DIESEL MECHANIC

MINING QUALIFICATIONS AUTHORITY

CODE: OT

OVERHAUL TURBO CHARGERS

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Owner : Learnership Department

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TRG 9

INDEX

The following elements are contained in this learning guide:

OBJECTIVE:

What you must do

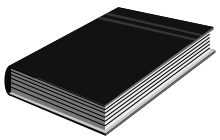
- Dismantle, assess and assemble a turbocharger.

What you will be given

- A turbocharger.
- All the necessary tools and equipment.

HOW WELL YOU MUST DO IT

- There must not be any damage to the fasteners.
- There must not be any damage to any parts.
- The end play on the turbocharger shaft must be within specification.
- The clearance between the bearings must be to specifications.
- All the bolts and nuts must be torqued to specifications.
- There must not be any metallic contact between the turbine wheel and the turbine housing.
- There must not be any metallic contact between the compressor wheel and the compressor housing.
- There must not be any oil leaks.



ADDITIONAL RESOURCES:

- A demonstration by a competent person, e.g. your Instructor.
- Workshop Manual.
- Audiovisual aids if available.

HAZARD IDENTIFICATION AND CONTROL (HIAC) FORM

OT

OVERHAUL AND MAINTAIN TURBO CHARGERS

STEPS IN OPERATION / PROCESS	POTENTIAL ACCIDENT / INCIDENT	CONTROLS(BY RESPONSIBLE PERSON)
• Use hand tools	• Using damaged tools or wrong tools for the job can cause injury and damage to equipment.	• Always use the correct tool for the job. • Ensure tools are in good condition. • Use tools correctly. • Wear appropriate PPE where necessary. • Always take good care of tools. Maintain, clean and store it properly.

NOTE:Before doing the practical work contained in this module, the learnermust study the content of the above HIAC form again and then sign the statement below.

The above risks, which will be encountered in this module, are fully understood and will be controlled during the practical work.

Signature of Learner: _____

Signature of Training Officer: _____

Date: _____

1. TURBO CHARGERS

ITEM/TASK: INTRODUCTION

DESCRIPTION:

As described in Module PDS, the main function of a turbo charger is to force more air into the engine cylinders by compressing the air. This will allow the engine to effectively burn more fuel and therefore produce more power.

The turbocharger consists of a turbine wheel and shaft, a compressor wheel, a centre housing which serves to support the rotating assembly bearings, a turbine housing and a compressor housing (Fig. 1).

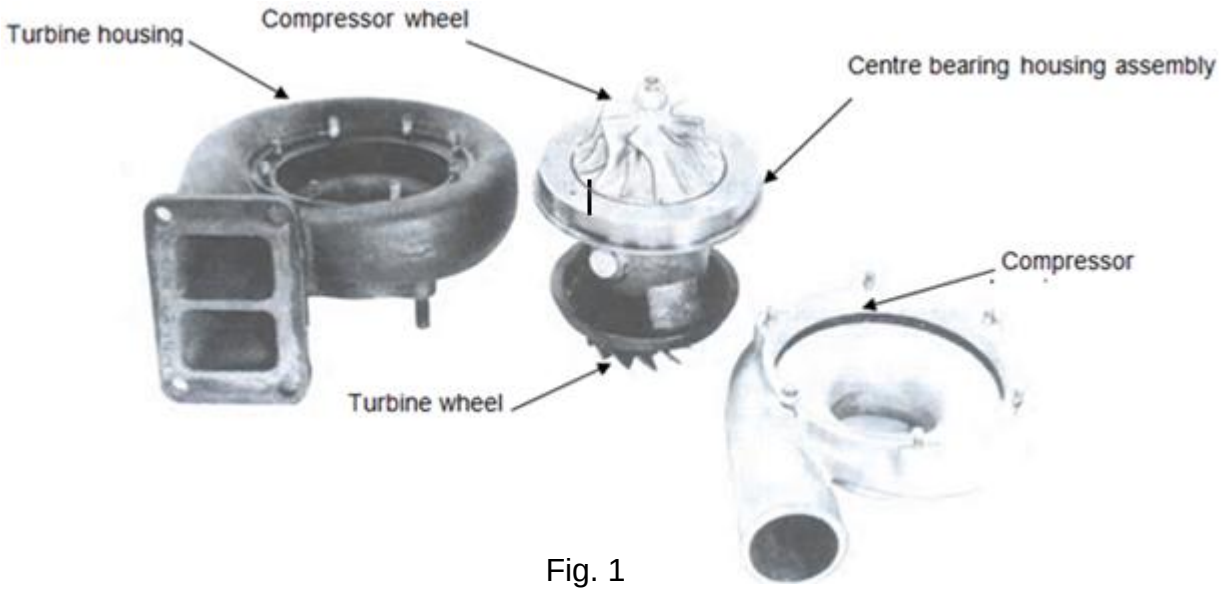


Fig. 1

The turbine wheel is located in the turbine housing and is mounted on one end of the turbine shaft (see Fig. 2 **on next page**). The compressor wheel is located in the compressor housing and is mounted on the opposite end of the turbine wheel shaft to form an integral rotating assembly (Fig. 2).

The rotating assembly consists of a turbine wheel and a shaft assembly, piston ring, thrust spacer, compressor wheel and wheel retaining nut. The rotating assembly is supported on a pressure lubricated bearing.

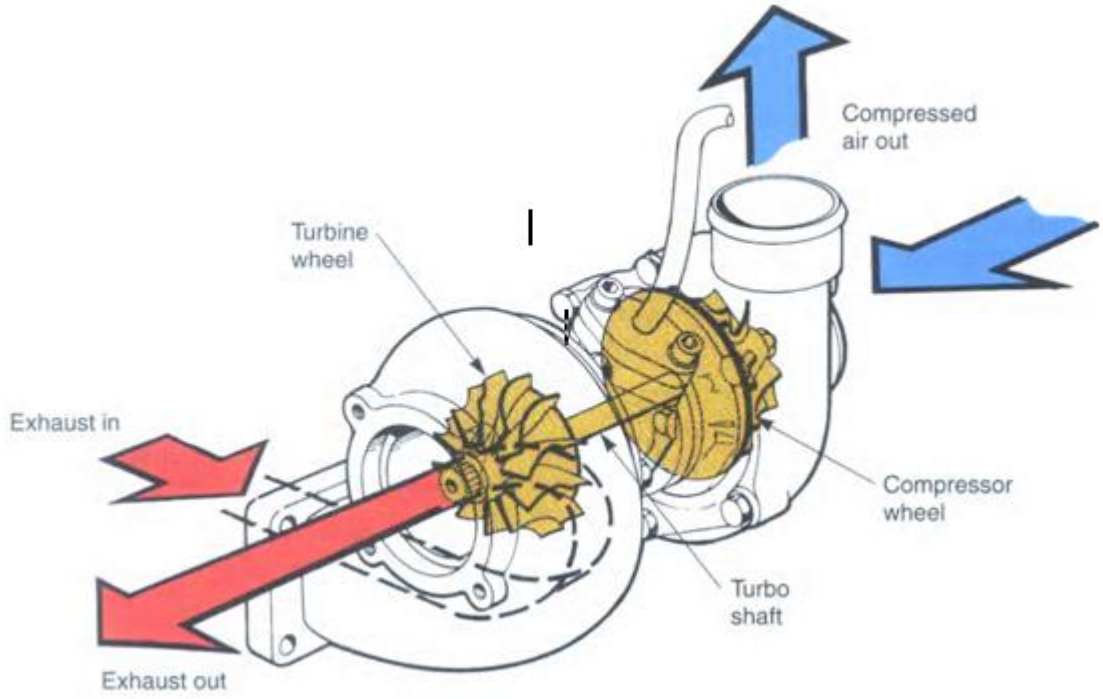


Fig. 2

The basic parts of a turbocharger are:

- **Turbine wheel**—exhaust-driven fan that turns the turbo shaft and compressor wheel.
- **Turbine housing**—outer enclosure that routes exhaust gases around the turbine wheel.
- **Turbo shaft**—steel shaft that connects the turbine and compressor wheels. It passes through centre of the bearing housing.
- **Compressor wheel**—driven fan that forces air into the engine intake manifold under pressure.
- **Compressor housing**—part of the turbo housing that surrounds the compressor wheel. Its shape helps pump air into the engine.
- **Bearing housing**—enclosure around the turbo shaft that contains bearings, seals, and oil passages.
- **Plain bearings**- Engine oil is fed to the bearings through the oil pressure line
- **Sealing rings** (piston-type rings) are placed around the turbo shaft at each end of the turbo housing. They prevent oil leakage into the compressor and turbine housings,
- **The rotating assembly** consists of a turbine wheel and a shaft assembly, piston ring, thrust spacer, compressor wheel and wheel retaining nut.

The rotating assembly is supported on a pressure lubricated bearing.

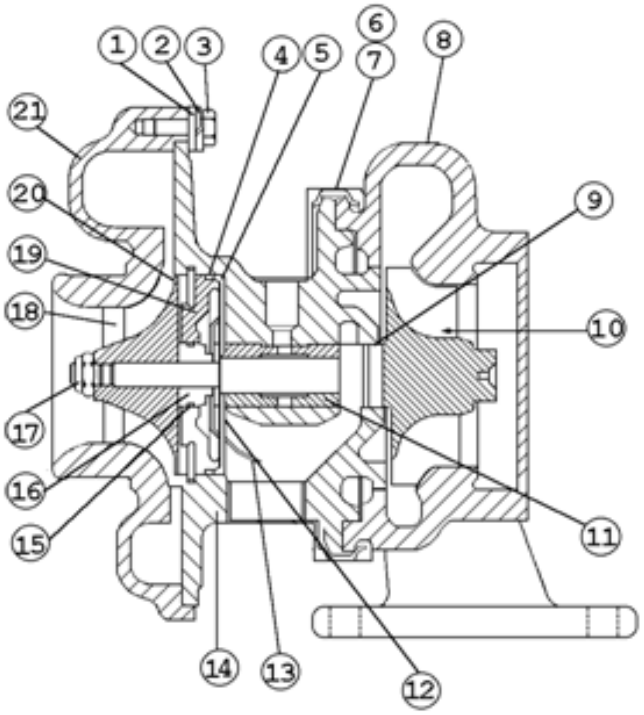


Fig. 3

1. Washer
2. Lockwasher
3. Bolt
4. 'O' Ring
5. Thrust plate
6. 'V' clamp locknut
7. 'V' clamp
8. Turbine housing
9. Seal ring
10. Shaft and turbine wheel assembly
11. Bearing
12. Thrust ring
13. Oil deflector
14. Bearing housing
15. Seal ring
16. Spacer sleeve
17. Compressor locknut
18. Compressor wheel
19. Compressor insert
20. Retaining ring
21. Compressor cover

2. OPERATION

ITEM/TASK: Operation

DESCRIPTION:
The turbocharger is mounted on the exhaust outlet flange of the engine exhaust manifold

- When the engine is running, hot exhaust gases blow out through the open exhaust valve ports and into the exhaust manifold.
- The exhaust manifold and connecting tubing route these gases into the turbine housing. Refer to Figure 4.
- As the gases pass through the turbine housing, they strike the fins on the turbine wheel. When engine load is high enough, there is enough exhaust gas flow to rapidly spin the turbine wheel, Figure 4.
- Since the turbine wheel is connected to the compressor wheel by the turbo shaft, the compressor wheel rotates with the turbine. Compressor wheel rotation pulls air into the compressor housing. Centrifugal force throws the spinning air outward.
- This causes air to flow out of the turbocharger and into the engine cylinder under pressure.

A turbocharger uses exhaust gas flow to spin a turbine wheel. The turbine wheel spins a shaft and a compressor wheel.
The compressor wheel then pressurizes the air entering the engine for more power output. (Fig. 4 next page).

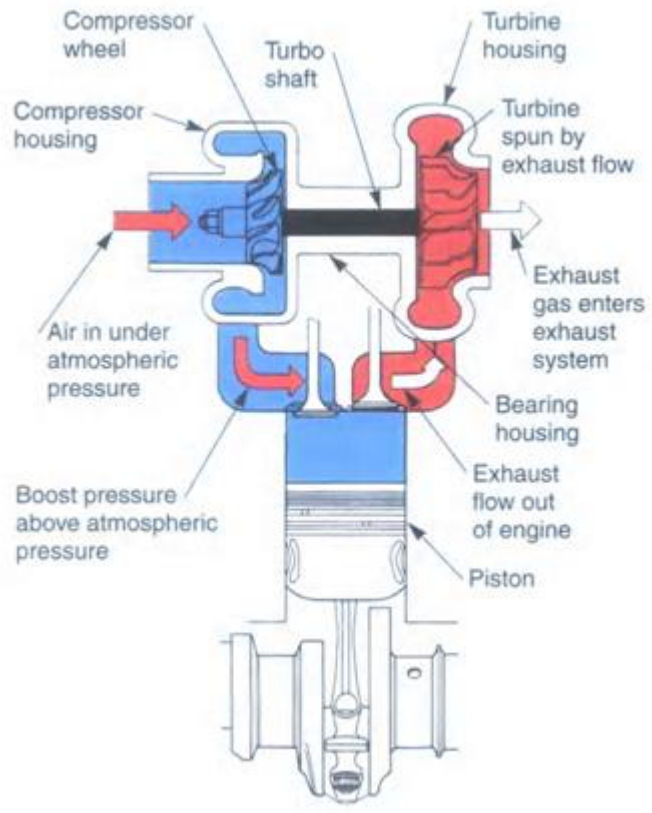


Fig. 4

2.1 Turbo Lag

- Turbo lag refers to a short delay before the turbo develops sufficient boost (pressure above atmospheric pressure) to meet engine demands
- When the accelerator pedal of a vehicle is pressed down for rapid acceleration, the engine may lack power for a few seconds.
- This is caused by the compressor and turbine wheels not spinning fast enough. It takes time for the exhaust gas to bring the turbo up to operating speed.
- Modem turbo systems suffer very little from turbo lag. Their turbine and compressor wheels are very light so that they can accelerate up to speed quickly.

2.2 Advantages of turbo charging

- Because the turbocharger is driven by exhaust- gas energy that would otherwise have been lost, a turbocharged engine offers several advantages over a naturally aspirated version:
- **Increased power-to-weight ratio**—a turbocharger can generally increase the power and torque output of a diesel engine by as much as 35 per cent above that of a naturally aspirated version. Thus many turbocharged smaller four- and six-cylinder

diesel engines are able to do the work of naturally aspirated larger capacity V8 engines.

- **Reduced engine noise**—the turbine housing acts as a noise absorption unit for the pulsating engine exhaust gases. So, too, does the compressor section help to reduce pulsating intake noises in the intake manifold. As a result of these factors, a turbocharged engine is generally quieter than a naturally aspirated unit, although a characteristic whine is usually audible when the engine is under load or accelerating.
- **Better fuel economy**—a turbocharged engine has a higher volumetric efficiency than a naturally aspirated engine, giving more complete combustion of the fuel and resulting in lower specific fuel consumption.
- **Reduced smoke output**—Turbochargers supply a surplus amount of air during medium- to high-speed operation, resulting in a much cleaner and efficient combustion phase, which reduces smoke output considerably.

2.3 Turbocharger Location

- A turbocharger is usually located on one side of the engine. An exhaust pipe connects the engine exhaust manifold to the turbine housing.
  The pulse-type turbocharger requires a specially designed exhaust manifold to deliver high-energy exhaust pulses to the turbocharger turbine.
- This design, with its individual branches as shown in Fig 5 prevents interference between the exhaust gas discharges from the separate cylinders, thus promoting a high-speed pulsing flow not achieved with other designs.
- As the compressor rotates, air is pressurised by centrifugal force and passes from the compressor housing to the engine inlet manifold, the quantity and/or pressure of the air being proportional to the speed of rotation

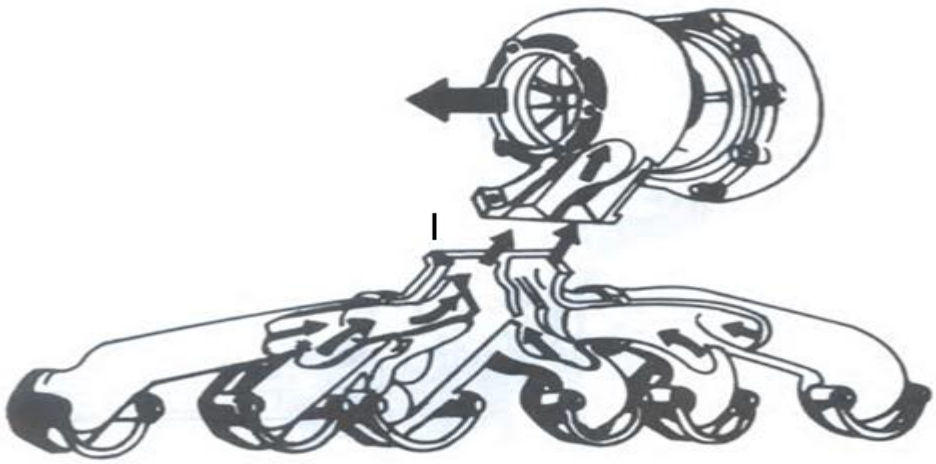


Fig. 5

3. TURBO CHARGER LUBRICATION

ITEM/TASK: Turbocharger Lubrication

DESCRIPTION:

The turbocharger lubricating oil is supplied under pressure through an external oil line extending from the engine cylinder block to the top of the centre housing (see Fig. 6 **on next page**).

- A turbocharger can operate at speeds up to 100,000 rpm. , for this reason, Turbocharger lubrication is needed to protect the turbo shaft and bearings from damage.
- Oil passages are provided in the turbo housing and bearings
- With the engine running, oil enters the turbo under pressure from the engine main oil supply channel Figure 6.
- Sealing rings (piston-type rings) are placed around the turbo shaft at each end of the turbo housing. They prevent oil leakage into the compressor and turbine housings, Figure 6.

A drain passage and drain line allow oil to return to the oil pan after passing through the turbo bearings.

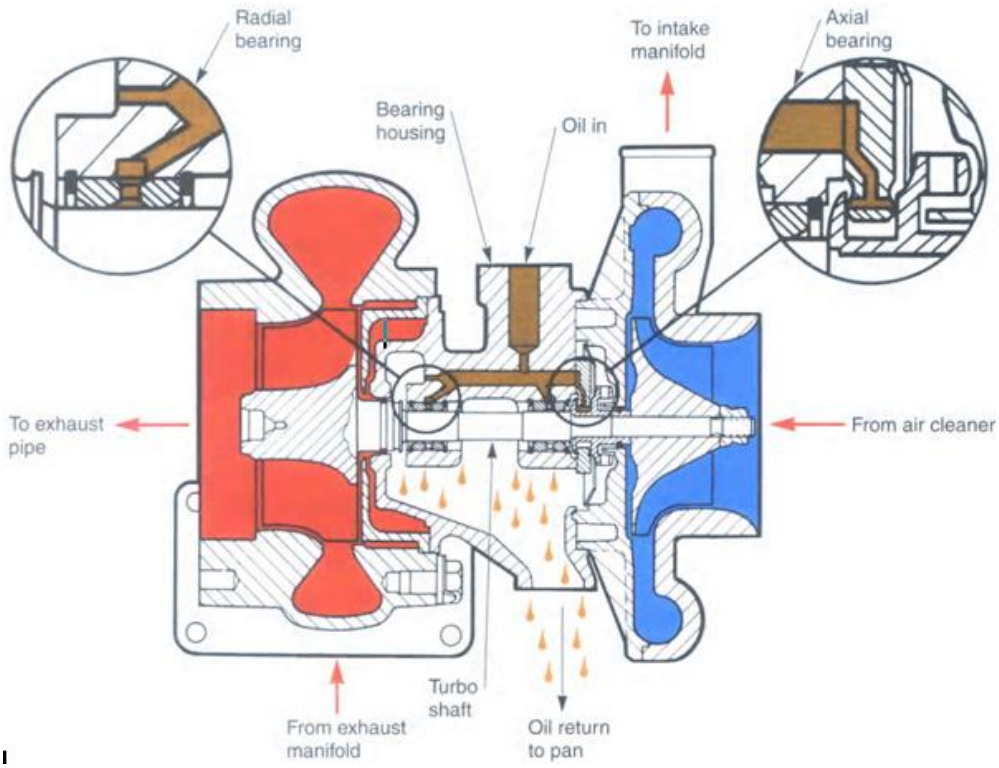


Fig. 6

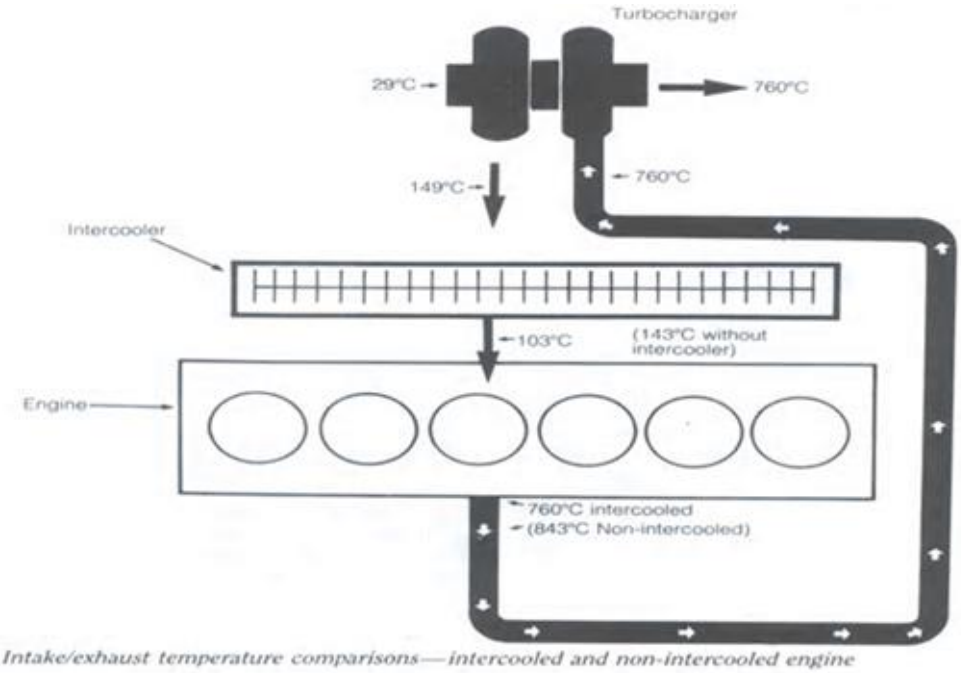
4. TURBOCHARGER INTERCOOLER

ITEM/TASK: INTERCOOLERS

DESCRIPTION:

- A turbocharger intercooler is an air-to-air heat exchanger that cools the air entering the engine. It is a radiator-like device mounted at the pressure outlet of the turbocharger (or supercharger). See Figure 7.
- When you compress air, its temperature increases, since hot air contains less energy-providing oxygen by volume, it will produce less power.
- A cooler charge of air is denser and can be mixed with more fuel to increase combustion and engine power.
- Outside air flows over and cools the fins and tubes of the intercooler, as the air flows through the inter-cooler, heat is removed.
- Inter cooling or charge-air cooling is the process of cooling the heated compressed air before it enters the engine cylinders.

In so doing, the air charge becomes denser, allowing additional fuel to be efficiently burned, resulting in increased engine power and torque above that possible with a non-intercooled turbocharged engine. Fig 7 shows typical air and exhaust gas temperatures for intercooled and intercooled engines and non-intercooled engines.



Intake/exhaust temperature comparisons—intercooled and non-intercooled engine

Fig. 7

There are two types of intercoolers in current use, namely the air-to-water and the air-to-air intercooler. Both are heat exchangers, devices that bring a hot medium (in this case, the charge air) into close contact with a cooler medium (either water or air), allowing heat to be conducted from the hot to the cold

4.1 Air-To-Water Inter cooler

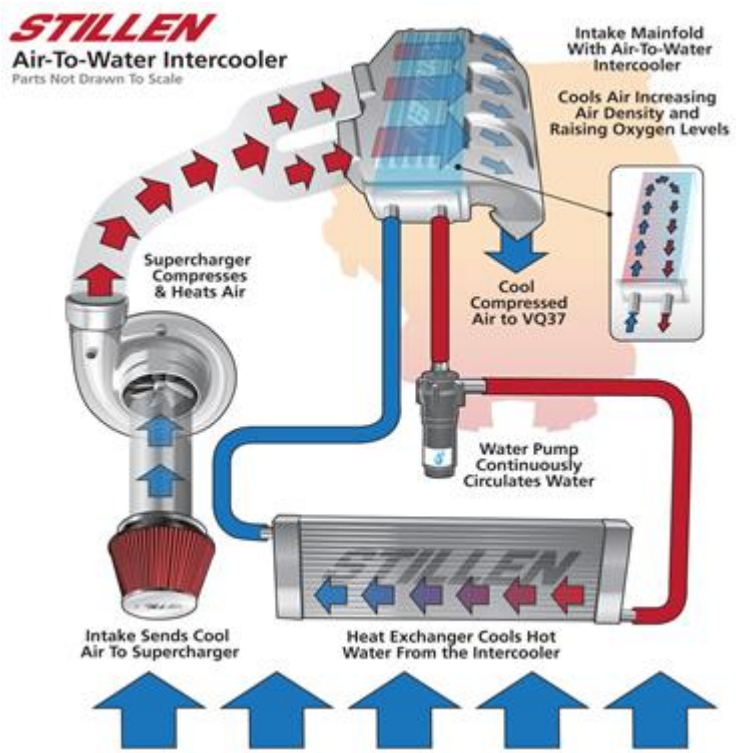


Fig. 8

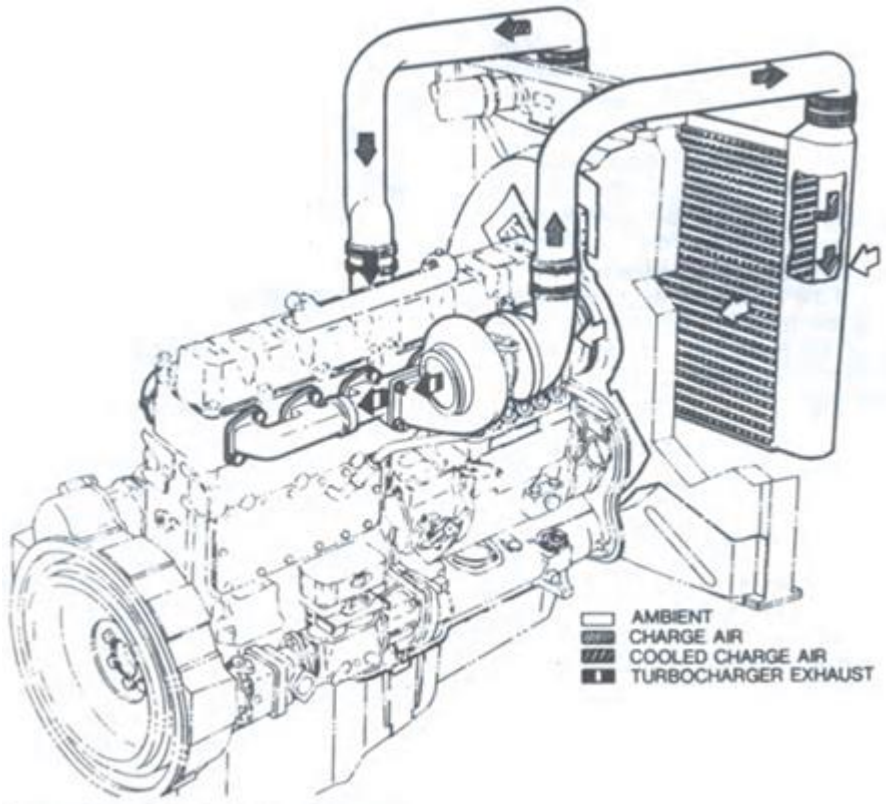
Water to Air Intercooler is one where the exchange of heat occurs between water and air. Water is pumped through the intercooler so that the heat from your charge pipes is transferred to the water. This type of set-up can be mounted anywhere, and just needs to have water plumbed to it. Because of its requirement for the flow of water, this type of intercooler requires a water pump, a reservoir, and a heat exchanger for the water mounted somewhere that will receive good airflow.

4.2 Air-to-air intercooler

- With air-to-air intercooling, the charge air is passed through a finned heat exchanger (like water in an engine radiator), and the vehicle's forward movement causes air to

flow across the fins of the heat exchanger thus cooling the charge air. A typical system is shown in Fig 9 next page.

- This type of intercooler can reduce charge-air temperature to as low as 15°C above ambient air temperature. With charge-air temperatures. as low as this and under pressure between 175— 189 kPa, it is possible to provide three times as much air for combustion as is possible in a naturally aspirated engine. Air-to-air intercoolers are used on mobile machines and are mounted in front of the engine radiator.



Layout of an air-to-air intercooler system

Fig. 9

5. TURBOCHARGER CONTROLS

ITEM/TASK: WASTE GATE VALVE.

DESCRIPTION:

- In certain applications where fast acceleration is needed, engines are fitted with large-capacity turbochargers that require a speed-control device.
- This device, commonly referred to as a waste gate (WGT valve) (as shown in Fig 9.1), prevents the turbocharger from over-speeding and subsequently over-boosting and damaging the engine.
- On the other hand, the smaller turbochargers fitted to stationary engines or slow moving diesel-powered equipment are self regulating in their maximum speed and charge pressure by the design of the turbine and compressor.
- Therefore it is essential that the turbocharger installed be matched to the engine and performance requirements. Fig 9.1 shows a typical performance comparison between a standard turbocharger and a turbocharger fitted with a waste gate.
- The waste gate turbocharger, however, is of a higher output capacity and capable of delivering sufficient charge air for complete combustion of the fuel during acceleration as well as in high-torque situations.
- As the engine speed and exhaust-gas energy increase, so the turbocharger speed increases and the charge-air pressure rises. Without the waste gate, charge pressure would continue to rise, with considerable risk to both the engine and the turbocharger.
- However, the increasing air pressure acts on the diaphragm in the waste gate until, at a pre-determined pressure , the resulting force is sufficient to compress the spring and open the exhaust bypass passage
- This allows sufficient exhaust gas to bypass the turbine to prevent any further rise in turbocharger speed and subsequent charge pressure

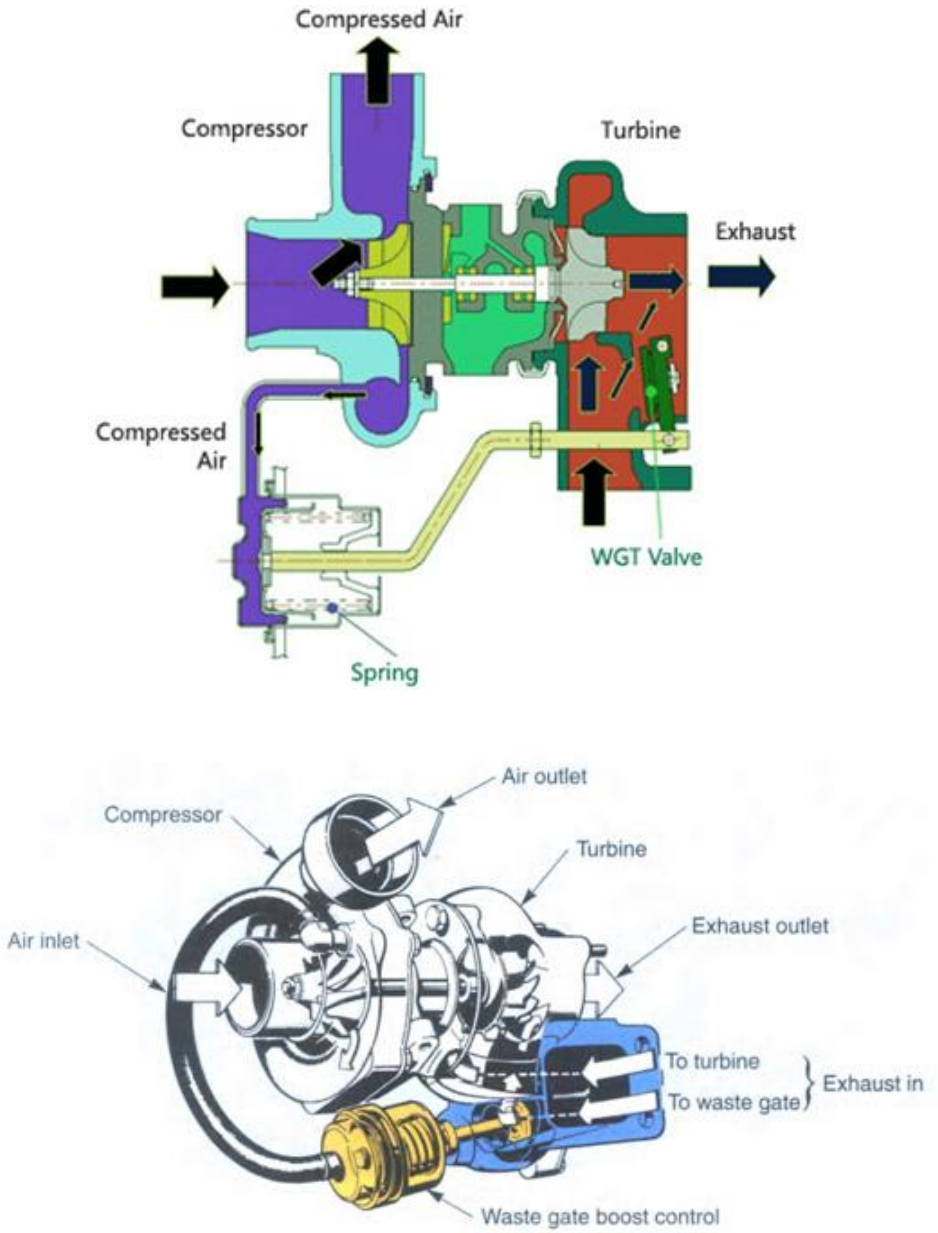


Fig. 9.1

Under full load, boost may become high enough to overcome the diaphragm spring pressure. Manifold pressure compresses the spring and opens the waste gate valve. This permits some of the exhaust gases to flow through the waste gate passage and into the exhaust system. Less exhaust is left to spin the turbine. Boost pressure is limited to a preset value. (Fig.9.2)

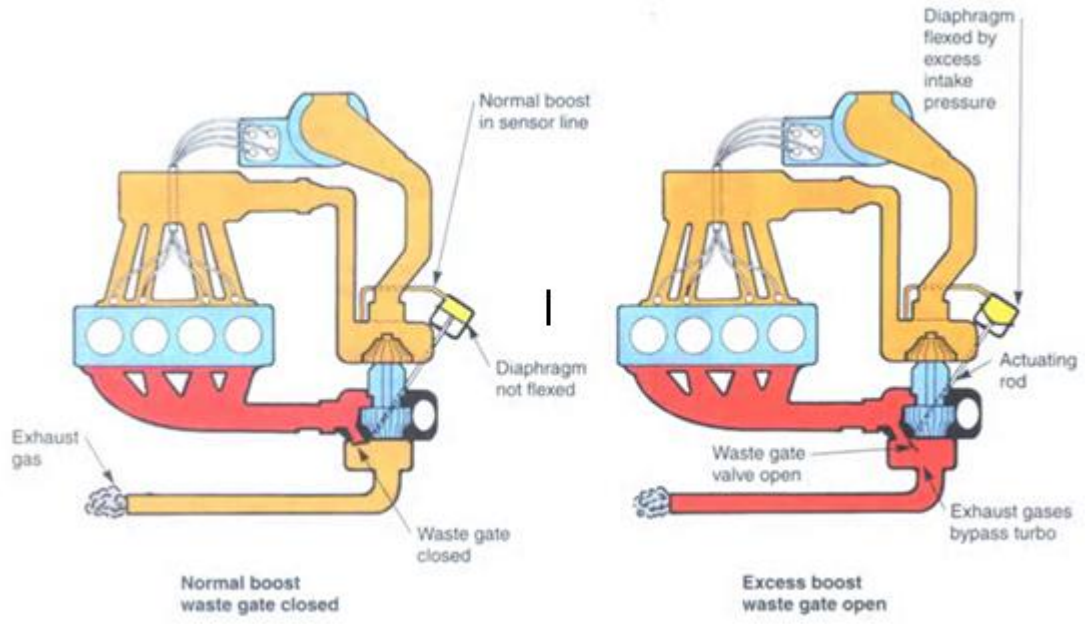


Fig. 9.2

6. ENGINE SHUTDOWN

ITEM/TASK: Engine shutdown.

DESCRIPTION:

- Before a turbocharged diesel engine is shut down, the engine should be run at idle speed for 3—4 minutes. This will allow the high-speed rotating assembly to slow down, allow the engine operating temperature to normalise, and allow excessive heat to be dissipated from the turbocharger
- If a turbocharged engine is shut down while operating at high speeds or under load, the turbocharger rotating assembly will continue to rotate for some time without oil for essential lubrication and cooling.
- Once the oil flow to the bearing housing stops, the heat in the shaft and housing is sufficient to decompose the oil to form gums and varnish, leaving no lubricating residue and causing premature wear to the rotating shaft, its support bearings and the bearing housing.

7. TURBOCHARGER SERVICE

ITEM/TASK: Turbocharger service

DESCRIPTION:
Being unlike any other component of the engine, turbochargers have the need for specific service procedures. Further, because of the high operating temperatures and high operating speeds, turbochargers are susceptible to heat cracking and unbalance to a degree seldom seen in engine ancillary equipment.

8. ENGINE LUBRICATION

ITEM/TASK: Engine lubrication

DESCRIPTION:

- Although not specifically a turbocharger service item, it is of the utmost importance to carry out regular oil and filter changes on turbocharged engines.
- It is just as important to monitor engine oil pressure and the quality of engine oil used. Turbocharged diesel engines should only operate on the lubricating oil recommended by the engine manufacturer, which is usually of a different classification from that required for naturally aspirated engines.

9. INSPECTION AND CLEANING

ITEM/TASK: Inspection and cleaning.

DESCRIPTION:

- Many engine manufacturers and/or turbocharger manufacturers recommend periodic disassembly, inspection and cleaning of the compressor housing and turbine.
- A small deposit on the turbine wheel can seriously affect turbocharger performance and should be removed. The usually recommended cleaning procedure is to use a solvent and soft (not wire) brush, taking care to ensure that solvent does not enter the turbocharger bearing housing.
- In addition to inspecting for deposits, the components should also be inspected for physical damage, paying particular attention to the turbine and compressor wheels and housings.

10. DISMANTLING THE TURBOCHARGER

ITEM/TASK: Dismantling the turbocharger.

DESCRIPTION:

- Clean the exterior of the turbocharger with a non-caustic cleaning solvent. Mount the unit on to a special fixture or in a vice as shown in Fig 10.
- Before removing the housings use a scribing tool to mark the relative location of compressor and turbine housings to the bearing housing.
- Remove the clamp or bolts securing the compressor housing and lift off the housing.
- Next remove the turbine housing clamp or bolts and lift the bearing housing clear of the turbine housing.
- Mount the bearing housing in an upright position in a special fixture or soft-jawed vice as seen in Fig 10, making sure that the vice jaws grip the turbine wheel extension nut only, and not the turbine fins.
- Unscrew the locknut retaining the compressor wheel and lift the wheel off the turbine shaft.

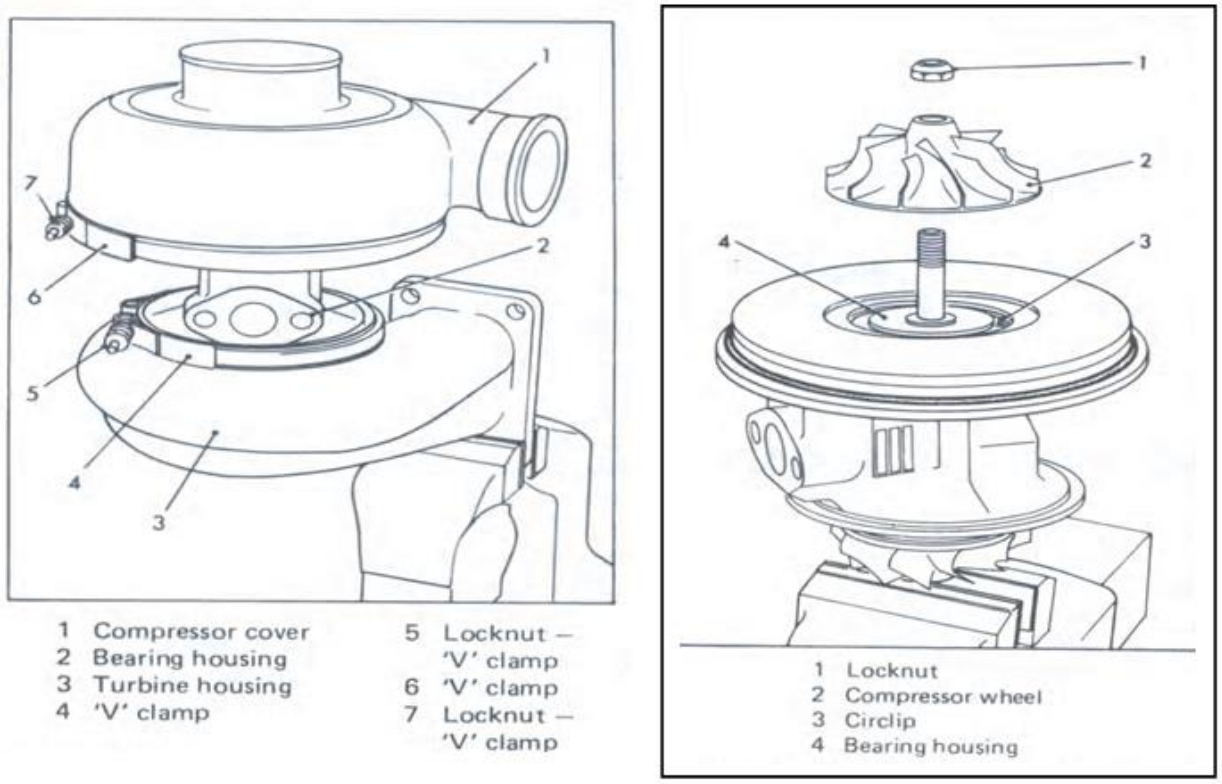
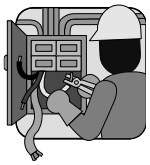


Fig. 10

- With the compressor wheel removed, the turbine shaft can be removed from the turbine end of the bearing housing.
- Next remove the circlip or cap screws from the thrust assembly located at the compressor end of the bearing housing, and, with a piece of wood doweling inserted into the centre hole of the thrust assembly, lever the assembly out of the bearing housing.
- Remove the remainder of the thrust assembly and the two plain turbine shaft support bearings and circlips.
- Finally remove all piston ring seals from the turbine shaft and thrust assembly spacer sleeves. The disassembled turbocharger is now ready for cleaning and inspection.
- Clean all the parts in a solvent.

GO ON FOR THE PRACTICE

PRACTICE



Take the turbocharger and by referring to your notes and Workshop Manual, dismantle it.

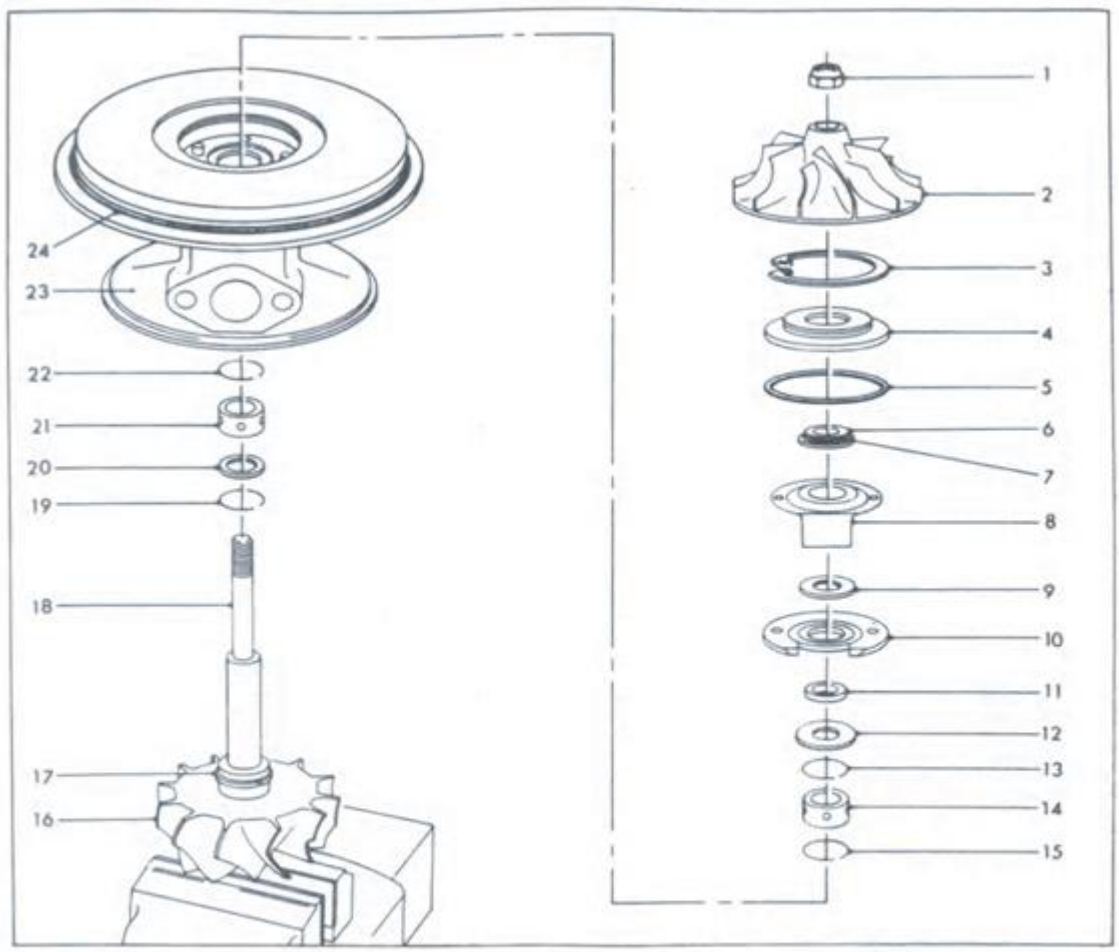
Call your Instructor to check your work. When you have achieved the required standards, ask him to sign you off and go on to the next section.

LEARNER	TRAINING OFFICER
DATE :	DATE :
SIGNATURE :	SIGNATURE :

11. ASSESSMENT OF THE TURBOCHARGER

ITEM/TASK: Assessment of the turbocharger

DESCRIPTION:



1 Locknut	7 Spacer sleeve	13 Circlip	19 Circlip
2 Compressor wheel	8 Oil deflector	14 Bearing	20 Oil control sleeve
3 Circlip	9 Thrust ring	15 Circlip	21 Bearing
4 Compressor insert	10 Thrust bearing	16 Turbine wheel	22 Circlip
5 Rubber 'O' ring	11 Spacer	17 Piston rings	23 Bearing housing
6 Piston ring	12 Thrust ring	18 Turbine shaft	24 Rubber 'O' ring

Fig. 11

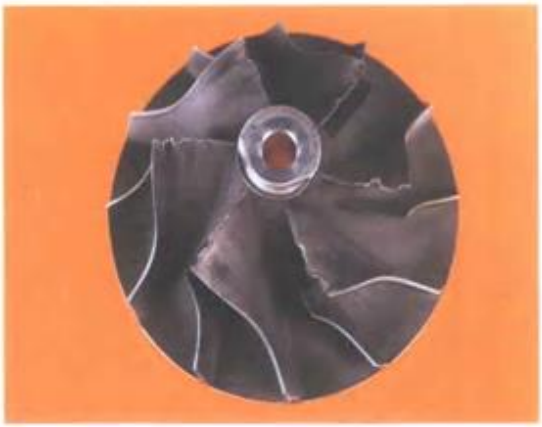
11.1 ASSESSMENT OF TURBOCHARGER

- Clean all components for inspection using an approved cleaner; caustic solutions will damage aluminium components and must not be used.
- All parts should be soaked in cleaning fluid until all foreign deposits have been removed.
- The turbine wheel and turbine housing can be bead blasted to remove carbon deposits provided that the smooth surface of the turbine shaft is protected.
- After soaking the components, blow out all passages and compartments with compressed air.
- Generally, no parts should show signs of wear, corrosion or damage.
- A wear evaluation in accordance with the manufacturer's specifications will determine whether parts are replaced or reused. Refer to Fig.11 for an exploded view of the layout of the turbocharger parts described below.

11.2 Turbine and compressor housings

- Inspect the turbine housing for erosion, cracking and nib marks in the vicinity of the turbine wheel.
- Also, the turbine housing to the exhaust manifold mounting flange is to be checked for surface trueness
- The compressor housing should also be checked for wheel rub marks and cracking**.**

Compressor wheels are made of high strength cast aluminum and have varying designs.



Smaller foreign material will do less severe damage at the same location. Dirt tracks trailing from the damage tell us that use after damage has occurred.

Fig. 12

11.3 **Bearing housing**

- The bearing housing must not show wear marks due to contact with rotating parts. Inspect the bores in which the bearings run for scores, and measure their diameter with a telescopic gauge.
- The bore diameter is critical, with permissible wear approximately 0.025 mm. If the bores are scored or are worn oversize or oval, a new housing should be fitted or the old housing sleeved.

11.4 Turbine shaft bearings

- Whenever the turbocharger is overhauled the shaft bearings (21, 14) (Fig.11) must be renewed, regardless of their condition.

Abrasive damage is more severe on outside surfaces than inside.

Fig. 13

11.5 Thrust bearing assembly

The thrust bearing (10) and thrust rings (12, 9) should be renewed, regardless of their condition. Measure the thrust spacer (11) and spacer sleeve (7) and inspect their surfaces for scoring or heat discoloration. Discard if worn, scored or discoloured

Thrust plates are made with copper/tin/lead overlaid on a high strength aluminum alloy, or of aluminum overlaid on steel.

General inspection shows that abrasive cutting is present, and a first preconceived idea might be that the customer has allowed debris to enter and cause the damage.

Fig. 14

11.6 Rotating assembly

- Examine the turbine wheel (16) and shaft (18) for any signs of wear.
- Inspect the fins of the wheel for cracks, carbon deposits, distortion of shape, erosion wear on the tips and foreign object damage. The shaft must show no signs of wear, scoring or discoloration.
- Measure the shaft journals for exact size and ovalness and check against the manufacturer's figures.

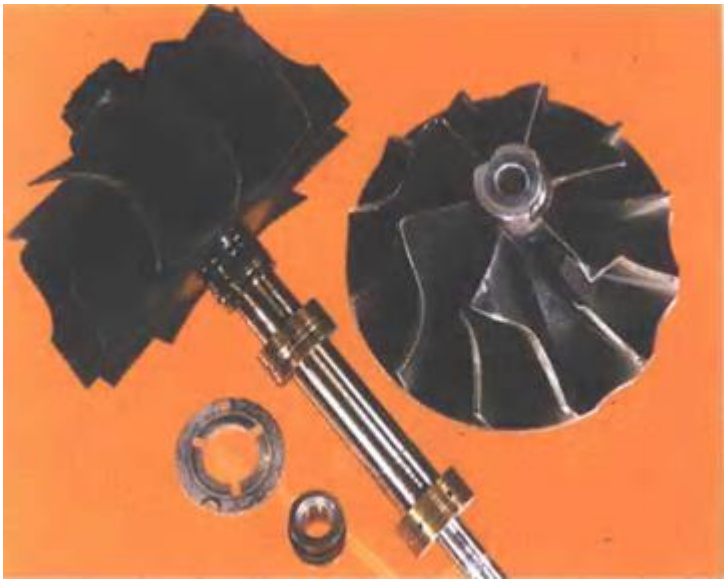


Fig. 15

- Check the width of the seal ring groove in front of the turbine wheel to ensure that the groove has not worn oversize.
- Inspect the compressor wheel blades for tip damage due to foreign objects or rubbing on the compressor housing.
- The wheel should also be checked for signs of rubbing between the underside of the wheel and the bearing housing.
- Any foreign object damage or wear marks on either the turbine or compressor wheels will cause them to run out of balance, creating undue vibration and wear within the turbocharger.
- Check that the bore of the compressor wheel is of the correct size—it may be either an interference fit or a slide fit onto the turbine shaft, depending on the type of turbocharger.
- Inspect the bearing journals for excessive scratches and wear. Measure the journal with an outside micrometer and compare the sizes with the specifications in the manual.

When foreign objects enter the turbine wheel, the outer edges of the blades are twisted and torn when the high speed blade hits a stationary object (even small, light foreign material will seem heavy to a high speed blade).

Fig. 16

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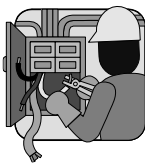
PRACTICE



Assess all the parts of the dismantled turbocharger and write down the names of all the parts which must be replaced.

Call your Instructor to check your work. When you have achieved the required standards, ask him to sign you off and go on to the next section

LEARNER	TRAINING OFFICER
DATE :	DATE :
SIGNATURE :	SIGNATURE :

12. ASSEMBLING THE TURBOCHARGER

ITEM/TASK: Reassembly

DESCRIPTION:

- When reassembling a turbocharger, cleanliness is vital to a long service life. All piston-ring-type seals, '0' rings, lock tabs, circlips and the compressor wheel retaining nut should be automatically renewed, together with all other parts that require replacement during the inspection period.

- Throughout assembly, lubricate all rotating parts with clean engine oil. Install the bearing retaining circlip (19) into the turbine end of the housing, taking care not to scratch the bearing bore.

- Fit the oil control sleeve (20) and the turbine end bearing (21) into the bore.

- Install the two inner bearing retainer circlips (22, 15), and the compressor end bearing (14) in the bore.

- With the turbine wheel (16) mounted in a vice as shown in Fig .11, fit the piston ring seals (17) into the oil ring grooves.

- Install the turbine shaft (18) in the bearing housing (23) from the turbine end.

- As the shaft is pushed into the housing, resistance will be felt as the chamfered of the housing bore butts against the piston ring seals on the shaft.

- Apply moderate pressure with a slight turning action to the turbine shaft, and the chamfer will compress the piston ring seals and allow them to enter the housing.

- Install the compressor wheel (2) on the turbine shaft. If it is an interference fit, it will have to be heated in hot clean engine oil to expand it before sliding it onto the turbine shaft. (Refer to the manual for correct oil temperature.) Secure the wheel with the self- locking nut, tensioned to the required torque.

- In order to check for correct running clearances of the rotating assembly, mount a dial indicator onto the compressor end of the bearing housing and measure the axial movement of the turbine shaft (refer to Fig 17). Reposition the dial indicator mounting so the rotating assembly can be checked for radial clearance (Fig 17 next page).

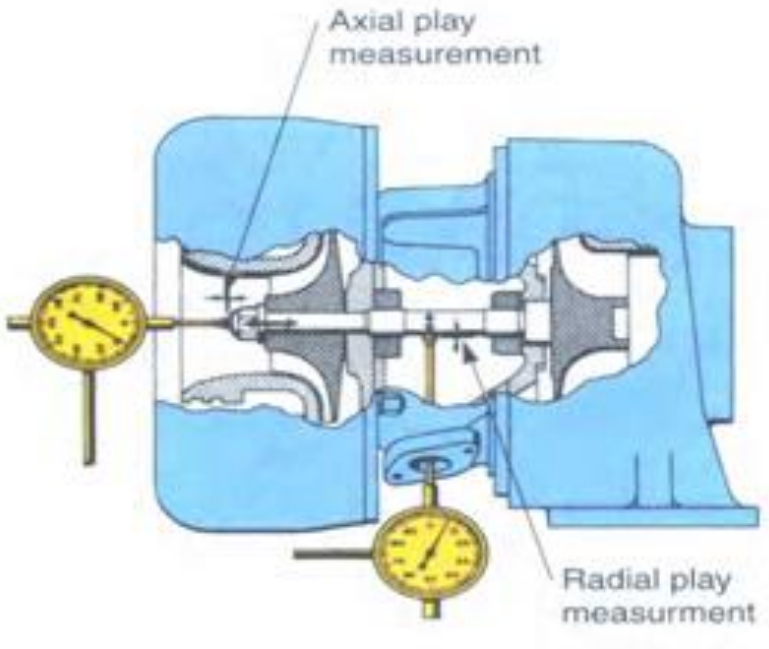


Fig. 17

- Refer to the turbocharger specifications for correct turbine shaft clearances. Excessive clearances must be corrected before proceeding further

- Install a new ‘0’ ring (24) onto the bearing housing and fit the compressor housing, at the same time aligning the assembly marks on both housings. Refit the ‘V clamp and tighten.
- Turn the turbocharger over and install the turbine housing, once again aligning the

- Refit the compressor housing.

- Torque all the bolts to specifications.

- Check that there is no metallic contact between the compressor wheel and the compressor housing.

NB: Metallic contact between the moving and stationary parts is caused by deformed or broken compressor blades, turbine blades, or incorrect assembling of the turbocharger.

- Check the radial movement of the shaft and compare the reading of the dial indicator with the specifications given in the Workshop Manual (Fig. 17).

Waste Gate Service

- An inoperative waste gate can either cause too much or too little boost pressure. If the waste gate is stuck open, the turbocharger will not produce boost pressure and the engine will lack power.
- If the gate is stuck closed, detonation and engine damage can result from excessive boost.
- Before replacing the waste gate, always check other parts. Check the knock sensor and the ignition timing. Make sure the vacuum pressure lines are all connected properly.
- Follow service manual instructions when testing or replacing a waste gate.
- As shown in Figure 15, waste gate removal is relatively easy. Simply unbolt the fasteners, remove the lines, and lift the unit off the engine.
- Many manuals recommend waste gate replacement, rather than in-shop repairs.
- Finally, cover all openings until the turbocharger is to be installed on the engine.

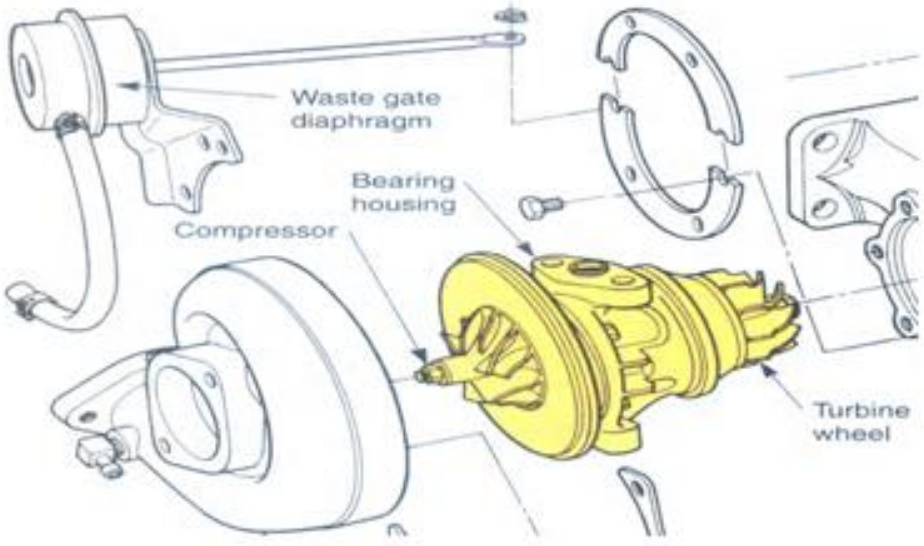


Fig. 18

13. THE REPLACEMENT OF A TURBO

ITEM/TASK: Installing a New Turbocharger

DESCRIPTION:

When installing a turbocharger, you should:

- Make sure the new turbo is the correct type. Compare part numbers.
- Use new gaskets and seals.
- Torque all fasteners to specifications.
- If needed, change the engine oil and flush the oil lines before starting the engine.
- If the failure was oil related, check the oil supply pressure in the feed line to the turbocharger.

13.1 Operating checks

Refer to a factory service manual for a detailed troubleshooting chart. It will list the common troubles for the particular turbo charging system

- With experience, it is possible to gain a good indication of turbocharger operation from the sounds it produces in operation.
- The engine should be operated through all speed and load ranges while paying particular attention to unusual noises coming from the turbocharger.
- Generally, the only noise that should be heard is a high-pitched whine that occurs when the engine is placed under load or accelerated.
- Check connection of all vacuum lines to the waste gate and oil lines to the turbocharger, Figure 10 next page.
- Use a regulated low-pressure air hose to check for waste gate diaphragm leakage and operation.
- Use the dash gauge or a test gauge to measure boost pressure (pressure developed by turbo under a load).
- If needed, connect the pressure gauge to an intake manifold fitting. Compare the gauge readings to specifications.
- Check connection of all vacuum lines to the waste gate and oil lines to the turbocharger, Figure 19 next page.
- Use a regulated low-pressure air hose to check for waste gate diaphragm leakage and operation.

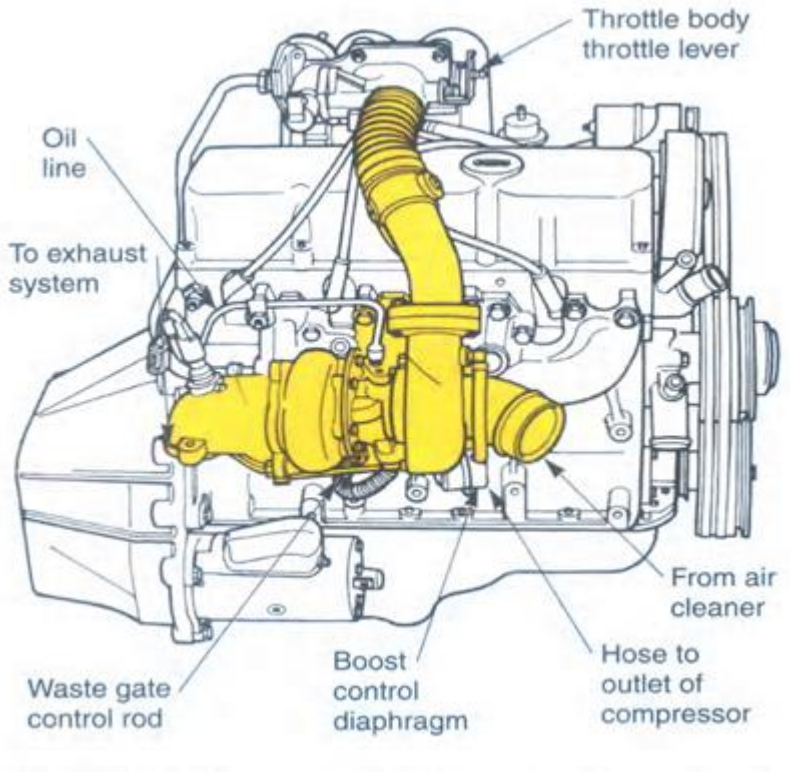


Fig. 19

14. PERFORMANCE TESTING

ITEM/TASK: Testing

DESCRIPTION:

- An accurate method of gauging an engine's performance output is by using test gauges to measure certain aspects of engine operation (see Fig 20 next page).
- A quick and accurate way of checking that the turbocharged engine's output is in accordance with the manufacturer's specifications is to measure the charge-air pressure in the intake manifold when the engine is operated under full load.

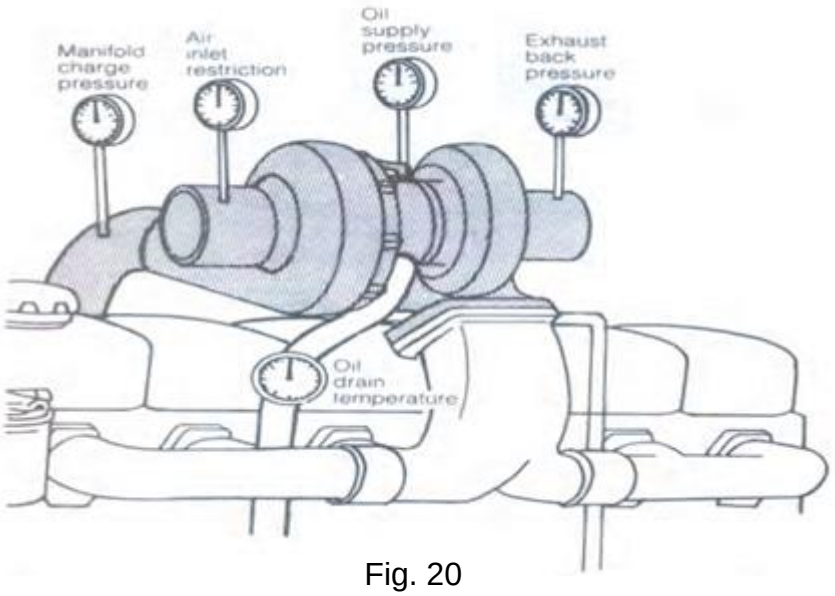


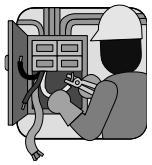
Fig. 20

- Correct charge-air pressure is indicative of:
    - correct metering and delivery of fuel from the injection pump and injectors
    - acceptable compression pressures
    - correct injection timing
    - efficient turbocharger operation
    - unrestricted engine breathing.
- Full load can be applied to an engine by loading it appropriately, care being taken to ensure that damage is not caused to either the engine or the equipment being driven.
- If the engine is installed in a piece of mobile equipment fitted with a torque converter, full load can be applied by applying the brakes and stalling out the torque converter with the transmission engaged in top gear.
- The engine should be running at full throttle and rated engine speed during any stall test.

Note: Do not run the engine under stall conditions for more than 30 seconds at one time as serious overheating of the engine and torque converter will occur.

GO ON TO THE NEXT PAGE FOR THE PRACTICE.

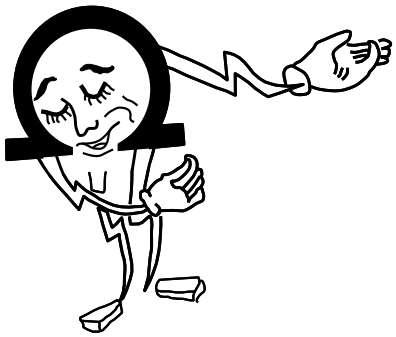
PRACTICE



Assemble the turbocharger by referring to your notes and Workshop Manual.

Call your Instructor to check your work. When you have achieved the required standards, ask him to sign you off.

LEARNER	TRAINING OFFICER
DATE :	DATE :
SIGNATURE :	SIGNATURE :



REMEMBER ALWAYS WORK SAFE

Once you have passed the entire practices, you are now at liberty to request a Formative Assessment from your Assessor.