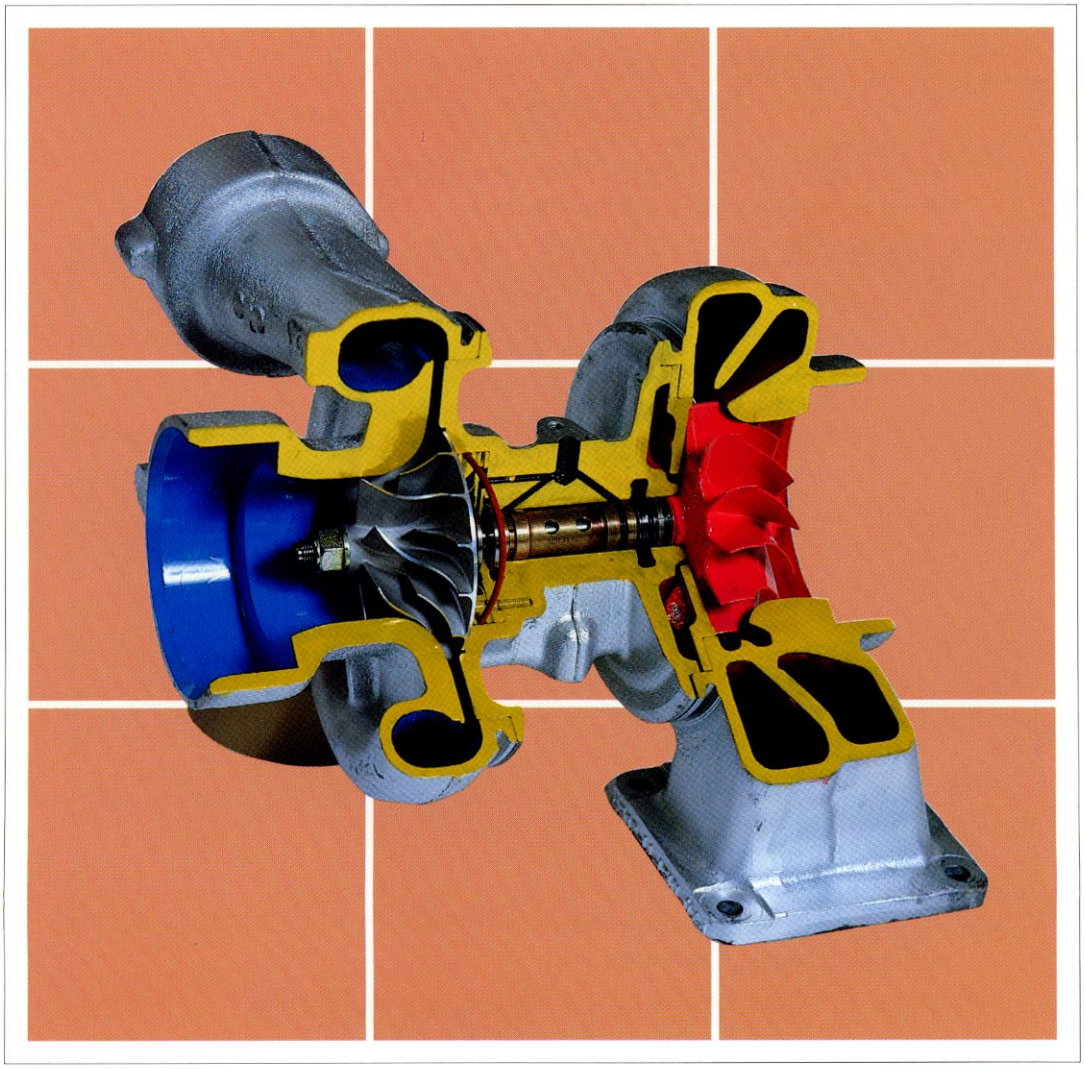
SHOP MANUAL

GUIDANCE FOR REUSABLE PARTS

TURBOCHARGER



GUIDANCE FOR REUSABLE PARTS

KOMATSU

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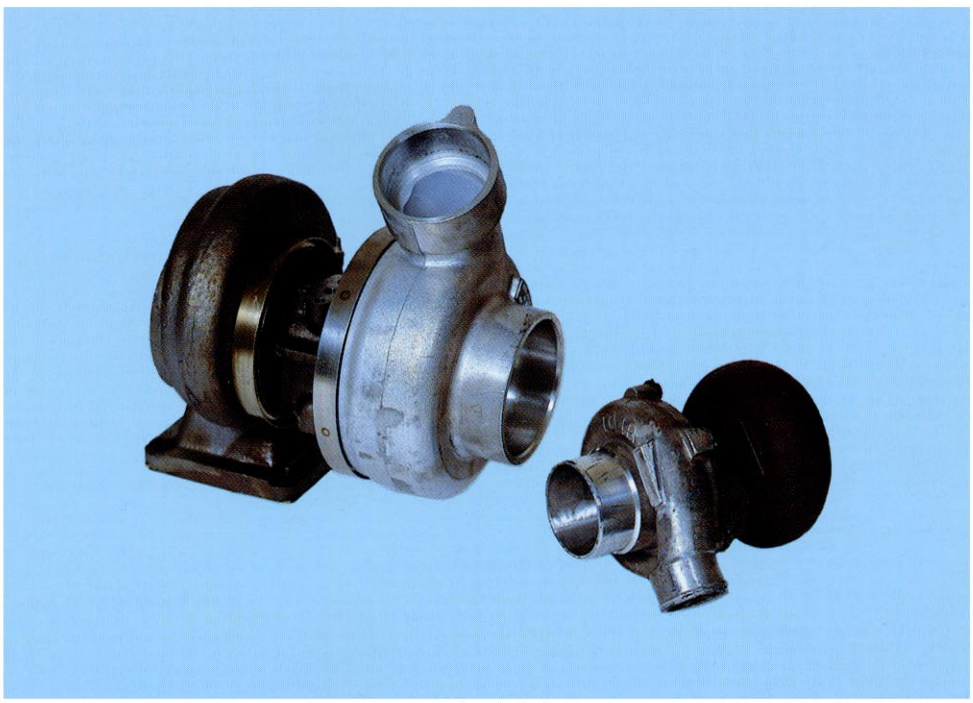
INTRODUCTION

Among the accessories for construction machine engines, turbochargers are operated in very severe conditions at high temperature and high speed. Most failures of turbochargers are caused by unsatisfactory maintenance or servicing conditions, mainly related to lubrication, foreign matter, or dust, and careless operation.

This publication gives the fundamental information about turbochargers and possible causes of failures. Photos are used to show how to make diagnoses of part failures in a turbocharger.

We hope that this publication will be used by all personnel involved in the troubleshooting, servicing, and repair of engines. We hope that you can *reduce repair costs* by carefully conducting daily preventive maintenance, detecting failures early, using correct remedial actions to *prevent recurrence of failures,* and by using the correct replacement parts.



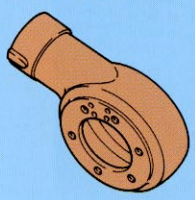
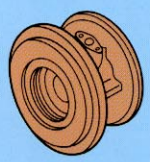
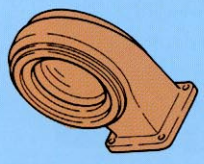
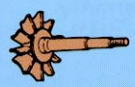
FAILURE SIGNS AND DIAGNOSIS FOR REUSE

When diagnosing faulty parts for reusability, the damage caused to engines or turbochargers will vary largely with the location and content of the faulty part. Particularly for a turbocharger running at high speed, its lack of structural balance may lead to serious damage, so careful consideration is required.

When determining the reusability of faulty parts, it is necessary to examine the reason why the failure has occurred, taking into full consideration the daily preventive maintenance and operating conditions and to diagnose them for reusability based on your accumulated know-how and experience and referring to the photos.

Inspection Points for Parts Reuse Diagnosis

In order to make correct diagnoses of faulty parts, first clean the parts, then inspect them, paying special attention to the following check points.

Part	Inspection points	Part	Inspection points
Blower housing 	• Contact with blower impeller • Damage or deformation of the surface fitted with the center housing • Deformation or failure at joints	**Blower impeller** 	• Damage or bending of the blade • Contact with blower housing
Center housing 	• Failure or wear at cylinder bore • Scratches at bearing bore • Deformation or failure at joints	**Journal bearing** 	• Scuffing and seizure • Wear
Turbine housing 	• Contact with turbine rotor • Corrosion of the inner surface	**Thrust bearing** 	• Wear and cracks
Turbine shaft 	• Damage or wear of the seal ring portion of the shaft • Wear, discoloration and seizure of the journal portion of the shaft • Bend of the shaft	**Shield** 	• Wear and cracks
		Flinger and thrust collar 	• Discoloration • Wear of the surface in contact with the back plate

Standards for Failure Determination

Rank	Failure degree
Use again	The machine functions properly and there is no possibility of the fault causing a secondary fault.
Use after reconditioning	The machine functions properly for the time being. However, if the present faulty condition is left as it is, a secondary fault may occur.
Do not use again	The fault or damage will definitely cause the machine to malfunction. If the faulty part continues to be used, serious damage will result.

*For criteria about wear and bending, refer to the Maintenance Standard in the applicable Shop Manual.

Standards for Reuse of Turbocharger Parts

Part name	Location or type of failure		Failure degree		
			Use again	**Use after reconditioning**	**Do not use again**
Blower housing	1	Inner surface of blower housing.	Light contact flaw not extending over the entire inner surface.	Flaws other than use again and do not use again. **1**	Flaw extending over the entire inner surface.
	2	Surface fitted to the center housing.	No damage or deformation.	The contacting surface has a flaw but does not allow air to leak.	There is clearance with the center housing caused by deformation.
	3	Connections at air inlet and outlet parts.	No deformation or cracks.	Minor deformation which does not allow air to leak.	More faulty condition than in use after reconditioning.
Center housing	1	Surface contacting journal bearing.	No scratches.	Very thin wear. **3**	Large scratches. **4 & 5** Wear. **6**
	2	Surface contacting seal ring.	No scratches. **2**	—	Going to seize. **8** Heavy calking. **7**
Turbine housing	1	Flaw due to contact with turbine rotor.	Light contact flaw not extending over the whole circumference.	Slight seizure on the contact surface.	Contact flaw extending over the entire circumference.
	2	Corrosion or oxidation of the inner surface.	No corroded or oxidized surface.	Removable corrosion.	Corrosion accompanied with cracks or unremovable oxide film. **9**
	3	Deformation.	When flatness of the inlet flange is less than 0.3 mm.	—	When there is a possibility that the turbine wheel will come into contact with the housing.

Note: Bold numbers refer to photos in the text.

Part name	Location or type of failure		Failure degree		
			Use again	**Use after reconditioning**	**Do not use again**
Turbine shaft	1	Bending, deformation of the blade.	There is a slight bend but no cracks at the tip.	—	Cracks, lack of metal at the tip, easily observable bend. **18 & 19**
	2	Flaw due to contact between blade and housing.	Trace of slight contact is on the whole surface of the blade. However, there are no burrs.	—	Burrs or deformation.
	3	Seal ring groove.	No wear or damage.	—	Deformation to the point that the seal ring is stuck. **15**
	4	Journal (discolored)	No discoloration.	Discolored surface can be easily removed with No. 400 to No. 600 sandpaper.	Discoloration other than use after reconditioning. **16**
	5	Journal (flaws)	Scratches not detectable by fingernail.	One or two flaws which catch on nails (Such flaws need not be repaired.)	Flaws other than use after reconditioning.
	6	Journal (seizure)	No seizure.	No seizure.	Seized bearing metal.
	7	Bend of the shaft.	0.01 or less T.I.R. (Total indicator reading)	—	Exceeding 0.01 T.I.R.
	8	Surface of fitted portion of a blower impeller.	No scuffing or flaw.	—	The surface has a flaw or scuffed area due to the turned impeller.
	9	Shaft back surface.	No trace of contact.	—	There is evidence of contact. **20**
Blower impeller	1	Bend of the blade tip.	Slight bending of the tip. **21**	—	Marked bending of the tip.
	2	Cracks or damage of the blade.	No cracks or damage.	—	Cracks or damage.
	3	Contact between blade and housing.	There is a trace of slight contact.	There is contact that can be easily removed with sandpaper.	Contact other than use again and use after reconditioning. **23 & 24**
	4	Contact with the back plate.	No contact.	No contact.	Contact.
	5	Damage of the contact surface with nut.	No damage.	No damage.	Damage.
	6	Damage of inner surface of shaft hole.	No damage.	No damage.	Damage.
	7	Flaw on the contact surface with thrust collar.	No flaw.	No flaw.	Flaw.

Note: Bold numbers refer to photos in the text.

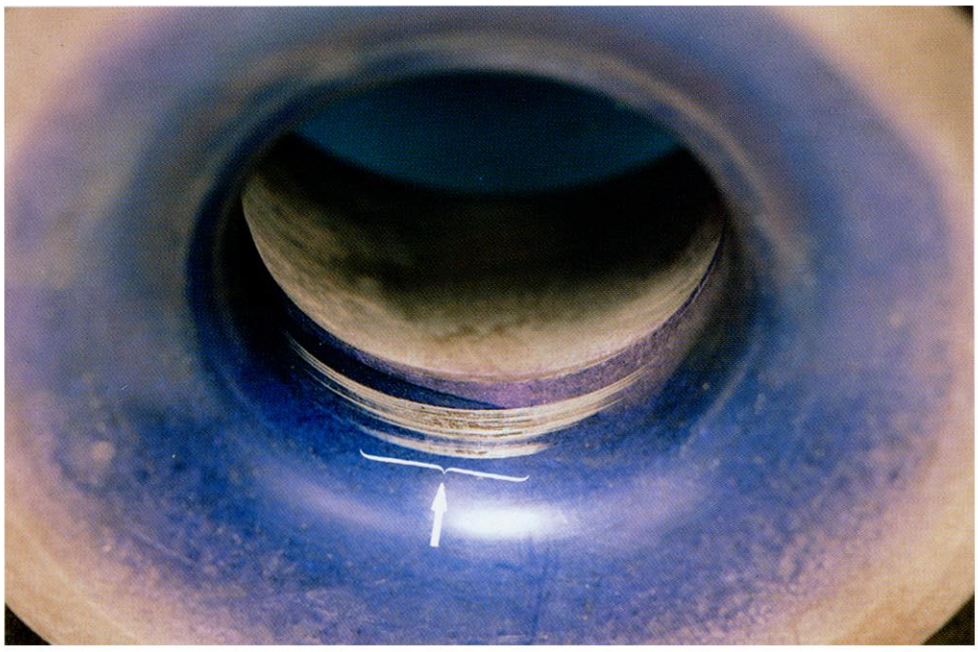
Part name	Location or type of failure		Failure degree		
			Use again	**Use after reconditioning**	**Do not use again**
Journal bearing	1	Cracks.	No cracks.	No cracks.	Cracks.
	2	Contact surface with thrust collar.	Flaw that catches on fingernail.	—	Marked degree of wear or flaw.
	3	Contact with the center housing. **25** (Bearing is chattering)	No chattering.	No chattering.	Chattering.
	4	Oil hole.	No clogging.	No clogging.	Clogged.
Thrust collar	1	Contact surface with the back plate.	Wear or flaws on the circumference that do not catch on a fingernail.	—	Wearing grooves on the surface that catch on a fingernail. **29**
	2	Thermal discoloration.	No discoloration.	No discoloration.	Partial discoloration. **30**
	3	Wear or damage of end surfaces.	No wear or damage.	No wear or damage.	Wear or damage.
Thrust bearing	1	Cracks.	No cracks.	No cracks.	Cracks.
	2	Wear (thickness)	Within the standard range. **33**	Within the standard range. **34**	Out of the standard range. **35**

Note: Bold numbers refer to photos in the text.

Failure Signs and Diagnosis for Reuse

Blower housing

1



USE AFTER RECONDITIONING

Failure Signs

- Blower housing comes into contact with the blower impeller.

Cause

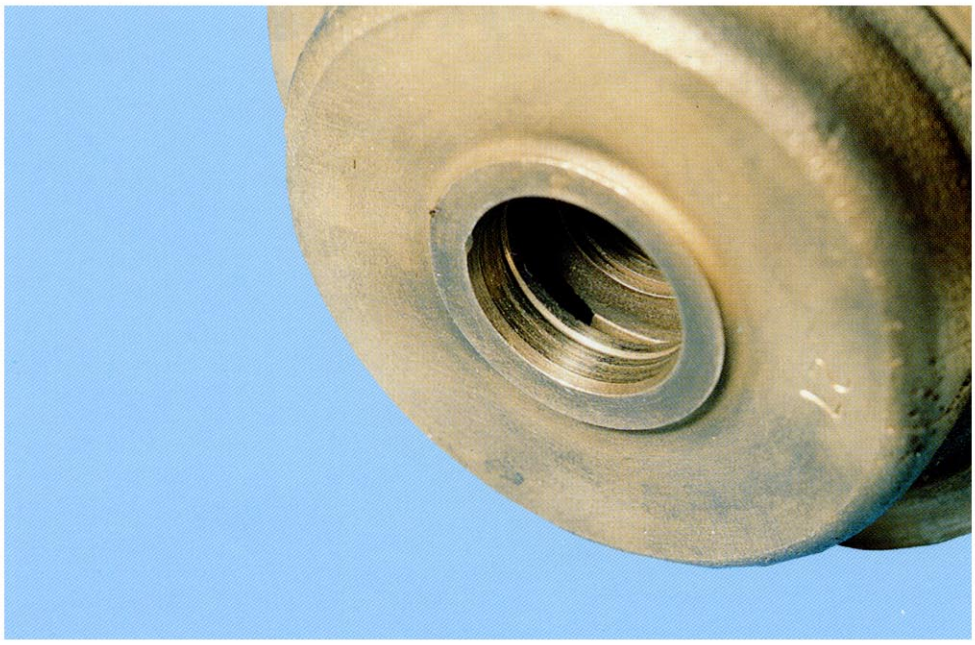
- Turbine shaft lacks balance.

Reconditioning Method

- Finish the portion in contact with the blower impeller smooth with No. 400 thru No. 600 sandpaper.

Center housing

2

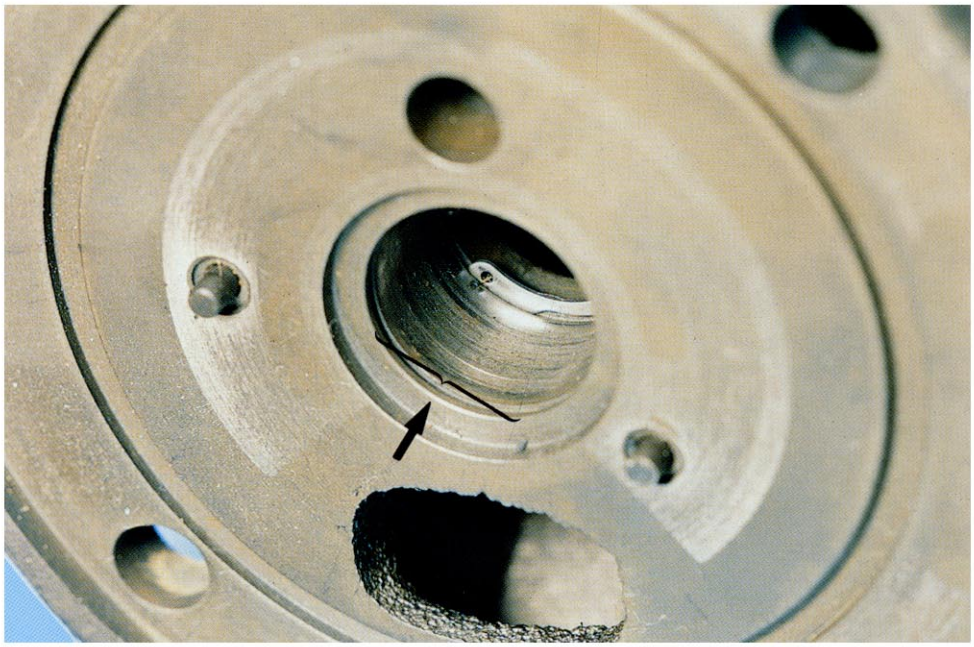


USE AGAIN

Failure Signs

- Center housing is sound, as no damages are observed in the sealing bore.

3



USE AFTER RECONDITIONING

Failure Signs

- There are many fine flows on the bearing bore of the center housing. These flaws do not catch on your finger nail.

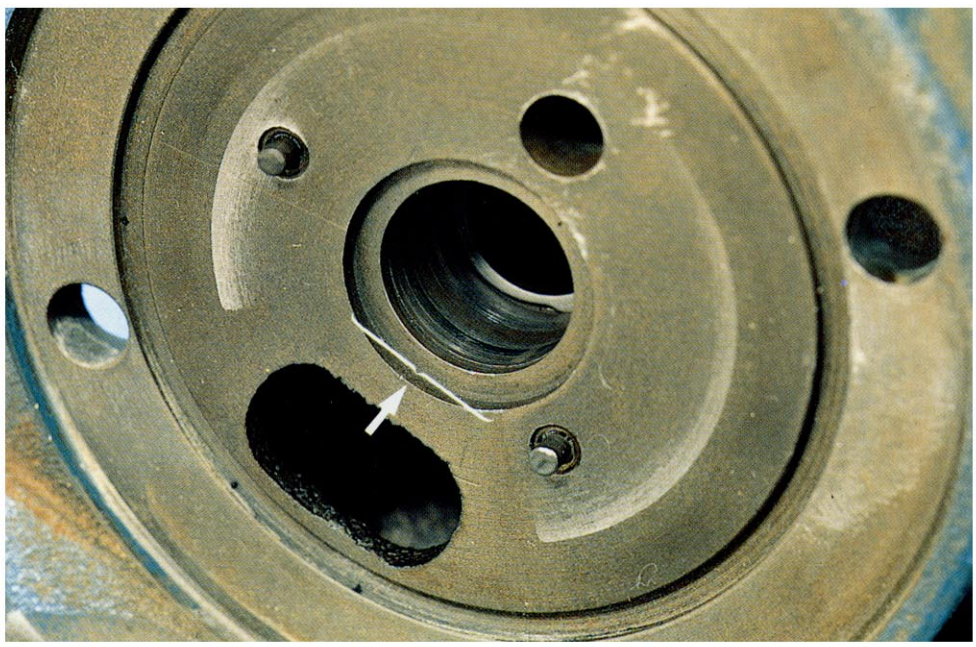
Cause

- Dust in the lubricating oil.

Reconditioning Method

- Finish the flawed surface smooth with No. 400 thru No. 600 sandpaper.

4



DO NOT USE AGAIN

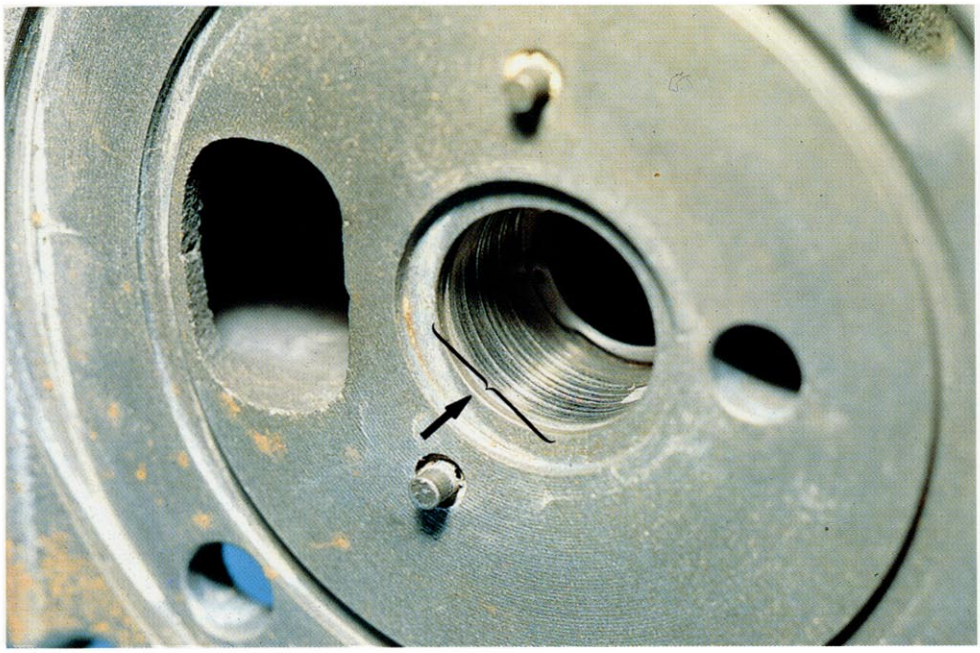
Failure Signs

- Wide flaws are on the bearing bore in the center housing.

Cause

- Dust in the lubricating oil.

5



DO NOT USE AGAIN

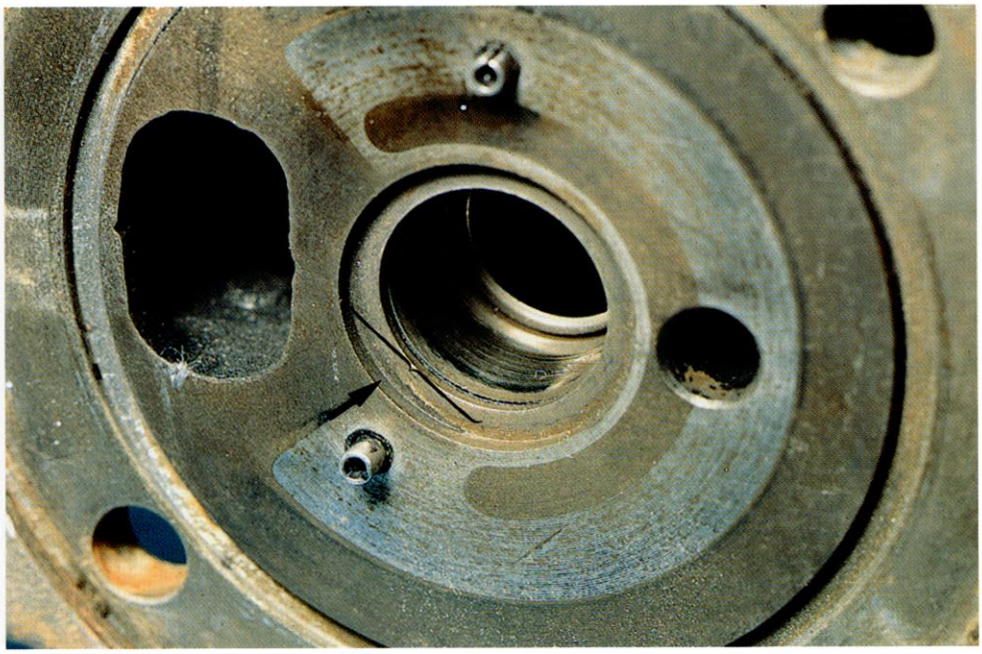
Failure Signs

- Dust in the lubricating oil caused many flaws on the bearing bore in the center housing which catch on a fingernail.

Cause

- Dust in the lubricating oil.

6



DO NOT USE AGAIN

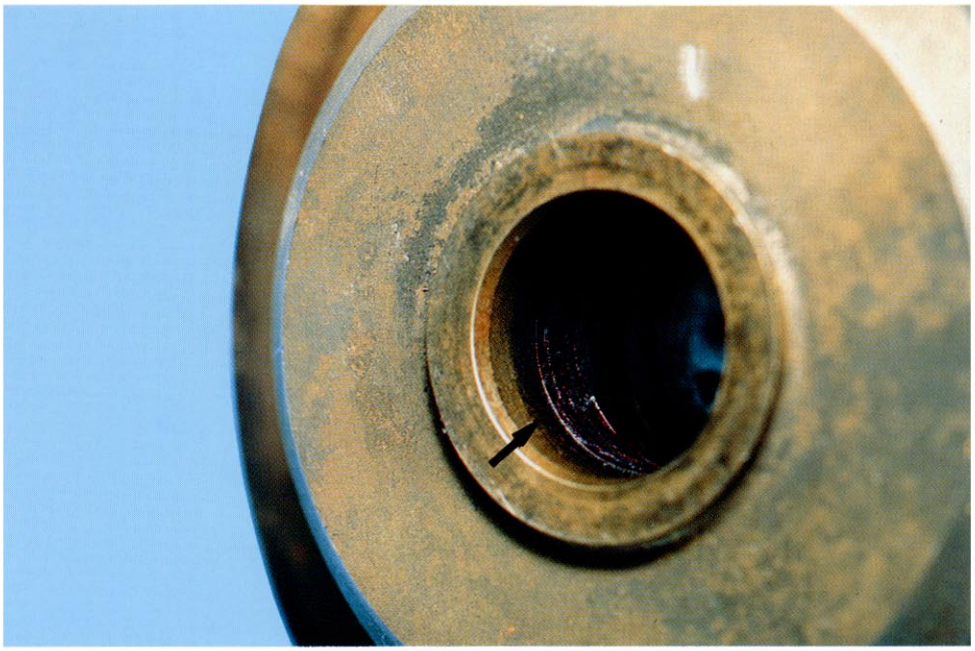
Failure Signs

- A marked degree of wear on the bearing bore in the center housing.

Cause

- Unsatisfactory lubrication.

7



DO NOT USE AGAIN

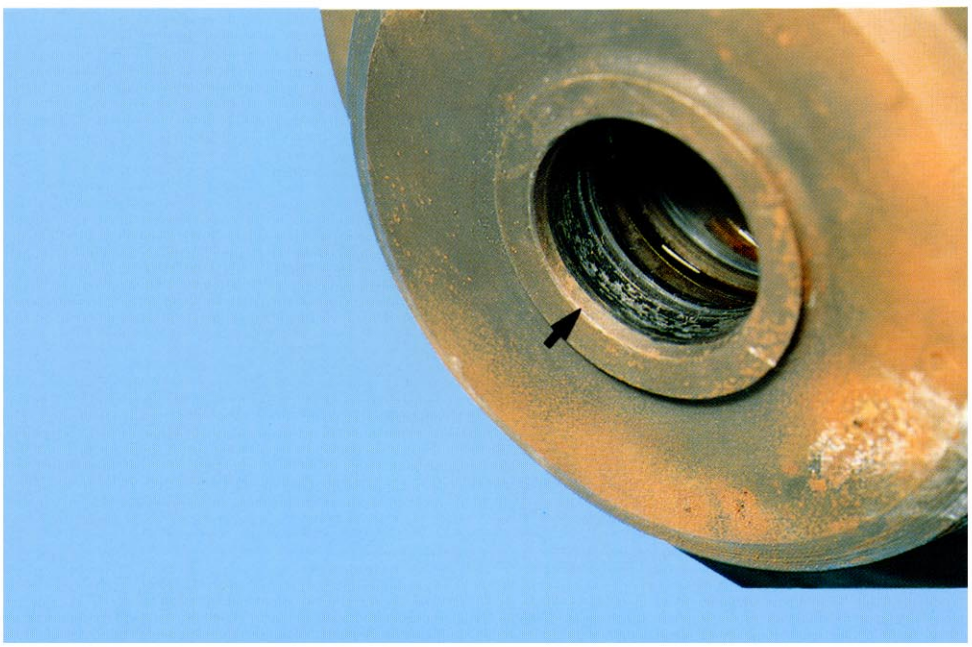
Failure Signs

- The center housing was badly calked or scuffed on its sealing bore.

Cause

- Unsatisfactory lubrication.

8



DO NOT USE AGAIN

Failure Signs

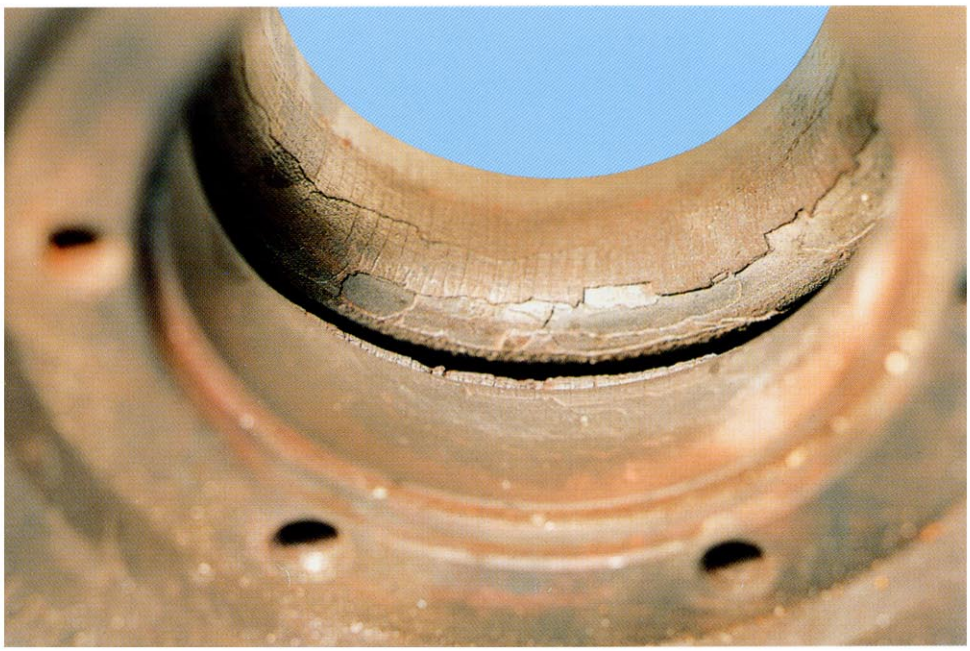
- This center housing has been seized.

Cause

- Contact with the sealing bore due to the unbalanced turbine shaft.

Turbine housing

9



DO NOT USE AGAIN

Failure Signs

- The inner surface is covered with thick oxide film. Surface flaking is also observed.

Cause

- Operation (rotation) at high temperature for many hours.

10

DO NOT USE AGAIN

Failure Signs

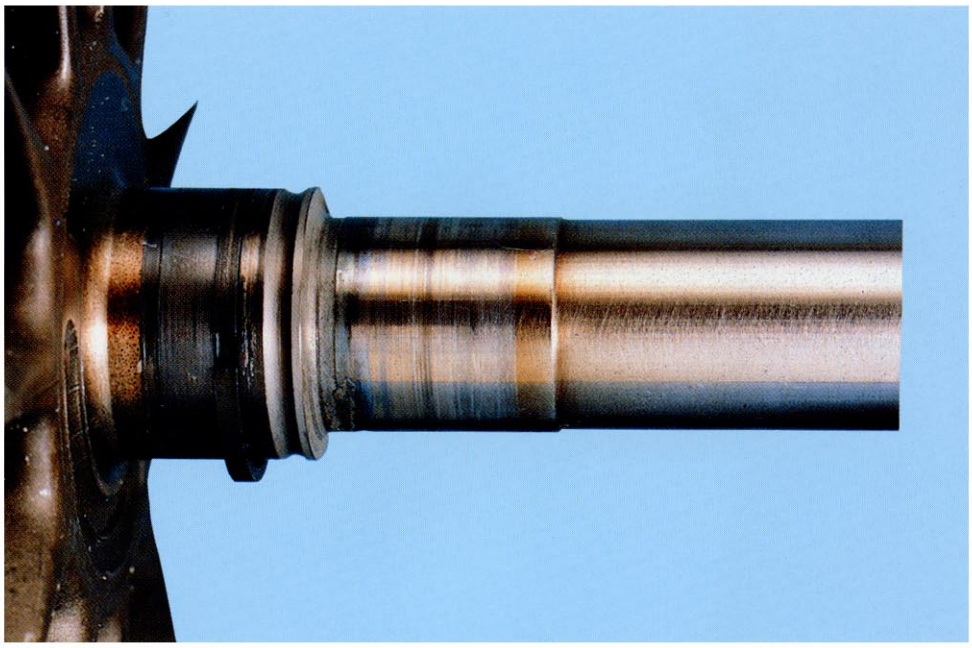
- This turbine housing has heat cracks.

Cause

- Excessive rise in exhaust temperature (The housing may sometimes crack due to entrance of foreign matter.)

Turbine shaft

11

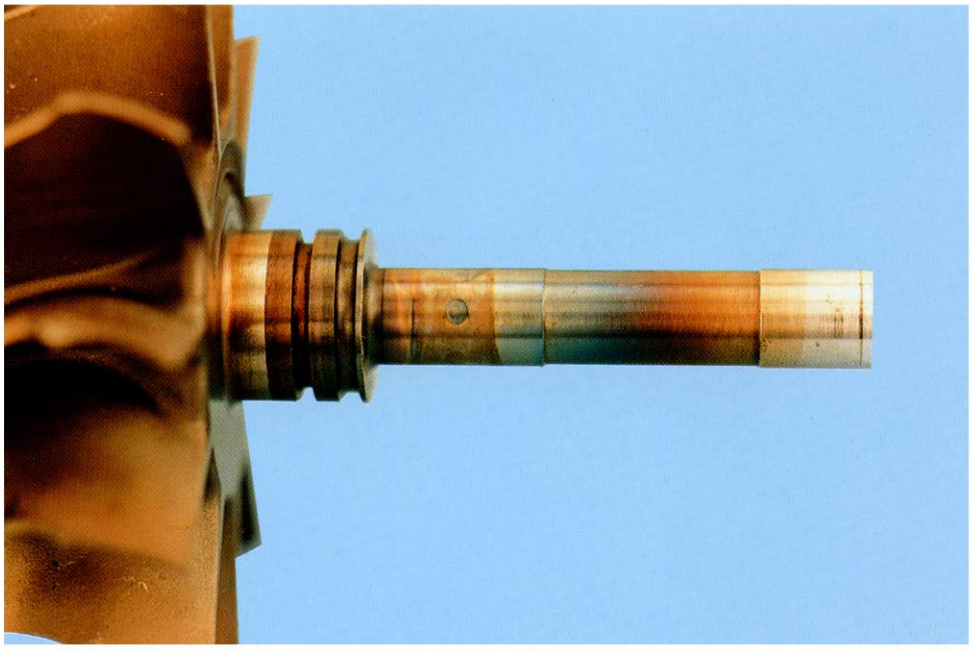


USE AGAIN

Failure Signs

- This is a sound turbine shaft, although its lubricated conditions seems unsatisfactory.

12



USE AFTER RECONDITIONING

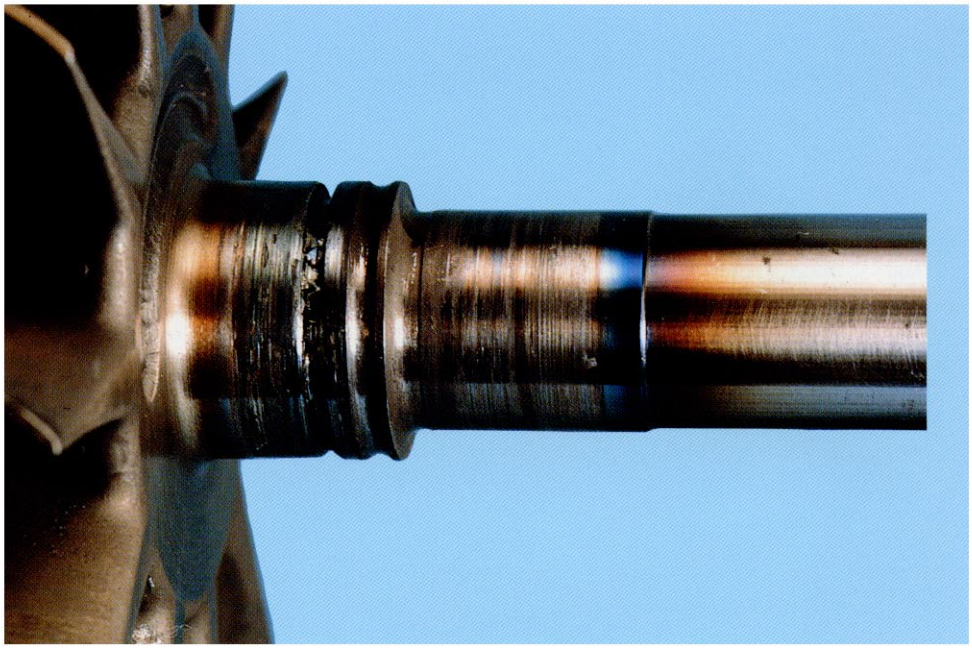
Failure Signs

- This turbine shaft has been thermally discolored.

Cause

- The shaft temperature has increased due to sudden stops. (No foreign matter was observed in the lubricating oil.)
- Finish the flawed surfaces smooth with No. 400 thru No. 600 sandpaper.

13

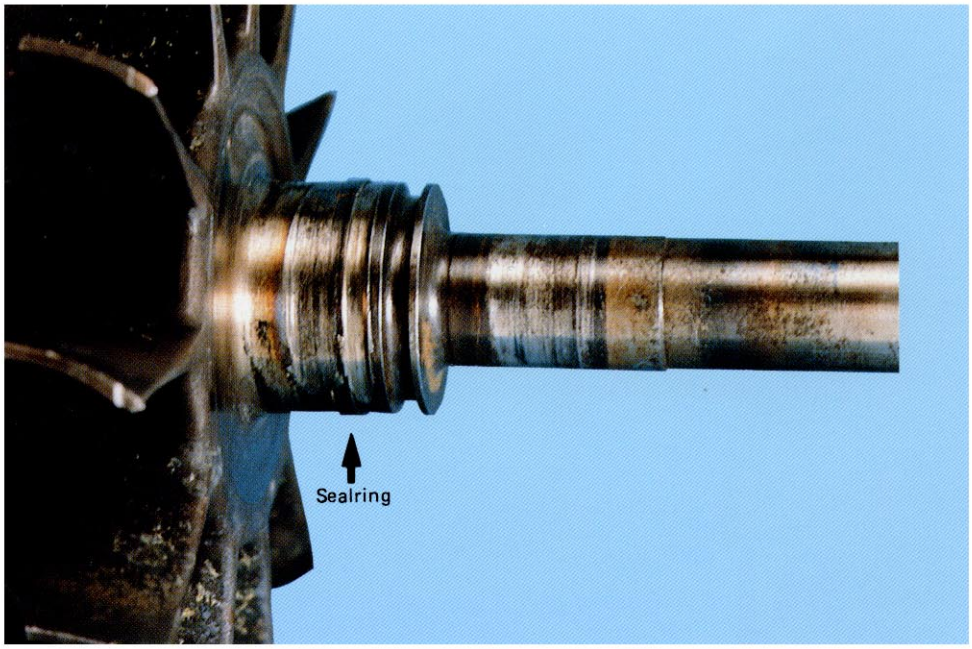


DO NOT USE AGAIN

Failure Signs
- This turbine shaft has seized due to the worn seal ring.

Cause
- Operation (rotation) in an insufficiently lubricated condition.

14

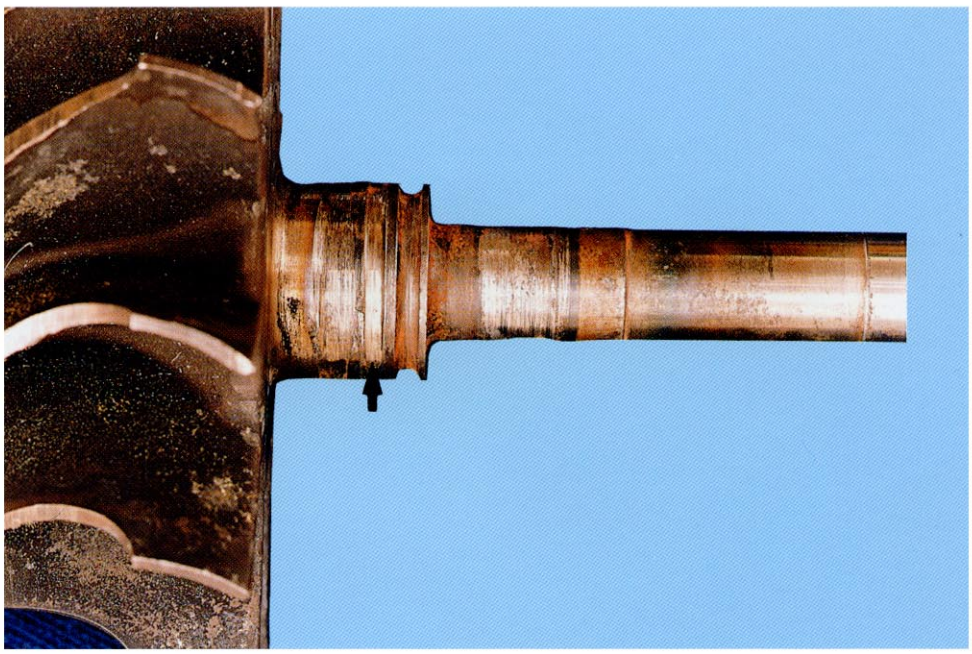


DO NOT USE AGAIN

Failure Signs
- Turbine shaft with a seized seal ring.

Cause
- The bearing was excessively worn due to unsatisfactory lubrication, causing the shaft to run out until it came into contact with the center housing. As a result, the sealing part wore out.

15



DO NOT USE AGAIN

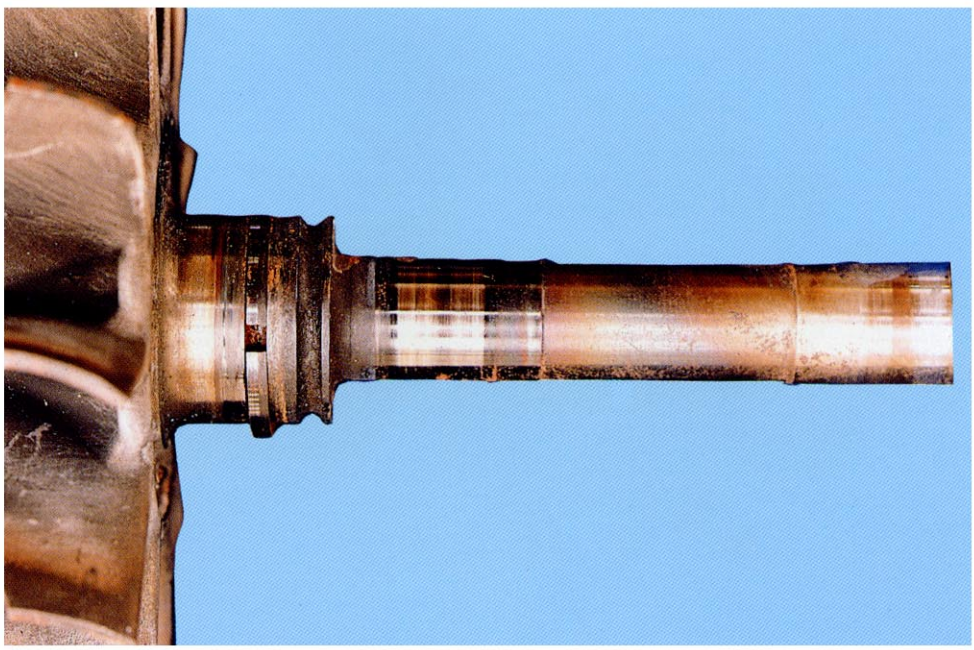
Failure Signs

- A turbine shaft with the sealing part worn out beyond the standard wear value.

Cause

- Calking or scuffing occured in the sealing bore due to unsatisfactory lubrication.

16



DO NOT USE AGAIN

Failure Signs

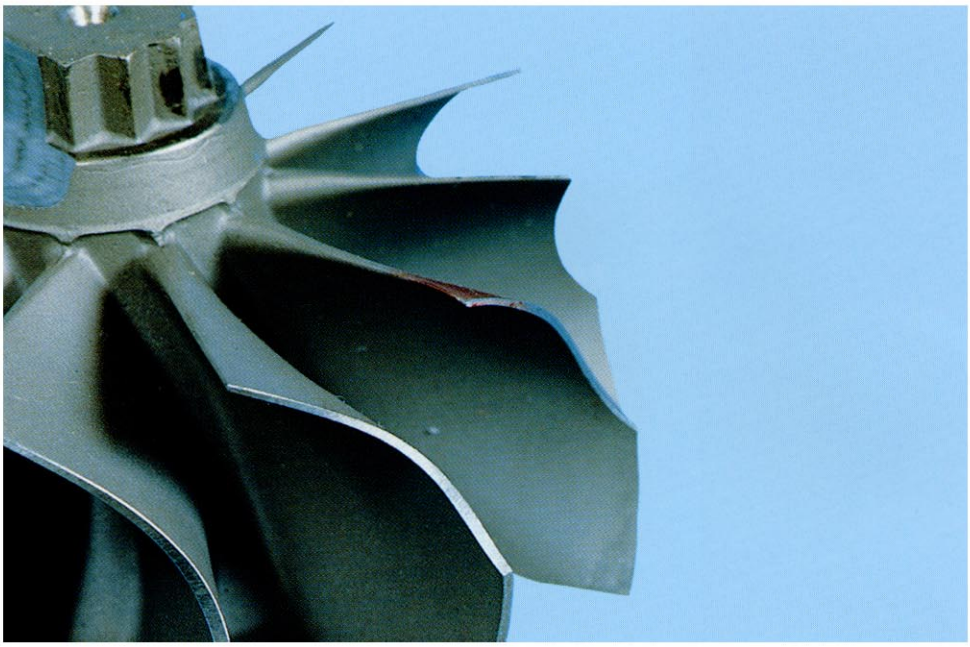
- A thermally discolored turbine shaft. Traces of the seal ring which rotated in the center housing are seen.

Cause

- The shaft temperature increased due to rotation in an insufficiently lubricated condition.

Tubine impeller

17



USE AFTER RECONDITIONING

Failure Signs

- Slight bends at the edge of the impeller blades.

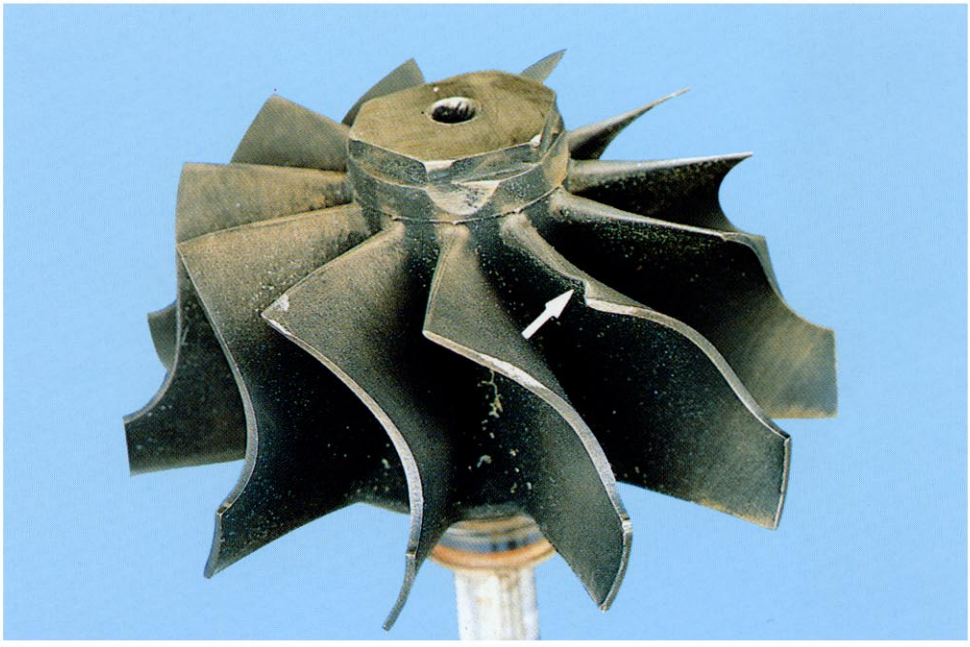
Cause

- Foreign matter (relatively soft) entered the turbine housing or careless handring of the turbine impeller.

Reconditioning Method

- Recondition the bends carefully with a pair of pliers and use a color check to make sure that no cracks are in the blades.

18



USE AFTER RECONDITIONING

Failure Signs

- This is a deformed turbine impeller.

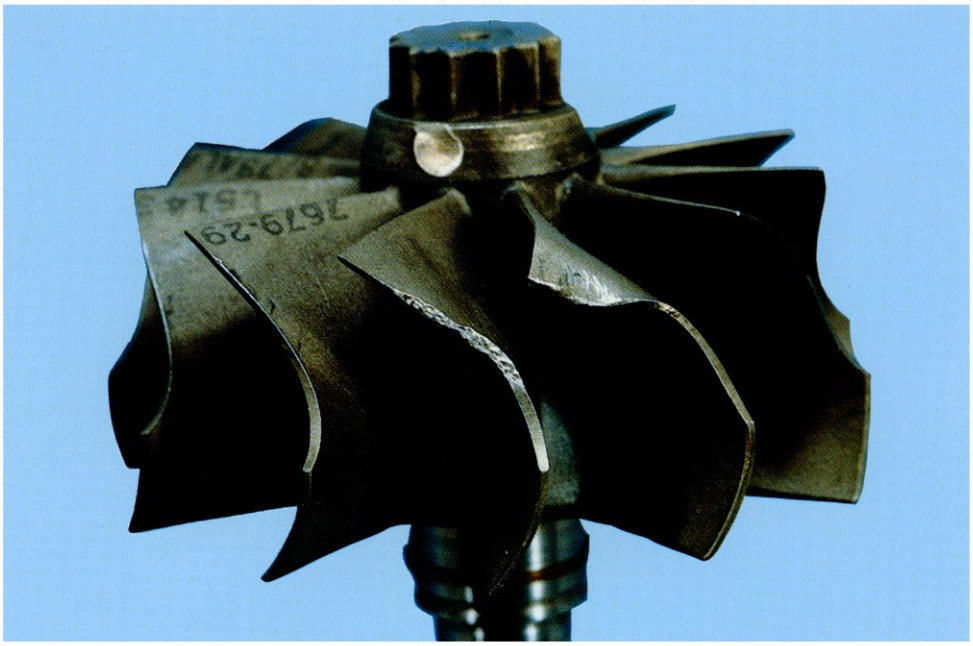
Cause

- Foreign matter in the turbine housing or careless handling of the impeller.

Reconditioning Method

- Carefully recondition the deformed impeller blade with a pair of pliers and use a color check to make sure that no cracks are in the blade.

19

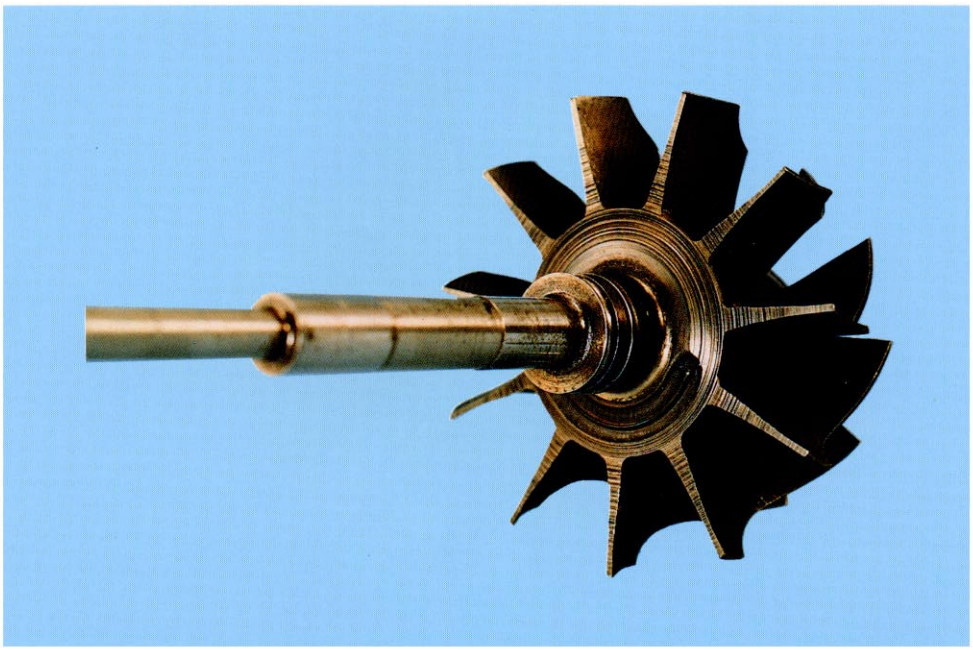


DO NOT USE AGAIN

Failure Signs
- This is a deformed turbine impeller.

Cause
- Careless handling (The impeller was allowed to fall.)

20



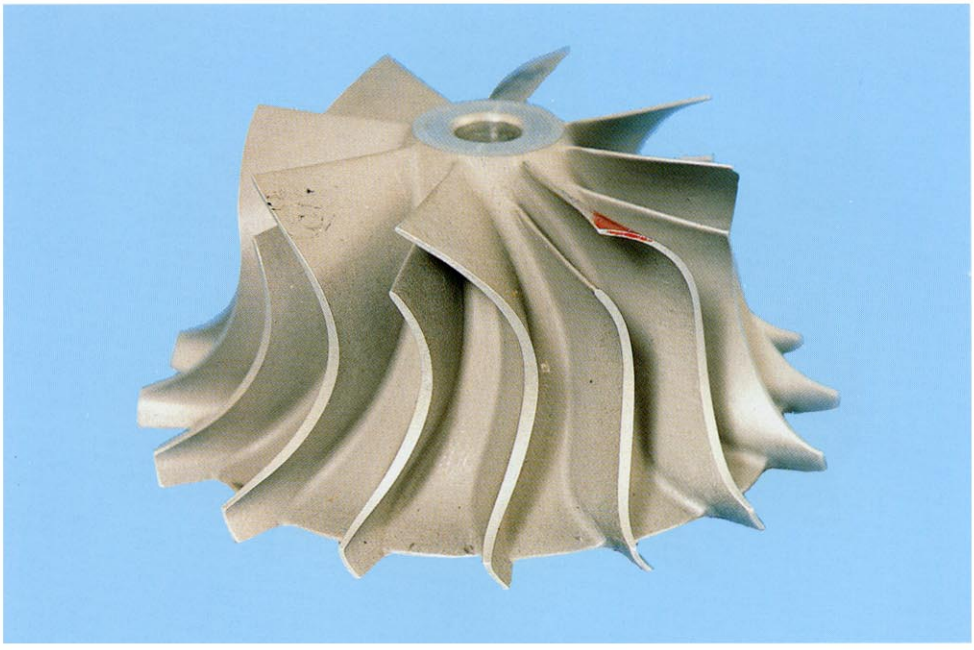
DO NOT USE AGAIN

Failure Signs
- The shield comes into contact with the rear side of this turbine impeller. (If the shield is deformed at an excessively high exhaust temperature, it might come into contact with the rear side of the impeller.)

Cause
- Worn thrust bearing due to unsatisfactory lubrication.

Blower impeller

21



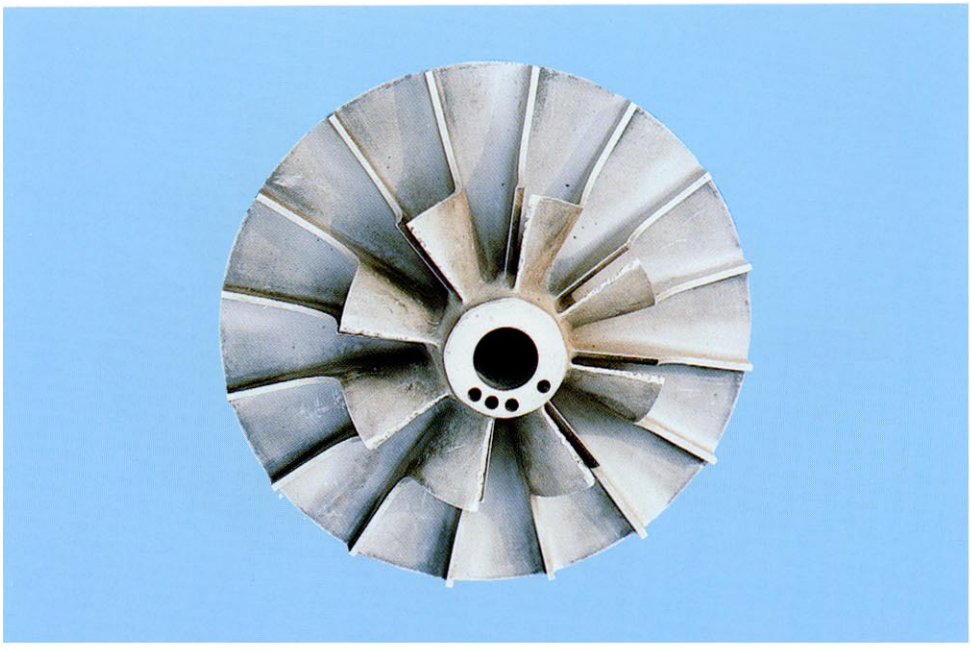
USE AGAIN

Failure Signs
- The blades of this blower impeller are slightly bent at the edges.

Cause
- Foreign matter (relatively soft) in the blower housing.

Note: Use a color-check to make sure that no cracks are in the impeller blades.

22

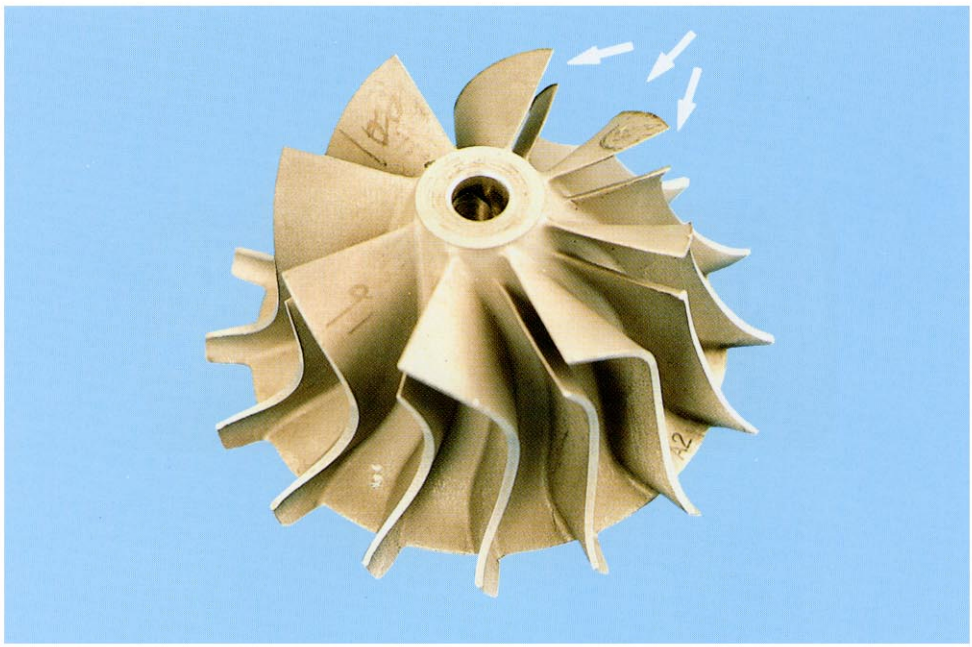


USE AGAIN

Failure Signs
- The blade edges of this blower impeller have been damaged.

Cause
- Hard small foreign matter entered the air intake system.

23



DO NOT USE AGAIN

Failure Signs

- This blower impeller has burrs due to contact with the blower housing. housing.

Cause

- The bearing has excessively worn due to insufficient lubrication.

24

DO NOT USE AGAIN

Failure Signs

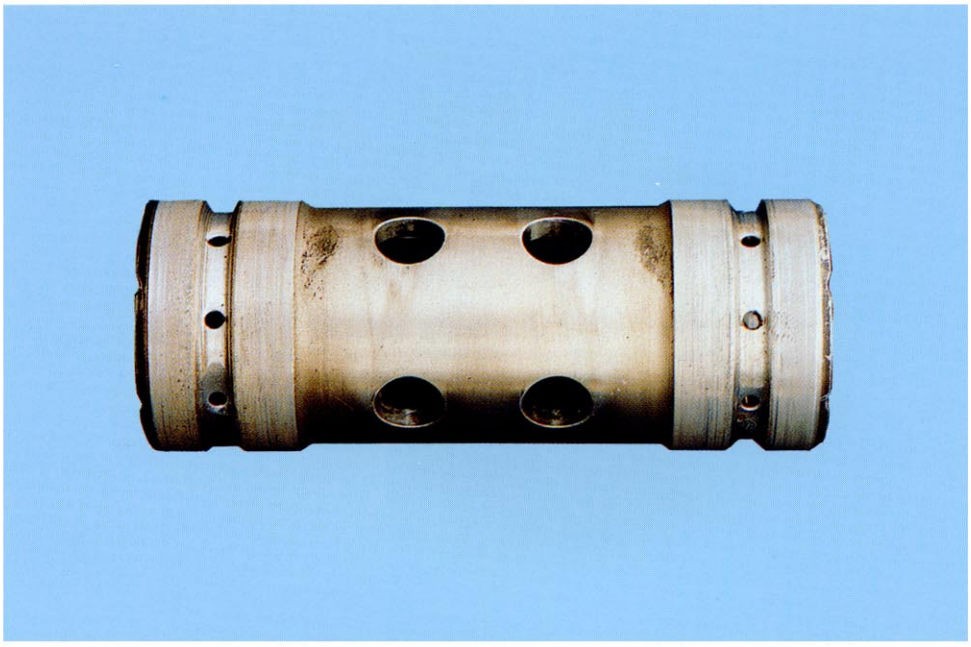
- This blower impeller has broken due to contact with the blower impeller.

Cause

- The runout of the impeller shaft increased because insufficient lubrication caused the bearing to wear out.

Journal bearing

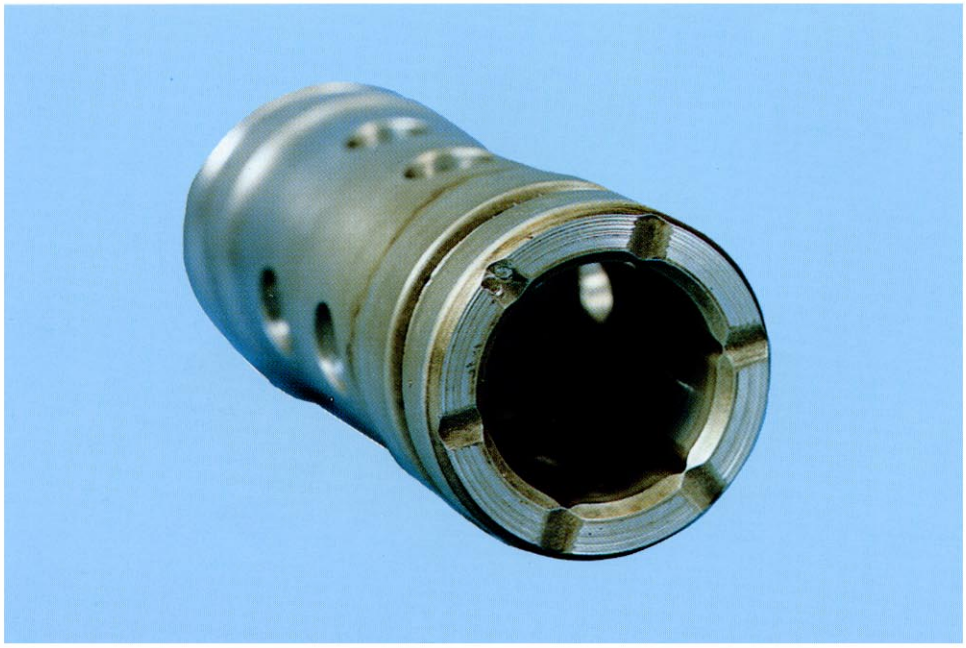
25



USE AGAIN

Failure Signs
- Sound journal bearing in uniform contact with the journal.

26



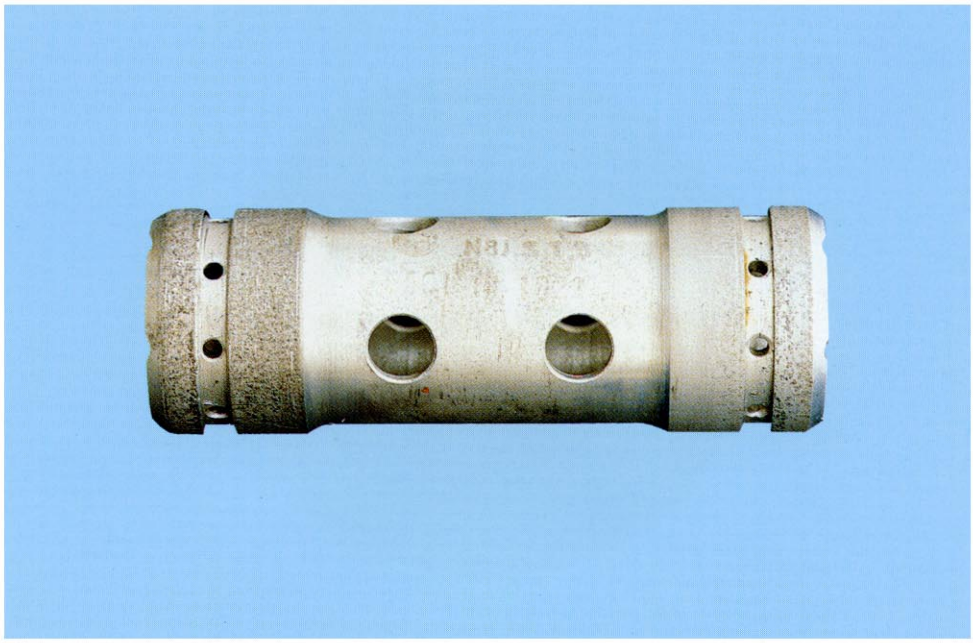
USE AFTER RECONDITIONING

Failure Signs
- This journal bearing is flawed.

Cause
- Dust in the lubricating oil.

Reconditioning Method
- Finish the flawed surfaces smooth with No. 400 thru No. 600 sandpaper.

27



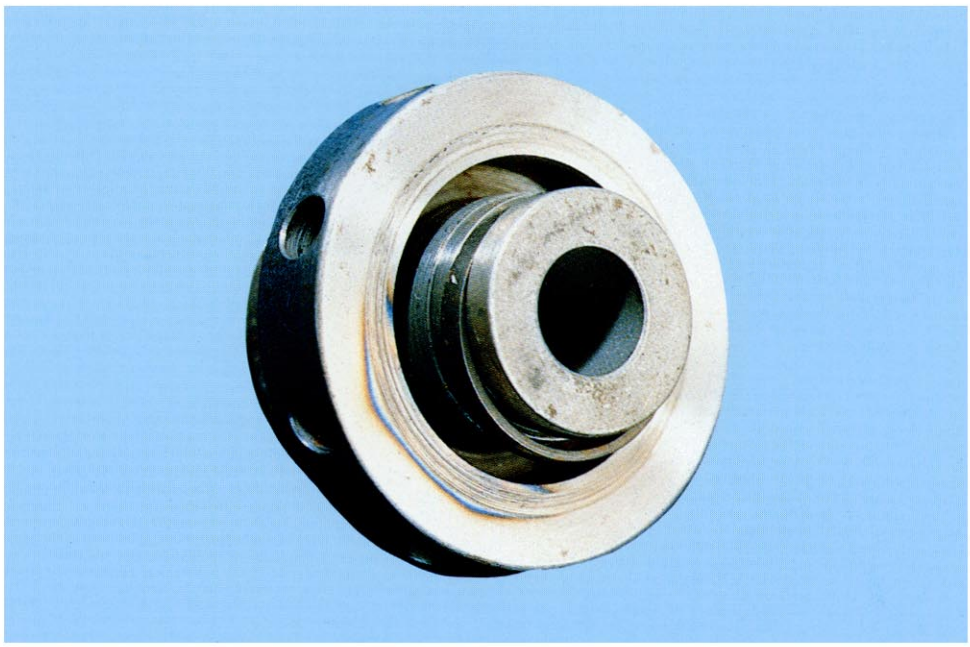
DO NOT USE AGAIN

Failure Signs
- This journal bearing is flawed.

Cause
- The lubricating oil was poor in quality.
  (Low quality oil or the oil contaminated with water).

Thrust collar

28



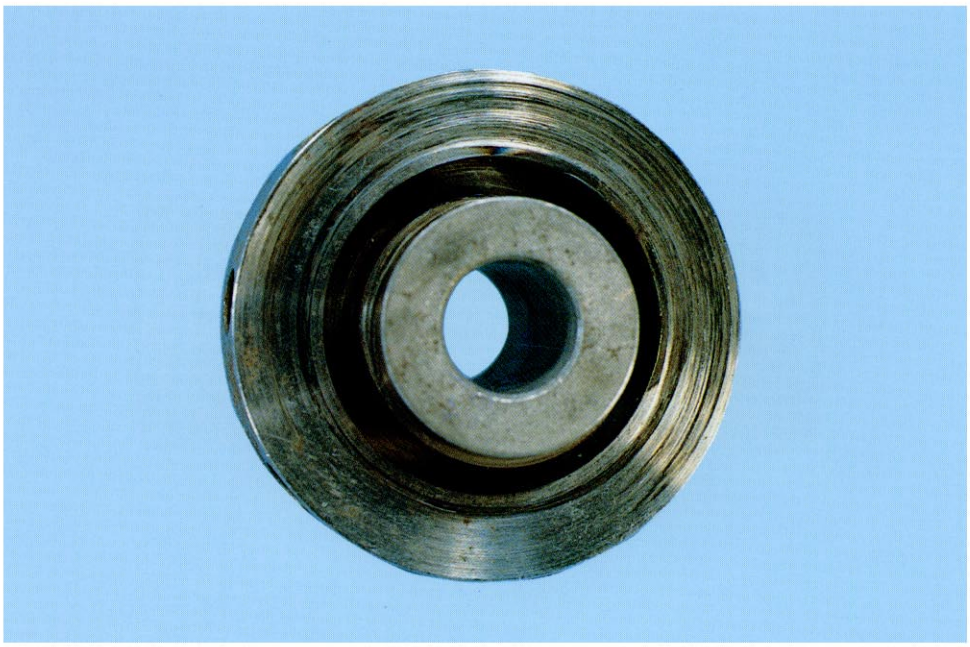
USE AFTER RECONDITIONING

Failure Signs
- This thrust collar has been thermally discolored due to contact with the seal land in the bank plate. Circular flaws do not catch on a fingernail.

Cause
- Temporary lack of lubricating oil

Reconditioning Method
- Finish the defective surface smooth with No. 400 thru No. 600 sandpaper.

29



DO NOT USE AGAIN

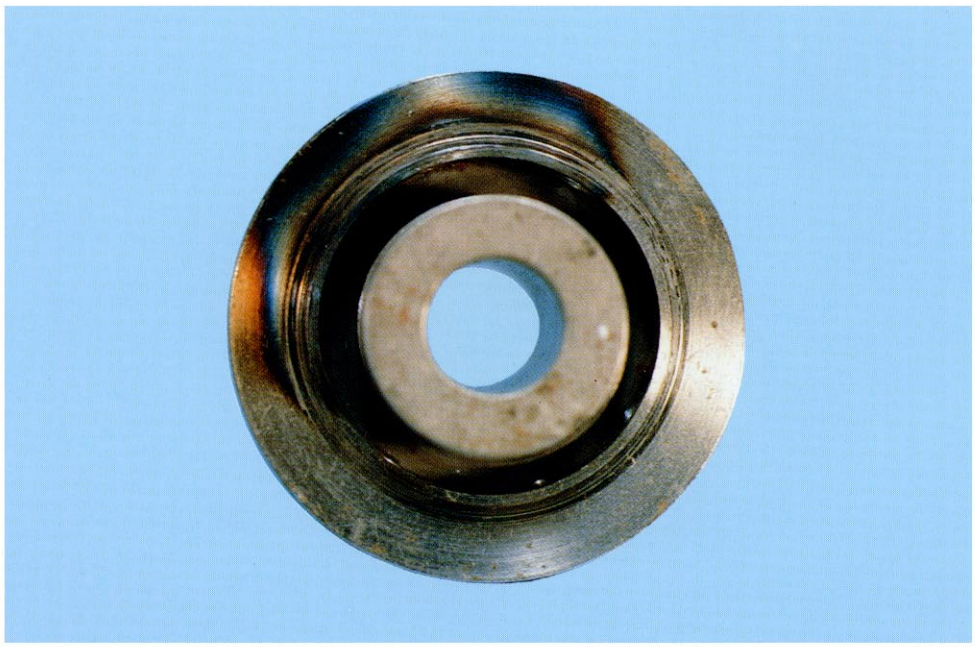
Failure Signs

- This thrust collar is worn all over the external surface due to contact with the back plate.

Cause

- Thrust bearing wore out due to insufficient lubrication.

30



DO NOT USE AGAIN

Failure Signs

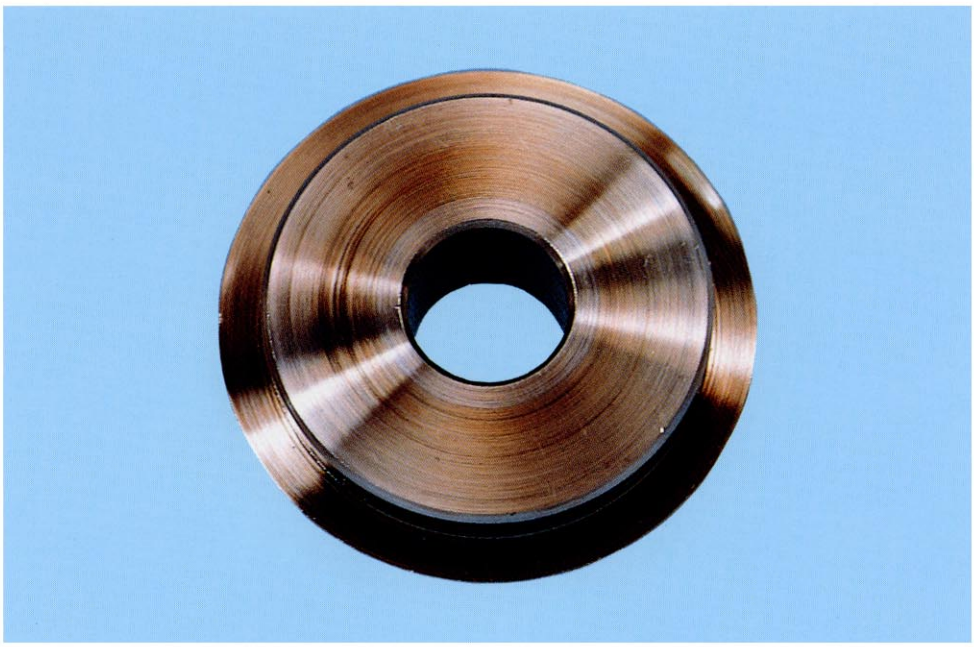
- This thrust collar has been thermally discolored due to contact with the back plate. Flaws on the circumference are deep.

Cause

- Blower impeller lacked dynamic balance due to unsatisfactory setting.

Flinger

31



USE AFTER RECONDITIONING

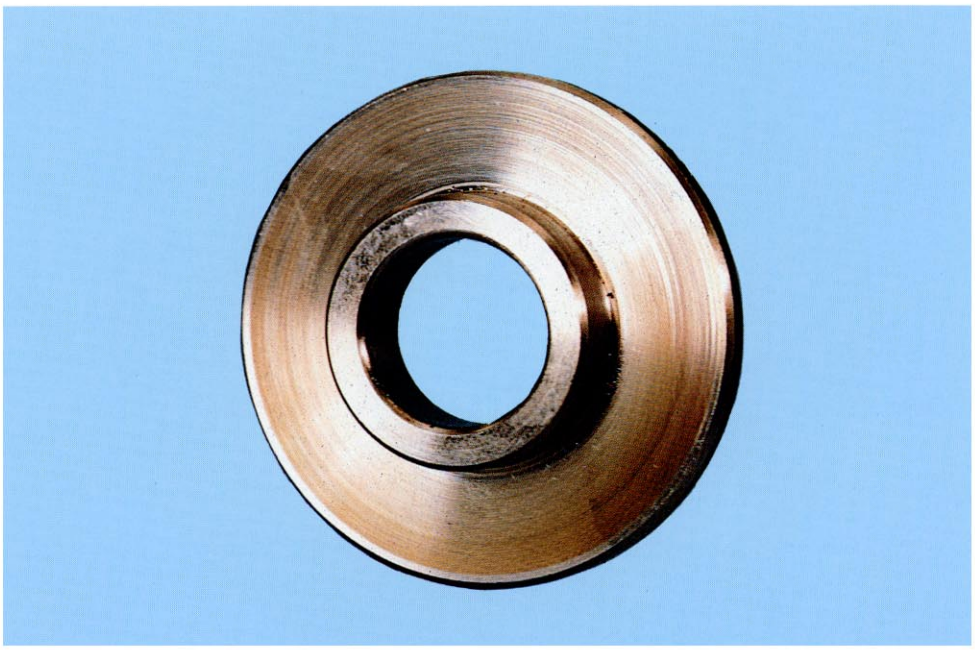
Failure Signs

- This flinger came into normal contact with the thrust bearing and wore out after many hours of operation.

Reconditioning Method

- Recondition the worn surface smooth with No. 400 thru No. 600 sandpaper.

32



USE AFTER RECONDITIONING

Failure Signs

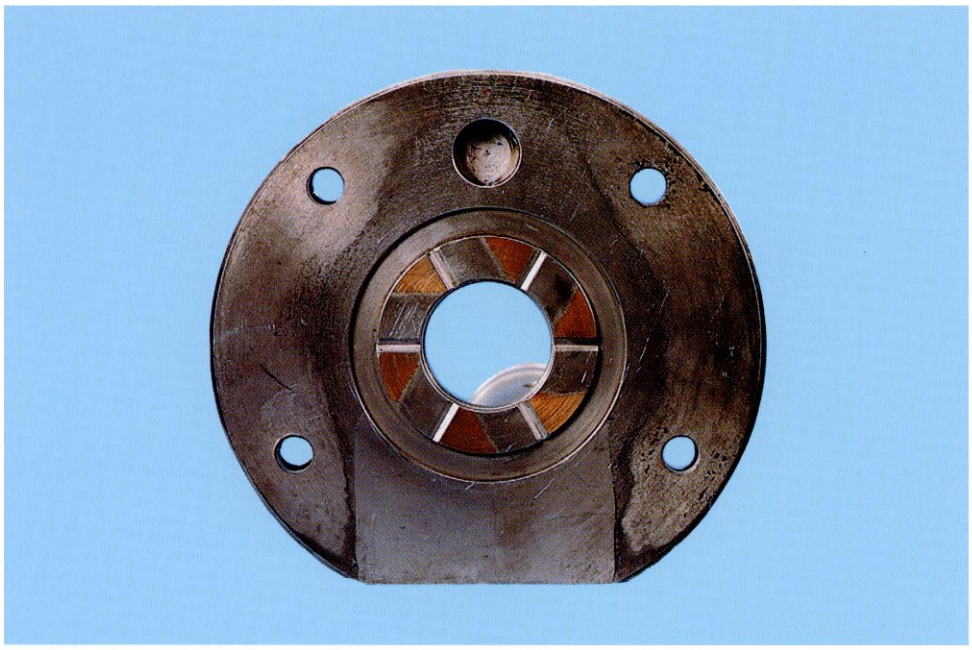
- This flinger wore out in normal contact with the thrust bearing after many hours of operation.

Reconditioning Method

- Finish the worn surface smooth with No. 400 thru No. 600 sandpaper.

Thrust bearing

33

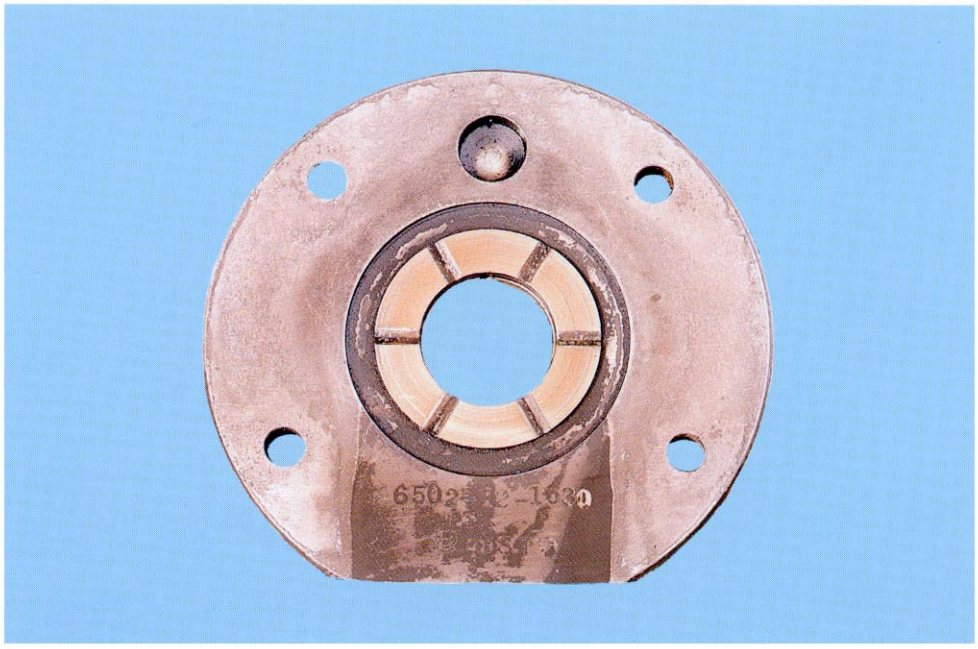


USE AGAIN

Failure Signs

- This thrust bearing has normal wear due to even contact.

34



USE AFTER RECONDITIONING

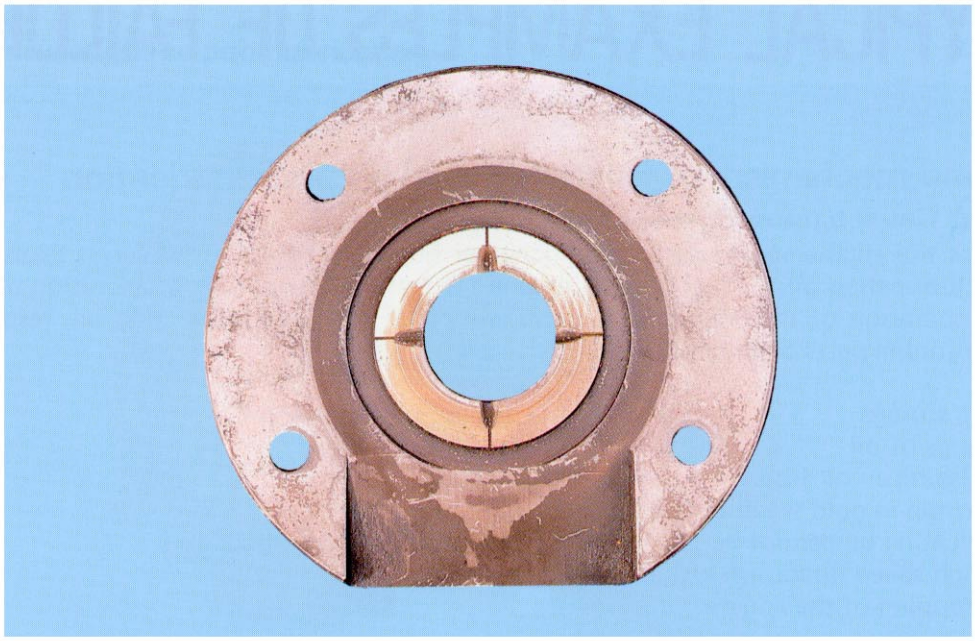
Failure Signs

- This thrust bearing has normal wear due to even contact.

Reconditioning Method

- Determine the usability by measuring the dimensions.

35



DO NOT USE AGAIN

Failure Signs

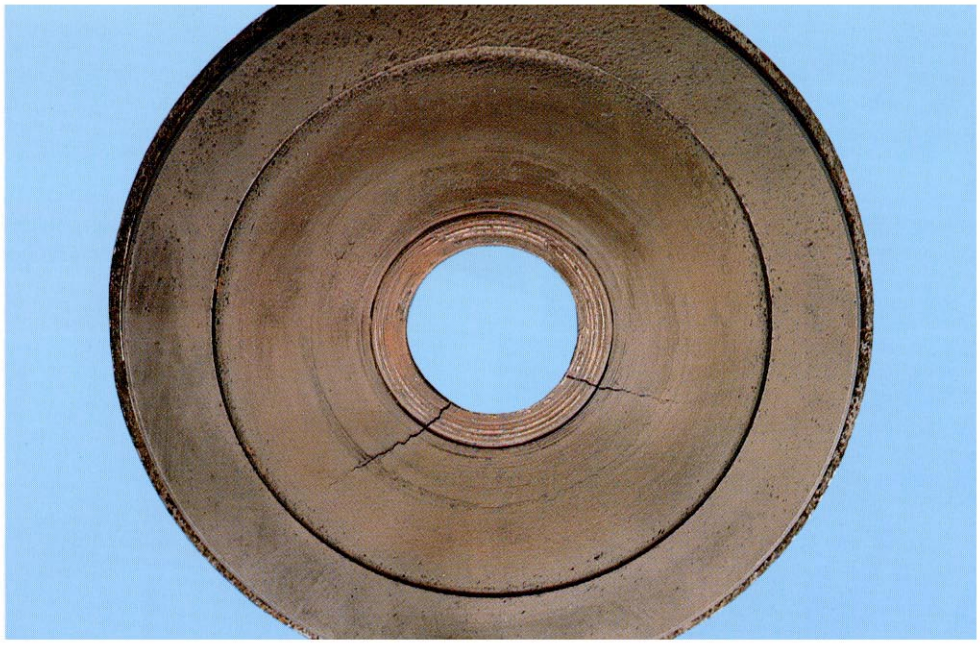
- The running parts of this thrust bearing have uneven wear due to their lack of balance.

Cause

- The impeller was deformed by foreign matter which entered the air intake system.

Shield

36



DO NOT USE AGAIN

Failure Signs

- Part of this shield has stuck on the rear side of the turbine impeller. Heat checks have also occurred.

Cause

- Thermal deformation due to the increased exhaust temperature.

TYPICAL EXAMPLES OF FAILURES

Causes and mechanism of failures caused by poor lubrication

Failure and Causes (causes in method of operation)

As soon as the engine starts up, the turbocharger begins to rotate. However, it takes a certain time to feed the lubricating oil throughout the engine. Therefore, the abrupt acceleration of the engine or the abrupt operation of the engine under load will cause a lack of lubricating oil, resulting in seized bearings or running parts of the engine.

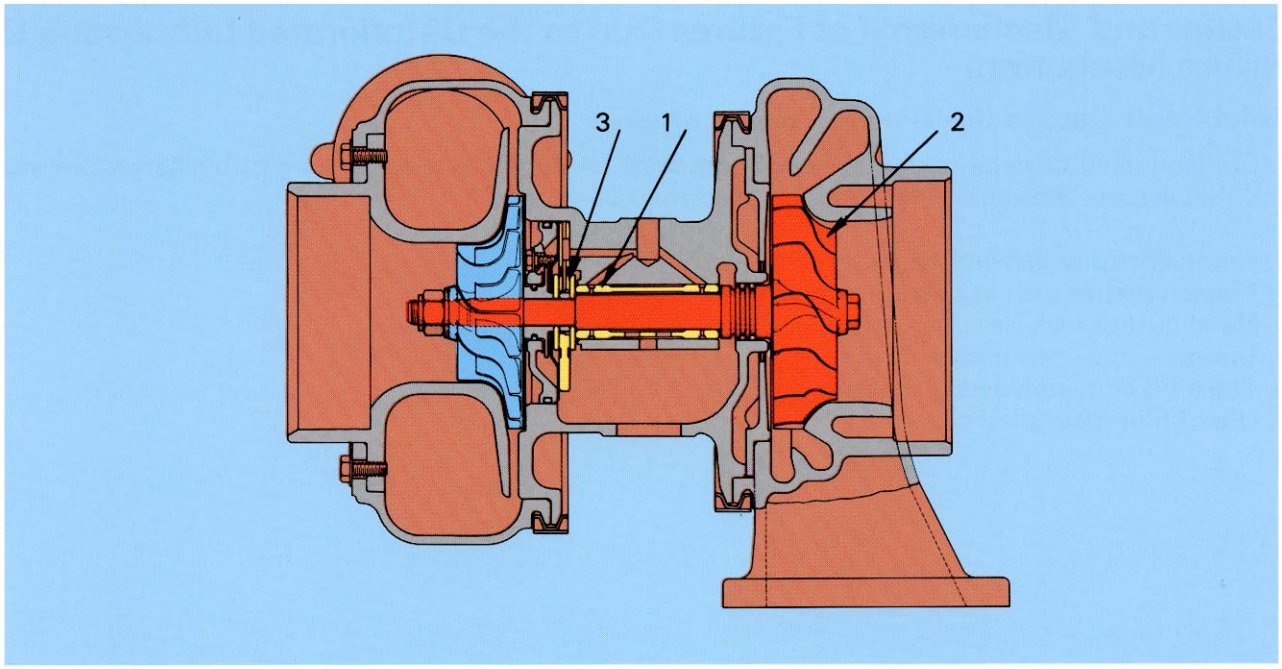
1. After long storage
2. After change of oil
3. After replacing an oil filter
4. When warmup in cold weather is too short
   (The lubricating oil cannot be fed smoothly because of its high viscosity.)
5. Abrupt high speed operation just after engine is started.
6. Abrupt stopping of the engine.

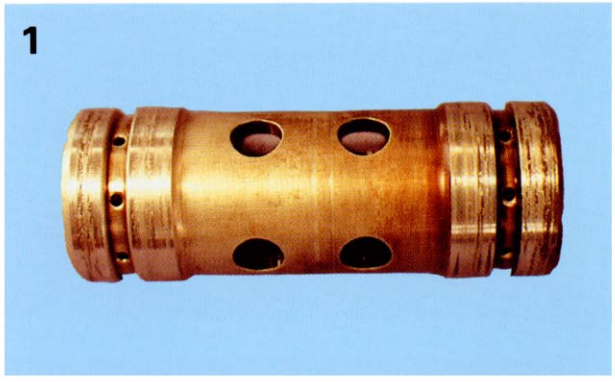
In addition, clogged oil circuits, oil leakage, crushed piping, and defective oil pumps are also causes of faults.

Failure mechanism

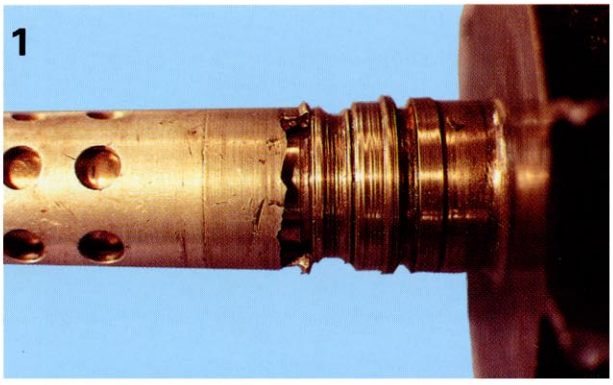
The floating sealing performance of journal bearings deteriorates, causing the bearings to wear prematurely. As a result, the bearings begin to move irregularly.	▶	The axial and radial runout of the impeller and its shaft increase.
Journal bearings are thermally discolored (blue) and wear out excessively, resulting in scuffing of the bearing or pick up. (The bearings cannot run smoothly.)	▶	Abnormal sound occurs intermittently. (The exhaust smoke temporarily becomes white).
Running parts are liable to seizure, resulting in reduced running speed.	▶	Lack of air supply causes black smoke to be emitted and reduces the engine horsepower.
Running parts are seized and deformed or deteriorated by frictional heat, resulting in damaged parts.		

Example of failures due to poor lubrication

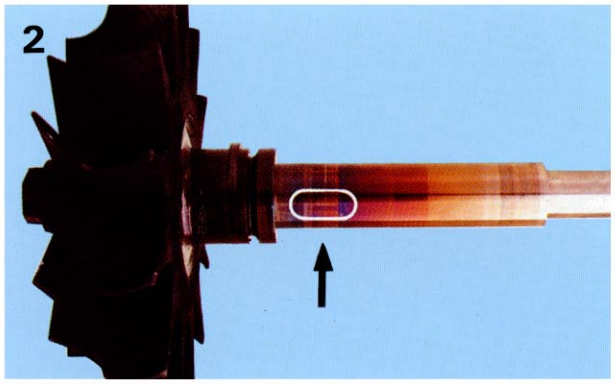




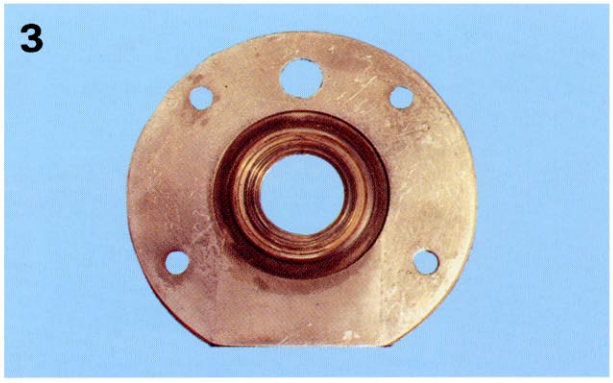
Journal bearing scuffed and worn excessively due to lack of lubricating oil.



Journal bearing seized and broken due to lack of lubricating oil.



Thermally discolored turbine shaft due to lack of lubricating oil. A spot mark (marked partial discoloration) is seen.



Thrust bearing excessively worn or scuffed due to the lack of lubricating oil.

Causes and Mechanisms of Failures Due to the Deteriorated Lubricating Oil and Failure Mechanism

Failure and Causes (faults due to kind of oil used)

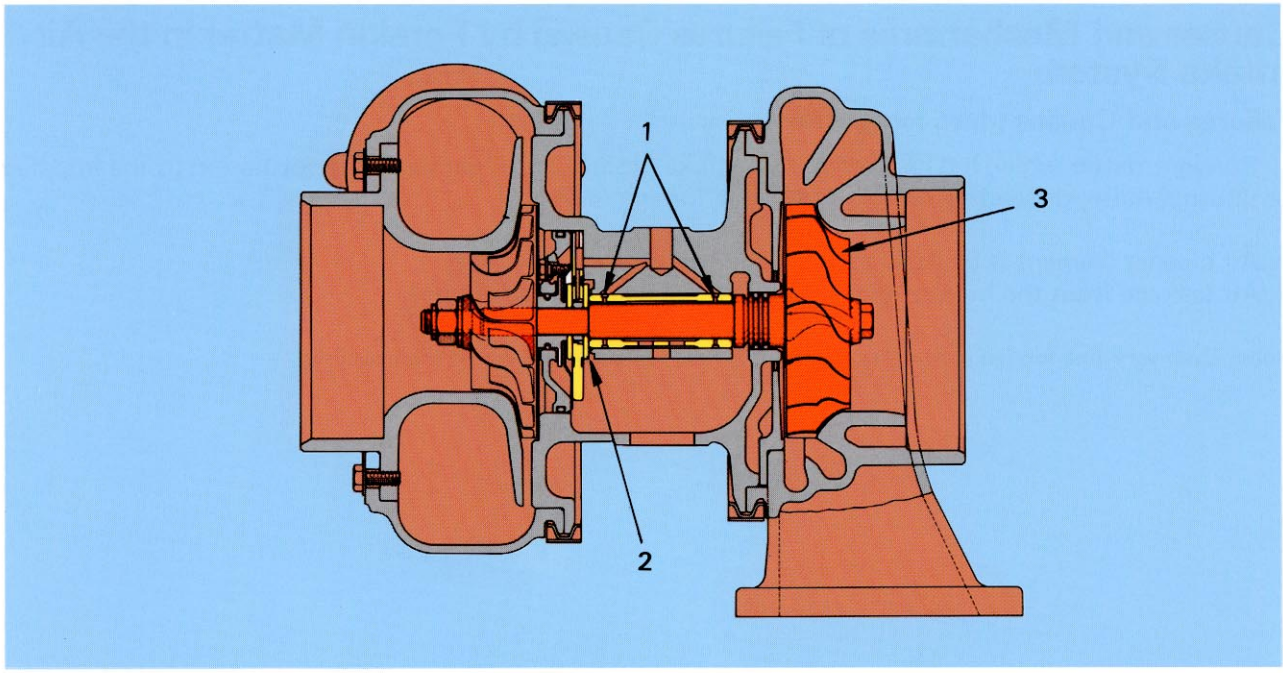
Contaminated or deteriorated oil accelerates wear of the high-speed running turbocharger bearings and sliding parts and causes these parts to be scuffed or seized.

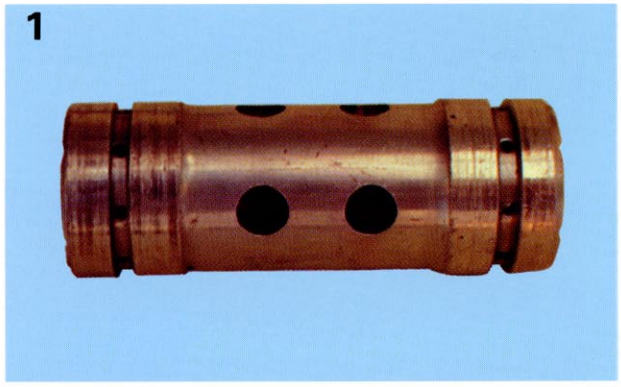
1. Unsatisfactorily installed or faulty oil filter element.
2. Foreign matter such as dust gets into the oil.
3. Metal dust or particles produced by internal engine wear enter the oil.
4. Unsatisfactory periodic oil change.
5. The oil is contaminated with water, fuel, etc.
6. Use of non-designated oil.

Failure Mechanism

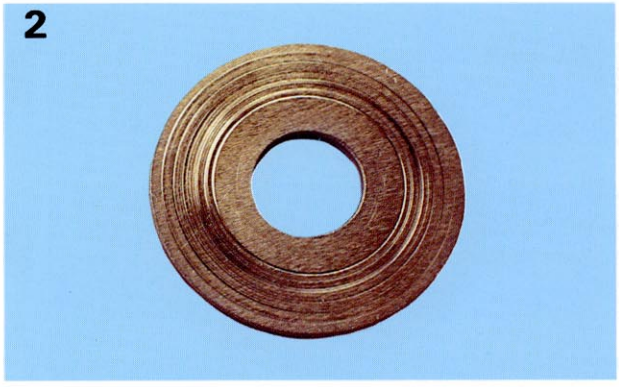
Foreign matter sticks on the surfaces of journals and thrust bearings.	▶	The turbocharger makes abnormal noise.
The housing bearing bore is rubbed off, resulting in looser bearings.	▶	Axial and radial runouts of the impeller and shaft are increased.
Thrust collars and bearings are likely to be scuffed or worn out.	▶	Axial and radial runouts of the impeller and shaft are increased.
Vibration of journal bearings on the external circumference is increased, resulting in large turning movement.	▶	Abnormal noise is made intermittently and the engine exhaust smoke becomes black.
The sealing effect of the lubricating oil is deteriorated, causing the blades to come into contact with the housing.	▶	The engine horsepower is reduced.
Running parts are seized and thermally discolored (blue), resulting in faulty shaft and seals.		

Examples of Failures Caused by Deteriorated Lubricating Oil

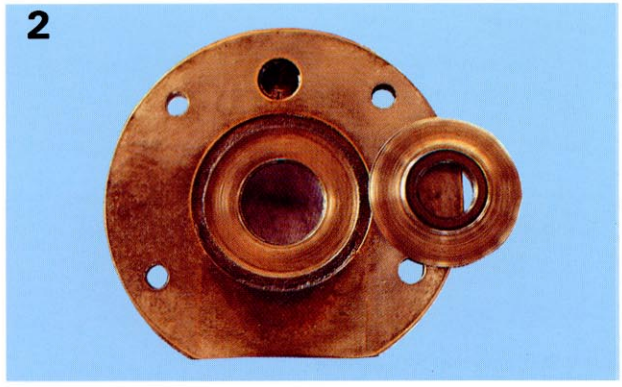




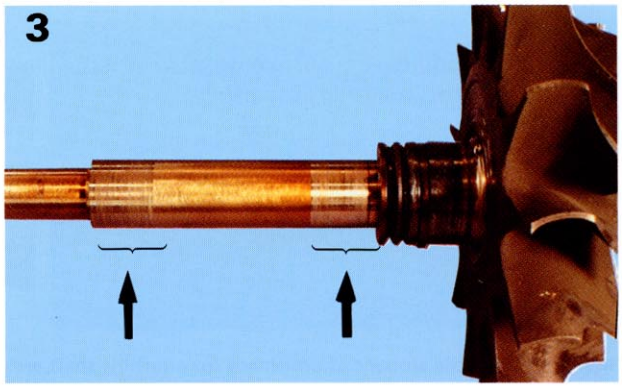
Scuffed or worn journal bearing due to contamination of lubricating oil with foreign matter.



Thrust collar having a pick-up or scuffing flaw on the contact surface with journal bearing due contamination of lubricating oil with foreign matter.



Thrust bearing and thrust collar excessively scuffed and worn after many hours of operation with a lubricating oil contaminated by foreign matter.



Turbine shaft whose sliding surface is scuffed and worn due to lubricating oil contaminated with foreign matter.

Causes and Mechanisms of Failures Caused by Foreign Matter in the Air Intake System

Failures and Causes (dust, foreign matter, etc.)

Foreign matter which has entered the air intake piping causes damage or deformation to the impeller or unusual noise, depending on the size of the foreign matter.

1. Air cleaner element is broken.
2. Air leakage from the hose or pipe connection on the air intake side.

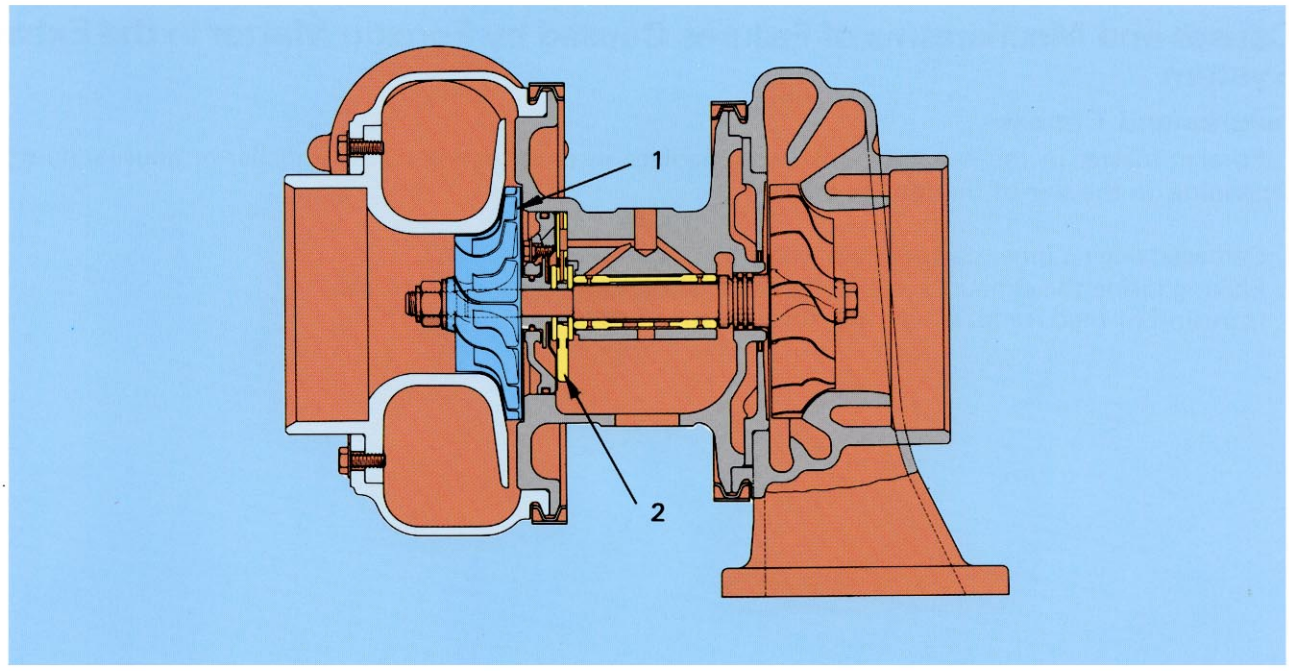
Note: Even very fine foreign matter like welding spatters can cause damage to the impeller.

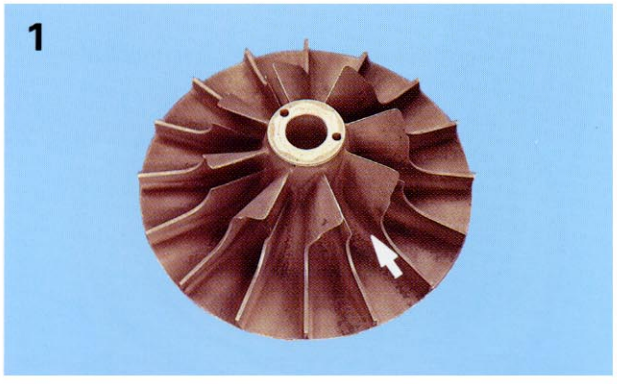
Failure Mechanism

The blower impeller is flawed.	→	When foreign matter is large, the impeller will be damaged.
The turbine shaft is unbalanced, resulting in more shaft runout.	→	The engine exhaust smoke is white.
The impeller shaft runs off center and wears out, causing the journal bearings to deform.	→	Black exhaust smoke is emitted and the engine horsepower is reduced.
The housing and the impeller come into contact with each other, resulting in scuffing.	→	The running speed goes down and the horsepower is reduced.
The blower impeller is damaged.	→	Broken pieces may be drawn into the engine, resulting in damage to the engine body.

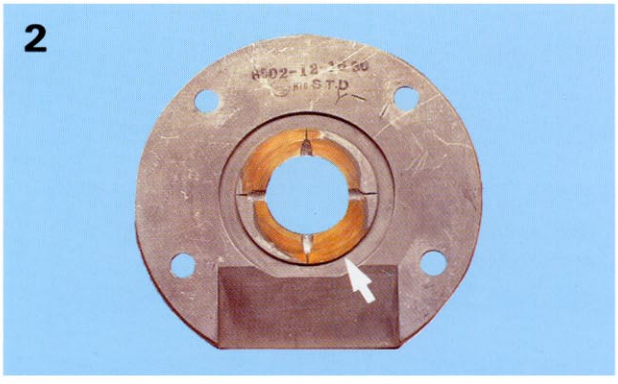
Note: The allowable amount of unbalance for a turbine shaft ass'y is about 0.005 g on the O.D. surface.

Example of Failures Caused by Foreign Matter in the Air Intake System

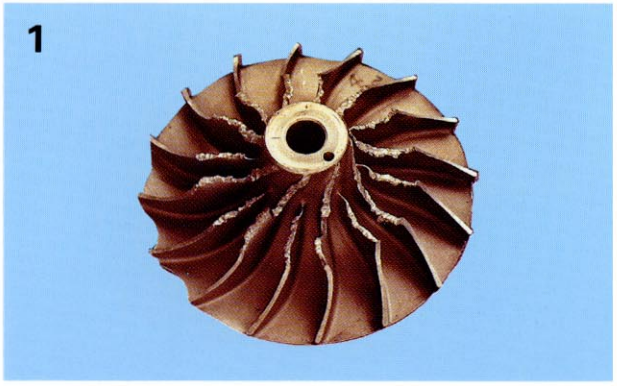




Blower impeller deformed with foreign matter like dust in the air intake system.



Thrust bearing unevenly worn because the running part is unbalanced by a damaged or deformed impeller.



Blower impeller damaged with foreign matter like stones, nuts, washers, etc.

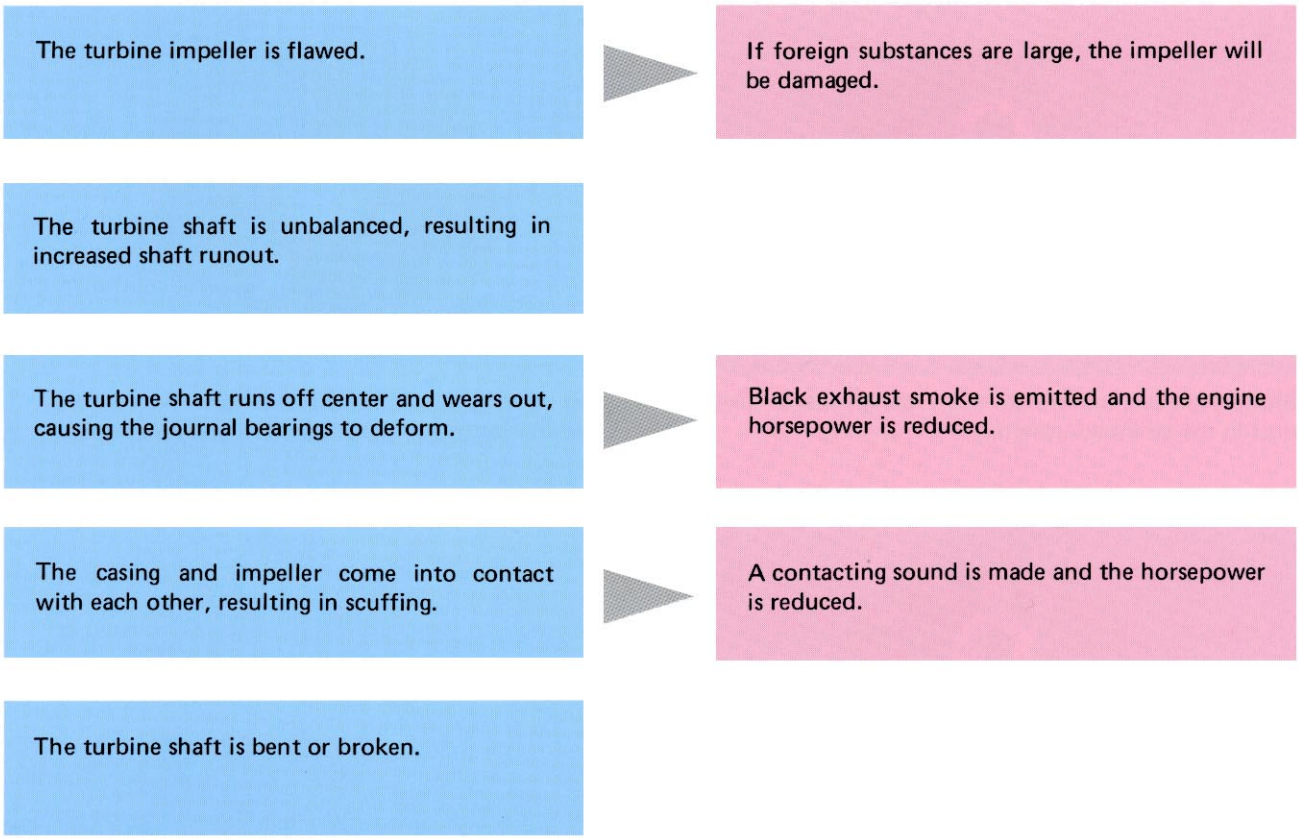
Causes and Mechanisms of Failures Caused by Foreign Matter in the Exhaust System

Failures and Causes

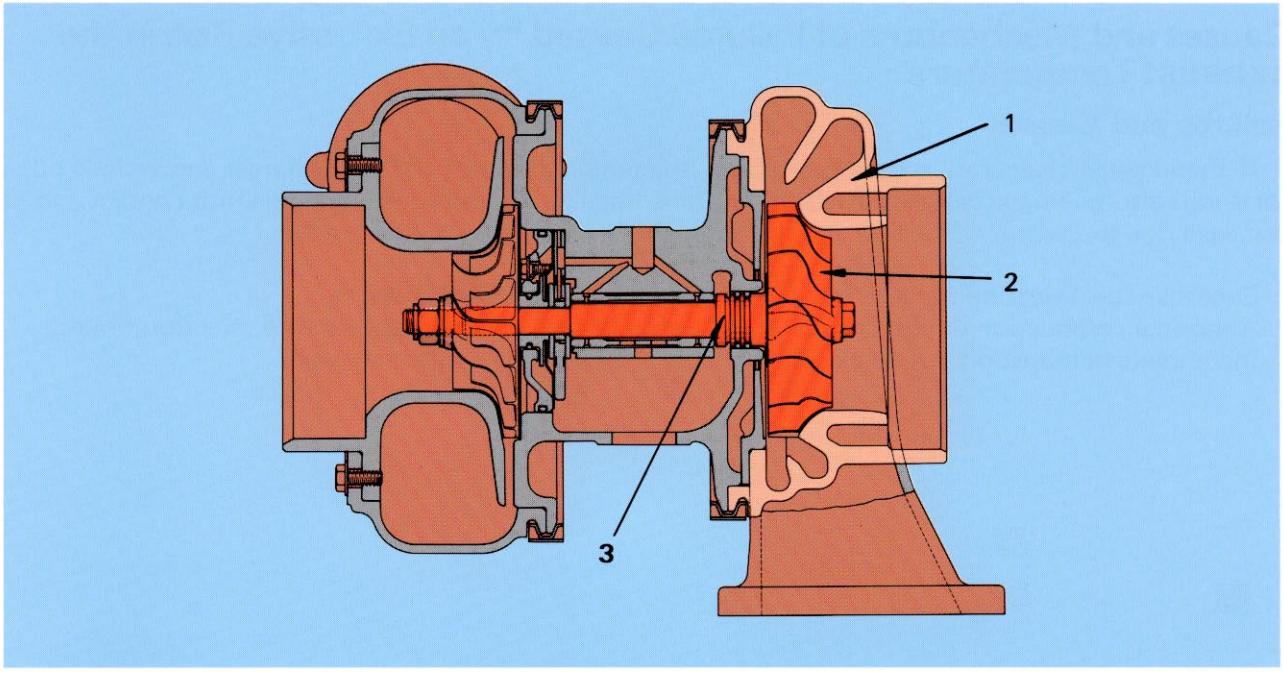
Foreign matter in the exhaust pipe causes damage or deformation to the impeller or unusual noise, depending on the size of the foreign matter.

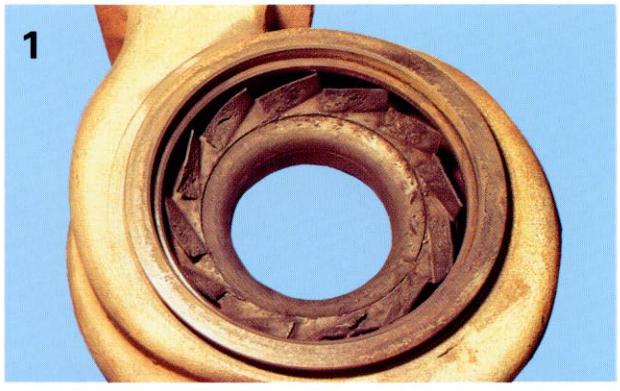
1. Damaged engine inner parts (valves, valve seats, cotters, etc.)
2. Flaking inside the exhaust system (Removal of the casting sand, burrs, etc.)
3. Intrusion of mud, sand, gravel, etc. through the muffler.

Failure Mechanism

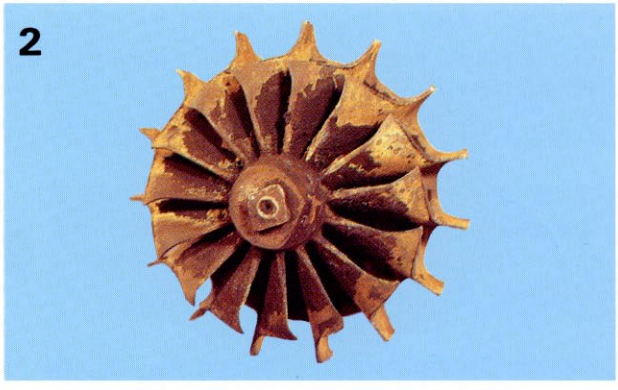


Example of Failures Caused by Foreign Matter in the Exhaust System

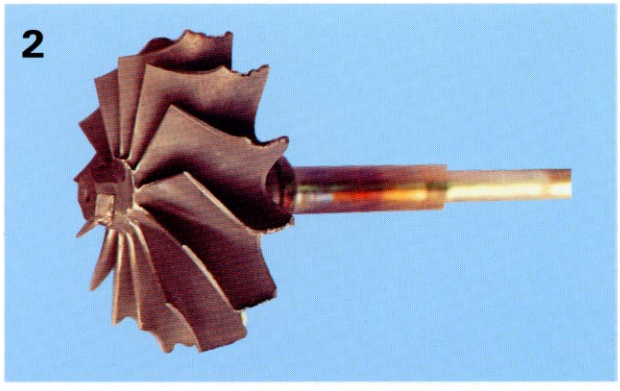




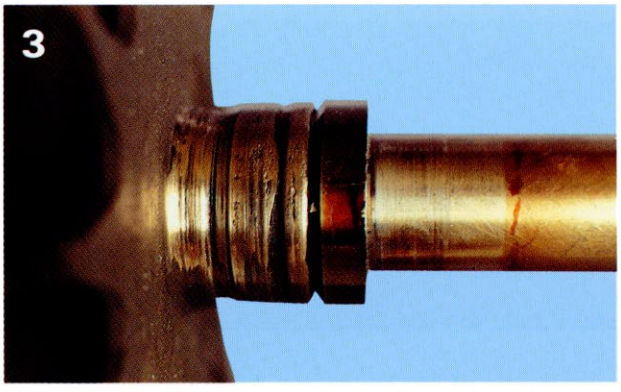
Turbine nozzle crushed or scored by foreign matter in the exhaust system.



Turbine impeller deformed by foreign matter.



Turbine impeller whose tip is broken by hard foreign matter.



Turbine shaft whose seal ring is scuffed or melted because the running part is unbalanced by a damaged or deformed impeller.

Causes and Mechanisms of Failures Caused by an Excessive Rise in the Exhaust Temperature

Failures and Causes

If the exhaust temperature rises excessively, the temperatures of the turbocharger and various other parts will also go up excessively. Then, the turbine impeller and housing will come into contact and be damaged due to thermal distortion and bearings will be seized due to overheating.

1. Excessive fuel injection because of poor adjustment of fuel injection pump.
2. Abnormal combustion due to unsatisfactory spray of fuel injection nozzles and injection timing.
3. Incomplete combustion due to clogged air cleaner element or leaking air pipe.

Failure Mechanism

The exhaust temperature goes up, causing various parts to be overheated.

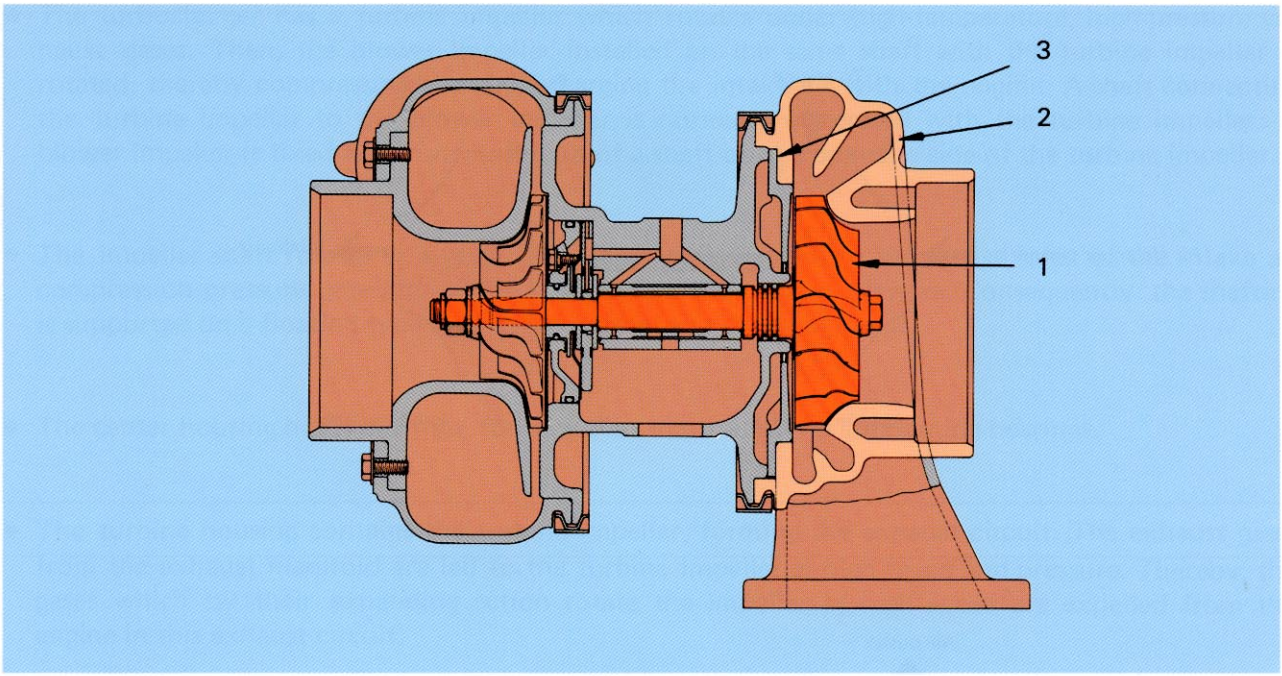
The thermally deformed turbine housing and shield come into contact with the turbine impeller. → The rotating speed slows down.

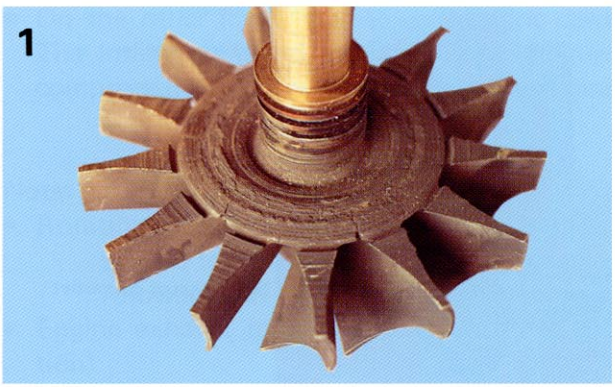
The amount of intake air is reduced. → An unusual noise made.

The turbine shaft is unbalanced, causing damage to journal bearings. → Black exhaust smoke is emitted and horse-power is reduced.

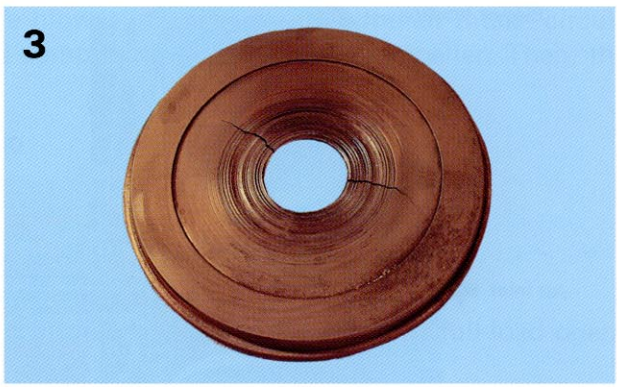
The running part is seized or broken.

Failures Due to Excessively High Exhaust Temperature





Turbine impeller whose shield is in contact with the impeller rear side due to thermal distortion.

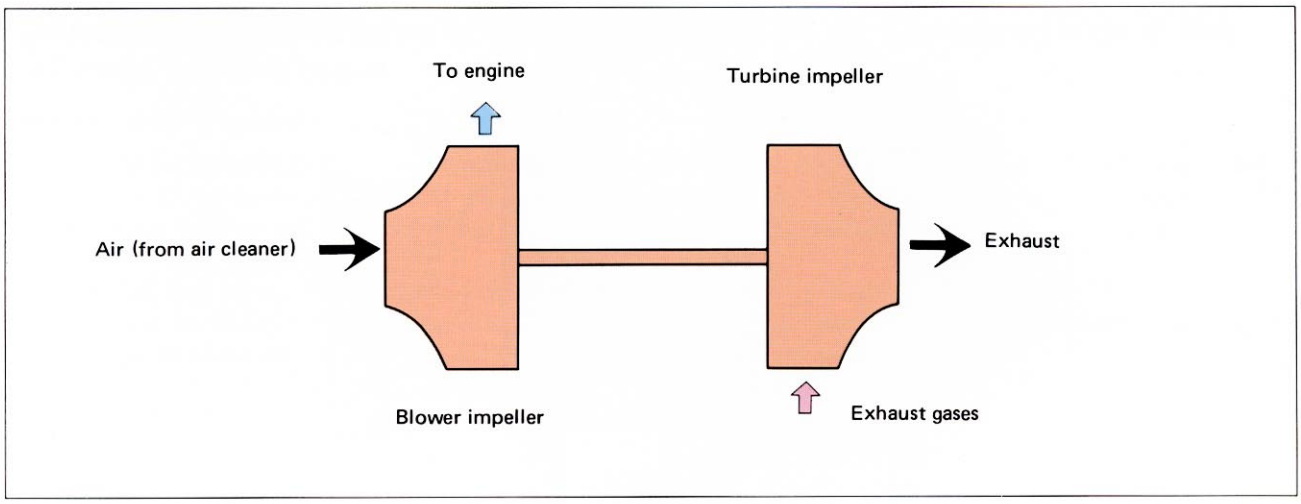


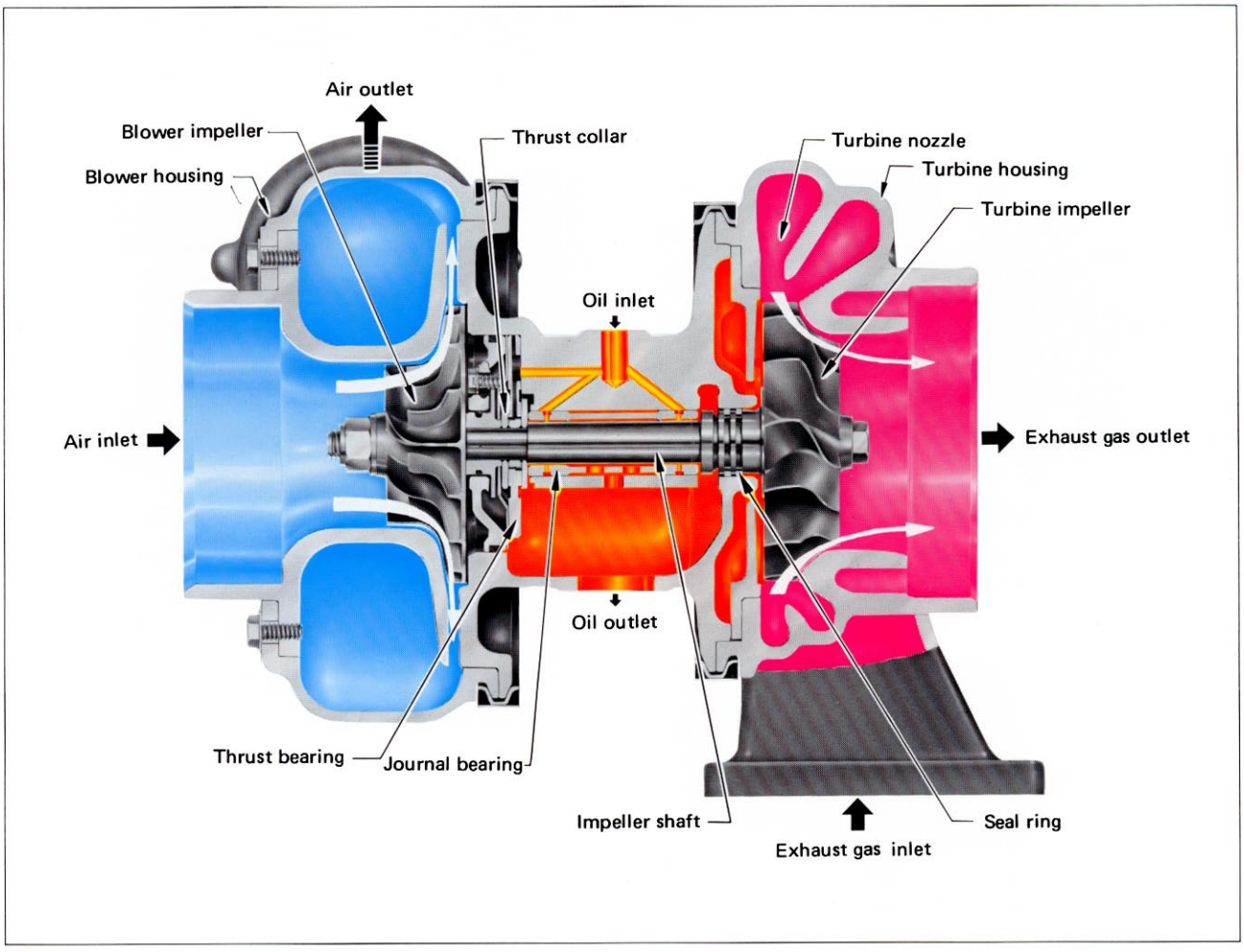
Shield in contact with the rear side of turbine impeller due to thermal distortion.

Turbine housing with heat cracks.

CONSTRUCTION AND FUNCTION

Relative Functions Between Turbocharger and Engine





The turbocharger serves to increase the engine horsepower, prevent black exhaust gas, and improve the fuel consumption ratio. Its turbine impeller rotates the blower impeller installed on the impeller shaft under high-temperature, high-pressure exhaust gases. Thereby, an amount of air corresponding to the fuel to be injected is compressed and supercharged into the engine cylinders.

Construction

- The turbocharger has a turbine impeller which rotates under high-temperature, high-pressure exhaust gases. Then, the blower impeller installed on the same shaft with the turbine impeller is rotated, thereby compressing and supercharging the intake air with the engine. A shaft connecting the turbine impeller to the blower impeller is normally integrated with the turbine impeller. A blower impeller is fixed with nuts to the tip of a shaft on the opposite side of the turbine impeller.

- The impeller shaft rotates at a very high speed while subject to the thrust force of the intake air compression pressure imposed on the impeller and the exhaust pressure. Consequently, the shafting is supported on a floating type cylindrical journal and thrust bearings.

- The center housing holds bearings, forming the circuit of oil for lubricating bearings.

- The turbine housing contains the turbine impeller, forming the exhaust circuit. The exhaust gases from the exhaust manifold are led to the turbine impeller at high speed and pressure. Thereby, the gases which by their expanding action rotate the impeller at high speed are expelled from the engine in this exhaust circuit.

- On the other hand, the blower housing contains a blower impeller, forming the air intake circuit. The intake air is led to the blower impeller and compressed by the rotating impeller. Then, this compressed air is supercharged into the engine.

Notes

- Rotating speed (revolutions) of turbochargers
  50,000 to 125,000 rpm (continuous allowable rotating speed)
  Allowable revolutions vary deprending on the size of the impeller.
- Engine exhaust temperature: 500 to 700°C (turbine impeller inlet temperature in full-load operation)

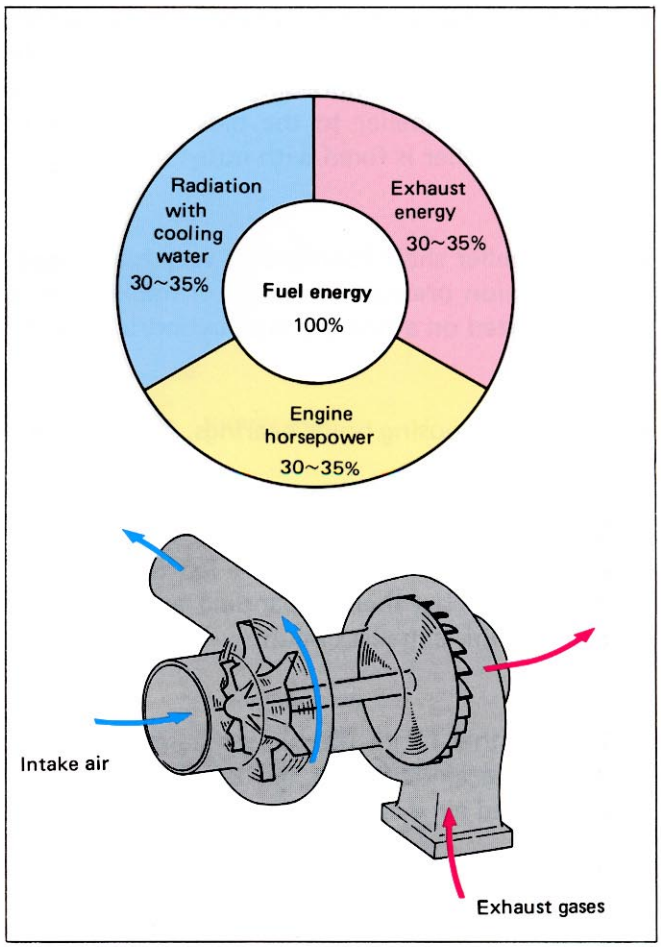
Function

In a diesel engine, the energy of fuels burnt in cylinders is in the ratios indicated at right.

The effective energy as shaft horsepower is approx. 1/3 of the fuel energy. The remainder is expelled from the engine.

A turbocharger takes the speed and pressure energy of high speed gases from the exhaust to be expelled from the engine with the turbine impeller as the rotating power source. Thereby, the blower impeller on the same shaft with the turbine impeller is rotated so that the air is compressed and supercharged into the engine.

In order to obtain the effective horsepower in a diesel engine, a quantity of air approx. 17 to 22 times greater than the amount of fuel to be injected is generally required. This corresponds to 1.2 to 1.5 the excess air ratio.

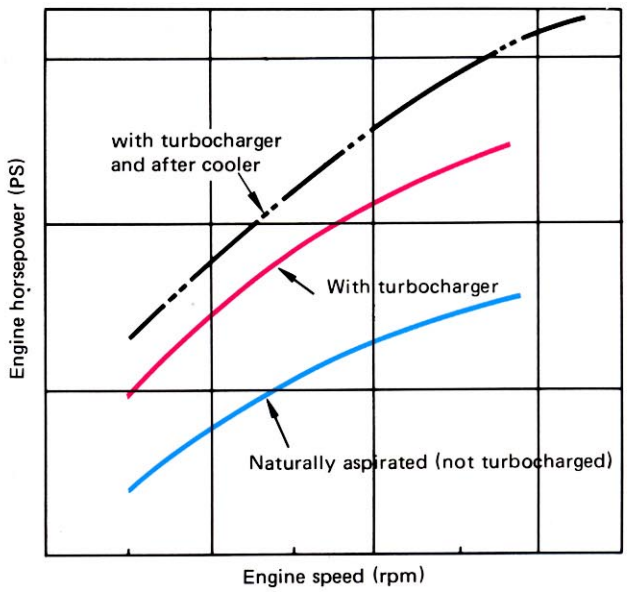


Note

Excess air ratio:

The ratio of the quantity of air necessary to actually obtain optimum combustion efficiency, assuming that the theoretical quantity of air required for complete fuel combustion is 1. For combustion in a diesel engine, an excess air ratio of 1.2 to 1.5 is required because of the fuel mist-air mixture, combustion time limit, etc. If the quantity of air is less than 1.2 to 1.5 the excess air ratio, incomplete combustion will take place, resulting in black exhaust smoke and an increased heat load.

In a turbocharged engine, a quantity of air corresponding to the fuel injection quantity is compressed and supercharged. In an engine of the same cylinder capacity, the horsepower can be increased as indicated in the graph at right. If an after-cooler is used with the turbocharger, the horsepower can be further improved.



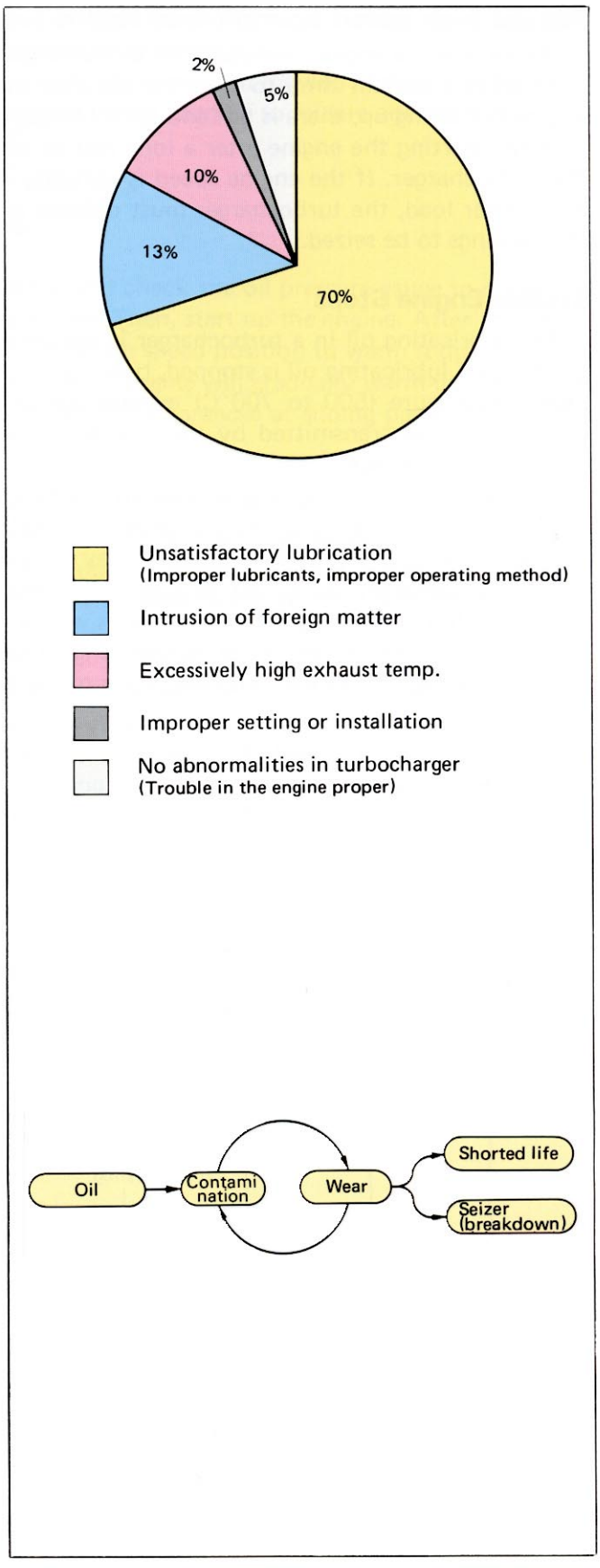
Comparison of horsepower between turbocharged and naturally aspirated engine (NTA 855 engine).

FAILURES AND THEIR CAUSES

Failures occur due to various factors or causes. Above all, the maintenance of lubricants, the method of operation, and the intrusion of foreign matter into the air intake system are the main factors.

Causes of failures in turbochargers can be roughly classified as indicated in the graph at the right.

Most of the causes pertain to lubrication. If care is used in lubrication and operation, most failures of turbochargers can be prevented.



Lubricating Oil

The lubricating oil gradually deteriorates due to the high temperature and blow-by gas, even in normal use. Further, if water, fuel, or dust get mixed into the oil, the lubricating ability will deteriorate markedly. It is also important to select a lubricating oil appropriate for the ambient temperature. Use of an oil of improper viscosity or in insufficient quantity will cause the oil film to be broken, resulting in seizure or scuffing.

Oil Contamination

Contamination of the engine oil accelerates wear of the turbocharger bearings running at high speed and sliding engine parts. Thus, the repeated contamination of oil and acceleration of wear shorten the life of the engine and turbocharger to a marked degree.

Oil Shortage

Oil shortage is caused by an insufficient oil supply, defective oil pump or oil regulator valve, leaking, or a clogged oil circuit.

Note

Shortage and contamination of oil must be checked daily through the oil level check, periodic oil and filter change, and use of designated oils.

Operation

Abrupt high speed operation of engine just after starting.

As soon as the engine starts up, the turbocharger beings rotation.

It takes a certain time to feed the oil into the engine from the oil pump. Particularly when the engine is starting up, there is not enough oil in the lubrication section of the turbocharger.

When starting the engine after a long rest or after an oil change, it takes more time to supply oil to the turbocharger. If the engine speed is abruptly increased or the engine is abruptly brought in operation under load, the turbocharger must operate at high speed with a shortage of lubrication, causing the bearings to be seized.

Sudden Engine Stops

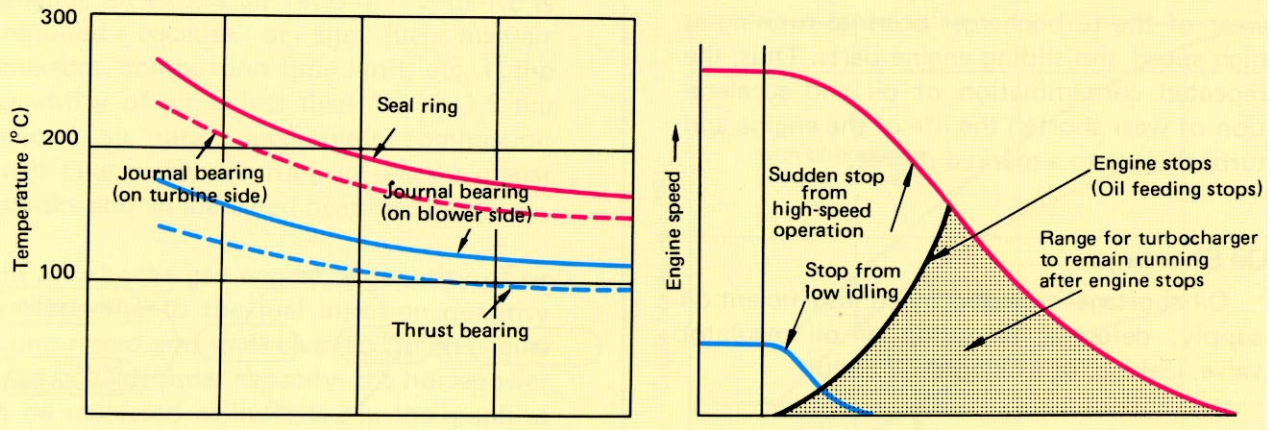
The lubricating oil in a turbocharger is not only used to lubricate bearings but also to cool them. If the flow of lubricating oil is stopped, bearings on the same shaft as the turbine impeller running under high temperature (500 to 700°C) exhaust gas pressure will soon be brought to a high temperature due to the heat transmitted by the high-temperature impeller and the turbine housing, even if not heated by the exhaust.

Sudden stopping of the engine causes oil in the lubrication section of bearings to get burnt.

In sudden stops when operating under full load, the bearing temperature reaches 200 to 300°C and the shaft nearest to the turbine impeller may sometimes be discolored. (See the graph below.)

The turbocharger continues to run by inertia even after a sudden engine stop. Therefore, the bearings continue running 20 to 30 seconds without circulation of the lubricating oil.

As has been explained above, sudden engine stops cause the turbocharger bearing temperature to rise and bearings to run without circulation of the lubricating oil, resulting in seizure and wear.



Engine idling time and temperatures after engine stops (KTR 130)

Operation

Before operating a machine, warm it up and avoid high-speed operation under overload. Pay attention to the oil pressure, oil quantity and oil temperature at all times.

Lack of warmup or operation at high speed under overload places each moving part in high load and high speed operation without thorough lubrication and clearance, leading to seizure and scuffing.

Notes

Method of starting and stopping an engine

Starting the engine:

First crank up the engine with the starting motor and check the oil pressure gauge to make sure that the engine oil has circulated throughout the engine. Then, start up the engine. After the engine has started, move the fuel control lever to a low or medium speed position to warm it up. Gradually increase the engine speed and load so that the parts of the engine will gradually warm up. (When the engine is cold, engine parts cannot fully be lubricated and clearances at sliding parts and bearings are larger than normal.)

Stopping the engine:

To stop the engine, first reduce the speed and load gradually. After the parts have cooled down after idling for at least 5 minutes, stop the engine. (If the engine is stopped suddenly, the circulation of the cooling water and the lubricating oil will be stopped, allowing the parts related to cylinders and turbocharger bearings to suddenly get hotter. This will cause heat distortion or burnt oil.)

Intake air (foreign matter, dust)

Generally, construction machines operate in a dusty environment. Therefore, an air cleaner is provided for the engine to draw clean air by screening out dust from the intake air. If the air cleaner element is damaged, gaskets in the intake air system will break, or if clamps on hoses or pipes are loose, dust will infiltrate into the lubricating oil, causing the running parts to be seized or scuffed. Foreign matter in the intake air pipe or exhaust pipe cause damage or deformation to the impellers or generate unusual noise.

The following are causes for infiltration of foreign matter.

1. Broken air cleaner element.
2. Air leakage from hose connections or pipe connections in the intake air circuit.
3. Foreign matter adhering to the insides of pipes.
4. Infiltration of foreign matter during servicing.
5. Entry of soil or sand from the muffler.

Excessively High Exhaust Temperature

If the exhaust temperature is too high, the temperatures of various parts of the turbocharger will also go up excessively, causing the turbine impeller and housing to be damaged by contact due to thermal distortion and causing bearings to be seized due to unsatisfactory lubrication.

The following are some causes of high exhaust temperature.

1. Excessive fuel injection due to poor adjustment of fuel injection pump.
2. Unsatisfactory spray of fuel injection nozzles and abnormal combustion due to improper injection timing.
3. Insufficient quantity of intake air due to a clogged air cleaner element or leakage from the intake air piping.
4. Shortage of intake air as a secondary failure due to impeller damage or bearing failure.

Unsatisfactory Installation

Pay special attention to correct and positive tightening, setting, and installation when servicing a turbocharger. (Leakage from air hoses, pipe connections, and piping is frequently caused by unsatisfactory setting or installation.) When connecting the intake air and exhaust pipes and feed and return oil pipes in the turbocharger, do not use undue force to bring bolt holes in line with each other. Otherwise, distortion will be imposed on the air system, affecting the balance of the rotating component parts.

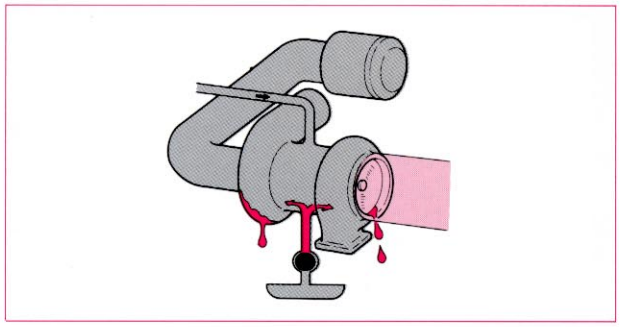
In a turbocharger rotating at high speed, the slightest unbalance of the component parts leads to such failures as seizure and breakage. Consequently, each component part should be set in place with the utmost care.

INTERNAL OIL LEAKAGE OF TURBOCHARGER AND ITS CAUSES

Oil Leakage and its Causes

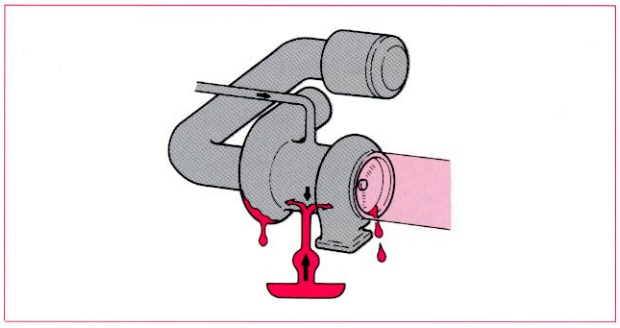
Oil leakage from a turbocharger causes oil contamination, oil deterioration, increased oil consumption, unsatisfactory exhaust smoke color, and fire.

Clogged lubricating oil return pipe



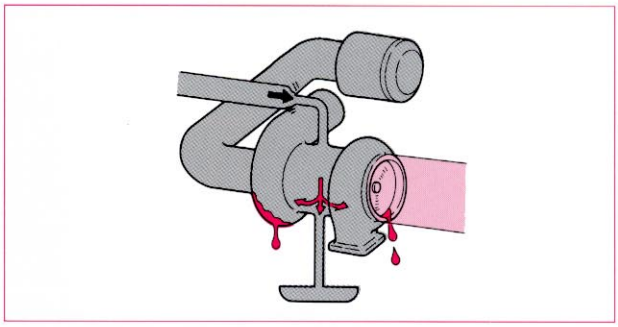
If the return oil pipe is crushed or clogged with foreign matter, the internal pressure in the lubrication section will increase, causing the oil to leak through sealing parts on the blower and turbine sides of the turbocharger.

Excessively high blow-by pressure



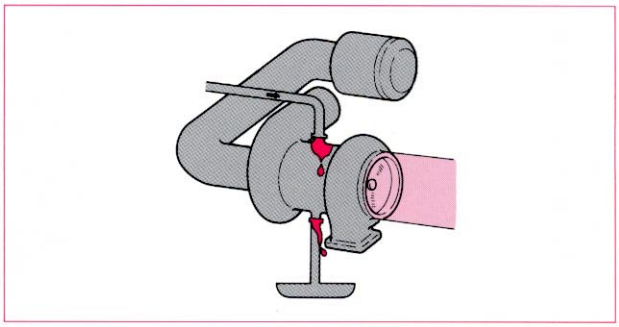
If the blow-by pressure (internal pressure in cylinder block) is too high due to a clogged breather, etc., the internal pressure of the turbocharger connected with the return oil pipe will go up, causing the same kind of oil leakage as described above in "Clogged lubricating oil return pipe".

Excessively high oil pressure



If the oil pressure is too high due to a faulty oil regulator valve, it will cause the same kind of oil leakage described in "Clogged lubricating oil return pipe" and "Excessively high blow-by pressure".

Erroneous installation of oil feed and return pipes



If a bolt securing an oil feed or return pipe is loose or if a pipe is distorted at its point of connection, the oil will leak through the connection.

Excessively long low idling

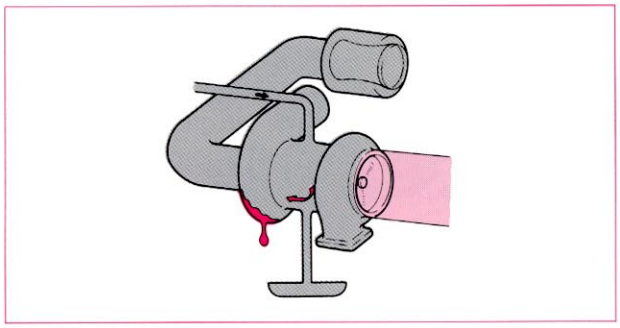
Idling for too long will cause oil leakage on the turbine side.

Do not run at low idle for more than 20 minutes. During low idling operation, apply load to the turbocharger from time to time.

Excessively long high idling

High idling operation for too long may cause oil leakage on the blower side. Do not run at high idle for more than 20 minutes.

Clogged air cleaner element

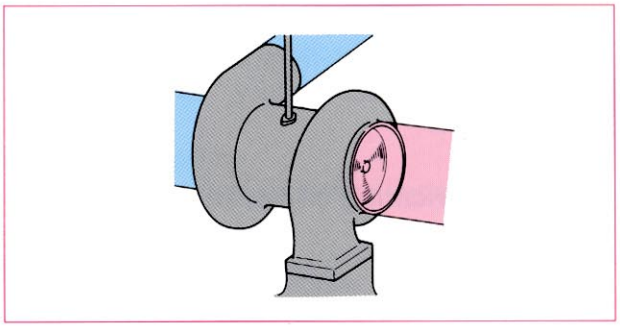


If the engine is continuously operated with a large intake air resistance caused by a clogged air cleaner element, the oil will leak on the blower side. Be sure to inspect and clean the air cleaner element.

Faulty seals

Even when all of the above items are normal, the oil will leak if seals are worn out.

Symptoms of oil leaking failures



The leaking oil is burnt and the exhaust smoke is light blue.

The oil is oozing from the connection on the blower side. The oil is oozing from the connection on the turbine side.

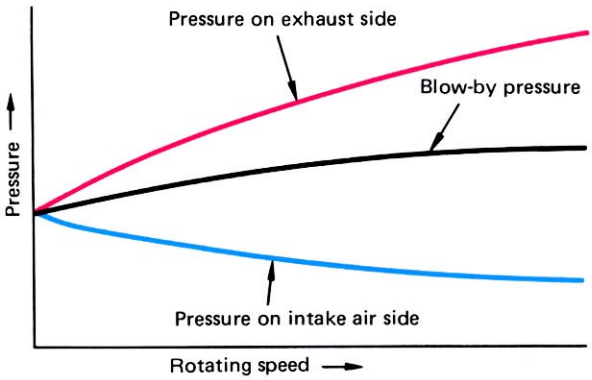
In the worst case, the oil flows out of the turbocharger.

Note:

Oil leakage from blower or turbine seal

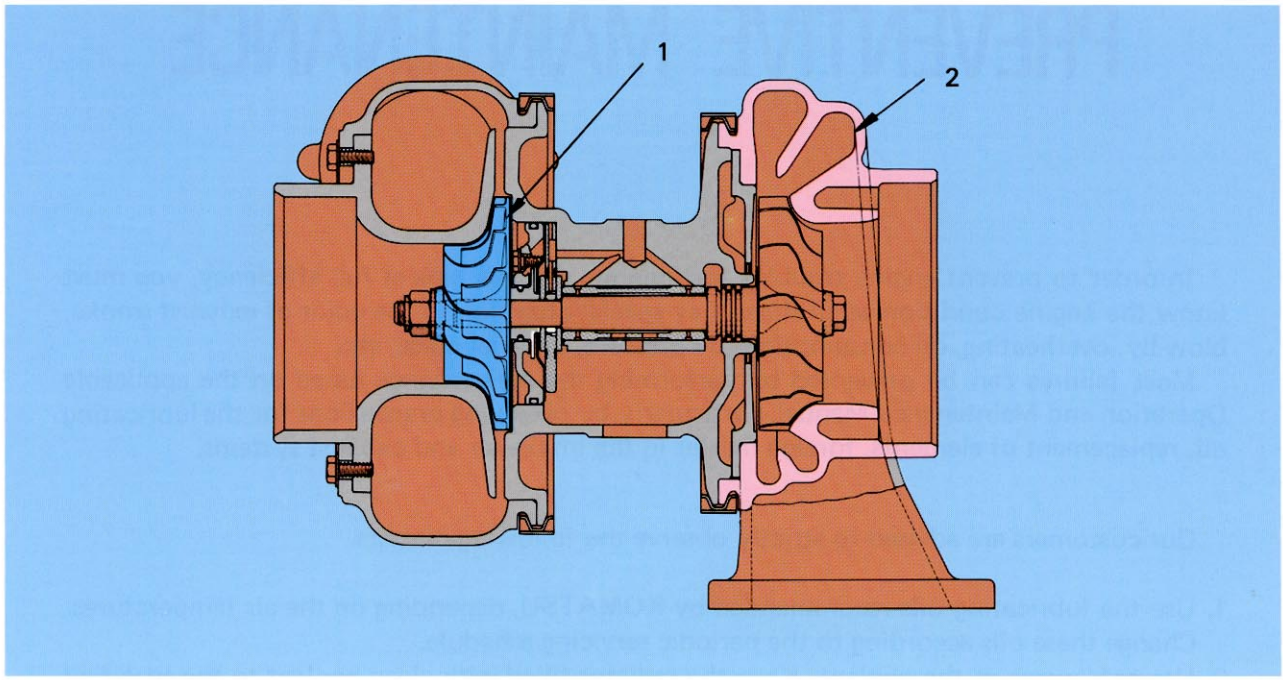
The pressure acting on the turbine side of the turbocharger depends on the quantity of exhaust (q'ty of intake air x combustion gas temperature). The quantity of combustion gases is in proportion to the fuel injection quantity.

On the other hand, the pressure acting on the blower side of the turbocharger consists of the intake negative pressure of a cylinder in proportion to the rotating speed only and the supercharging pressure in proportion to the exhaust gas quantity. Further, blow-by pressure is imposed inside the turbocharger.



In normal operation, the pressures acting on the turbine side, the blower side and inside the turbocharger are kept in a well-balanced condition. In a high speed operation without load (a high idling operation), the negative pressure drawn in by the cylinder is increased. If this operation is continued, the oil may leak by a suction pumping action from the blower side. This applies when the intake air resistance is increased due to a clogged air cleaner element. In a low speed operation without load (a low-idling operation), the pressure on the exhaust side is low. If the operation is continued in this condition, the oil may ooze through the turbine seal. If the oil leaks on the turbine side, the leaking oil should be burnt away in an operation under load.

Oil leaking in the turbocharger



Oil adhering to back face of blower impeller.

Stains caused by oil which leaked to turbine side.

Note

In addition to the above faults, note that oil leaking from the turbocharger will cause interference of the impeller due to carbon piling.

PREVENTIVE MAINTENANCE

In order to prevent engine troubles and operate the machine at full efficiency, you must know the engine condition at all times, pay special attention to the color of exhaust smoke, blow-by, overheating, oil consumption, oil pressure, unusual noise, etc.

Most failures can be prevented by performing the maintenance based on the applicable Operation and Maintenance Manual, particularly by observing precautions for the lubricating oil, replacement of elements, foreign matter in the intake air and exhaust systems.

Our customers are advised to strictly observe the following matters.

1. Use the lubricating oils recommended by KOMATSU, depending on the air temperatures. Change these oils according to the periodic servicing schedule.
2. Use soft water as the coolant. Keep the radiator filled with clean coolant to the specified level.
3. Warm up the engine thoroughly. Avoid operation under overload, abrupt acceleration, sudden stops of the engine, etc.

* Whenever any abnormality is suspected in engine operation, examine the cause, using the following measuring instruments.

Measuring instrument	P/N	Item of measurement
Blow-by checker	799-201-1502	Measuring the blow-by pressure
Hydraulic tester	790-301-1103	Measuring the oil pressure
Thermistor kit	790-500-1300	Measuring the water or oil temperature
Engine oil checker	799-201-6000	Checking the engine oil for contamination with moisture and fuel.
Water tester	799-202-7001	Checking the cooling water for suitability
Smoke tester	799-201-9000	Measuring the exhaust smoke color

For the methods of using the above instruments and the applicable standard values, refer to the section on Testing and Adjusting in the applicable Shop Manual.

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