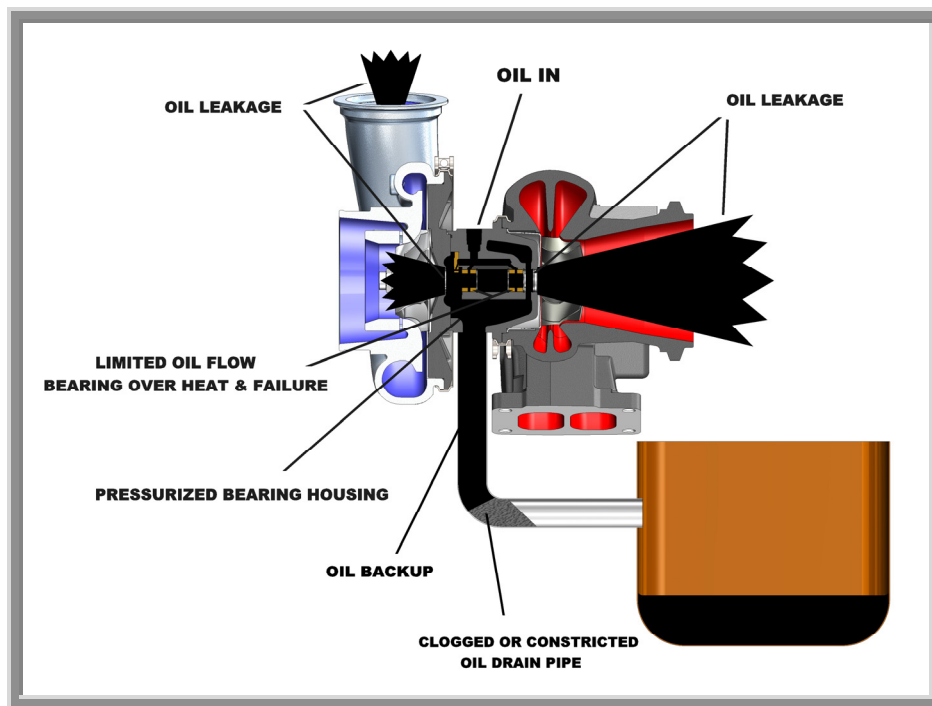


Figure 21: Clogged Oil Drain Pipe

Oil cannot flow and pressurizes the drain area causing oil leakage and bearing failure



3.5. Common Failure Diagrams (Continued)

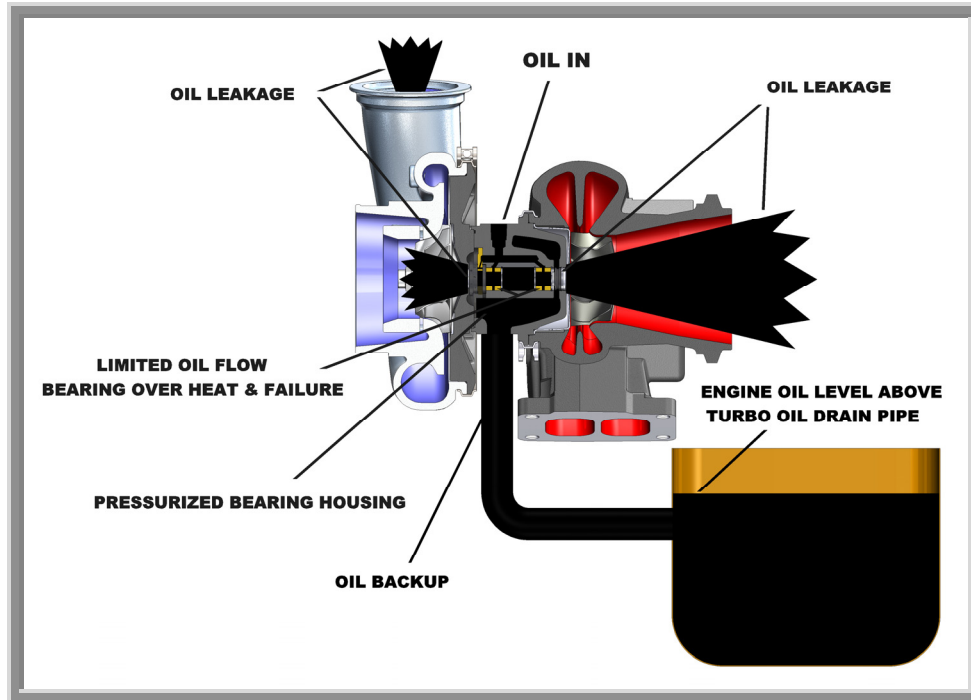


Figure 22: Oil Level Too High

Any minor pressure in the crank case will prevent oil from flowing which pressurizes the drain area causing oil leakage and bearing failure

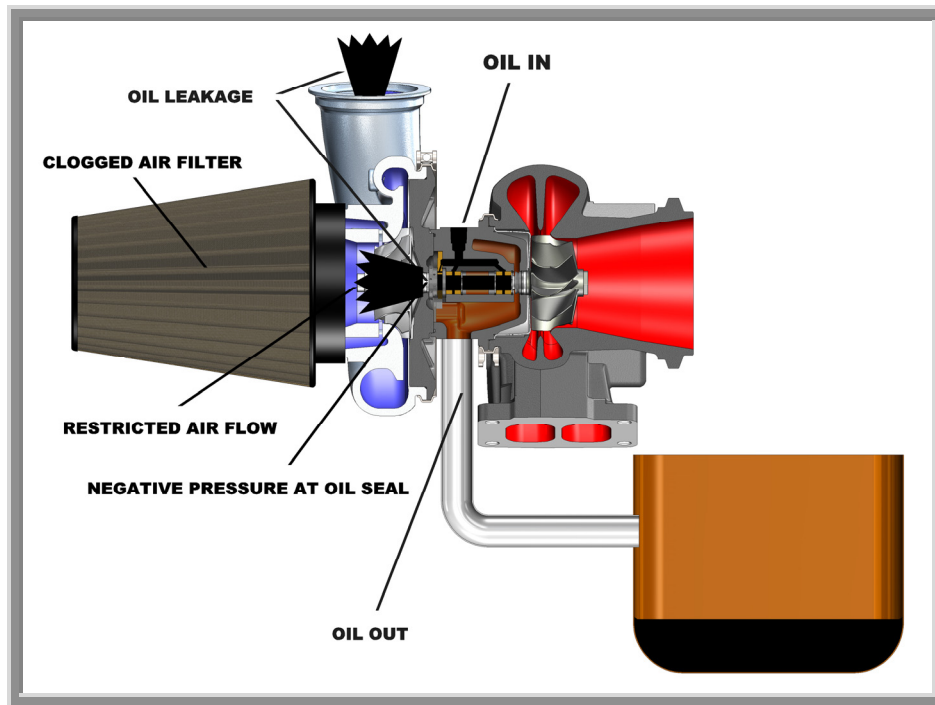


Figure 23: Clogged Air Filter

Reduced air flow in the compressor inducer will create high vacuum area which will pull oil into the compressor side of the turbocharger



4. Before a New Turbocharger is Installed

It is important to inform the customer of the analysis results. In most cases, the cause of failure originates from either an installation error (foreign material, etc.), improper vehicle systems (oil lines, etc.), or improper operation of the vehicle (hot shutdown, etc.). Ensure the cause of failure is fixed and/or the customer is educated about the cause of failure prior to installing a new turbocharger to avoid a repeat failure.

5. Summary

There are many factors that can greatly reduce the life of a turbocharger. This text was designed to serve as an educational guide to improve our customer's knowledge. In most cases, turbochargers fail due to improper use or maintenance by the end user. It is hoped that better informing our customers will reduce the time required to get this information to the end user and also reduce costs related to warranty returns.

Please contact Rotomaster toll free at 1-888-800-3826 if you have any questions regarding this text or if you encounter a failure which is not discussed or difficult to determine the root cause.



6. Warranty Reporting Process

We encourage our customers to understand that there can be long delays and costs related to warranty returns. For this reason, Rotomaster developed an “authorized agent training course”. This course is designed to better explain multiple failure scenarios and teach them how to quickly determine the signs related to failures. Attendees will leave the course with a certificate allowing them to perform limited “in-the-field” warranty analysis procedures. Rotomaster customers with an authorized agent are asked to perform the following procedures prior to sending a failed turbocharger to Rotomaster:

- Agent to complete exterior analysis at their facility upon arrival
- If the agent determines that the cause of failure was installation or vehicle related without further inspection, they are to inform the customer and scrap the turbocharger
- If the agent cannot determine the cause of failure or determines that it was caused by a manufacturer’s defect, they are to call Rotomaster to obtain and RGA #
- The agent must then obtain the information shown below and send it to Rotomaster along with the RGA # and the failed turbocharger
- Rotomaster will then asses this information, analyze the turbocharger, and grant or decline the warranty request

Authorized agents are to supply the following information if a turbocharger is returned for further analysis:

Turbocharger Warranty Report	RGA #:	
	Date:	

Customer Information					
Customer:		Contact Name:		Invoice #:	
Phone #:		Fax #:		E-Mail:	

Product Information					
Part #:		Model #:		Serial #:	
Install Date:		Failure Date:		Hrs in Operation:	

Failure Description: