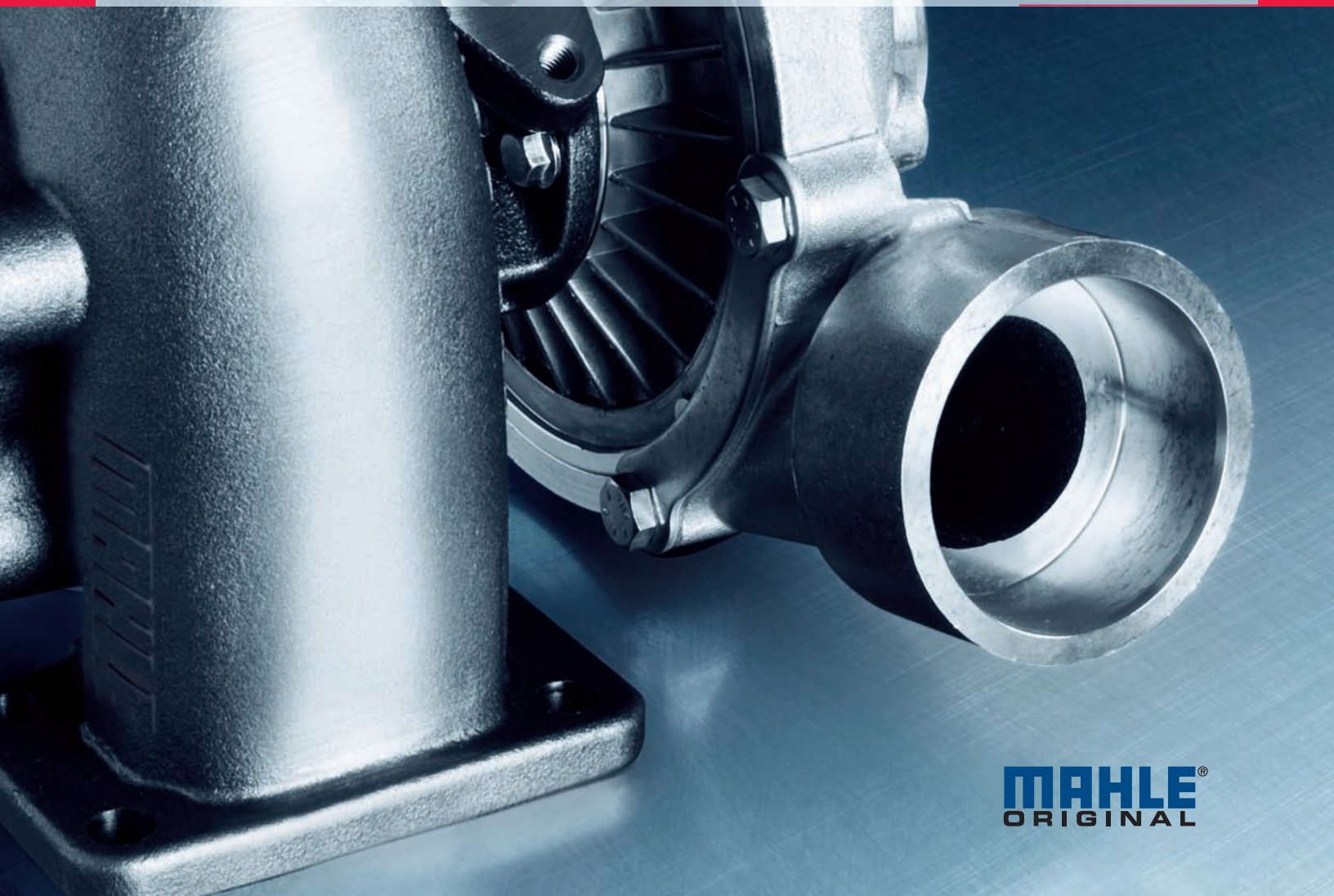
MAHLE

Driven by performance

THE TURBO
FOR THE AFTERMARKET.

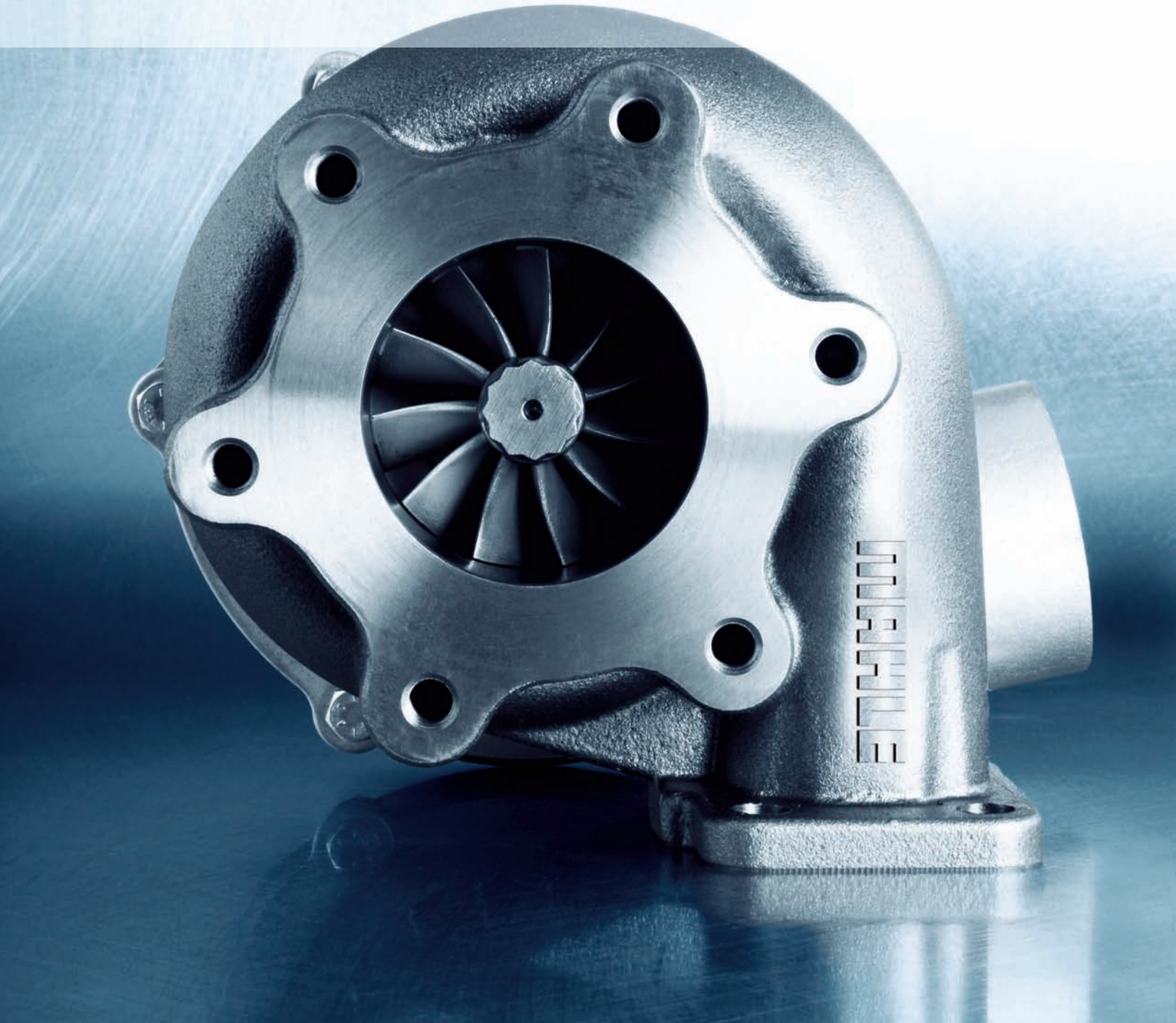
TURBOCHARGERS BY MAHLE

AFTERMARKET



MAHLE® ORIGINAL

WE TURBOCHARGE.



The turbocharger: a growing business segment...

Turbochargers are a key technology to enhance performance, reduce fuel consumption, and lower exhaust emissions. When fitted to direct-injection diesel engines, they reduce fuel consumption by up to 25 percent compared to similar gasoline engines with duct injection. For this reason, they have taken over almost the entire market segment. The trend with gasoline engines is decreasing (reducing in cubic capacity for the same power output). This is achievable by turbocharging, since the high power-to-capacity ratio of these engines requires an increase in the air mass supplied to the engine. Inevitably, the number of turbocharged gasoline engines will grow significantly worldwide.

Experts estimate that in 10 years, there will be about 160 million cars and roughly 16 million trucks (> 3.5 metric tons) running on this key technology, and the trend will continue to rise. As a result, the turbocharger segment represents one of the largest growth markets in the automotive industry worldwide.

... Also for retail outlets and car repair shops

The rising number of turbocharged vehicles also offers a high sales potential for the aftermarket. Although the service life of a turbocharger is normally identical to that of an engine, defects may occur that require premature replacement, for example poor vehicle maintenance, inadequate lubrication, or excessive exhaust-gas temperatures. Please read more on pages 6/7.

However, it is not only the turbocharger itself that offers sales opportunities. Car repair shops that are service and sales-oriented also have the opportunity of acquiring additional business in the segment of servicing or reconditioning, for example, filter changes.

MAHLE OE technologies for the aftermarket

MAHLE is one of the technology leaders and system developers in the field of internal combustion engines and engine peripherals. It is also a long-standing business partner to international automotive and engine manufacturers in the development and production of turbocharger components.

Efficiency benefits from downsizing engines. When efficiency is higher, better technologies are matched to each other, such as turbochargers, fuel injection technology, variable valve timing, exhaust-gas recirculation, and charge-air cooling. The MAHLE Downsizing Engine was specifically designed and built to prove real-world application/ benefits to these technologies . It certainly proved MAHLE is a technology leader – as it is capable of achieving a CO_2 reduction of up to 30 percent.

As part of the systematic enhancement of the product portfolio for the aftermarket, we are now supplementing our range with turbocharger systems for high-performance and high fuel-economy diesel and gasoline engines. Not only that, we are placing our innovative MAHLE turbocharger technologies at the disposal of the retail trade and to car repair shops.

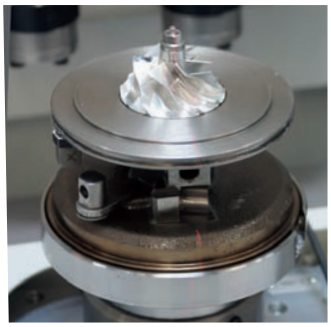
The product range will be continuously expanded. By the year 2012 it will cover roughly 80 percent of all fast mover applications and will be supplemented by car applications. The wide range of different sizes and types with power outputs from 75 through 1000 KW guarantee optimized compatibility with the most diverse requirements of car, truck, construction, and agricultural engines.

New in the aftermarket product portfolio: MAHLE Original turbochargers.

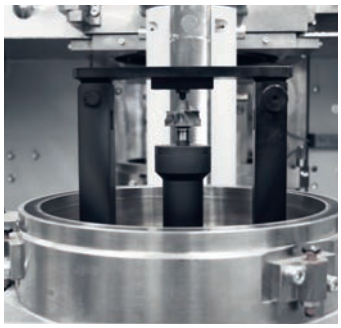
Cutting-edge quality through integrated development and manufacturing processes

Rotational speeds of over 300,000 rpm and exhaust-gas temperatures of more than 1832 ºF are the conditions for some turbochargers. To achieve high efficiency under such extreme conditions over a wide map of characteristics requires extremely high development competence and manufacturing precision.

Our engineers utilize state-of-the-art simulation tools in the initial phase to guarantee the required thermodynamic and thermo-mechanical characteristics of components during the complete integrated development process. Thermo-



Using what is known as field balancing, specific in-service conditions are simulated and dynamic unbalance is detected.



Since the shaft and the turbine wheel are made of different materials, welding these two components together represents a special challenge. MAHLE engineers found the solution: electron beam welding – a process that permits extremely precise and reliable joining.

mechanical calculations are conducted to determine the durability of the turbine housing. After the design and calculation phase, the turbocharger is subjected to an extensive series of tests on hot-gas test benches and engine test benches. The criteria here include thermodynamic maps, shaft displacement curves, and product life cycle.

MAHLE Original turbochargers are manufactured throughout the world based on high-quality standards. Modern, computer-controlled production machines guarantee optimized precision to machine housing components made of aluminum and cast steel. Turbine wheels are manufactured from high temperature resistant materials and feature premium cast quality and precision balancing. This is the only way in which they can withstand extreme conditions in the long term.

To comply with very high quality standards in turbocharger production, a team of product and process engineers are permanently deployed to continue development in production, assembly, and test processes, such as high-speed machining, joining technology, coating with fluid and solid materials, or balancing. The team can harness the wide range of production competence gained from all previous product areas.

MAHLE Original turbochargers – Production quality without compromises
High-speed compressor wheels Provide greater balancing precision, optimized speed stability, and reduced running noise.
Double piston rings on rotor shaft Reduce oil consumption and enhance protection against foreign particles.
Turbine housings made of high-tech materials Achieve greater thermal stability and longevity.
Functionally process-controlled center housing Attain progressive balancing of the rotor shaft, enhanced running performance, reduced abrasion, and less noise emission.
Electron-welded rotor shaft and wheels Guarantee high strength.

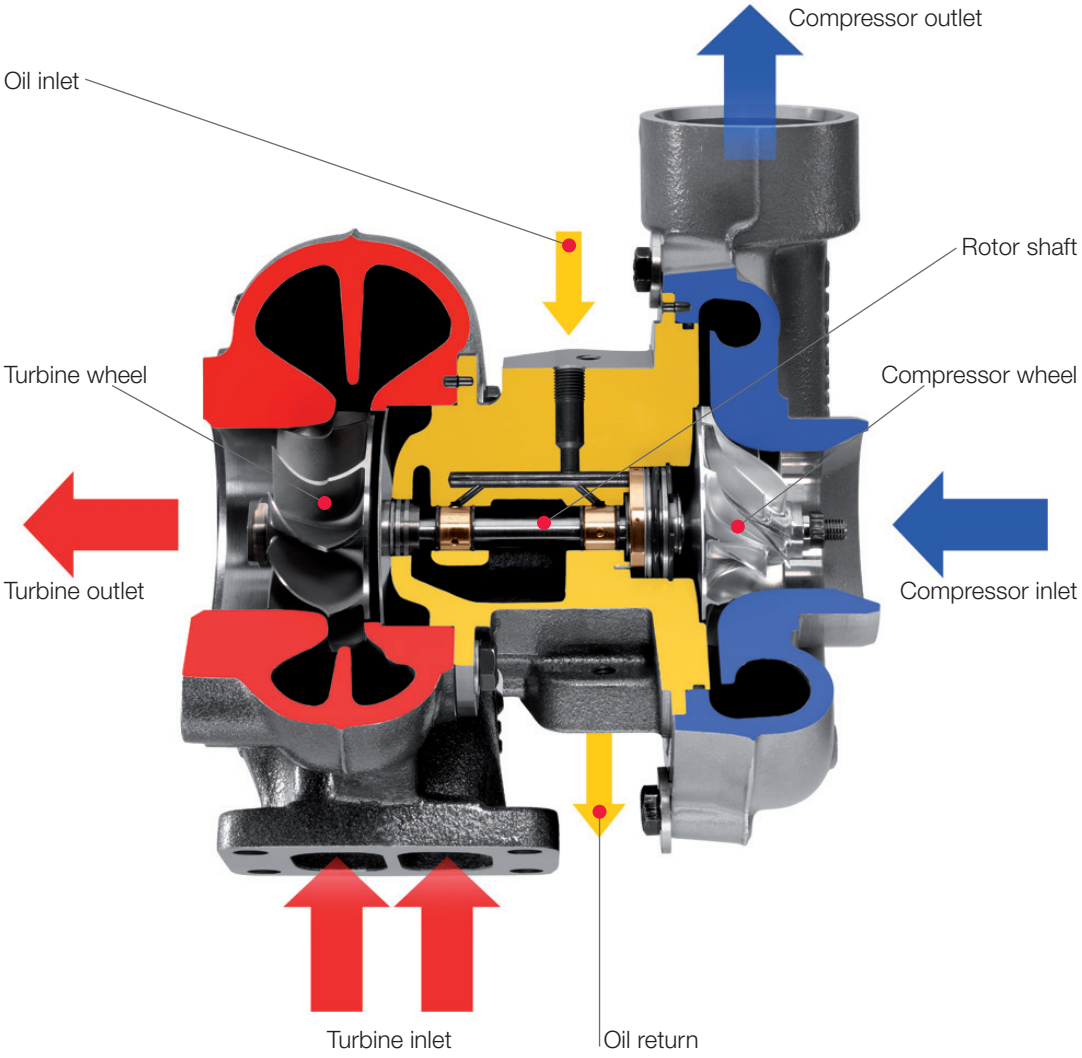
Sustainability as obligation

When it comes to environment protection, MAHLE is one of the leading automotive suppliers in this discipline. Our mission is to promote technical progress and human future in harmony with our environment. We have proven our commitment through certification of our locations in compliance with DIN EN ISO 14001. Besides the economical deployment of resources and ecological production processes, it is our core products that make the greatest contribution to environmental protection. They produce a sustainable positive impact on the ecological balance since they are installed in millions of vehicles worldwide to reduce fuel consumption and lower exhaust-gas emissions.

Design and function of turbochargers

The power output of an internal combustion engine mainly depends on the air mass supplied to the combustion process and this is achieved by using a turbocharger. It utilizes exhaust-gas energy to precompress the intake air and supply a greater air mass – and therefore more oxygen – to the engine, achieving greater efficiency in the combustion process.

Turbocharging permits an increase in maximum torque and maximum power output (while retaining constant work volume), and a rise in mean pressure, without requiring any mechanical drive output from the engine that normally occurs with mechanical supercharging, e. g. a compressor. This increase can be harnessed to fit a more powerful engine with approximately the same dimensions as the original engine. Alternatively, which the trend is pointing in this direction, it can be utilized to implement downsizing concepts that can lower fuel consumption and CO_2 emissions without a trade-off on power output.



The turbocharger is driven by engine exhaust gases that are supplied to the turbine blades or the turbine wheel (red) at high speed and high temperatures of up to 1740 °F. In turn, the turbine wheel drives the compressor wheel that is mounted on the same rotor shaft. During the resulting rotation, the compressor wheel draws in ambient air through the intake duct and from there the air is routed to the cylinders (blue). The yellow marking shows the oil circuit – from the inlet to the return pipe.

Turbo tips from professionals

Maintenance and care

Turbochargers are designed to last for the service life of the engine. Monitoring is restricted to a few periodic checks that should be performed during every engine service. One condition for achieving longevity, however, is exact compliance with the engine manufacturer's servicing specifications – such as oil change intervals, oil-filter system maintenance, oil-pressure checks, cleaning of all filter systems, and regular, professional filter changes.

- This matrix is intended to help pinpoint the causes of damage or failure
- Such causes must be eliminated before the turbocharger is replaced
- If the true causes of damage or failure are not found and corrected, they will probably recur with a new turbocharger
- Please do not disassemble any part of the turbocharger

Possible Causes / Problem	Compressor/turbine wheel defective	Low power/boost pressure too low	Boost pressure too high	Black smoke	Blue Smoke	Turbocharger is noisy	High oil consumption	Oil leakage at compressor	Oil leakage at turbine
Dirty air filter system		•		•	•		•	•	
Air-intake and pressure line distorted or leaking		•		•		•			
Excessive flow resistance in exhaust system / leakage upstream of turbine		•		•	•	•	•	•	
Oil feed and drain lines clogged, leaking or distorted					•		•	•	•
Crankcase ventilation clogged or distorted					•		•	•	•
Coke or sludge in turbocharger bearing housing					•		•	•	•
Fuel system/injection system defective or improperly adjusted		•	•	•					
Valve guide, piston rings, engine, or cylinder liners worn / increased blow-by		•		•	•		•	•	•
Dirty compressor or charge air cooler		•		•	•	•	•	•	
Boost pressure control swing valve / poppet valve does not close		•		•					
Boost pressure control swing valve / poppet valve does not open			•						
Control line to swing valve / poppet valve defective		•	•						
Piston ring seals defective					•		•	•	•
Turbocharger bearing damage	•	•		•	•	•	•	•	•
Foreign-body damage to compressor or turbine	•	•		•		•			
Exhaust gas leakage between turbine outlet and exhaust pipe						•			
Engine air collector cracked / missing, loose gaskets		•		•		•			
Turbine housing / swing valve damaged	•	•		•		•			
Insufficient oil supply to turbocharger	•	•		•		•			

How turbocharger damage is caused

Defects on the turbocharger mostly have one of the following causes:

- **Inadequate lubrication**
  If there is insufficient lubrication, the bearings will fail and the compressor and turbine wheels grind against their housings.
- **Contaminated oil**
  Contaminated oil leads to score marks on shaft journals and bearings. Oil bore holes and seals become clogged and cause insufficient oil supply.
- **Intrusion of foreign bodies**
  Foreign bodies that, for example, enter through a defective air filter, damage the turbine or compressor wheels. The resulting unbalance damages the turbocharger bearing.

What must be followed when handling turbochargers

The turbocharger is a technically complex unit with precisely matched components. When handling, the turbocharger it is important to:

- **Train repair shop personnel**
  Turbochargers reach speeds of up to 300,000 rpm. Their individual components are made to minimum manufacturing tolerances. Maintenance and replacement should therefore be carried out by suitably qualified personnel. What is important here is also the use of special tools and machines, for example for balancing.
- **Do not modify the turbocharger**
  Turbocharger design is optimized for a specific engine type at the manufacturing plant. For this reason, no adjustments or modifications should be made to them. For example, if the boost pressure increases, it may cause the engine to overheat, resulting in damage to the pistons, cylinder head, or engine mounts.
- **Use the correct engine oil**
  Important when changing the oil: Only use engine oil recommended by the manufacturer. Any deviation in viscosity may cause incorrect lubrication and damage the turbocharger.

Advice that competent car repair shops can give their customers

Here are a few tips for the customers of car repair shops which can help keep turbochargers running at top performance.

- **If the turbocharger is producing any unusual noises, oil leaks, or vibrations**
  Stop the engine immediately and have the engine checked by a technician.
- **The turbocharger needs time to lubricate**
  After starting the engine, it takes about 30 seconds until the oil flows completely through the oil circuit. Only then may you rev the engine at high speed.
- **Do not shut the engine off immediately**
  If the engine was running at high speeds, do not shut it off immediately. The reason is that the turbocharger will continue to run without sufficient lubrication. An important tip for car repair shop customers: Before shutting down the engine, let it run at idle for about 20 seconds.

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