

TURBOCHARGERS OUTLINE & TROUBLE SHOOTING

MITSUBISHI HEAVY INDUSTRIES LTD.

Outline of Turbocharger

1. Purpose of Turbocharger

- (1) Fuel Consumption Ratio Improvement
- (2) Reducing environmental Pollution
- (3) Higher Torque and Output



280HP



**Turbocharged
sports car**

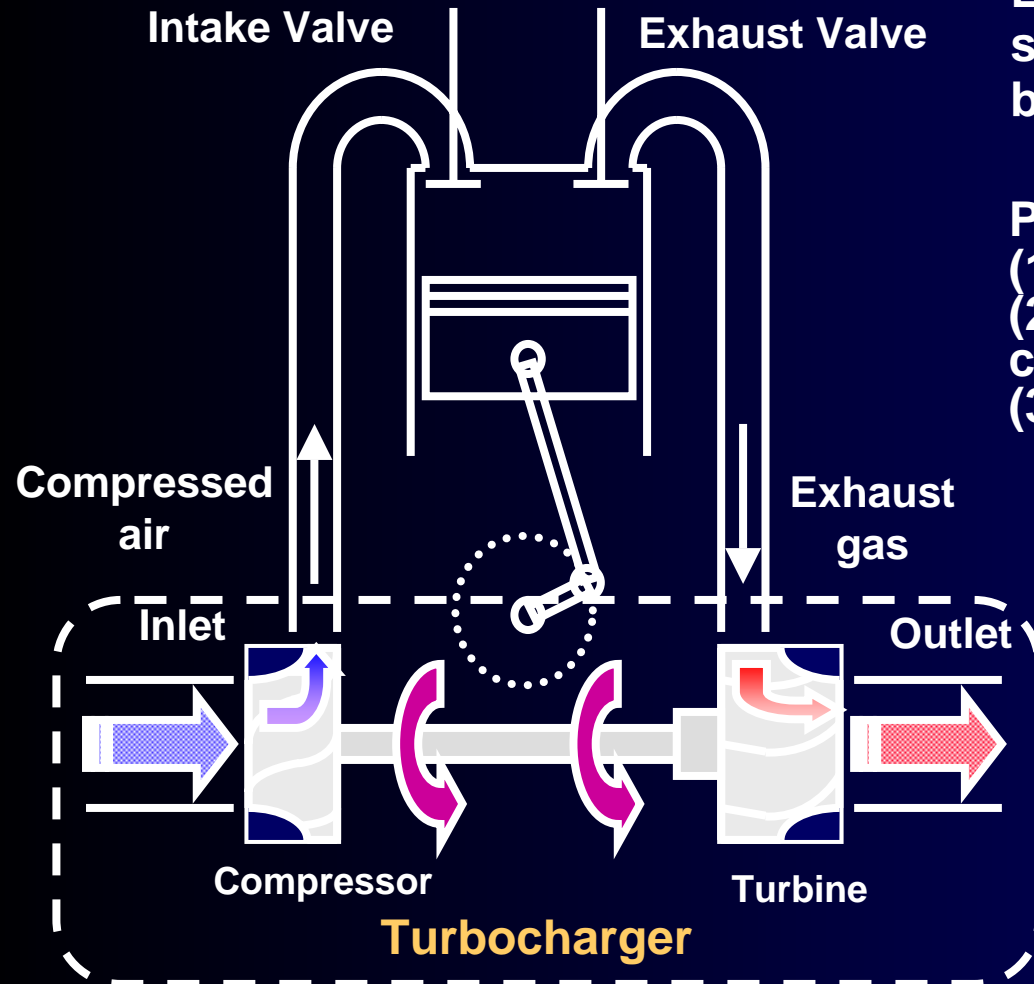
130HP



Ordinary Sedan

Turbocharger

Working Theory



Turbocharger is

Equipment which compress the air and supply much air to the engine cylinder by using the exhaust gas energy.

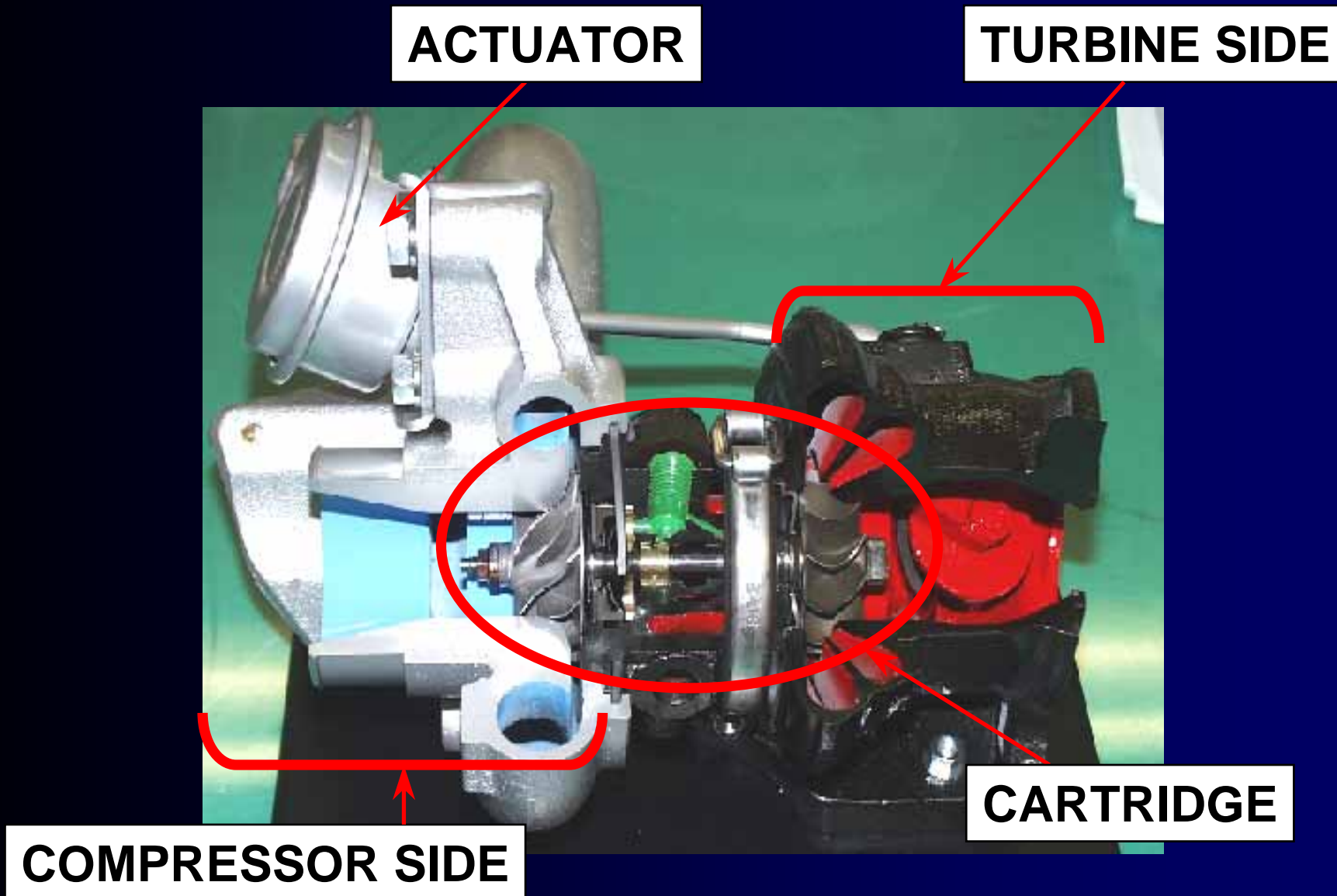
Process

- (1) Exhaust gas rotate the turbine wheel
- (2) Turbine rotation translate to the compressor by connecting shaft.
- (3) compressor wheel compress the air.

Purpose of using

1. High output by increasing the air flow rate
2. Low fuel consumption and less pollution by using the exhaust gas energy

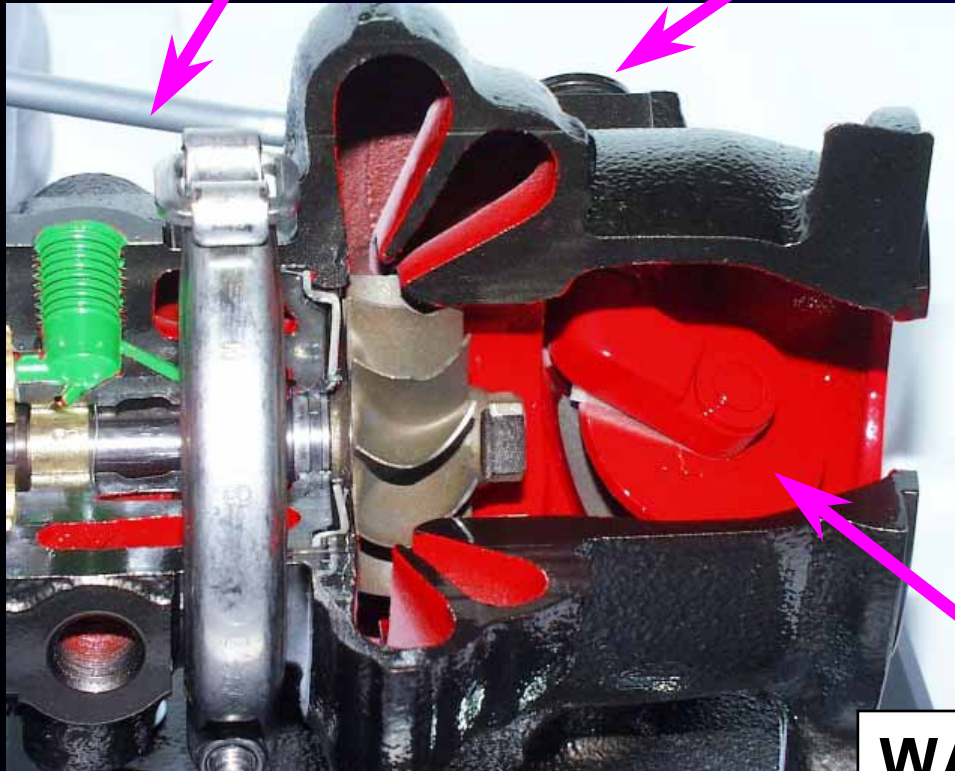
Outline of structure



Actuator and Waste gate valve

ACTUATOR ROD

LEVER



Boost pressure exceeds
specified pressure.



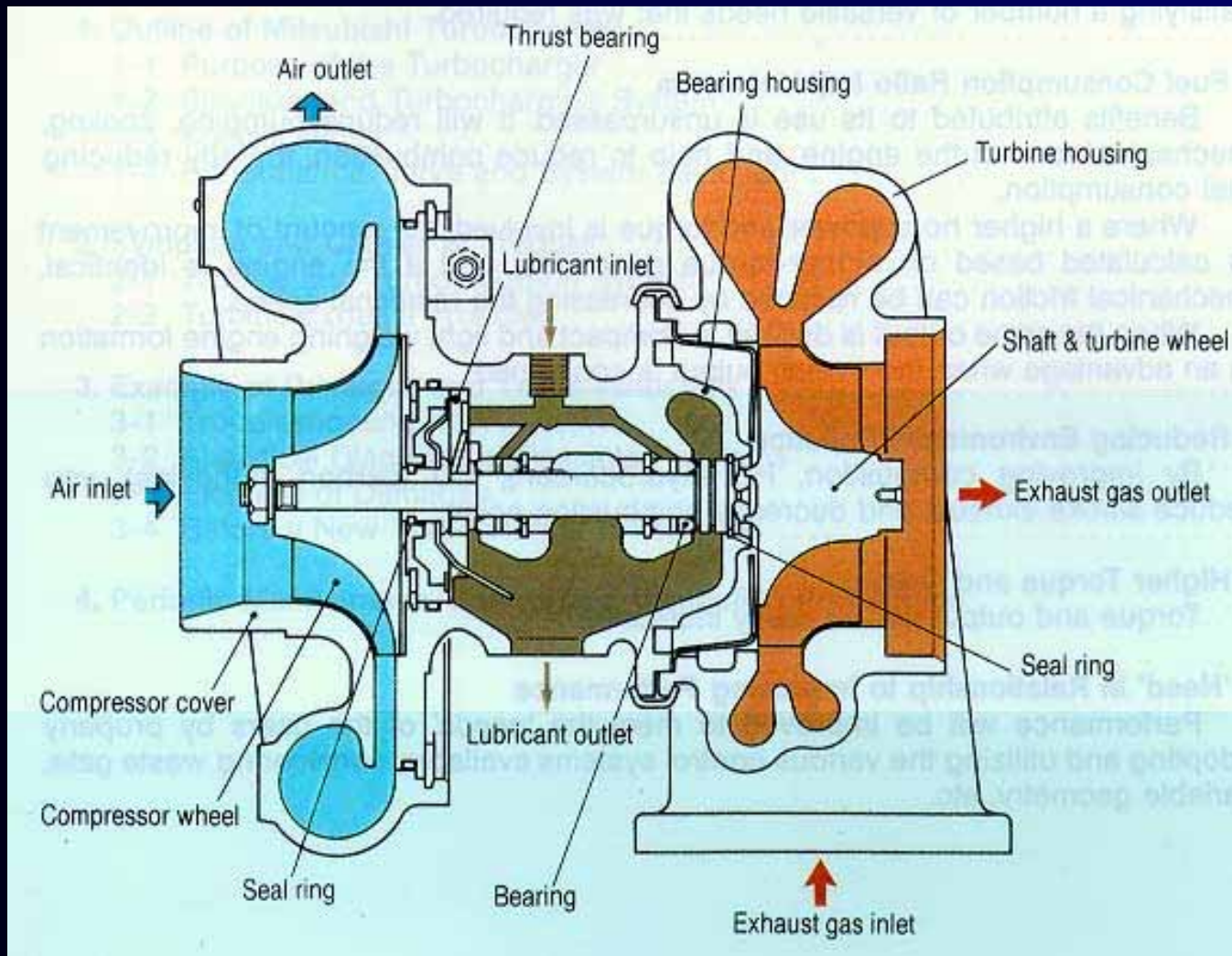
Actuator rod move and
waste gate valve open.



A part of exhaust gas is
released from waste gate and
boost pressure is kept
constant.

WASTE GATE VALVE

Sectional view



MHI TURBO FEATURES

- HIGH PERFORMANCE
- HIGH RELIABILITY
- SIMPLE & COMPACT
- LIGHT WEIGHT



Causes and Symptom of Troubles

Causes of Turbocharger troubles

1. Poor lubrication
2. Foreign particles
3. High exhaust temperature and excessive rotational speed
4. Operator errors

1. Poor lubrication

Improper lubrication may cause serious problems.

(1) Shortage or excessive oil amounts and low oil pressure

- Oil shortage and low oil pressure

- ↳ Bearing and seal ring wear

- ↳ Carbon deposit (oil cauking)



Turbocharger failure from sliding parts

- Excessive oil

- ↳ Oil leakage from Compressor and Turbine sealing

(2) Contaminated oil or poor oil quality

- Dirt in oil — metal or carbon particles

Journal bearing and thrust bearing scratch

Lapping on the bearing and changes the clearance ratio

↳ Shaft vibration

- Low quality oils

Low viscosity at high exhaust gas temperature — poor oil film

↳ Turbine side journal and thrust bearing wear

Insufficient cooling by evaporation of lube oil volatile contents

↳ Seal ring wear and stick

↳ Oil caulking and deposit

Dirt in oil



Continued operation under the state of journal bearing wear as the result of insufficient lubrication will cause progressive wear and close oil hole (pole) as well as severely damage the inner turbine. (left:turbine side;right:compressor side)

Foreign particles in oil

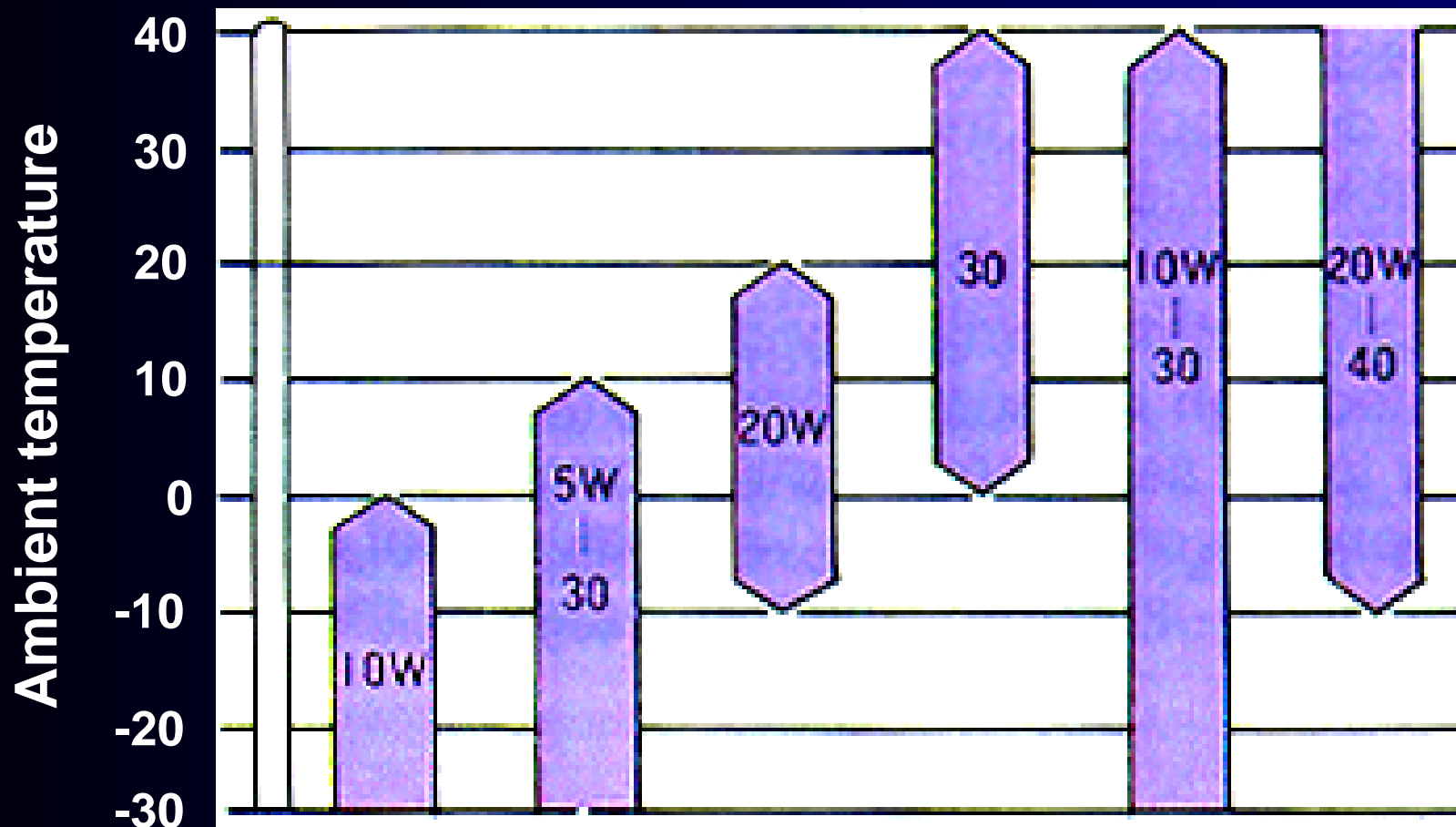


Scars caused by foreign particles on the journal bearing.
Side of the foreign particles can be anywhere from small,
medium to big from the left side.



Oily caulk like layers on the bearing housing.

Grade of the lubricant (SAE-specification)



Deterioration of lub-oil

Cause	Formed material	Property change	Effect
Mixture created from burned products	Inorganic acid (sulfuric acid) H ₂ O Salts	Decrease in basic (salts) value Acidic value, moisture increase	Errosion/wear Lubrication inhibition
Mixture created from incompletely burned products	Sludge Organic acid, carbon	Insoluble solvents Increase in viscosity	Contamination by dirt particles Oil filter element clog
Dilution by fuel oil	Fuel oil	Decline in ignition point and viscosity	Decrease in maitaining the holding power of oil film
Deterioration of lub-oil	Organic acid Sludge	Insoluble solvents viscosity Increase in acid value	Contamination Accelerate errosive wear
Consumption in additive agents (cleaning dispersion elements)	-	Decrease in basic (salts) value Increase in insoluble solvents	Contamination Decrease in prevention against erosion
Abrasive powder mixture	Metal powder	Metal contents, Increase in ashes	Oxidation, deterioration, and abnormal wear acceleration
Mixture of foreign particles such as sand, etc.	Solid matters	Insoluble solvents, Increase in ashes	Wear acceleration

2. Foreign particles

- Large foreign particles ---- metal or wood pieces etc

Damage at compressor vanes, valves or pistons on engine

↳ Lack of vane cause imbalance in the rotor shaft

↳ Excessive vibration cause various troubles

- Small Foreign particles ---- sand, metal powder etc

Very small scars at inlet of compressor wheel

↳ These scars may develop into a crack at long operation

↳ Damage of compressor vanes



Damage to the turbine wheel at the gas inlet due to plunged metal pieces obtrusion.



Damaged compressor wheel and cover because of foreign particles. The compressor wheel tip of the suction part is cut as the result of the foreign particles, such as sand or metal powder, etc.

3. High exhaust temperature and excessive rotational speed

Long term operation at high temperature over limit

- Turbine wheel damage by stress rupture and thermal cycle fatigue
- Seal ring damage by oil carbonation labyrinth section
- Back Plate deformation

(a) Racing specifications

Special attention for exhaust temperature and rotational speed
of the turbine

(b) Stress rupture

Gradual material strength deterioration at high tensile stress
and high exhaust temperature for long time

4. Operator errors

Running the cold engine at high speed and high load from start

→ Oil viscosity is high, therefore oil amount is shortage at
turbocharger

Sudden engine stop from high speed and high load condition

→ accelerate oil deterioration

Sudden engine stop



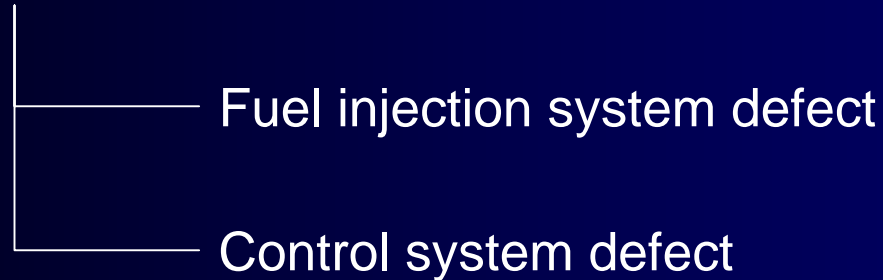
Pb and Sn defussion by high metal temperature of the journal bearing. (left:turbine side;right:compressor side)

Symptom of Turbocharger troubles

1. Lack of engine Power
2. Smoke exhaust color aggravation
3. Too high exhaust temperature
4. Abnormal sound (noise) and vibration
5. Increase in oil consumption

1. Lack of engine Power

- Insufficient fuel supply



- Insufficient air supply



Turbocharging system defect

- Defect of air supply system
 - High suction loss of air element etc by dust
 - Air leakage from air intake system etc
 - High pressure loss of inter-cooler
 - High pressure loss by defective throttle valve
- Defect of exhaust system
 - High exhaust loss by clogging muffler or catalyst
 - Gas leakage from exhaust manifold flange surface
 - Low torque at low speed by defective waste gate
- Defect of control system
 - Air flow sensor defect
 - Knock sensor defect
- Defect turbocharger
 -

2. Smoke exhaust color aggravation

Smoke exhaust defined: The hue of smoke indicates the source or probable causes of the trouble.

Black smoke: Indicates incomplete combustion due to air shortage.

Blue-white smoke: Results due to blowby trouble in the suction system, possibly because of oil mixture.

White smoke: A mixture of oil in the exhaust system.

Blue-white smoke (compressor side)

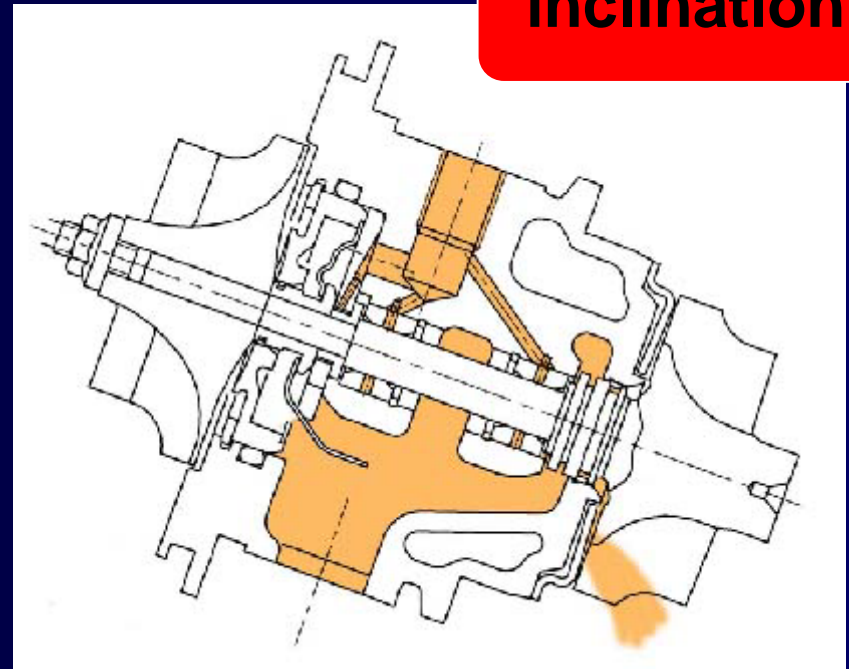
- keeping idle speed (long time)
- seal ring damaged
- inclination
- high oil pressure
- depression at air inlet

→ Next page

White smoke (turbine side)

- keeping idle speed (long time)
- seal ring damaged
- inclination
- high oil pressure
- oil caulking

inclination



Turbocharger oil sealing

Idle speed

**Low back pressure
(because of Idling)**

**Step
bore**

Finger slot

Seal ring

little clearance

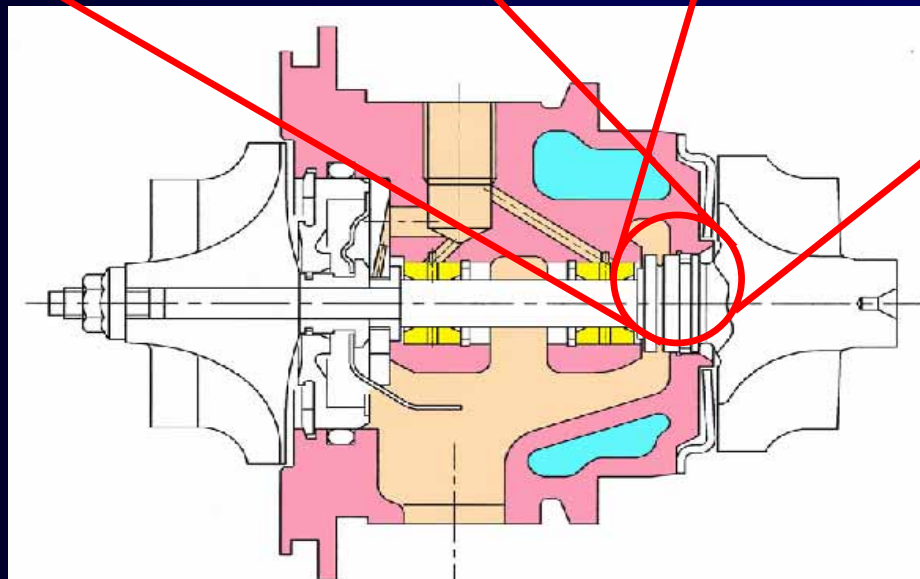
**Normal
speed**

**High back
pressure**

**Seal
ring**

No clearance

**If it keeps idle
speed longtime,
oil leak may occur.**



3. Too high exhaust temperature

- Excessive fuel supply and post burning
 - Highest level of rack or timing position
 - Defective O2 sensor
- Air supply shortage by defective intake system
- Resistance of exhaust system
- Turbocharger defect

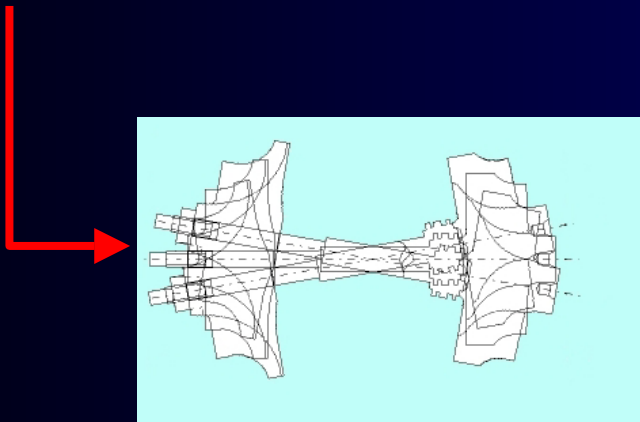
4. Abnormal sound (noise) and vibration

- Poor maintenance

 - Improper clamping of suction system

 - Loose clamping of exhaust system

- Turbocharger imbalances

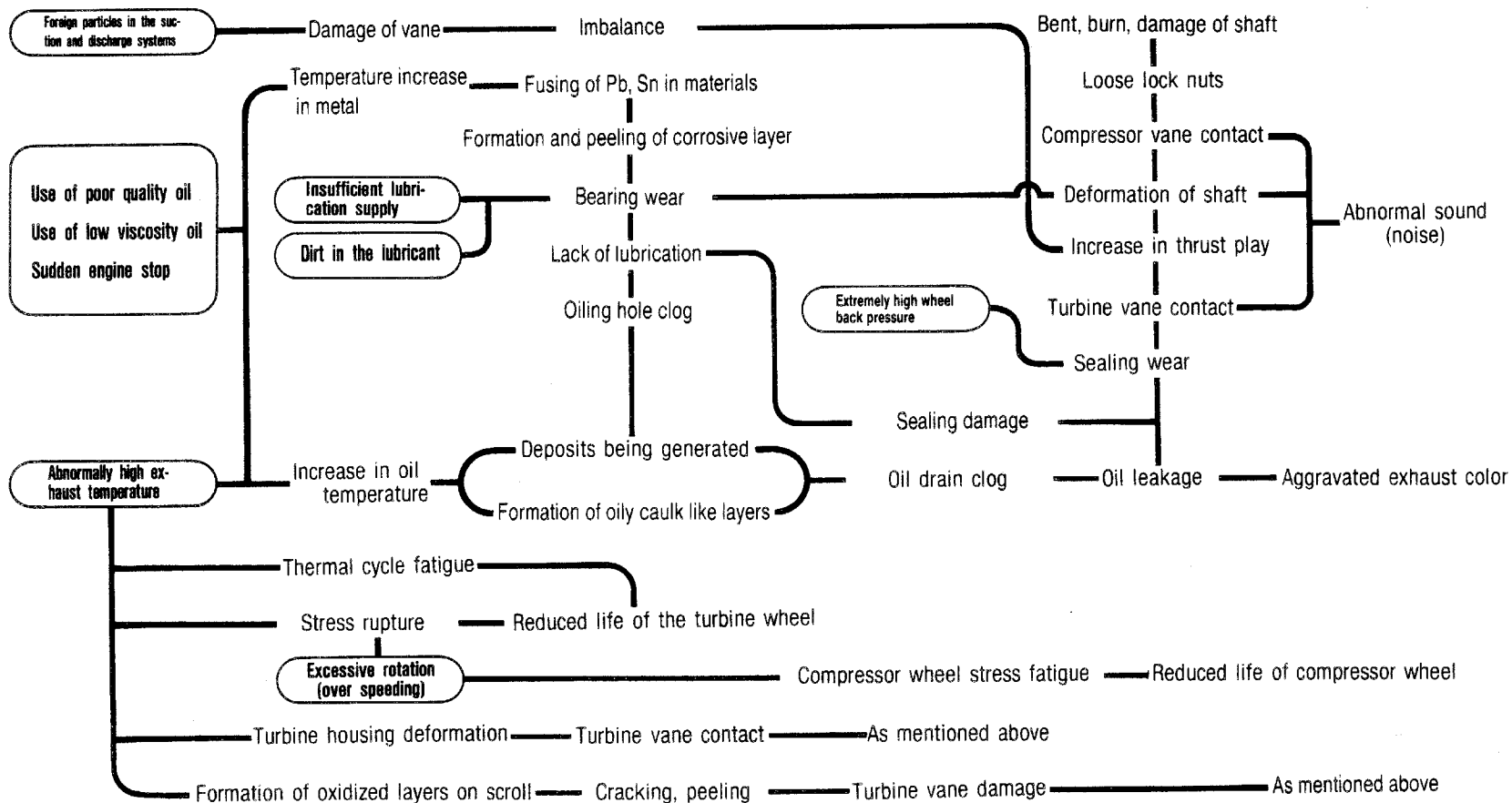


If there is any trouble on turbine rotor or compressor wheel or journal bearings, vibration should become large.

5. Increase in oil consumption

- The scuffing of the piston rings of the engine
 - Slight scuff —increasing of blow-by
 - Oil leakage from compressor side of turbocharger
 - Traces of blow-by on vane inlet of the turbocharger
 - compressor or air element in the suction system
 - yes —> slight scuff
 - no —> oil leakage from compressor side of turbocharger
- } very similar
- Oil leakage from turbine sealing
 - increase in consumption with white smoke exhaust

Analytical Diagram of the Source of Turbocharger Problem



Maintenance and Operation

1. Troubles of Turbocharger

Most of Problems are caused by mishandling or improper engine maintenance

Most of Defects progress during long time

—> Early detection and immediate remedial action is important

2. Maintenance

Periodic Maintenance and Inspection

Even in repair of the other part of engine, check the turbocharger briefly.

Check point (Turbocharger)

(1) Wheel condition and rotation

(2) End play of shaft

If there are any troubles, replace the cartridge assembly or turbocharger assembly.

If there is no trouble, do not disassemble turbocharger.

Check point (Engine)

(1) Lubricant and system

Oil; Maker, type, duration of usage, analytical data

Oil filter; Type, mesh-size, clogging state

Clogging state of oil pipe at inlet / outlet

Oil level of engine, Hydraulic pressure of main gallery and turbo-inlet

Oil temperature, Inside pressure of oil pan, etc.

(2) Operation state

Abnormal sound (noise). degree of vibration, color and analytical data pertaining to smoke exhaust, temperature and gas pressure at the turbine inlet / outlet and at the compressor air at inlet / outlet.

(3) Air supply / discharge system

State within the silencer and air element

Dirt within the suction pipe and supply / discharge manifold

Dirt in the inter-cooler and after-cooler

Catalyst clogging state etc.

(4) Control system

Control sensor, circuit

3. Operation

(1) Control standard

General Control Standard

1. V- coupling manual assembly procedure

- * Apply Molycote Grease to the bolt threads.
- * Tighten the nut to the specified torque setting.
- * Hammer in equidistant spaced places around the circumference at least three times at each, using a soft faced hammer.
- * Re - tighten the nut to the specified torque setting.

2. Oil Pressure

- * The minimum oil pressure requirement at full load rated speed is 2 - 5kg/cm².
- * The recommended oil pressure at F.L.R.S. 3 - 3.5kg/cm².
- * Min oil pressure requirement at low idle is 0.8 kg/cm².

3. Oil Delay

- * Oil pressure not less than 1.5 kg/cm² must be achieved within three seconds of engine start up.
- * Maximum rotational speed of the turbocharger must not exceed 0.5 x Nmax until the above oil pressure is attained.
- * Particular attention must be paid to the above recommendations following prolonged periods of rest (in excess of 15 hours), and after oil and filter changes (no oil in main gallery/filter).

4. Oil Properties

- * Must not be less than SAE #30 (CD class: API SE).
- * Max permissible oil temperature: 120 degrees C.
- * Oil change interval: Automobiles: 5000 - 10000 km. Industrial: 250 - 500 hours.

5. Bearing Housing Orientation

- * No turbocharger inclination is recommended.
- * If needed, oil Inlet centerline should be within +/- 10 deg from the vertical, rotor centerline should be within +/- 5 deg from the horizontal.

6. Oil Drain

- * The cross sectional area of the oil drain pipe must be larger than the bearing housing oil outlet.
- * The slope of the oil drain pipe must be positive throughout the run of the pipe length.
- * The oil drain outlet must be located at least 5cm above the max oil level in the sump pan.

7. Mechanical Loading

- * The maximum engine vibration input to the turbocharger must not exceed 8.9 g. In accordance with JIS - D1601.
- * Exhaust pipe work must be supported independently from the turbocharger to prevent excessive loading of the turbine housing/turbine inlet flange.

8. Oil Filtration

- * Oil filter must be of the full - flow paper element type, having a mesh not greater than 30 microns

9. Air Filtration

- * Pressure drop across the air filter should not exceed 400 mmH₂O, and must be replaced at 700mmH₂O.

(2) When starting engine

1. Operate engine at low idle speeds for several minutes before applying load. This will prevent oil starvation damage to turbocharger.

After a short suspension of operation, 30 minutes or so, idling time may be shortened accordingly.

2. After engine has been left standing for some period of time, a week or more, after oil or oil filter element has changed, or after the turbocharger has been replaced, fill the turbocharger with oil through its inlet port. (In refilling, be careful to prevent particles of dirt from getting inside the turbocharger.)

After starting engine, operate it at low idle speeds, with oil inlet connector kept loosened until a steady oil flow is seen, and then tighten the connector and apply load.

(3) When stopping engine

1. Operate engine at low idle speeds for several minutes for cooling down. This will prevent turbocharger from overheating due to stop of oil supply from engine.



Injured by overheating

(4) Before a New Turbocharger is Mounted

1. Clarify probable cause, locate the trouble site
2. Remove the cause of trouble
 - Clean the intake and exhaust manifold
 - Replace the oil filter and lubrication oil
3. Mounting of the replaced turbocharger
 - Check the turbocharger rotation
 - Check the oil supply before clamping the oil supply line to the turbocharger
 - Measure the oil pressure after engine start

Thank you !